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Doctoral Thesis

STRATEGIC KNOWLEDGE CREATION THROUGH THE ANALYSIS OF THE STRUCTURE OF THE NETWORK FORMED BY THE PARTICIPANTS OF EUROPEAN R&D PROJECTS.

CASE OF THE EMERGING SECTOR OF RENEWABLE ENERGIES, AT ORGANIZATIONS AND LOCAL REGIONS LEVEL

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To my parents, for the "education of curiosity" they have taught me,

and to Fer and Nahia, for being my great support.

Abstract

The European Research Area (ERA) strategy aims to increase the share of renewable energy in the energy mix to 20% by 2020, boosting this multidisciplinary and emerging sector. There is the uncertainty of creating consortia of R&D projects including inefficient collaborations in the transmission of information and knowledge between partners and local regions. This doctoral thesis focuses on European R&D projects in the wind, solar, marine, geothermal and biomass sectors for the period 2000-2013. The final objective of the thesis has been to present the potential of the Social Network Analysis technique to obtain strategic knowledge for the decision making of an emerging and multidisciplinary technological sector. To this end, the applicability of social network theory and the usefulness of the information provided by R&D projects have been taken as a basis. On the one hand, it shows theoretically the potential of project information to create strategic knowledge through the integrated application of the centrality and structural hole approaches of Social Network Analysis. On the other hand, it provides the creation of strategic knowledge in the renewable energy sector in Europe, providing value-added knowledge based on efficiency on the organizations and local regions participating in these projects. It concludes on how they influence the other actors in the collaboration networks, who are efficient and who have a facilitating role of cohesion of the network of information and knowledge transfer acquired through R&D projects, applicable to any sector, normally subsidized by public bodies when they are emerging sectors. This study constitutes a novel contribution, being a complementary tool to the studies of patents and publications that policy makers must consider when investing in public R&D projects, to build ERA efficiently.

Keywords:

R&D Projects; Social Network Analysis; Structural Holes; European Research Area; Technological Knowledge and Information Transmission; Renewable Energy

Resumen

La estrategia del Espacio Europeo de Investigación (ERA) tiene como objetivo aumentar el porcentaje de energías renovables en el mix energético hasta el 20% para el año 2020, impulsando este sector multidisciplinar y emergente. Existe la incertidumbre de crear consorcios de proyectos de I+D incluyendo colaboraciones ineficientes de transmisión de información y conocimiento entre los socios y las regiones locales. Esta tesis doctoral se centra en los proyectos europeos de I + D en los sectores de energía eólica, solar, marina, geotérmica y biomasa, para el período 2000-2013. El objetivo final de la tesis ha sido presentar el potencial de la técnica Análisis de Redes Sociales, para obtener conocimiento estratégico para la toma de decisiones de un sector tecnológico emergente y multidisciplinar. Para ello, se ha tomado como base la aplicabilidad de la teoría de redes sociales y la utilidad de la información que proporcionan los proyectos de I+D. Por un lado, muestra teóricamente el potencial de la información sobre proyectos para crear conocimiento estratégico a través de la aplicación integrada de los enfoques de centralidad y "structural hole" de Análisis de Redes Sociales. Por otro lado, aporta la creación de conocimiento estratégico en el sector de las energías renovables en Europa, proporcionando conocimiento de valor añadido en base a la eficiencia sobre las organizaciones y regiones locales participantes en estos proyectos. Concluye en cómo influyen estos en el resto de actores de las redes de colaboración, quiénes son eficientes y quiénes tienen un rol facilitador de cohesión de la red de transferencia de información y conocimiento adquirido a través de los proyectos I&D, aplicable a cualquier sector, normalmente subvencionados por organismos públicos cuando son sectores emergentes. Este estudio constituye una novedosa contribución, siendo una herramienta complementaria a los estudios de patentes y publicaciones que los responsables políticos deben considerar al invertir en proyectos públicos de I+D, para construir ERA eficientemente.

Palabras clave:

Proyectos I+D; Análisis de Redes Sociales; Structural Holes; Espacio Europeo de Investigación; Transmisión de Información y Conocimiento; Energías Renovables.

Resumen ampliado

Las fuentes de energía renovable han sido ampliamente estudiadas en términos de tecnología y economía, confirmando que la inversión en este sector emergente generará un efecto multiplicador en la economía y que será necesaria la creación de nuevas estructuras organizativas. La extensa y rápida evolución de las empresas en este sector muestra que la industria basada en el conocimiento y la información crecerá exponencialmente en los próximos años, previéndolo como crucial a nivel global y local. La Comisión Europea diseñó la estrategia del Espacio Europeo de Investigación (ERA) con el objetivo de aumentar el porcentaje de energías renovables en el mix energético hasta el 20% para el año 2020, impulsando un sector industrial multidisciplinar, incluyendo: eólico, solar, marina, geotérmica y biomasa. Sin embargo, la necesidad de incorporar un mayor porcentaje de tecnologías diferentes en las nuevas estructuras de generación y distribución de energía hace que la participación, interacción y relación de actores y regiones europeas sean cada vez más importantes en términos de desarrollo industrial, basado en el conocimiento y la información. Desafortunadamente, se han planteado **preocupaciones** por los consorcios de proyectos públicos europeos y su transmisión de información y conocimiento para construir ERA con coherencia. Los responsables políticos se enfrentan a la incertidumbre de crear consorcios de proyectos de I+D que podrían incluir colaboraciones ineficientes entre los socios y las regiones locales. Esta **incertidumbre** es la principal **motivación** de esta tesis.

Esta investigación se centra en los proyectos europeos de I+D en los sectores de energía eólica, solar, marina, geotérmica y biomasa, debido a su interés actual, centrándose en el período 2000-2013. El **objetivo final** de la tesis ha sido presentar el potencial de una técnica en auge, como es el Análisis de Redes Sociales (SNA), para obtener conocimiento estratégico para la toma de decisiones a la hora de crear el espacio de investigación y desarrollo de un sector tecnológico emergente y multidisciplinar. Para ello, se ha tomado como base la aplicabilidad de la teoría de redes sociales y la utilidad de la información que proporcionan los proyectos de investigación y desarrollo.

La **contribución** de esta tesis se divide principalmente en **dos partes.** La primera, por un lado, nos muestra teóricamente el **potencial de la información sobre proyectos para crear conocimiento estratégico a través de Análisis de Redes Sociales.** Para ello, se ha analizado el vínculo entre la información disponible sobre proyectos de colaboración con las estructuras de transferencia de información y conocimiento, así como los conceptos críticos necesarios para extraer conocimiento estratégico de un sector emergente a través de un particular enfoque de Análisis de Redes Sociales. La segunda, por otro lado, aporta la **creación de conocimiento estratégico en el sector de las energías renovables en Europa.** En este caso, y teniendo en cuenta su carácter teórico-práctico, se delimita el sector de energías renovables en Europa, acotando con gran detalle el sector emergente bajo estudio, mediante la información disponible sobre proyectos de investigación y desarrollo, analizando las posibilidades y limitaciones de esa información, así como creando la estructura que muestra la red de transferencia de información y conocimiento entre actores del sector de energías renovables en Europa, proporcionando la visión del sistema de red que componen los diferentes actores que participan en los proyectos de investigación y desarrollo, desde el punto de vista relacional. Y se concluye con la identificación de principales actores que juegan un papel clave en función de su eficiencia en la transferencia de información y conocimiento, siendo esto estratégico y de gran utilidad para los responsables políticos encargados de diseñar las políticas del espacio europeo de investigación y desarrollo. Siempre se enfoca el estudio desde dos perspectivas: organizaciones (centros de investigación y tecnológicos, universidades, empresas, administraciones públicas, asociaciones, etc…) y regiones locales.

En la **primera parte**, se analiza el estado del arte, así como la base teórica y conceptual de los tres ejes fundamentales en los que se sustenta la teoría de esta tesis doctoral: las relaciones inter-organizacionales, las redes de colaboración de proyectos de investigación y desarrollo, y el análisis de redes sociales. Para ello, por un lado, se realizará un análisis detallado de las redes inter-organizacionales, desde la perspectiva de la Teoría Organizacional y las relaciones inter-organizacionales, incluyendo las funciones y los tipos de redes. Para ello, se realiza un análisis bibliográfico del estado del arte, analizando la evolución de estos conceptos y su relación con las estructuras de transferencia de información y conocimiento, siendo este último el enfoque que se quiere abordar con la tesis. Cabe destacar la importancia de incluir el concepto de eficiencia a la hora de analizar estas estructuras. Además, se ha revisado la relación que tienen las nuevas estructuras organizativas en los sectores emergentes (como pueden ser los clústeres locales) con la localización y el carácter local, así como las herramientas actuales para su análisis, tales como Análisis de Redes Sociales (SNA) y Análisis de Ventaja Competitiva (CCA).

Por otro lado, la revisión bibliográfica de áreas como análisis de sistemas de innovación y redes de proyectos de colaboración nos permite adentrarnos en conocer el porqué del auge de explorar nuevos enfoques de análisis de estructuras organizativas. Se revisa la importancia que desempeñan los proyectos de I+D en los sectores emergentes como instrumento de transferencia de información y conocimiento tecnológico, así como comprender esas redes en su complejidad, concluyendo que para ello es necesario, primordial, conocer sus estructuras organizacionales. No obstante, es necesario, además, comprender las características propias de los sectores emergentes y los problemas reales de promocionarlos: problemas institucionales, estructuras de mercado fuertemente dependientes de acciones gubernamentales, falta o deficiencia en la difusión de conocimiento entre actores.

Seguidamente, se describen las características principales del Análisis de Redes Sociales y cómo se puede utilizar para generar conocimiento estratégico sobre un sector tecnológico. Se analizan en detalle las herramientas de software Pajek y Ucinet, que siendo las más consolidadas entre los académicos, serán base de esta tesis por su gran capacidad de cálculo de indicadores y su posterior análisis. Aunque existen numerosos trabajos basados en su aplicación a bases de datos de publicaciones científicas o patentes, menor es la existencia de investigación aplicado a bases de datos de proyectos. Se realiza un análisis de casos de trabajos de investigación realizados en el ámbito de publicaciones y patentes, que nos servirá como base para enfocar la necesidad de esta tesis: la aplicación de Análisis de Redes Sociales a redes de participantes de proyectos.

Por último, para poder analizar los conceptos críticos necesarios para extraer conocimiento estratégico de un sector emergente a través de un particular enfoque de Análisis de Redes Sociales, se describen los conceptos clave para su aplicación al entorno de proyectos de I+D. Estos conceptos clave se extraen desde la literatura científica, entre los que cabe destacar: la creación de las redes a analizar, los enfoques a elegir, así como la identificación de actores clave y eficiencia. Cobra especial importancia, por un lado, la descripción de los dos enfoques tradicionalmente más utilizados y que se emplean independientemente, y que permiten un análisis del proceso de intercambiar información y conocimiento de diferentes actores en una red, y por otro, la identificación de actores clave mediante la combinación de ambos enfoques. Además de las organizaciones, también cobran importancia las regiones locales, a raíz del auge de la tensión entre "globalización" y "territorialismo", así como el rápido ascenso de estructuras organizativas regionales basadas en el conocimiento, como son los clústeres. No es tanto definir un método, sino puntualizar en los aspectos críticos a tener en cuenta a la hora de crear conocimiento estratégico con SNA aplicado a redes de proyectos, en este caso a proyectos I+D, en sectores emergentes. Es por este motivo que esta tesis doctoral cobra mayor importancia, sobre todo, teniendo en cuenta que no existe ningún trabajo de investigación integrando los objetivos mencionados anteriormente.

La metodología general para la **segunda parte de la tesis**, creación de conocimiento estratégico en el sector de las energías renovables en Europa, consistirá en la aplicación práctica de los conceptos críticos analizados en el apartado teórico en un contexto real: sector de las energías renovables en Europa. Se realiza en tres diferentes fases.

La primera fase será la **delimitación del sector de energías renovables en Europa**. Es un punto crítico para la realización de este trabajo de investigación, ya que es la base para acotar y obtener la información de proyectos necesaria para abordar la parte práctica. Se ha seguido la metodología propuesta por la literatura en este ámbito, teniendo en cuenta la limitación de la disponibilidad y la calidad de la información, y que constará a su vez de tres fases: análisis tradicional del sector, incluyendo la descripción de los sub-sectores eólico solar, marino, geotérmico y biomasa, y su estado actual bajo la perspectiva estratégica de la Unión europea; selección de la base de datos CORDIS, que almacena todos los proyectos de I+D financiados por la Unión Europea desde 1980; y definición de la estrategia para extraer la información. Esta última constará, a su vez, de las siguientes fases según la literatura de Text Data Mining: selección de "Keywords", "Title" "Activity Area" y "Objective" como los campos identificativos, elaboración de la estrategia de consultas, limpieza (mediante el software OpenRefine), verificación de los datos y proceso de fusión de datos; además del proceso de geolocalización de los actores (mediante el software GPSVisualizer). Se utilizará la estadística descriptiva enfocada al análisis de la red de proyectos, organizaciones y regiones locales (a nivel de codificación europea NUTS3). Se identificaron 4.324 proyectos de energías renovables de estos sub-sectores, así como 5.736 actores participantes, desde el año 2000 hasta 2013.

La segunda fase consistió en **crear la estructura que muestra la red de transferencia de información y conocimiento entre actores del sector de energías renovables en Europa.** La metodología para este apartado se basará en la parte teórica analizada y aplicada al sector de energías renovables, utilizando para ello los proyectos de I+D identificados en el apartado anterior para el periodo 2000-2013, desde el punto de vista de organizaciones y regiones locales. Para ello, se utilizará el software "Txt2Pajek". Se transforma la información de proyectos en "relacional", creando así las redes de estructura de transferencia de información y conocimiento de la red de participantes y sus regiones locales. Se realizará el análisis topológico de la estructura de cada una de las redes de cada sector, así como un proceso de visualización de esas redes para su mejor entendimiento, utilizando indicadores contrastados por la inmensa mayoría de trabajos de investigación consultados por el autor.

La tercera fase consistió en **identificar principales actores que juegan un papel clave en el sector de energías renovables de Europa en función de su eficiencia en la transferencia de información y conocimiento.** La metodología para este apartado se basará, por un lado, en la aplicación práctica de los enfoques de análisis de redes sociales analizadas, utilizando los indicadores propuestos por la literatura reciente y que se analizan en la parte teórica. Se utilizaron principalmente indicadores de centralidad como son grado (degree), intermediación (betweenness) y cercanía (closeness), y para “Structural Hole”, el indicador restricción (Constraint), para obtener los rankings de las organizaciones y regiones locales. Por otro lado, además, se realizará un mapeo de términos clave (utilizando la información de los campos “Keywords” y “Subject”) para describir cada uno de los sectores renovables para obtener una descripción más en detalle en relación con la tecnológica y áreas de actuación. Se terminará con un análisis integral del conocimiento estratégico obtenido durante el desarrollo de la implementación del Análisis de Redes Sociales.

La **primera conclusión** de esta tesis doctoral es la posible utilización de las bases de datos de proyectos I&D como fuente para crear, representar y conocer las estructuras de redes de transmisión de información y conocimiento que se forman entre los consorcios de participantes. La **segunda conclusión** es la importancia de los pasos cruciales que se necesitan dar para poder obtener el conocimiento estratégico de un sector emergente a través de proyectos I&D y que son: creación de información relacional, la necesidad de integrar la perspectiva de la centralidad y “structural holes”, y su aplicación para obtener información sobre los actores participantes, en función de su eficiencia en la transmisión de la posible información y conocimiento adquirido durante el proyecto. Como **tercera conclusión,** se observa la utilidad real de las bases de datos de proyectos I&D para delimitar un sector emergente y multidisciplinar, identificando actores que de otra forma sería difícil identificar, ya que no hay registro oficial de dichos sectores, en este caso: eólico, solar, marino, geotérmico y biomasa. Hoy en día los sectores son cada vez más multidisciplinares y si a esto se le añade la característica de emergente, este proceso es eficaz como complementario a la información obtenida de bases de datos de publicaciones (perspectiva científica) o patentes (contexto tecnológico). De esta forma, se observa que para los sectores más maduros dentro de las renovables (como es el solar) los proyectos se realizan con menos participantes, mientras que para los menos maduros (como son la energía marina) los consorcios son más amplios. Se observa, además, que en general hay mayor participación de empresas, mientras que la experiencia se focaliza todavía en centros de investigación/tecnológicos y universidades. Este hecho se relaciona directamente con la característica de tecnologías emergentes que todavía están bajo investigación y desarrollo, previo a su comercialización. Como **cuarta conclusión**, se muestra la utilidad del Análisis de Redes Sociales para describir la topología y estructura de las redes de transferencia de información y conocimiento entre actores y regiones locales que participan en proyectos I&D. Así, se concluye que las redes de regiones locales muestran mayor cohesión que las de las organizaciones, aunque el efecto de "small world" existe en ambas, mostrando una estructura no completamente aleatoria ni homogénea en términos de cohesión. Por otra parte, como **quinta conclusión**, se confirma la existencia de múltiples zonas de "structural holes" en las redes tanto de organizaciones como regiones locales a nivel europeo, lo que demuestra que existen actores que tienen un rol más eficiente a la hora de transmitir información y conocimiento entre los demás actores. Un análisis por separado de los indicadores de redes sociales demuestra que los centros de investigación/tecnológicos y las universidades se benefician de estas zonas especialmente en los sectores eólico, marino y biomasa, siendo su posición influyente a la hora de cohesionar la red. Mientras que las empresas se muestran rodeadas de estas zonas sobre todo en los sectores solar y geotérmico. Un análisis en conjunto de los indicadores de centralidad y "structural holes" muestran que los sectores marino y geotérmico son menos eficientes a la hora de crear redes para la transmisión de información y conocimiento, estando sobre todo los centros de investigación/tecnológicos y las universidades en las primeras posiciones de los rankings en todos los sectores. Por otro lado, se observa que las empresas están tomando posición en el sector eólico, ya que lideran las primeras posiciones, al contrario que en los demás sectores.

En relación con las **limitaciones**, en primer lugar, esta tesis doctoral se basa en la base de datos de proyectos de investigación y desarrollo de la Unión Europea (CORDIS) para los sectores de energías renovables, y los resultados deben considerarse complementarios, ya que no todos los proyectos de los sectores están cubiertos. En segundo lugar, este estudio se ha basado en un modelo agregado de 2000 a 2013 (hasta el último marco europeo cerrado) y, en cierta medida, una vez obtenidos los resultados agregados, los trabajos de investigación futuros deberían centrarse, por ejemplo, en la información anual sobre la evolución de los actores y sus relaciones en cada sector, para obtener más detalle de sus estructuras de transmisión de información y conocimiento.

Como **conclusión general**, se destaca la importancia de complementar la información que se obtiene de recursos tradicionales hasta ahora utilizados (como son indicadores económicos, publicaciones científicas, así como las patentes) con la información que se obtiene de la aplicación de Análisis de Redes Sociales a las bases de datos de proyectos de I&D, como fuente de conocimiento estratégico para su utilización por parte de los responsables políticos encargados de diseñar las políticas del espacio europeo de investigación y desarrollo. De esta forma, se extrae valor añadido a la información de los proyectos, ya que en la sociedad actual, multidisciplinar e interconectado, no es suficiente tener datos de las organizaciones y regiones locales de forma individual, sino cómo están relacionados. Se concluye en cómo influyen en el resto de actores de las redes de colaboración, así como quiénes son eficientes o quiénes tienen un rol facilitador de cohesión de la red de transferencia de información y conocimiento adquirido a través de los proyectos I&D, aplicable a cualquier sector, nivel y ámbito, normalmente subvencionados por organismos públicos cuando son sectores emergentes.

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CHAPTER 1

1. Introduction

1.1. Context and motivation of the thesis

Renewable Energy (RE) Sources have been widely studied in terms of technology and economy (Pacesila et al. 2016). The majority of them confirming that the investment in this emergent sector will generate a multiplying effect in the economy, and that the creation of new organizational structures will become necessary (Marques & Fuinhas 2012).

The extensive and speedy evolution of RE enterprises shows that industry based on knowledge and information will grow exponentially in the next few years, foreseeing it as an industrial hallmark at global and local level.

Europe designed the European Research Area (ERA) strategy (Commission 2000) following up with its line of integration policies for all the member countries, and with an objective to increase the percentage of renewable energy (RE) in the European energy mix to 20% by 2020 (European 2011; Commission 2012; da Graça Carvalho 2012; Giacomarra & Bono 2015; Kitzing et al. 2012; Klessmann et al. 2011) aimed at boosting a new multi-discipline industrial sector, including mainly: wind, solar, sea, geothermal and biomass (International Renewable Energy Agency 2013; Vantoch-Wood & Connor 2013; Blanco & Rodrigues 2009), even less developed ones such as wave, tidal and small wind energies.

Nevertheless, the need to incorporate a greater percentage of different technologies within the new energy generation and distribution structures makes the participation, interaction and relationship of European actors and regions increasingly important in terms of industrial development based on knowledge and information (Matt et al. 2012).

However, unfortunately, concerns have been raised regarding the consortiums in European public projects and their knowledge and information transmission to build ERA with coherence

(Giacomarra & Bono 2015; Kitzing et al. 2012). Policy makers face the uncertainty of creating R&D projects in RE that could include inefficient or ineffective collaborations between partners and local regions.

This uncertainty is the main motivation of this thesis. Given the professional career of the author in the area of project management in different emerging industrial sectors, his relationship for more than 3 years with the different structures of innovation and development policies of the European Commission, his involvement as part of the team responsible of the creation and positioning of the Cluster of Renewable Energies and Energy Efficiency of San Sebastián, as well as his membership in the research group “Technology, Foresight and Management” (TFM) of the University of the Basque Country, where “Competitive Intelligence” and “Knowledge Management” are being working on, this doctoral thesis is considered motivated. It contributes adding added-value extracted from R&D projects through cutting-edge methods, such as Social Network Analysis, to the existing knowledge of consortia, which are the basis for the creation of the European research and development area.

1.2. Fitting in of the doctoral thesis

This research targets European R&D projects in wind, solar, sea, geothermal and biomass RE sectors because of their current interest, focusing on 28 European members in 2000-2013 period where the last significant publicly funded promotion was carried out under several programmes.

This study employs inter-organizational theories, knowledge about R&D consortiums collaboration networks, and social network analysis (SNA) as a main research tool, used in wide range of research and studies, focusing on the added value of its indicators using not only the traditional centrality approach but also the structural hole theory that emphasize the need of taking the potential of organizations and local regions into account in the overall collaboration networks. It is perfectly aligned with the "Project Management" doctorate program of the department of "Graphic Design and Engineering Projects" due to its focus on the analysis of projects as a basis, as well as with the department of "Business Organization" because of its link with the analysis of organizational structures.

1.3. Structure of the thesis

The content of this doctoral thesis is divided into two main parts: theoretical and practical implementation. Before addressing them, in chapters 1 and 2, a brief description is made as an introduction of the context and the motivation to carry out this study, as well as the fitting with nowadays academic, industrial and technological fields. Then, the objectives of this thesis are described, including details of the methodology that will be applied to achieve them.

The first part of the doctoral thesis is made up of chapters 3, 4, 5, which constitute the three fundamental axes for the development of the theoretical-conceptual background, and which will be used in turn to structure the methodological framework and its subsequent implementation in a real context in the second part. First, chapter 3 addresses the state of the art of Inter-Organizational Networks, based on Network Theory and Inter-Organizational Relationships as a tool for transferring information and knowledge, as well as a brief description and explanation of clusters in emerging sectors that will serve as a starting point. Chapter 4 addresses collaborative R&D projects by describing their organization, their relationship to innovation, and their relationship with information and knowledge transfer structures in emerging sectors. It also addresses the issue of public institutional financing that is currently being carried out for projects in emerging technologies and sectors. Once the previous topics are related, how the concepts of the previous points can be analysed and studied is discussed, linking with the objectives pursued by the thesis. Chapter 5 explores Social Network Analysis as a most effective tool and method for creating strategic knowledge, describing how that potential fits into project networks, and what are the main approaches to optimize this method.

The conceptual and theoretical framework of the first part will lead to real implementation in an emerging sector, such as the renewable energy sector in Europe, which covers the whole of Chapter 6. This chapter begins with the description of the objectives of this second part and the design of the methodology to reach them. This chapter will be divided in three fundamental phases for the successful implementation of Social Network Analysis to the sector, including all the theoretical aspects contemplated in the first part. In this way, the first phase focuses on the delimitation of the renewable sector, with the selection of the database to be used and the definition and implementation of the information capture strategy. The second phase describes the necessary steps to be taken to transform the information obtained into relational information for use as the basis of a network analysis method, focusing the process on the necessary units of analysis. Finally, the third phase will focus on the analysis of the networks obtained, following the theoretical-conceptual framework described above. It will start with the longitudinal and structural analysis of the networks. It will continue to apply the different approaches, both separately and in conjunction with an overall analysis of both. In addition, a mapping of key terms will be carried out to describe each of the renewable sectors to obtain a more detailed description in relation to the technology and action areas. It will conclude with a comprehensive analysis of the strategic knowledge obtained during the development of the Social Network Analysis implementation.

Chapter 7 will show and analyze each of the results obtained in that implementation, as well as the partial conclusions that will be divided into two parts, to follow and better understand the process. It will conclude with a general summary of the process, as well as general limitations and conclusions.

Chapter 8 will show the possible research work that may arise from this doctoral thesis, both to fence in the limitations and to propose different approaches to advance in this area with future projection for the academic, institutional and industrial fields.

The chapters are composed of *sections* and all the *annexes* are added at the end of the document for use as a reference.

CHAPTER 2

2. Objectives and methodology

2.1. Objectives

The **final objective** of the thesis is to present the potential of a booming technique, such as the Social Network Analysis, to obtain strategic knowledge for decision making when creating the research and development space of an emerging, multidisciplinary technological sector.

For this, this thesis is based on the applicability of social network theory and the usefulness of the information provided by research and development projects.

The **contribution** of this thesis is divided mainly into two parts, having each of them a clear objective:

1. **Potential of information about projects to create strategic knowledge through Social Network Analysis.**
2. **Creation of strategic knowledge in the field of renewable energy in Europe.**

On the one hand, the **objective of the first part** would group the following sub-objectives, which present a theoretical basis:

- **To analyse the link between available information on collaborative projects with information and knowledge transfer structures.** This analysis will provide an overview of how the information available on collaborative projects, such as research and development, could be analysed to describe how the transfer of information and knowledge is carried out among the different actors that are part of that context of research and development.
- **To analyse the critical concepts needed to extract strategic knowledge from an emerging sector through a particular approach of Social Network Analysis.** This

analysis would allow us to develop a methodological framework to obtain information about the efficiency of its actors in the transfer of information and knowledge.

While the first part has a theoretical and general character for any emerging sector, this second part presents a theoretical and practical basis oriented to the sector of renewable energies in Europe. In turn, it would group the following sub-objectives:

- **To delimit the renewable energy sector in Europe.** This process would allow us to define in detail the emerging sector under study, through available information on research and development projects, analysing the possibilities and limitations of this information.
- **To create the structure that shows the network of information transfer and conformation between actors of the sector of renewable energies in Europe.** This process would provide us with the vision of the network system that make up the different actors involved in research and development projects from a relational point of view.
- **To identify key players who play a key role in Europe's renewable energy sector in terms of their efficiency in the transfer of information and knowledge.** This identification will provide information on the most influential actors in the sector in terms of their efficiency in transmitting information and knowledge, and can use it as strategic knowledge of the sector for decision-making in structuring the European research and development area. This information could be very useful for policy-makers in charge of designing the policies of the European research and development area.

This second part focuses on the point of view of:

• Organizations: All the organizations participating in the different European research and development projects, which contribute to the creation of the European research and development area, such as research and technological centers, universities, companies, public administrations, associations, etc. ...

• Local Regions: In this case, the focus of analysis would be all the European local regions that are part of the projects.

2.2. Methodology

This section describes in detail the methodology that has been followed in the elaboration of each one of the phases of this doctoral thesis to reach the established objectives.

2.2.1. Potential of information about projects to create strategic knowledge through Social Network Analysis

As detailed in the section of objectives, this first part aims, on the one hand, **to analyse the link between available information on collaborative projects with information and knowledge transfer structures,** and on the other hand, **to analyse the critical concepts needed to extract strategic knowledge from an emerging sector through a particular approach of Social Network Analysis.**

Each of these two parts needs to be approached with a methodology according to their needs and characteristics.

2.2.1.1. To analyse the link between available information on collaborative projects with information and knowledge transfer structures

In this section, we analyse the state of the art, as well as the theoretical and conceptual basis of the three fundamental axes on which the theory of this doctoral thesis is based: interorganizational relations, collaboration networks of research and development projects, and social network analysis.

On the one hand, a detailed analysis of inter-organizational networks will be carried out, from the perspective of Organizational Theory and inter-organizational relationships, including the functions and types of networks that exist in this area. For this, a bibliographic analysis of the state of the art is carried out, analysing the evolution of these concepts and their relationship with the structures of information and knowledge transference, being the latter one the approach that is wanted to follow in the thesis. It is important to emphasize the importance of including the concept of efficiency when analysing the structures of information and knowledge transfer. In addition, the relationship between new organizational structures in emerging sectors (such as local clusters) with localization and local character has been reviewed.

The study of this last part was published in "Management Complexity. Challenges for Industrial Engineering and Operations Management ", Springer ISBN: 978-3-319-04704-1, under the title" Applying Cluster Analysis to Renewable Energy Emergent Sector at Local Level. " (Larruscain, Río-Belver, et al. 2014).

On the other hand, the bibliographic review of areas such as analysis of innovation systems and networks of collaborative projects allows us to delve into the why of the rise of exploring new approaches of analysis of organizational structures. The importance of R&D projects in emerging sectors as an instrument for the transfer of information and technological knowledge is reviewed, as well as the understanding of these networks in their complexity, and the necessity to know their organizational structures. However, it is also necessary to understand the characteristics of emerging sectors and the real problems of promoting them.

Finally, the main features of Social Network Analysis are described and how it can be used to generate strategic knowledge about a technological sector. Although there are many papers based on their application to databases of scientific publications or patents, there is less research applied to project databases. An analysis of cases of research work carried out in the field of publications and patents is done, which will serve as a basis to focus the need for this thesis: the application of Social Network Analysis to networks of project participants.

2.2.1.2. **To analyse the critical concepts needed to extract strategic knowledge from an emerging sector through a particular approach of Social Network Analysis**

Finally, the key concepts for the application of Social Network Analysis to the R&D project environment are described. These key concepts are drawn from the scientific literature, including the creation of networks to be analysed, the approaches to be chosen, as well as the identification of key actors and efficiency. It is particularly important, on the one hand, to describe the two approaches that are traditionally most used and implemented independently, and which allow an analysis of the process of exchanging information and knowledge of different actors in a network, and on the other hand, the identification of actors by combining both approaches. In addition to the organizations, local regions are also important because of the heightened tension between "globalization" and "territorialism", as well as the rapid rise of regional organizational structures based on knowledge, such as clusters.

It is not so much to define a method, but to point out in the critical aspects to be considered when creating strategic knowledge with SNA applied to project networks, in this case R&D projects, in emerging sectors.

It is for this reason that this doctoral thesis becomes more important, especially considering that there is no research work integrating the objectives mentioned above.

2.2.2. Creation of strategic knowledge in the field of renewable energy in Europe

As detailed in the objectives section, this second part aims, on the one hand, **to delimit the renewable energy sector in Europe**, on the other, **to create the structure that shows the network of information and knowledge transfer between actors in the energy sector Renewable energies in Europe** and, finally, **to identify key players who play a key role in Europe's renewable energy sector in terms of efficiency in the transfer of information and knowledge**.

The general methodology for this section will be the practical application of the critical concepts analysed in the theoretical section in a real context: renewable energy sector. The methodology used for each sub-objective is detailed below.

2.2.2.1. **To delimit the renewable energy sector in Europe**

This is a critical point for the realization of this research work, since it will be the basis for defining and obtaining the necessary project information to address the practical part.

The methodology proposed by the literature in this area will be followed, considering that the limited availability and quality of the information, and will consist of three phases: traditional analysis of the sector, including the description of each sub-sector and characteristics, and current status under the strategic perspective of the European Union; Selection of the database; and definition of the strategy to extract the information. The latter will consist, in turn, of the following phases according to the Text Data Mining literature: selection of the identification fields, elaboration of the strategy of consultations, cleaning and verification of the data, process of fusion of data; and the process of geolocation of the actors.

Descriptive statistics will be used to analyse the network of projects, organizations and local regions.

The development of the methodology is described in more detail in section 6.3. And the results will be explained in section 7.2.

As for the validation of the preliminary results of sectoral delimitation of the sector, the paper "Understanding of European Sea Energy sector structure through R&D social network analysis" was presented at the congress "International Congress Water, Waste and Energy Management" held in Porto in 2014, with its subsequent publication (Larruscain, Rodriguez, et al. 2014).

2.2.2.2. **To create the structure that shows the network of information and knowledge transfer between actors in the energy sector Renewable energies in Europe**

The methodology for this section will be based on the theoretical part discussed in section 5.6.1., And applied to the renewable energy sector, using the R&D projects identified in the previous section for the period 2000-2013, from the Point of view of local organizations and regions.

The topological analysis of the structure of each of the networks of each sector will be carried out, as well as a process of visualization of those networks for their better understanding.

The development of the methodology is described in more detail in section 6.4. The description of the indicators, contrasted by the vast majority of the research work consulted by the author, will be shown in section 6.5.1. And the results will be explained in section 7.3.

On the one hand, as regards the process validation of this section, the preliminary development of these three phases was presented in the paper "Local clusters forecasting model, applied to new renewable energy emerging technologies, through Network Theory" presented in "Manchester International Summer School on Emerging Technologies" organized by the Manchester Business School of the University of Manchester in June 2014. Feedback was received from experts in the field of Tech Data Mining as well as in emerging sectors. One of the main recommendations of the experts was to add the field "objectives" to delimit with more precision the emerging sector.

On the other hand, the preliminary results were also presented as a presentation at the 4th Global Tech-Mining Conference held in Leiden (Netherlands) in September 2014, under the title "Structural analysis of European renewable energy R&D Network from 2000 to 2013" (Larruscain, Rio-Belver, Cilleruelo & Garechana 2014), as well as at the 8th International Conference on Industrial Engineering and Industrial Management held in Malaga in 2014, under the title "Analysis of the R&D Collaboration Network in the European Renewable Energy Sector" (Larruscain, Rio-Belver, Cilleruelo, Garechana, et al. 2014).

2.2.2.3. **To identify key players who play a key role in Europe's renewable energy sector in terms of efficiency in the transfer of information and knowledge**

The methodology for this section will be based, on the one hand, on the practical application of the approaches of analysis of social networks analysed in section 5.6.3., using the indicators proposed by the recent literature that are described in sections 6.5.2, 6.5.3, 6.5.4 and 6.5.5; on the other hand, on clustering analysis based on the two proposed approaches, adding information extracted from maps of key terms in each of the sectors.

For this process, the development of the methodology is described in more detail in section 6.5, 6.5.2. The description of the indicators, contrasted by the vast majority of the research work consulted by the author, will be shown in section 6.5.1. And the results will be explained in section 7.4.

The results were exposed, on the one hand, in "2nd Manchester Forum on Data Science, Tech Mining and Innovation. MIoIR ", held at the Manchester Institute of Innovation Research in 2015, entitled "Analyzing the Influence of Renewable Energy R&D Projects on Local Clusters in Europe" (Larruscain et al. 2015). And on the other hand, in "21st International Conference on Science and Technology Indicators (STI)" held in Valencia in 2016, under the title "Structural Analysis of redundancy in local energy regions in R&D Project in Europe" (Larruscain et al. 2016).

In addition, the results were submitted as an article-proposal tiled "Efficiency in organizational structure of European consortium networks of R&D projects in Renewable Energy sector. Technological knowledge and information transmission efficiency and effectiveness at local regional level" to the journal "Renewable and Sustainable Energy Reviews" in January 2017 (manuscript number RSER-D-17-00179), being one of the journals of high impact in the field of renewable energies at the international level.

CHAPTER 3

3. Inter-Organizational Networks

3.1. Introduction

In this chapter, first, an overview of Inter-Organizational Networks is given, based on the Organizational Theory and Inter-Organizational Relationships perspectives, including networks functions and types. Then, the evolution of research and the context of Inter-Organizational Relationships in technological knowledge and information transfer through networks is presented, detailing types of knowledge in IOR, levels of analysis as well as the purpose of the introduction of efficiency concept. Finally, an introduction to industrial local clusters is given through RE sector case, identifying different tools used to identify them.

3.2. Networks

Organizations are considered as a key element of our current societies, where their influence and presence are in wide range of fields of human life (Turker 2014). They became principal actors leaving politics, finance, technology, religion, family and social psychology as a dependant variables (Perrow 1991).

Taking into account this sociological circumstance, organizations could be described as "a social system, which focused for the purpose of reaching a relatively specific goal that contributes to a principal function of an extensive system – usually society " (Turker 2014; Parsons 1956).

According several authors and researchers, **Organizational Theory** focuses on two levels of analysis (Jaffee 2001; Turker 2014; Zey 2015; Provan et al. 2007).

On the one hand, **Intra-Organizational level perspective**, that includes the analysis of the inner dynamics of an organization and all factors related to its internal environment, where organization is considered as a closed system.

However, **networks** built from the contact between organizations are needed to reduce uncertainty, avoid threats in nowadays changing environment (Turker 2014) and to address complex social issues (Popp et al. 2013).

This indeed leads to the other level of analysis: **Inter-Organizational level or network level perspective**. In this sense, the organization ceases to be independent to its environment and becomes involved "into continuous interaction with other organizations which gives a meaning and a role" (Håkansson & Snehota 1989) and creating "networks".

As explained by some scholars, since the traditional economic views, based on the schema of markets or hierarchies, was failing to explain correctly these network forms of organizations in the global environment, researchers started paying their attention into the concept of "network of organizations" (Antivachis & Angelis 2015; Everett & Borgatti 2005; Borgatti & Foster 2003; Knoben et al. 2006).

"**Network**" could be described as "enduring exchange relations established between organizations, individuals and groups" (Popp et al. 2013; Weber & Khademian 2008) or just "an emerging organizational mode that perform as a locus for innovation" (Cassi et al. 2008a).

Other definitions for networks of organizations are the following (Antivachis & Angelis 2015):

- "A set of nodes and the set of ties representing some relationship or lack of relationship between the nodes" (Brass et al. 2004).
- "Constellations of organizations that come together through the establishment and maintenance of social contracts or agreements rather than legally binding contracts" (Barringer & Harrison 2000).

While Intra-Organizational level perspective is widely studied by researchers and scholars, this thesis is focusing the attention in Inter-Organizational level. The main reason is that nowadays, when organizations tackle the competitive environment of industrial sectors not only is their own strategic knowledge, which is built at “intra-organization”, critical and useful, but the strategic knowledge learnt from their partners is becoming more and more crucial. These networks are called **Inter-Organizational Network** and are based on **Inter-Organizational Relationships.**

Inter-Organizational networks are usually described taking into account their relation with “informal social systems” rather than with “bureaucratic structures” when uncertain and competitive environment occurs, as well as when referring to the coordination of complex products and services (Antivachis & Angelis 2015; Powell 1990). Thus, network mapping became suitable for indicative and prescriptive way to analysis (Cross et al. 2002; Knoben et al. 2006). “Activity”, “Goals” and “Outcomes” terms are mainly used as a network type descriptive indicators. The following table summarizes the type of networks (Table 1).

Table 1. Network types and function.

Network Type	Functions
Information sharing, informational, information diffusion	Primary focus is on sharing information across organizational boundaries. A number of authors make a distinction between information sharing and knowledge exchange.
Knowledge generation and exchange, knowledge management	Primary focus is the generation of new knowledge, as well as the spread of new ideas and practices between organizations.
Capacity building, social capital, outreach	Primary focus is on building social capital in community settings, and on improving the administrative capacity of the network members.

Individual, organizational, network and community learning	Primary focus here is learning, which overlaps both with knowledge exchange and capacity building.
Problem solving, complex issue management	Primary focus is on improving response to complex issues, and/or solving complex problems (where a solution is possible). Often emerges from an information diffusion or knowledge exchange network.
Effective service delivery, service implementation, service coordination, action	Primary focus is service delivery, where services are jointly produced by more than two organizations. Collaboration is often between programs in larger organizations.
Innovation	Primary focus is on creating an environment where diversity, collaboration and openness are promoted with the goal of enabling and diffusing innovation.
Policy	Primary focus here is an interest in public decisions within a particular area of policy. The original conceptualization of policy networks concerned decision making about public resource allocation.
Collaborative governance	Primary focus on direction, control and coordination of collective action between government agencies and non-public groups, including government funded initiatives or contracts.

Source: modified from (Provan et al. 2007).

As explained by several scholars (Ahuja et al. 2012; Provan et al. 2007) networks structures are based on nodes, ties which connect the nodes, as well as the structures resulted from these connections, focusing in “identity, number and features of nodes; and the way the ties are carried out as well as location, content and strength of them”.

The term “**effectiveness**” is gaining much attention among scholars studying inter-organizational networks.

3.3. Inter-Organizational Relationships (IOR) in technological knowledge and information transfer

The simplest definition of Inter-Organizational Relationships is clearly proposed in Oxford Handbook “Introducing Inter-Organizational Relationships” (Cropper et al. 2009) as: “relationships between and among organizations” and then, it leads to it is concerned with “understanding the character and pattern, origins, rationale, and consequences of such relationships”, being the organizations public, business, or non-profit (referred them as Inter-Organizational Entities, IOE) and taking into account that their relationships can vary from “dyadic, involving just two organizations”, to “multiplicitous, involving huge networks of many organizations”.

Another definition is given by (Turker 2014; Bachmann & van Witteloostuijn 2009): “IOR are formal arrangements that bring together assets (of whatever kind, tangible and intangible) of two or more legally independent organizations with the aim to produce joint value added (of whatever kind, tangible or intangible)’’.

The growth of research of IOR (using several different terms to describe it) started in 1957 and has evolved considerably until these days. In the following Table 2, this exponential growth and evolution of research including these terms related to IOR is shown:

Table 2. Evolution of research in IOR.

Topic	**1957–66**	**1967–76**	**1977–86**	**1987–96**	**1997–2006**
Inter-organizational relations	1/5/51	3/129/1087	4/126/1616	4/172/3563	7/373/9609

Strategic alliances	0/3/38	0/13/96	1/25/230	41/258/2113	110/909/8170
Joint ventures	3/15/152	9/49/370	36/107/803	110/343/3362	199/817/7961
Networks	3/3/10	10/10/32	15/18/27	51/124/193	136/331/531

Notes: The first number in a cell reflects the number of times the topic appears in a title of a refereed journal article; the second the number of times it is used as a subject term for a refereed journal article; and the third is the number of times it appears in the text of a refereed journal article. We have not included 'Partnerships' in this list because it is impossible to make an automated search that distinguishes Inter-organizational partnerships from organizational governance partnerships. Source: modified from (Cropper et al. 2009)

The wide range of relations could be analyzed taking into account that there are four groups to classify IORs: **dyadic connections between two organizations**, **organization sets**, **action sets**, and **networks** (Whetten 1981). As described in chapter 3.2, Organizational theory mainly focuses its approach in **social embeddedness perspective** and **social capital perspective**.

The first one, it takes into account that "context of social relationships in which actors are embedded influences organizational behavior and economic outcomes" (Granovetter 1992; Granovetter 1985; Uzzi 1996; Uzzi 1997; Gulati et al. 2011), while in the second one, the focus is specially pointed in the benefit of organizations according to their positions in particular social networks (Adler & Kwon 2002; Gulati et al. 2011; Coleman 1988; Portes 1998; Putnam 1993; Burt 1997).

Moreover, embeddedness concept encompasses two sub-facets (Gulati et al. 2011). On the one hand, **Relational embeddedness**, referring to characteristics of dyadic ties, and paying attention into the "cohesive direct ties that reinforce collaboration by providing trusted channels for **knowledge and information**"; and on the other hand, **Structural embeddedness** that focused the attention in the whole network structure, "encompassing not only just its direct ties but also its position in a larger network", giving importance to "third parties" linkages (Emirbayer & Goodwin 1994; Gulati et al. 2011). These sub-facets lead to the need to analysis and understand how independent or dependent are the cohesiveness of organizations' dyadic ties (a relational perspective) and a central network position (a structural perspective) to assess the performance and effectiveness in networks (Gulati et al. 2011).

As knowledge and information transfer concept is mentioned, “how organizations create, retain and transfer it” is widely covered in recent research works, mainly focusing in the added value gained by organizations when it is done **efficiently** and enabling them to survive in these days competitive environment (Tang et al. 2006; Argote et al. 2003). Moreover, some other researchers state that organizations must “rely on building and creating knowledge as a necessary condition to survive” (Loebbecke et al. 2016; Matusik & Hill 1998).

According several researchers, knowledge and information transfer could be described taking into account two aspects: on the one hand, “associative learning and absorptive capacity”, while on the other hand, “tie strength, social cohesion and network range” is pondered (Tang et al. 2006; Cohen & Levinthal 1990; 9 Hansen & Hansen 1999; Reagans & McEvily 2003). This leads to define knowledge sharing as “‘the transfer of useful know-how or information across company lines” (Appleyard 1996).

However, Inter-Organizational Knowledge sharing becomes a contradictory paradox for organizations (Smith & Lewis 2011; van Fenema & Loebbecke 2014). While business opportunity is supposed to emerge thanks to the knowledge transmission as “unique, scarcely resource” way from partners, competitiveness is affected since the uniqueness status is loosen. For the moment, few is researched about making capital of benefits of collaborating in terms of knowledge and information transfer, but without the own advantage is dwindled (Loebbecke et al. 2016).

Although knowledge and information sharing has been widely studied at micro-level (Intra-Organizational level), increasing interest is observed in Inter-Organizational level at the last decade (Lepak et al. 2007).

For his purpose, the types of knowledge must be analysed to understand the transfer between organizations. In this sense, according to Matusik (Matusik & Hill 1998), all of them cod be descried using the following concepts: private and public (depending on the owner of the knowledge), component and architectural (depending on knowing about work elements or the whole process) (Loebbecke et al. 2016), individual and collective, and finally tacit and explicit (depending on skills and insights embedded in persons and organizations acquired by experience, or in corporate rules and procedures) (Figure 1).

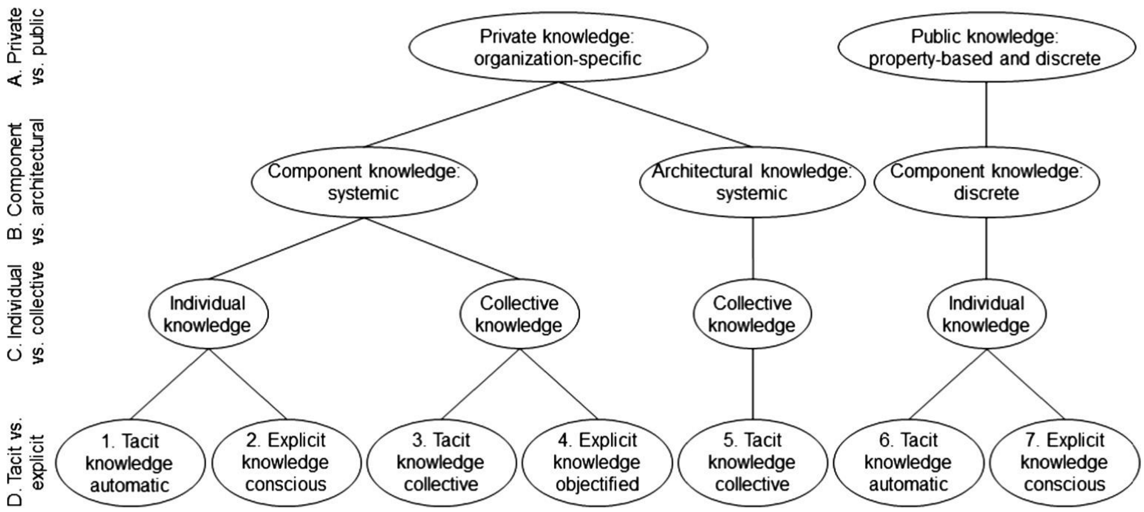


Figure 1.Types of Knowledge in IOR. Source: (Matusik & Hill 1998; Loebbecke et al. 2016).

Moreover, these schema could be completed adding “unilateral” and “bilateral” sharing concept (Gittell & Weiss 2004) to understand different configurations of them.

Table 3 describes the relationships between tacit/explicit and unilateral/bilateral knowledge sharing.

Table 3. Inter-Organizational knowledge and information sharing configuration.

	Unilateral knowledge sharing	Bilateral knowledge sharing
Tacit knowledge	Outsourcing strategies: client-supplier	Exchange of complementary information between competitors
Explicit knowledge	Client-supplier nexus	Collaboration in R&D

Source: modified from (Loebbecke et al. 2016)

In bilateral sharing of explicit knowledge, not only bureaucratic and contractual mechanisms are to be taken into account, but social mechanism also are crucial to be considered (Vlaar et al. 2007). Thus, social analysis tools are required to understand this type of sharing in Inter-Organizational networks.

Besides the type and configuration, the network structure contributes to describe the knowledge and information transfer through Inter-Organizational relationships. Since the positioning of each organization in the network influences the effectiveness of this transfer, the understanding of network structure and the connections of organizations is crucial (Provan et al. 2007).

Several researchers (Provan & Lemaire 2012) emphasize these two key points to identify **effective** knowledge and information transfer through networks:

- Selective Integration: stating that links between organizations in networks should be targeted and appropriate.
- Strong and Weak ties: stating that strong links lead to keep network closure, while weak ones connect quite unconnected sub-networks which may bring different knowledge and information.

Since the **effectiveness** of networks and Inter-Organizational Relationships could be defined as positive outcomes that could not be achieved when organizations work independently (Provan & Kenins 2007; Arranz & Fdez. de Arroyabe 2012), it is analyzed in two levels: organization and whole network level. However, the trend of research is going towards examining it taking into account the complete network structures (Arroyabe et al. 2015; Hossain 2009; van der Valk et al. 2011). Additionally, stating that the outcomes to examine the efficiency depend on the concrete networks within each specific sector, as well as the analysis require multi-level perspective (Popp et al. 2013).

In the following table (Table 4) four levels of analysis in Inter-Organizational networks is shown.

Table 4. Levels of analysis in Inter-Organizational networks evaluation.

Level of analysis	Description	Sample outcomes
Individual	Assessment of the impact that the network has on the individuals who interact in the network on behalf of their respective organizations and on individual clients.	• Increased job satisfaction • Increased capacity • Increased client satisfaction with services • Improved client outcomes
Organization	Assessment of the impact that the network has on member organizations, as the success of network members is critical to overall network effectiveness.	• Agency/organization survival • Enhanced legitimacy • Resource acquisition • Improvement in referrals
Network	**Assessment of the network itself can have a variety of foci, many of which depend on the relative maturity of the network. The strength of relationships across the whole network is always an important focus.**	• Network membership growth • **Relationship strength** • Member commitment to network goals
Community	Assessment of the contributions that the network makes to the community it was established to serve.	• Better integration of services • Less duplication of and fewer gaps in services • Services provided at lower cost to the community • Positive policy change • Improved population-level outcomes

Source: adapted from (Popp et al. 2013; Provan & Milward 1995; Provan & Milward 2001)

Even multi-level perspective to examine IOR has evolved rapidly, researcher community is working on identifying more outcomes as efficiency indicator, as well as more approaches to complement existing ones, both using already consolidated ones and finding new ones that fit with this purpose.

3.4. Sectorial local clusters in emergent sectors

In this section, some key points about sectorial local clusters in emergent sector are described and pointed. The detailed information about this was exposed in the "7th International Conference on Industrial Engineering and Industrial Management" celebrated in Valladolid (Spain) in 2013, in the research work "Applying Cluster Analysis to Renewable Energy Emergent Sector at Local Level" and published in "Management Complexity. Challenges for Industrial Engineering and Operations Management" by Springer (Larruscain, Río-Belver, et al. 2014).

The competitiveness of a sector can be measured by its organizations clusters, formed by IOR. These clusters in turn can be analyzed by the numerous methods used by the scientific community. Whilst most these methods are applied to geographical areas of nations or regions, there is a growing need to be able to apply them to more restricted areas, such as local regions.

Local Region Clusterisation

According to Porter (1998), an industrial cluster is defined as: "a geographic concentration of interconnected businesses and institutions in a particular field, creating a matrix crucial for increasing productivity". Accordingly, clusters have a competitive advantage due to their co-localization (Doeringer & Terkla 1995).

Modern clusterization theories affirm that the experience and know-how shared by actors of a cluster are the greatest source of benefit, as a result of being close by and maintaining local innovation networks (Porter 2000).

The type of industry is usually a factor that influences the typology of a cluster, which changes from a temporary phase to another, going through the embryonic, established, mature and declining stages. In the case of the emergent sector at a local level, they are currently in the first phase and have a mixed typology (He & Fallah 2011) between the Marshallian, Hub-and-spoke, Satellite platform or State-anchored form (Markusen 1996).

Whilst national and regional clusters have been studied in detail by the scientific community, no specific studies have been carried out at a local level.

At local level, the success of a cluster is largely determined by the growth potential of its small and medium sized industries. For instance, one of the main priorities for policymakers is to promote local enterprise and to allow SMEs to benefit from the availability of the cluster's resources (He & Fallah 2011).

The extensive and speedy evolution of emergent sectors enterprises shows that local clusters as well as industry based on knowledge will grow exponentially in the next few years. Clusterization in these emergent sectors is an industrial hallmark.

Porter (1998) argued that although the role of localization has been ignored in the era of global markets, lasting competitive advantages are to be found in the local characteristics that cannot be matched by far-off competition and that these characteristics, among others the relationships, will have to be studied and analyzed in detail, especially in local new clusters.

Cluster Analysis Tools

Cluster analysis is an essential tool in the identification of areas of local-regional economy where there are comparable advantages in terms of the productivity and economic growth of a cluster. Comprehensive analysis of a cluster requires paying attention to concepts such as industrial structure, business strategy, competitiveness between industries and the relationship between knowledge and technology (Iammarino & McCann 2006).

In general terms, most authors suggest an analysis that considers two aspects. On the one hand, the impact indicator (to measure the impact of the network on its members) (Newman 2001) and, on the other, the size of the network and its average path length (the average number of links between its members).

It has been observed that businesses embedded in alliance networks, which show a high clustering impact and reach (very short lengths of links between businesses), tend to show high innovation performance (Schilling & Phelps 2007). With regard to its own growth, this will be directly related to the benefits obtained from being a member of the network, such as economies of scale (Doeringer & Terkla 1995).

General Methods

Although literature relating to methods is varied and extensive, the methods can be grouped according to the origins of baseline data. Quantitative methods are used in the generic analysis of the properties of the network, both at the general and restricted levels (Bergman & Feser n.d.). The most important methods in this group are: input-output (analyzing an approximation of interdependencies between different areas of the network), cluster dependency (analyzing the dependency ratios which can easily be visualized with the Fuzzy tool), and network analysis (together with the Graph theory) (Stejskal & Hajek 2012). Alternatively, qualitative methods, which provide greater sensitivity regarding the relationship between the actors in the cluster (Doeringer & Terkla 1995), would be: specialised databases, expert opinion, surveys and industry research.

Social Network Analysis (SNA) will specifically provide information that enables possible actors to be aware of the existence, needs and ability requirements of others, including help to develop new alliances (Gulati et al. 2000). This becomes a key element in the study of relationships at an organizational level, inside and outside the clusters (Johannisson 1995; He & Fallah 2011).

Its objective is to detect and interpret patterns in the links between the different actors in the network, which are represented as vertices (Nooy et al. 2005). In addition, attributes (characteristics of the actors, which are not based on their structural position within the network, and calculated statistically) provide added value to the interpretation of the structure.

The network typology of a cluster is critical from the first moment of its existence, as it will determine its success or failure during the later phase of expansion, growth and development. Analysis of this first phase is essential, particularly to identify the cluster potential (He & Fallah 2011).

Identification Methods and Limitations in RE Sector

The emergence of a cluster can be attributed to historical circumstances, even before the appearance of the contributing industries themselves, or could even be due to chance or coincidence (Porter 1998). It may also be the result of a business opportunity, of the presence of a unique added value, an increase in the influence exercised by a business, an increase in the undertaking or even a change in the policies of a given sector (Su & Hung 2009). The latter applies to most emergent sectors' clusters.

There are numerous methods used in identification, such as: Location Quotients, Shift-Share Analysis, Expert Opinion, Input-Output Analysis (trade-based and innovation-based), Social Network Analysis, Competitive Advantage Analysis (CAA), Surveys or Giniho coefficient of Localization (Bergman & Feser n.d.; Stejskal & Hajek 2012).

In emergent sector, local clusters are still in their first phases (embryonic, established) being their success largely determined by the growth potential of their small and medium sized industries. An analysis of these clusters formed by the different participating actors will be the key to safeguarding economic development.

Identification methods appear to be essential and crucial (He & Fallah 2011) in emergent sectors where local clusters' births are becoming increasingly important. The order of applicability efficiency of these clusters' identification could be said to be CAA, Shift-Share analysis and Ellison and Glaeser index of agglomeration (Stejskal & Hajek 2012). However, limitations could appear in two senses for emergent sectors. On the one hand, regarding the baseline data, there could be no consensus within the public administration on how to define the sector itself (lack of official and standardized data at local level owing to multidisciplinary diversified industrial activities in no-mature technology), no availability of long time windows (essential to accurate and comparable results) and a difficulty for companies' managers to provide sensitivity information such as their relationships with others. On the other hand, applying methods which are used in regions analysis, inaccuracies in several result-factors might appear. But, before this identification, the analysis of the current baseline status of organizations' structures is needed.

CHAPTER 4

4. R&D Project collaboration networks

4.1. Introduction

In this chapter, the connection between innovation system and collaborative R&D networks is reviewed. Then, focus of collaborative R&D project networks in renewable energy sector as technological knowledge and information transfer structures is treated. Finally, an overview of existing public R&D collaboration support issues is examined.

4.2. Innovation system and Collaborative R&D networks

When talking about emerging technological fields, scholars state as the departure point that the innovation process is not occurred as an isolated action, but in the context of a system (Lundvall & Pavitt 1995; Negro et al. 2013). Networks built from organizations and individuals are fostering the generation and implementation of this innovation; indeed, Inter-organizational relationships are the basis (van der Valk et al. 2011; Grant & Baden-Fuller 2004), and as a consequence its sub-systems' quality is needed to be understood, mainly in R&D activities (Negro et al. 2013).

From the last decades, policy makers are trying to emphasize the importance of collaboration networks as innovation drivers in technological sectors, and focusing their attention into the knowledge and information circulation through these networks. Moreover, with the purpose of designing precise policies for stimulating networks developments in these fields, understanding in what grade these networks are well connected is gaining interest (van der Valk et al. 2011). However, researchers and policy makers state that the traditional methods of Innovation System Analysis are inefficient (Hekkert et al. 2007), proposing to focus more in the outcomes of innovation systems in order to understand technological changes and their innovations' results (Sagar & Holdren 2002; Cassi et al. 2008a).

As described by Hekkert et al. 2007, Innovation System (IS) expression is used as an "heuristic attempt, developed to analyse all societal subsystems, actors, and institutions contributing in one way or the other, directly or indirectly, intentionally or not, to the emergence or production of innovation" (Hekkert et al. 2007). However, using it to analyse and understand the technological change that leads innovation implies two deficiencies.

On the one and, less importance is put into the analysis of the dynamics of innovation than comparing the social structures of actors, institutions and the relationships between them. An on the other hand, putting more emphasis to macro-level (institutions) than micro-level (firms and entrepreneurs) when these second are often the main actors in innovation changes and technology advances (Hekkert et al. 2007).

The innovation systems involve a wide heterogenous range of organizations, such as research centres, universities, firms and public administrations, operating in different levels and arenas, enabling the knowledge and information transfer between them. Thus, while these organizations, their relations and the whole networks form the "static structure of innovation", the "functions", as described above, constitute the "dynamic of the Innovation Systems" (Negro et al. 2013).

Majority of scholars agree that a dynamic innovation system approach is recommended and needed to transform the current innovations systems where technological change is done (Hekkert et al. 2007). And this is the reason why systematically mapping the activities is suggested as effective and useful tool to understand the new innovations systems which lead to real technological change.

The focus is put in the wide range of processes that are called "functions" and linking the key activities and their interactions, needed to well perform the innovation. University of Utrecht proposes the following set of functions that are the main relevant ones:

- Entrepreneurial activities
- **Knowledge development**
- **Knowledge and information diffusion through networks**
- Guidance of the search
- Market formation
- Resources mobilization
- Creation of legitimacy/counteract resistance to change

"Knowledge development" and "Knowledge and information diffusion through networks" are considered the basis of these processes or functions (Negro et al. 2013), and became an essential understanding for policy-makers and government that seek fostering and promoting new innovation processes.

Moreover, although science, technology and innovation networks as working as an emerging organizational structure with the aim of being the crucial "locus for innovation" (Cassi et al. 2008a), an important distinction should be carried out.

While **science and technology networks** are carried out by collaborations in research, **innovation networks** are focused on novel and complex technologies, products and services which aim to provide economic development and growth and search new markets (Borrás & Haakonsson 2012; European Commission 2015). Additionally,

These **collaboration networks**, and **mainly R&D collaboration networks**, have been widely studied through patents and scientific publications approaches (Cassi et al. 2008a). However, research on **R&D collaboration networks based on projects** is scarcely examined by scholars.

In general, R&D networks are defined as a form of business organization, being intermediate organizational forms where a degree of interactions between partners and shared objectives happens (Hagedoorn et al. 2000).

As described by various stream of research, Collaboration or Joint Projects are "strategic devices where the union of two or more parties, institutions or individuals, who pursue a distinct assignment together is carried out" (Arranz & Fernández de Arroyabe 2006).

First studies have widely examined the most efficient form of organizations and their relationships in collaboration networks based on projects from cost perspective (Miotti & Sachwald 2003); however, further research concluded that the attributes of the knowledge involved and the characteristics of the innovation process itself in the cooperation must be also examined in order to have a complete analysis. This lead to start using also the strategic management perspectives as a complementary tools (Hagedoorn et al. 2000).

In general terms, collaboration or Joint R&D projects are formed by "the development of the R&D process" and "the organizational structure as R&D network". On the one hand, the first one exists thanks to a set of partners (universities, research centres, firms) to perform technological activities through a series of stages such as identification of needs or technological descriptions (Resource-based perspective). On the other and, the organizational structure is needed to fulfil the objectives and manage the consortia (relationships between partners) and could be seen as social structure according to Social Capital theory perspective (Arranz & Fernández de Arroyabe 2006; Arroyabe et al. 2015).

In this chapter, resource-based perspective is detailed while Social capital theory perspective is developed in next chapter.

From the resource-based perspective, R&D collaboration schemas are requested by firms when expensive, complex and risky research projects are carried out (Miotti & Sachwald 2003), being R&D partnership considered as a major area of co-operation, for example in high-tech and emergent sectors. Stablished firms (incumbents) corporations could work in these collaboration schemas to easily and in a cheap way expand their knowledge sources without expensive investment, testing new technology or evaluate new solutions without major risk (Mitchell & Singh 1992) and promoting intra-sectorial cooperation patterns.

Thus, one of the reasons why organizations collaborate in these schemas is the benefit obtained when the ned of externalisation of the technological resources is done more than internalisation (Arranz & Fernández de Arroyabe 2006; Robertson & Gatignon 1998).

This collaboration in R&D alliances is more frequent in early stages of emergent sectors (Cainarca et al. 1992), being the necessity of complementary resources a key driver of inter-organizational cooperation and innovation.

The need to generate scale economies and the uncertainty of technological processes in terms of results and time are the main difficulties that organizations should face with (Arranz Peña & Fernández de Arroyabe 2002). As far as R&D becomes less tangible, these uncertainties rise rapidly (Arranz & Fernández de Arroyabe 2006).

Collaboration in R&D could be done through two ways: involving similar resources and complementary ones. The first one is carried out when the aim is to reduce costs and risks in economies of scale, while the second one is performed when organizations need to manage the technological convergence (Miotti & Sachwald 2003).

In this sense, choosing the right partner is becoming a challenge for private and public organizations and of course for institutions promoting these R&D alliances. An especial attention is given to rival partners since although they could help to access complementary resources of knowledge and information, they could also rise a potentially risky situation due to the fact that they sell in similar markets (Miotti & Sachwald 2003).

However, **collaboration with public partners** appears secure in terms of commercial risk and in general, it is carried out when the consortia does not seek commercial applications or the objective is related to "generic and basic end of the R&D complex", involving a large number of partners, often supported by public funds, maximizing disclosure and spill overs (Sakakibara 2001). If international collaborations are added to these schemas, country-specific advantages embedded in the partners' countries are gained.

Taking in to account these characteristics related to resource-based perspective, some scholars pointed that two main types of collaboration R&D project exist, depending on “the need to use existing information to improve efficiency and returns from present strategies, competencies and procedures” and exploit an existing capability, or “searching and experimenting to find emerging innovations which will produce future profits” and explore new opportunities (Koza & Lewin 2000). The first one are called “exploitation” and second ones “exploration” projects (Arroyabe et al. 2015; March 1991).

In terms of structural perspective, “cohesion, strong ties, and small sizes” are the main features of exploitation joint R&D projects, while “sparseness, weak ties, and large size” is observed for exploration ones (Lavie & Rosenkopf 2006; Gilsing & Nooteboom 2006). Specially in exploration collaborations, small group or clusters appears as a consequence of these weak ties and the large size of networks, while strong cohesion in exploitation promote redundant information though the network (Gilsing et al. 2008).

4.3. Collaborative R&D project networks in emerging sectors as technological knowledge and information transfer structures

Not only term map construction through patents and publications (i.e. scientific production in RET doubled in 2002-2007 at European levels (Luz M Romo-Fernández et al. 2011)) seem useful to analyse scientific and technological based knowledge structures in a research area (Step et al. 2009; Arranz & Fdez. de Arroyabe 2008; Darmani et al. 2014; Geum et al. 2013), but also data from R&D collaboration projects become crucial, especially for analysing knowledge and information transfer in European Research Area, ERA (Matt et al. 2012; Arroyabe et al. 2015; Mote 2005; Yin Krogmann Ulrich Schwalbe 2013).

It is necessary to analyze the two-side collaborations because, since one-side collaborations are imports from technology or direct investments, they tend only to promote the transfer of products of innovation and not basic technological knowledge (Paulsson 2009).

The extensive literature on collaborative R&D in different sectors indicates that the first step towards analyzing these networks is to understand their organizational structure (Arranz & Fdez. de Arroyabe 2012). Within an organizational network perspective, organizations constitute the appropriate unit of observation, being a broad self-organized set of heterogeneous actors (firms, universities, research centers and associations) playing within specific sectors and rules imposed by EU, which shifted their focus from supply-side factors to diffusion-oriented projects, increasing knowledge diffusion among European partners and their local regions (Siokas 2008). Not only did access to the resources of their closest partners appear (partners in the same project), but also - to a certain extent - to those with whom their partners collaborate (Siokas 2008).

In the context of Social Network Analysis, several studies concluded that R&D network structures under European Framework Programmes increased in density and size (Heller-Schuh et al. 2011; Barber et al. 2009; Matt et al. 2012; Wanzenböck et al. 2014), becoming core-periphery structures and enabling the existence of central actors acting as a knowledge and information transfer leaders, although the core and peripheral partners are not always easily connected, producing a set of actors less balanced in terms of integration.

However, little is known about these structures in emergent sectors. Understanding the topology and architecture of networks, their cohesion and density as well as the efficiency and influence that each partner or local region have in the process of knowledge transference within whole networks, provides a detailed view of determinant factors (Verspagen 2006; Cowan 2005). These would be of great importance to design and assess future policy measures, paying attention to the integration and cohesion of partners or local regions (Copenhagen Cleantech Cluster et al. 2012) with the aim of strengthening the European Research Area (Siokas 2008) and contributing to the European Commissions' regional Competitiveness Index (RCI).

4.4. Emergent sectors and public R&D Collaboration support issues

The European Union finances most collaborative R&D technological projects in Europe (Dimos & Pugh 2016; Schwartz et al. 2012), particularly the ones relating to emergent sectors (Ragwitz & Miola 2005) with slower innovation cycles than those from other sectors, long lead time ventures (Stephen M McCauley & Stephens 2012) and relatively weak position newcomers with a high percentage of public support (Menegaki 2011).

According to the Lisbon Treaty and European Council Conclusions, the European Commission gives this definition for ERA: “a unified research area open to the world based on the Internal Market, in which researchers, scientific knowledge and technology circulate freely and through which the Union and its Member States strengthen their scientific and technological bases, their competitiveness and their capacity to collectively address grand challenges.” (European Commission 2012).

For this purpose, EU suggest that “27 national research systems must be more open to each other and to the world, more inter-connected and more inter-operable. This will generate both more competition and more cooperation. Competition ensures that funding is allocated to the best researchers and research teams, while co-operation enables the brightest minds to work together to speed up breakthroughs to tackle grand challenges (…) and **prevents unnecessary duplication of national research and infrastructure investment (…)** driving a process of **smart specialisation** ” (European Commission 2012).

And after a detailed analysis of the strengths and weakness of Europe's research systems, as well as the objective of inducing lasting step-changes in Europe's research performance and effectiveness by 2014, European Commission defined the following priorities:

- More effective national research systems
- Optimal transnational co-operation and competition
- An open labour market for researchers

- Gender equality and gender mainstreaming in research
- **Optimal circulation, access to and transfer of scientific knowledge**" (European Commission 2012).

Extensive research work has been carried out to analyze and assess these programmes whose aim is the integration and cohesion of ERA, particularly in terms of decisions by policy makers in response to improved fuel dependency rates, economic growth rates, technology boost and promotion (Kitzing et al. 2012) as well as European Knowledge creation (Hervás Soriano & Mulatero 2011).

Several systematic difficulties were found, such as hard institutional problems (highly volatile decision and subsidy schemes, inconsistent policies, misalignment between different levels of government), market structures with a dominant incumbent role or strong dependence on government action, lack of knowledge diffusion between actors (Negro et al. 2012; Jaegersberg & Ure 2011; Michalena & Hills 2012) as well as doubts on the effectiveness of coordination, involving different type of actors at EU level (Hoekman et al. n.d.). The latter is especially important within the strategy of foreseen future programmes to avoid short term individually oriented policies for actors seeking to join the research arena through R&D project consortiums and a lack of shared vision of future technology developments (Negro et al. 2012; Costa-Campi et al. 2014; Boie et al. 2014).

CHAPTER 5

5. Social Network Analysis

5.1. Introduction

In this chapter, a brief presentation of Social Network Analysis with its history and the evolution is described in section 5.2. Then, section 5.3. points the most important current tools to undertake these kinds of analysis. Section 5.4. examines how Social Network Analysis and the creation of strategic knowledge are connected, being this part the core of this doctoral thesis. Moreover, as an increasing trend of research topic, section 5.5. explains how to use SNA in project environment with its own features and limitations. Furthermore, section 5.6. addresses the crucial concepts when applying SNA to projects, such as the relational networks construction, the different available approaches as well as the identification of key actors in those networks under the efficiency concept.

5.2. Social Network Analysis: history and evolution for researchers

Social Network Analysis is considered as a branch of mathematics named Graph Theory (Carrington & Scott 2011), formed by axioms and deductions that were based on Euler's Mathematical research of the problem of the seven bridges problem of Königsberg in 1736 (Gribkovskaia et al. 2007) (Figure 2).

Figure 2. Euler's Mathematical research of the problem of the seven bridges problem of Königsberg in 1736. Source: (Gribkovskaia et al. 2007).

Graph Theory examines the features and properties of the graphs in terms of their points (nodes) and lines (relations). Thus, these points represent groups, organizations or individuals, and their relations are drawn as lines.

Social Network Analysis emerged around the 1930s, when researchers and theorists started employing structural thinking ideas to their works of social structures. As research on SNA history shows, German sociology, mainly Simmel, started using new terminology to the patterns of formal properties in social relations: "points", "lines" and "ties or connections" (Carrington & Scott 2011). Researchers such as Moreno (1934) and Lewin (1936) carried out research on social relations and network characteristics of these individuals, using a new approach called "sociometry" using the first visual way of representing social networks: "sociogram" (Zheng et al. 2016).

As a consequence, the traditional application of SNA based on a triangulated theoretical ground in sociological and anthropological perspectives of informal relations (Zheng et al. 2016), such as social comparison in social psychology (Festinger, 1954) or balance theory (Cartwright and Harary, 1956), "sociometry" approach became the major field of study for research community (Carrington & Scott 2011).

However, this approach was discussed and criticised by next social anthropologist community in 50s, mainly leaded by University of Manchester, and emerging new approaches of formal social network methodology, employing ideas of connectedness and density (Barnes (1954) and Bott (1955)) (Carrington & Scott 2011).

Moreover, the first team of researches responsible of developing and spreading social network analysis through international community started with White (1963) when algebra was used for the first time to represent relations, positions and roles, inspired on the methodology developed by Lévi-Strauss (1969) (Carrington & Scott 2011).

Subsequent studies were carried out based on the previous approaches. For instance, Bearden's (1975) work based on the idea of centrality to examine influence and power in American bank field as the main important research, as well as others studies related to different networks such as: policy, social movements, criminality and terrorism, cultural, scientific, economics, geography (Carrington & Scott 2011), developing several theories with different perspectives: network exchange theory, network flow theory, small world theory, and the strength of weak ties theory (Carrington & Scott 2011).

Furthermore, since late 70s, a wide range of new techniques and applications were designed and developed by important researchers whose works are considered as a reference in social network analysis field nowadays: Burt (), Freeman and his colleagues (1989), Wasserman and Faust (1994) and Scott (1991) (Carrington & Scott 2011).

However, not only were researchers from social sciences interested in these theories and methodologies, but others also started applying them, mainly physicists. For example, by Watts and Strogatz (1998) applying the concept of 'small worlds' and "random networks" (Carrington & Scott 2011) to real situations.

As commented, although its start was originally for traditional sciences such as sociology, psychology or anthropology, during the last decades several disciplines took it as a powerful tool to analysis, such as communication science, organizational science or economics, becoming a multidisciplinary area (Prem Sankar et al. 2015). And thanks to new developments in softwares and more sophisticated studies in network theory, a rising tendency of research in this area appeared (Prem Sankar et al. 2015). Nowadays, a solid mechanism structure is functioning in this field with exclusive three peer-reviewed journals: Journal of Social Structure, Social Networks, Connections and the Journal of Social Structure, with the support of INSNA, which is the worldwide professional association for researchers interested in social network analysis.

5.3. Tools for SNA

Several social network analysts (Carrington & Scott 2011) widely agree that quantitative analysis packages developed for individual and only attribute-based analyses are not useful to work with social networks since it is necessary to not take individuals as their units of analysis. This fact triggered many software applications developments which gave a solution to this problem.

In recent research studies, several works listed the different SNA software tools depending on the purpose of the use such as general, specialized or visualization.

The most complete list was created by the researchers Mark Huisman and Marijtje van Duijn (Huisman & van Duijn 2011), as a chapter of the reference book "The SAGE Handbook of Social Network Analysis" (Carrington & Scott 2011).

From 2011 to 2017, some of them were modified with new features, even new ones are added to this list (Apostolato 2013; Agrawal et al. 2015), mainly for visualization process due to the rapid development of graphics softwares, such as VOSViewer (available for free at http://www.vosviewer.com/).

However, majority of researchers tend to carry out their networks analysis using the following three consolidated softwares which are validated by academic community:

- Pajek (Batagelj and Mrvar, 2007; Nooy et al., 2005)
- UCINET (Borgatti et al., 2002)
- R programme (Butts, 2008) (van Rijnsoever et al. 2015)

In this thesis, Pajek and Ucinet were used since they became the most used SNA tools amongst researchers in the recent years for collaboration networks, genealogies, Internet networks, citation networks, diffusion networks (news, innovations) or data-mining (2-mode networks) (Apostolato 2013; Batagelj & Mrvar 2011).

Pajek Software:

Pajek software is a free software application for analysis and visualization of large networks which was developed by Andrej Mrvar and Vladimir Batagelj in November 1996 (Batagelj & Mrvar 2011). This Slovene word means spider.

Its objective is mainly provide a user-friendly and powerful tool to visualize and analyse, through efficient algorithms, large networks and abstraction by factorization of large network into smaller networks (Apostolato 2013). Six structures are used to implement the algorithms: network, permutation, vector, cluster, partition and hierarchy (Apostolato 2013; Batagelj & Mrvar 2011). Amongst the several algorithms to analyse these large networks, the following are the main ones (Apostolato 2013):

- Partitions: degree, depth, core, p-cliques, centres.
- Binary operations: union, intersection, difference.
- Components: strong, weak, bi-connected, symmetric.
- Decomposition: symmetric-acyclic.
- Paths: all paths between two vertices, shortest path(s).
- Flows: maximum flow between two vertices.
- Citation weights.
- Neighbourhood: k-neighbour.
- Critical Path Method.
- Extracting sub-network.
- Shrinking clusters in network.
- Reordering: topological ordering, Richard’s numbering, depth/breadth first search.
- Reduction: hierarchy, subdivision, degree.

- Simplifications and transformations: multiple lines, deleting loops, transforming arcs to edges.

The next figures are related to Pajek software v. 3.12. for Windows32 and 4GB, having its last update in May 2013 (downloaded from the official website: http://mrvar.fdv.uni-lj.si/pajek).

On the one hand, the main interface window (Figure 3) and, on the other hand, the interface for visualizing drawings of networks (Figure 4) are shown.

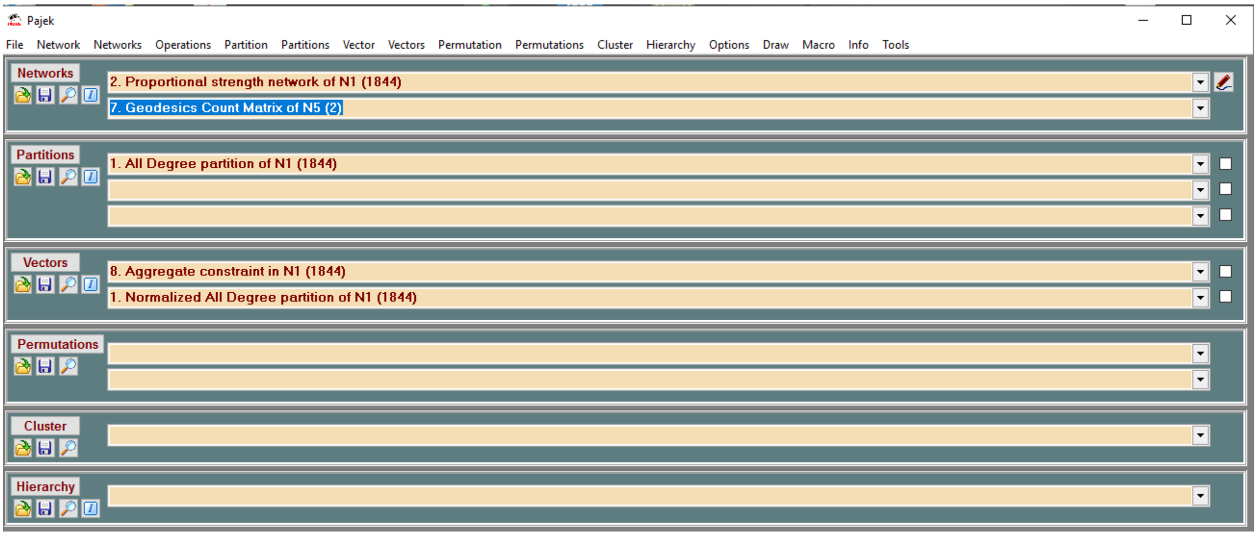


Figure 3. Main interface window for Pajek Software (Win32, 4GB) v. 3.12.

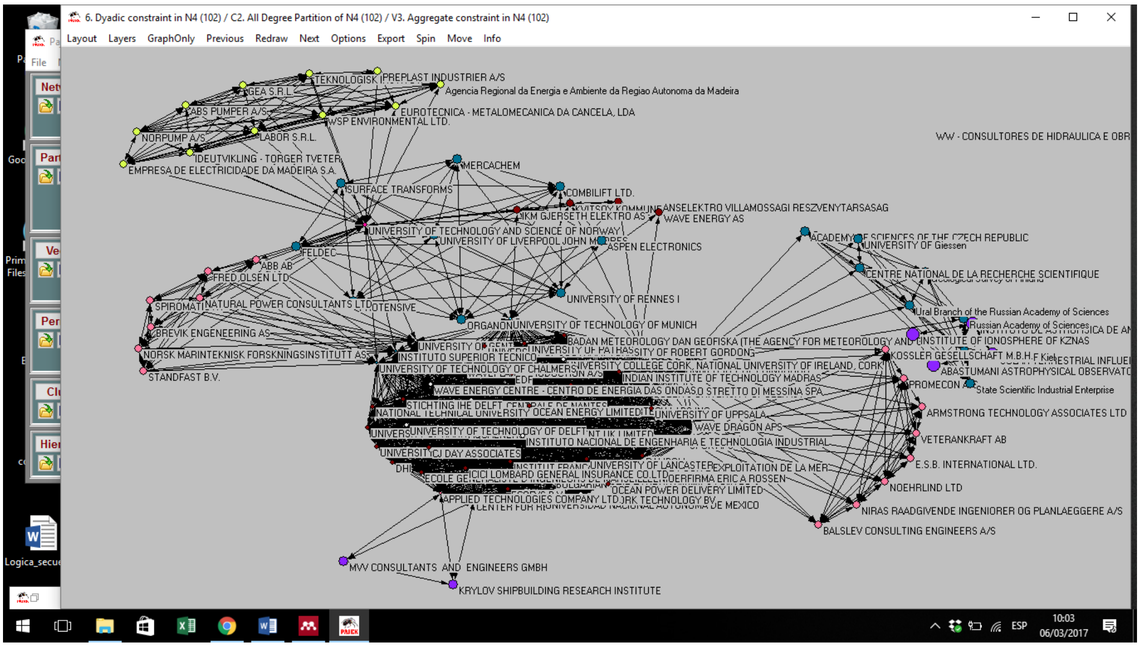


Figure 4.Pajek Software interface for visualizing drawings of networks in Pajek.

In this visualization window, analysts can modify the graphs and networks according to their needs, automatically or by hand, selecting the whole network or part of it, and visualizing in 2D or 3D.

UCINET:

This Windows software package is like Pajek, but it gives more user-friendly ways to export and analyse data. It was developed by Steve Borgatti, Martin Everett and Lin Freeman (Borgatti et al. 2002).

It also provides the tools to analyse 1-mode or 2-mode data, handling until two million nodes. The main analytical algorithms that are available in this software are the following (Apostolato 2013):

- Centrality measure
- Subgroup identification
- Role analysis
- Elementary graph theory and permutation-based statistical analysis.
- Data transformation such as:
  - Sub-graphs and sub-matrices.
  - Merging datasets.
  - Permutation and sorts.
  - Transposing and reshaping.
  - Linear transformations.
  - Geodesic distances and reachability.
  - Aggregation, normalizing and standardizing.

Moreover, several tools to work with matrix algebra and multivariate statistics are available. This software and its last versions could be downloaded through the official website: https://sites.google.com/site/ucinetsoftware/

The following pictures show, on the one hand, the user-friendly main window (Figure 5); and on the other hand, the main window of Netdraw, which Ucinet uses as its visualization subprogram (Figure 6).

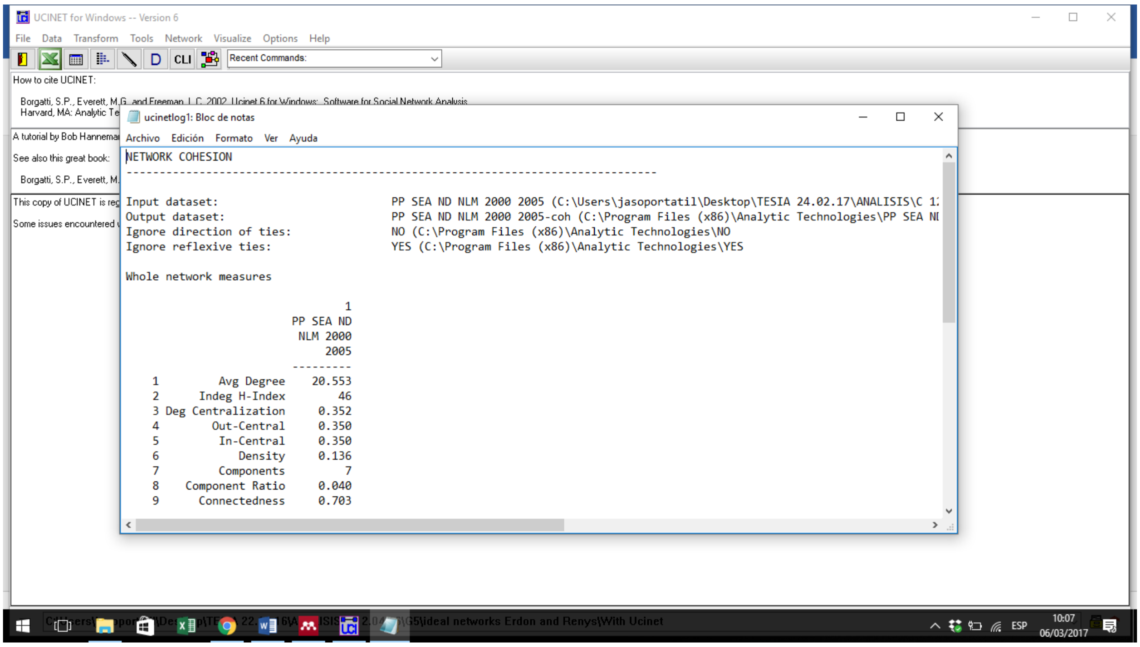


Figure 5.Ucinet Software interface for uploading networks. Source: (Borgatti et al. 2002)

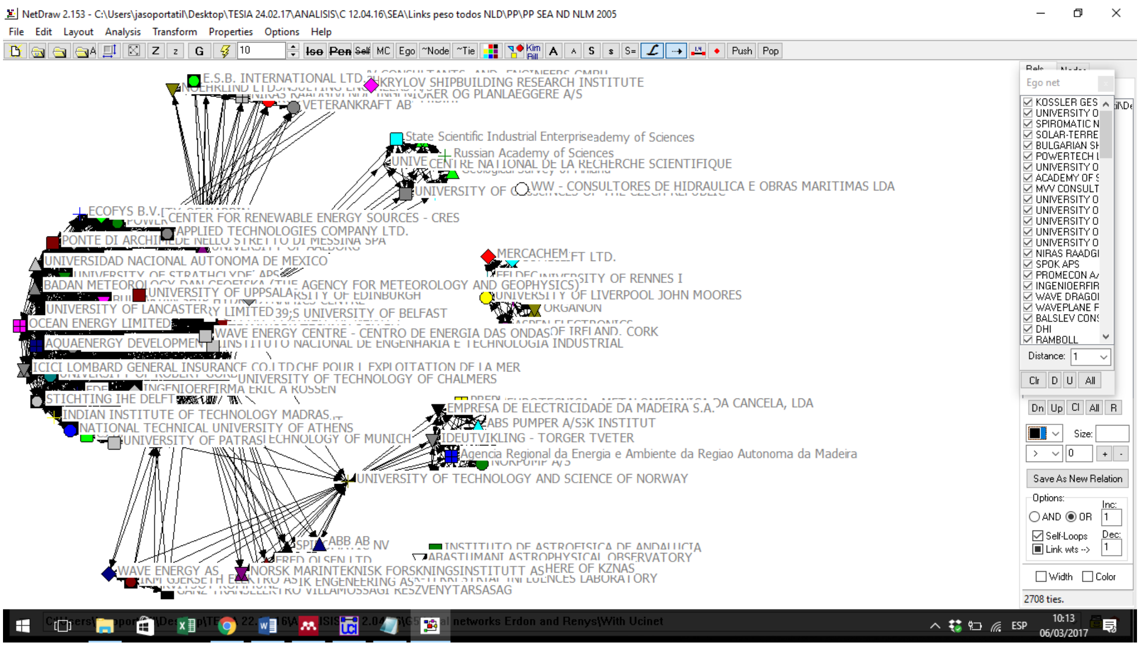


Figure 6.Ucinet Software interface for visualization of networks using NetDraw. Source: (Borgatti et al. 2002)

5.4. SNA to create strategic network knowledge

As defined above, a social network is formed by nodes connected by one or more relations, and the selection of these nodes to delimit boundaries of the network and their relations are becoming crucial task to undertake any research in social networks (Carrington & Scott 2011).

On the one hand, even there are many contributions of researchers in this, Laumann et al. (1983) (Laumann et al. 1983; Carrington & Scott 2011) proposed three approaches that are not mutually exclusive:

- Position-based approach: it considers those actors who are members of an organization. Example: organizations within a country or industrial sector.
- Event based approach: it considers those nodes that have participated in an event. Example: organizations within a project.
- Relation-based approach: it considers an initial small set of nodes within the population of interest, and then, adding others that are connected through a concrete relation. Example: organizations within different projects.

On the other hand, connections or relations between these nodes need to be examined to end with the delimitation. In this sense, four categories of relations are possible: similarities (when two nodes share the kinds of attributes), social relations (when nodes shares kinship or role relation), interactions and flows (when behaviour-based ties is considered, or resources, information or influence flow through networks) (Borgatti et al. 2009; Carrington & Scott 2011).

Moreover, as the SNA community state that these analyses require some assumptions about how best to describe and explain the social phenomena of interest, always it is necessary to take into account the context where these relations of nodes are done and that they are not independent (Carrington & Scott 2011).

The main two theories in which the current social network analysis is based are: formalist theories and structural theories (Carrington & Scott 2011).

On the one hand, **formalist theories** are those that are emerged from the mathematical perspective and they do not need empirical data (Duncan J Watts & Strogatz 1998). Thus, mathematical modelling and computer simulations build some sort of networks to extract from them patterns of relations and rules of ties. For example, they are used to describe the possible network for real-world as well as small-world situations (Duncan J Watts & Strogatz 1998).

On the other hand, how patterns of the ties or relations provide some information about concrete topics is studied under the **structuralist theories**. In this case, the following four approaches are taken place (Carrington & Scott 2011):

- Definition of key concepts in network terms (Stern 2008)
- Testing an existing theory (Smith 2005)
- Looking at network causes of phenomena of interest (Burt 2004)
- Looking at network effects of phenomena of interest (Hampton & Wellman 2003)

In social network analysis, mainly three type of data are used: **attribute**, **relational** and **ideational** data. Of course, always under a process of interpretation (Carrington & Scott 2011).

The first one, attribute data, are inherent to nodes' "properties, qualities or characteristics". The second one, relational data, is the basis of social network analysis due to it concerns the ties and relationships between nodes, and it is not inherent to the nodes. The third one, ideational data, comprises the "meanings, motives, definitions and typifications involved in actions" (Carrington & Scott 2011).

Furthermore, and concerned with the methods to collect these data, there is not still a unified consensus in research community. Although attribute data were indisputably used to social sciences, relational data is gaining importance due to its potential to analyse complex networks. However, this rational data used to be inaccessible to the majority of researchers until the last decade (Zheng et al. 2016).

In the following picture (Figure 7) the style of research, source of evidence, type of data and type of analysis are shown in a schematic way (Scott 2017).

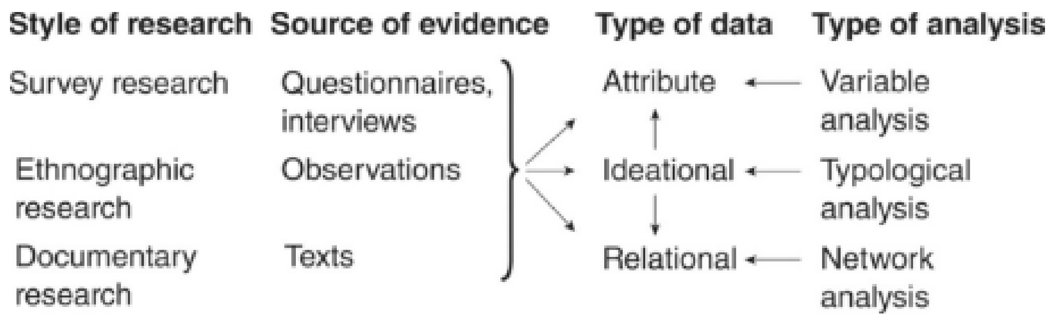


Figure 7. Types of data and analysis for social network analysis. Source: (Scott 2017).

Related to the scope of this thesis, knowledge and information transfer through collaboration networks, generally **scientific and researchers' publication citations** (Garechana et al. 2012) and **patents citation data** (Choe et al. 2016; Guan & Liu 2015; Choi & Hwang 2014; Gavilanes-Trapote et al. 2015) is used to build networks and extract relational data. However, an increasing trend of works appears using other data such as **company databases**, more useful for economic and organizational fields (A. Marra et al. 2015).

Some examples using **scientific and researchers' publication data** in different sectors and fields are the following:

- In the next example (Figure 8), Waste Recycling sector field was analysed using keywords from publications of World of Knowledge (WoS, http://www.webofknowledge.com) for the year 2010, and creating a network with Science Citations between papers (Garechana et al. 2012).

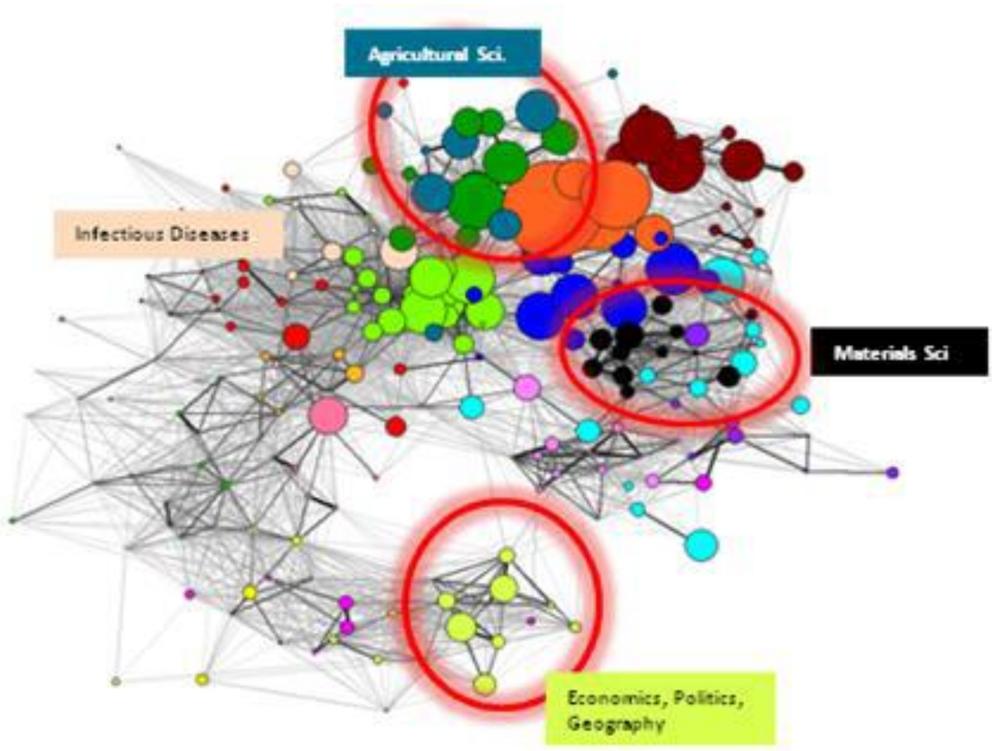


Figure 8. Subject Categories (SC) network based on keywords from scientific publication in Waste Recycling sector in 2010. Source: (Garechana et al. 2012).

On the other hand, some examples using **patent data** in different sectors and fields are the following:

- In this is example, online patent search service WIPS (wips.co.kr) (it contains information from USPTO about patents from Korea, the U.S., EU, China, and Japan) was used to construct a patent citation network in the field of organic photovoltaic cells (Choe et al. 2013). With a list of key words searched in the title, abstract and exemplary claim, 172 patents were found for the period from 1970 to 2010, and three different patent citation networks created using 2,858 nodes: country, institution and technology patent citation networks (Figure 9, Figure 10, Figure 11).

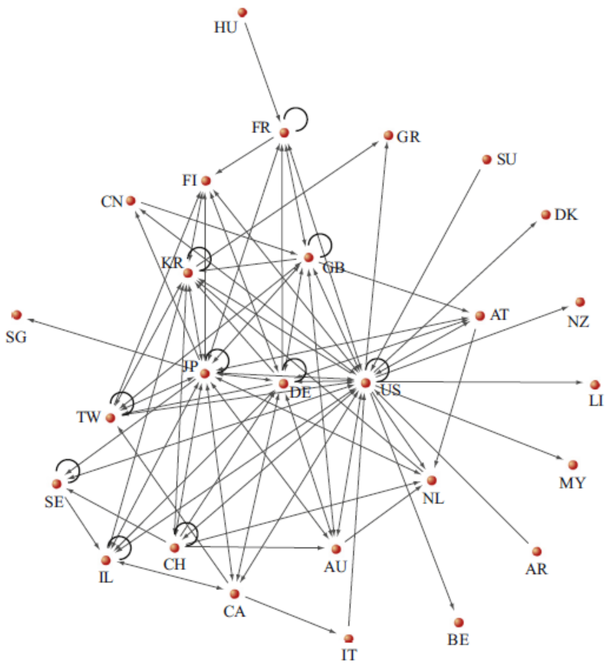


Fig. 4. The country citation network.

Figure 9. The country patent citation network. Source: (Choe et al. 2013)

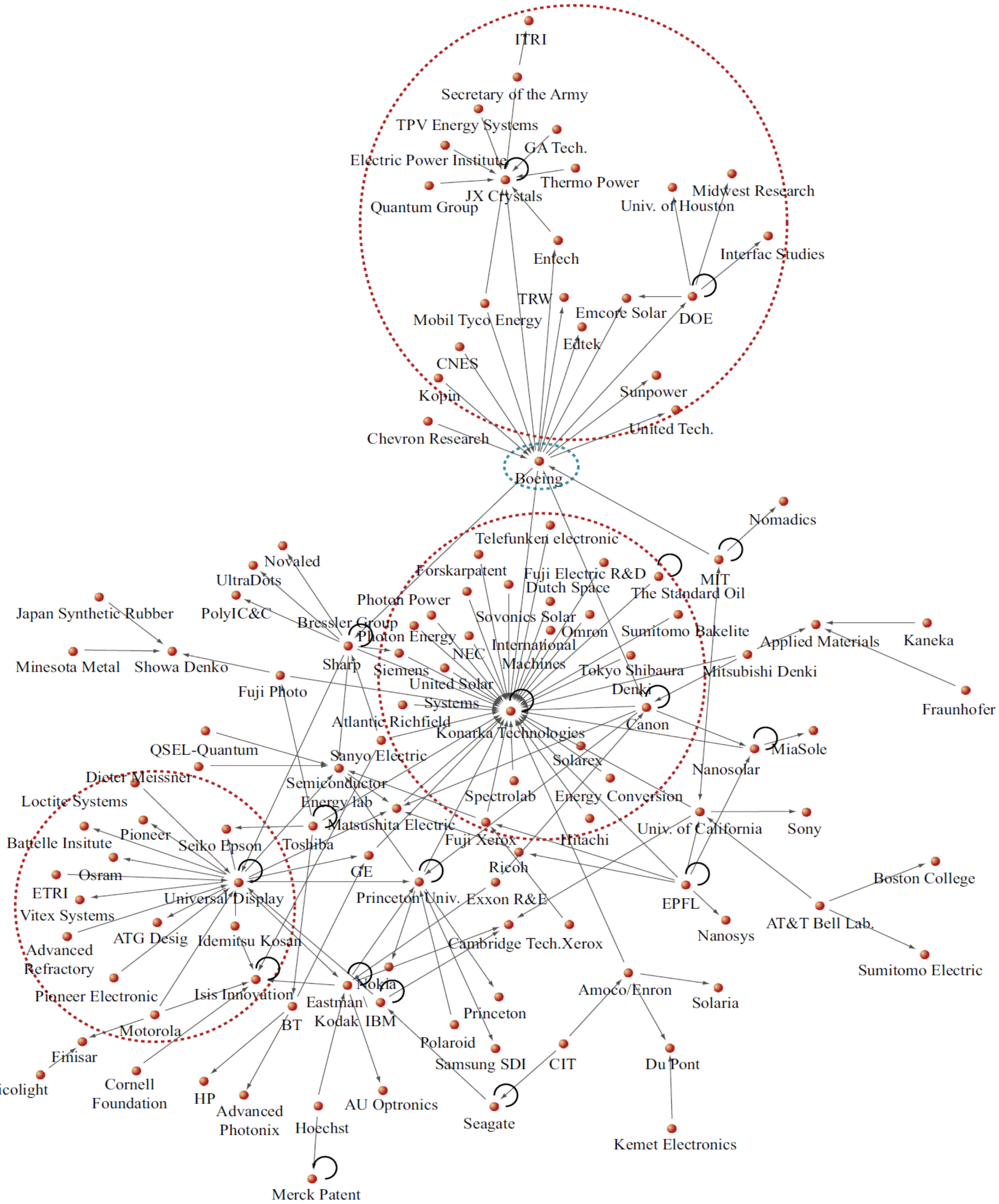


Figure 10. The institution patent citation network for which the number of links is more than three. Source: (Choe et al. 2013)

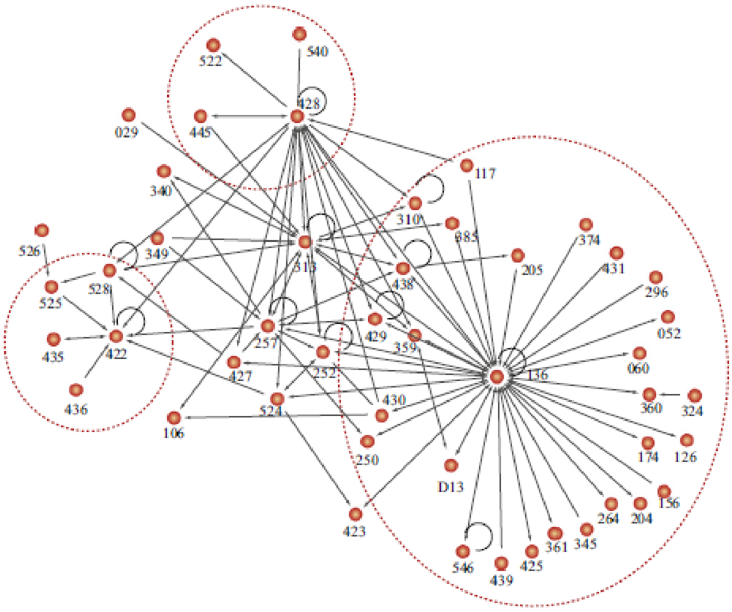


Figure 11. The technology patent citation network. Source: (Choe et al. 2013)

- In the next example (Figure 12), the nano-energy patents data was extracted from Derwent Innovation Index database (DII), which contains information about patent from more than 100 countries and 40 patent authorities, including USPTO, EPO, JPO and SIPO. In these citation networks, nodes represent the patent documents and lines represent when a patent cites other patents (Guan & Liu 2015).

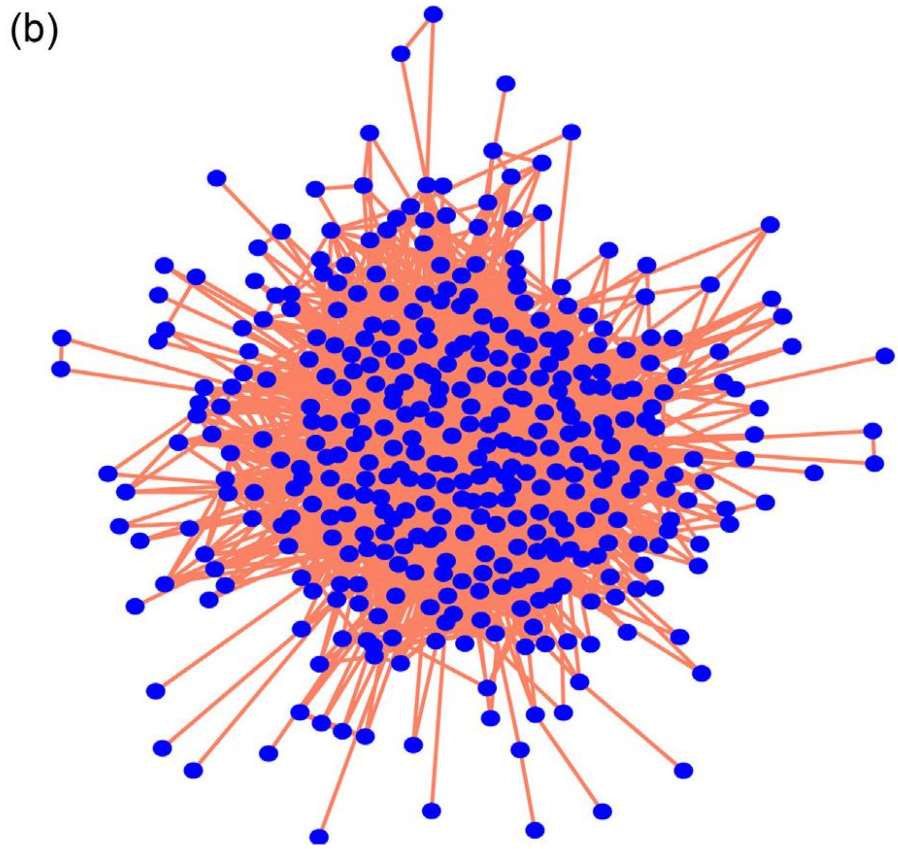


Figure 12. A knowledge network in the nano-energy field characterized by a high degree of associative integration, 2000–2004. Source: (Guan & Liu 2015)

- In the following example (Figure 13), information about Light Emitting Diode (LED) was extracted from Patent and Trademark Office (USPTO) for the period 2000-2011 collecting all the details about 331 LED patents (Choi & Hwang 2014).

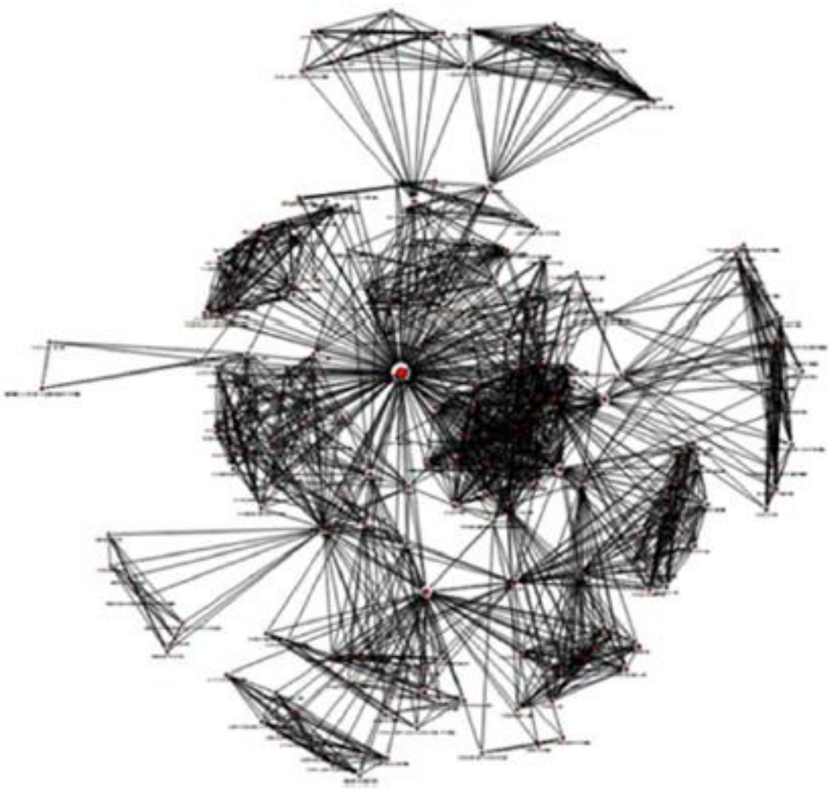


Figure 13. Schematic diagram of LED patent keyword networks (based only on data between 2000 and 2003). Source: (Choi & Hwang 2014)

- In the following example (Figure 14), the collaboration network is based on the patent citation data between more than a thousand high-tech companies extracted from CrunchBase database (the world's most comprehensive database on high-tech companies which contains more than 2000,000 profiles of start-ups from several high-tech industries including bio-tech, clean-tech, nano-tech, finance, hardware, software, mobile, e-commerce, and provides information about the city of registration and operating offices, number of employees, category code, total money raised, number and timing of financing rounds and tags related to markets, products, services, technologies, and so on) (M. Marra et al. 2015).

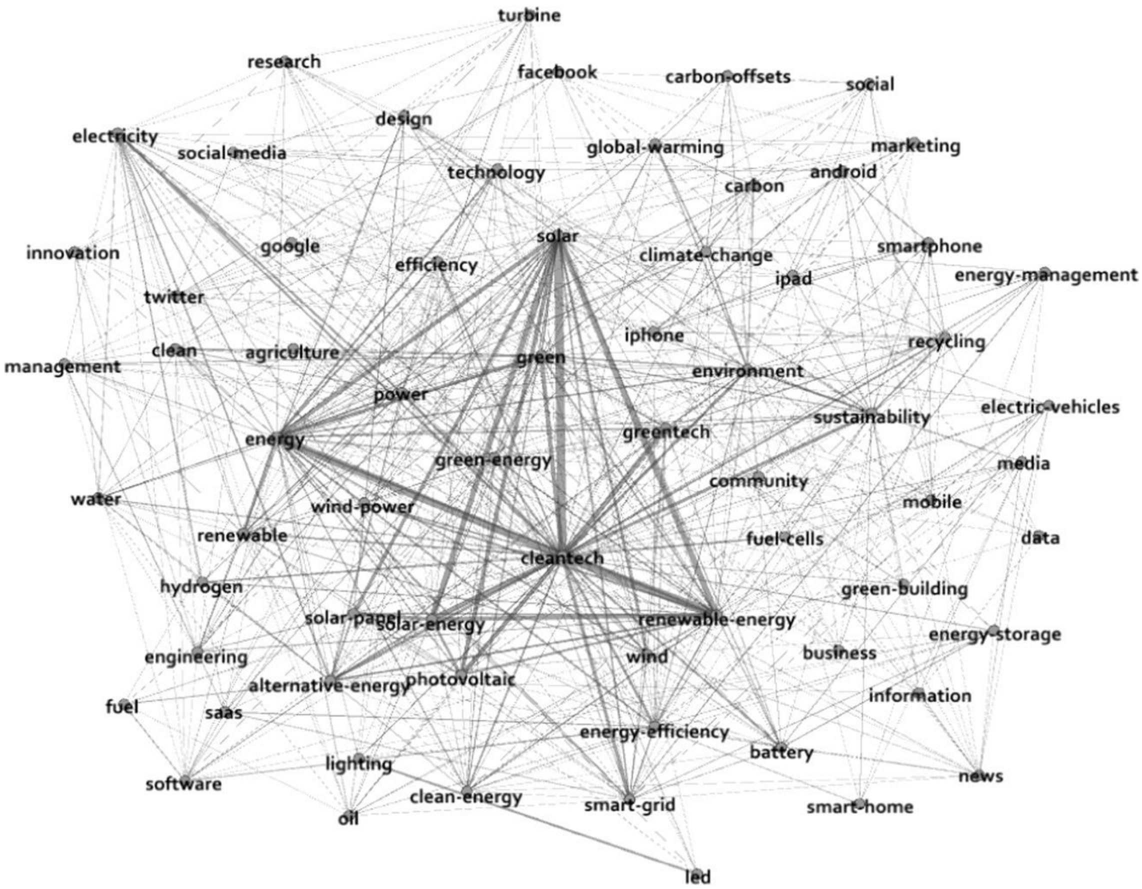


Figure 14. The clean-tech industry worldwide for a degree range set above 35, the resulting network has 68 nodes and 598 edges. Source: (Choi & Hwang 2014)

Specially in the last decades, some researchers focused their attention into renewable energy sector, carrying out social network analysis research using both **publications** (Luz M Romo-Fernández et al. 2011; Montoya et al. 2014; Rizzi et al. 2014) and **patents data** (Choe et al. 2016; Choe et al. 2013). Some of these examples are the following:

- The next figure (Figure 15) shows the term map based on all Renewable Energy sectors' manuscripts publications between 1992-2011. In the term map, four different colours were used to indicate a cluster of related terms (Rizzi et al. 2014).

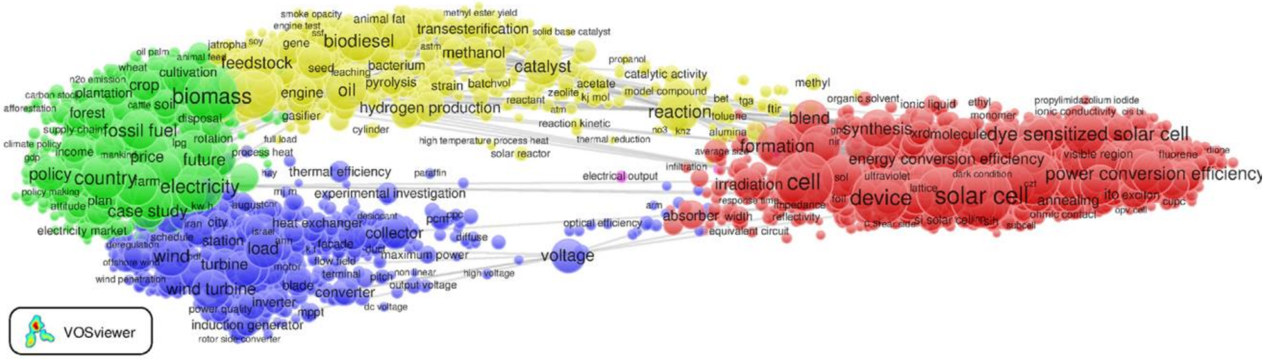


Figure 15.Term map based on all Renewable Energy sectors' manuscripts between 1992-2011. Source: (Rizzi et al. 2014)

- The following research work (Figure 16) focused the attention into the patents registered in USPTO database to analyse the network showing the technological knowledge transfer between organizations in the field of organic solar cells for the period 1977-2011 (Choe et al. 2016).

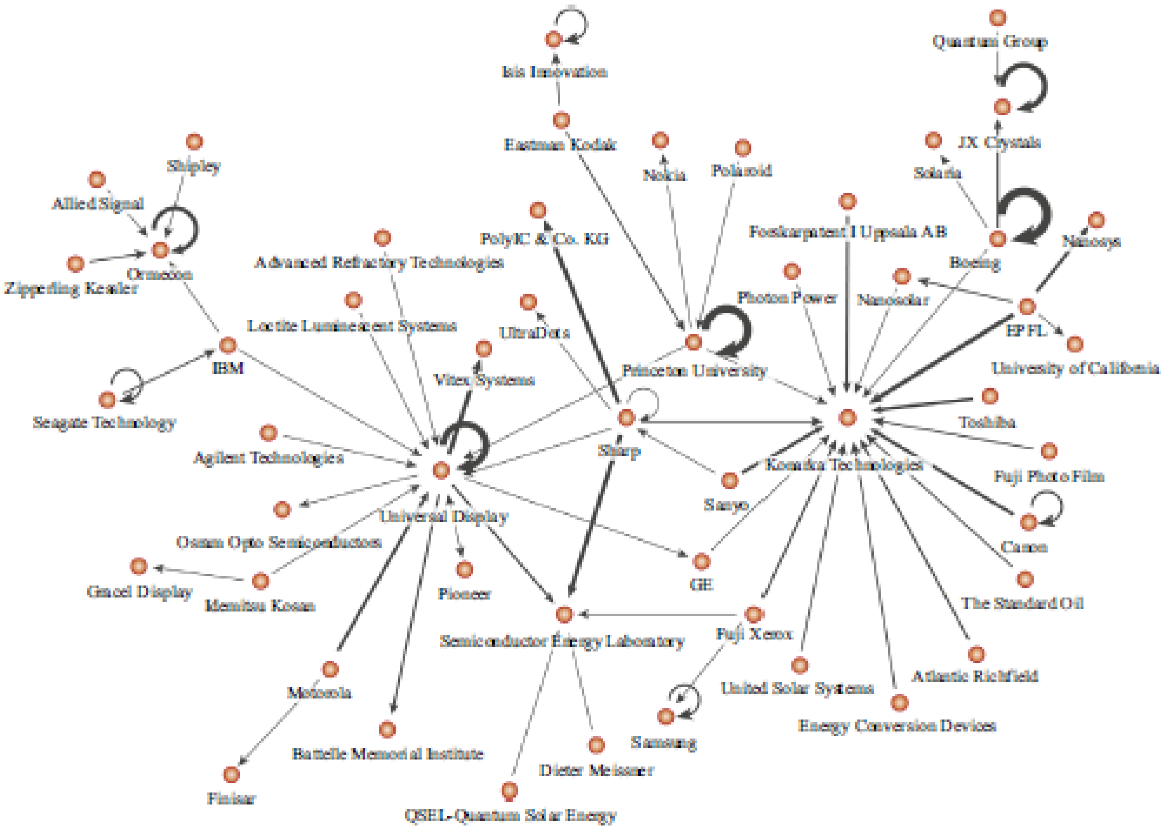


Figure 16. The network showing the technological knowledge transfer between organizations in the field of organic solar cells for the period 1977-2011. Source: (Choe et al. 2016)

5.5. Applying SNA to project environment to create strategic network knowledge

Although an extensive literature and research works on SNA could be found in academic field, few studies were carried out related to projects and their networks. However, in the past three decades more attention is paid into **project-based networks** (Zheng et al. 2016), mainly to study network characteristics and effects within the organizational networks, specially to analyse “knowledge transfer, resource mobilization and consensus building” (Zheng et al. 2016; Bodin & Crona 2009); in particular, cross-organizational networks in business activities, supply chain management and strategic alliances, introducing slowly characteristics and effects of inter-organizational networks (Zheng et al. 2016).

- The next work employs data on projects registered at the clean development mechanism (CDM) extracted from The United Nations Framework Convention on Climate Change website (UNFCCC, http://unfccc.int) to analyse the network structure of 3816 projects for the period 2005-2011. In the following figure (Figure 17) the dynamics of collaboration networks in the CDM partnership from 2005 to 2011is shown (Kang & Park 2013).

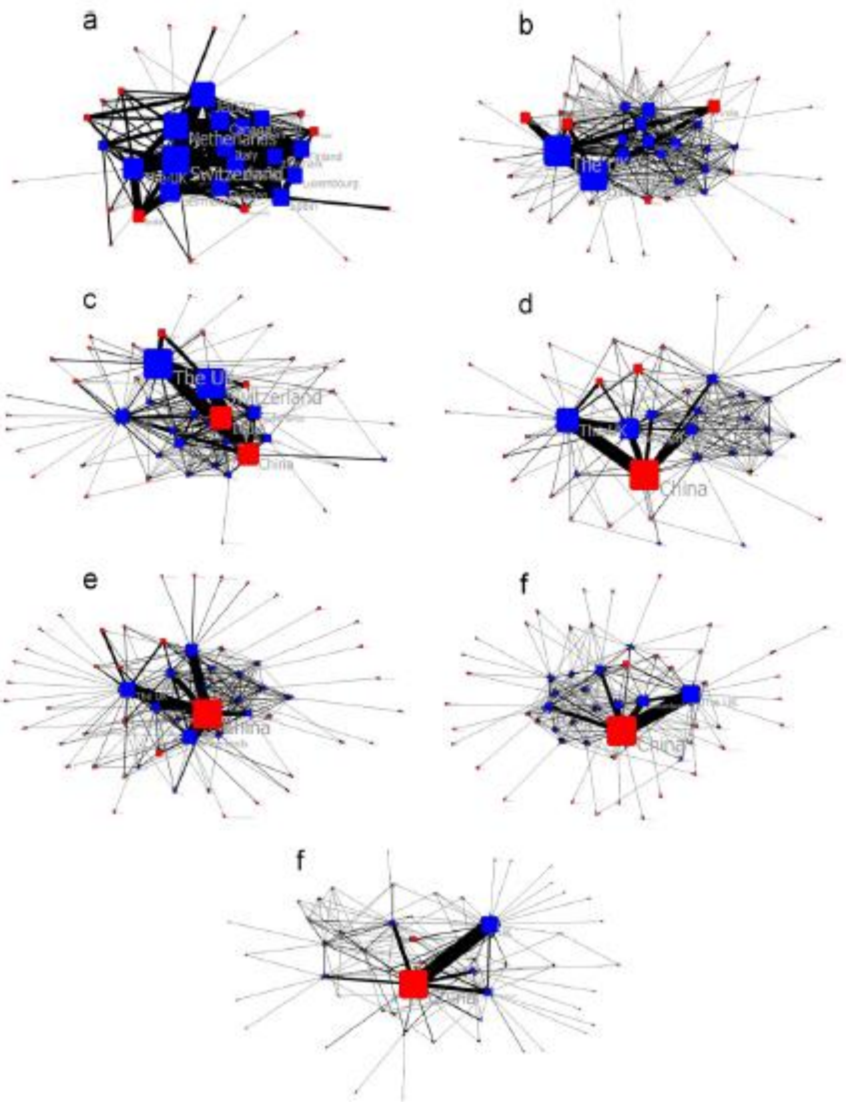


Figure 17. The dynamics of collaboration networks in the CDM partnership from 2005 to 2011. (a) 2005, (b) 2006, (c) 2007, (d) 2008, (e) 2009, (f) 2010 and (f) 2011. Source: (Kang & Park 2013)

Within **projects area**, the role of networks is essential in order to transfer and disseminate information and knowledge through all the members, providing access to resources, capabilities and markets, improving innovation and increasing the competitiveness of involved actors (Cassi et al. 2008b). Taking advantage of this characteristic, networking is becoming part of the policy agenda for science and technology. In particular for EU agenda which aims to create an European Research Area which integrates the different innovation systems of member states into a coherent whole (Cassi et al. 2008b), using mainly a systematic mechanism of research programmes frameworks.

An increase in studying these research programmes frameworks is observing in recently research works about social network analysis (Breschi & Cusmano 2002; Roediger-Schluga & Barber 2008), carrying out empirical studies as well as testing and developing new methodological approaches for new emerged issues specially in R&D project networks. And specially, those carried out using social network analysis are the following:

- Analysis of network created using collaborative projects and all organizational sub entities for 3th Framework Programme from EU (Figure 18). The data was extracted from the Sysres EUPRO database (http://ww http://cordis.europa.eu/) which contains all information publicly available through the European Union projects database and is maintained by ARC systems research (ARC sys). The communities are shown as vertices and their area is proportional to the number of members, while the width of the edges is proportional to the number of relationships between different communities. Additionally, they are labelled with the most frequently occurring subject index (Roediger-Schluga & Barber 2008).

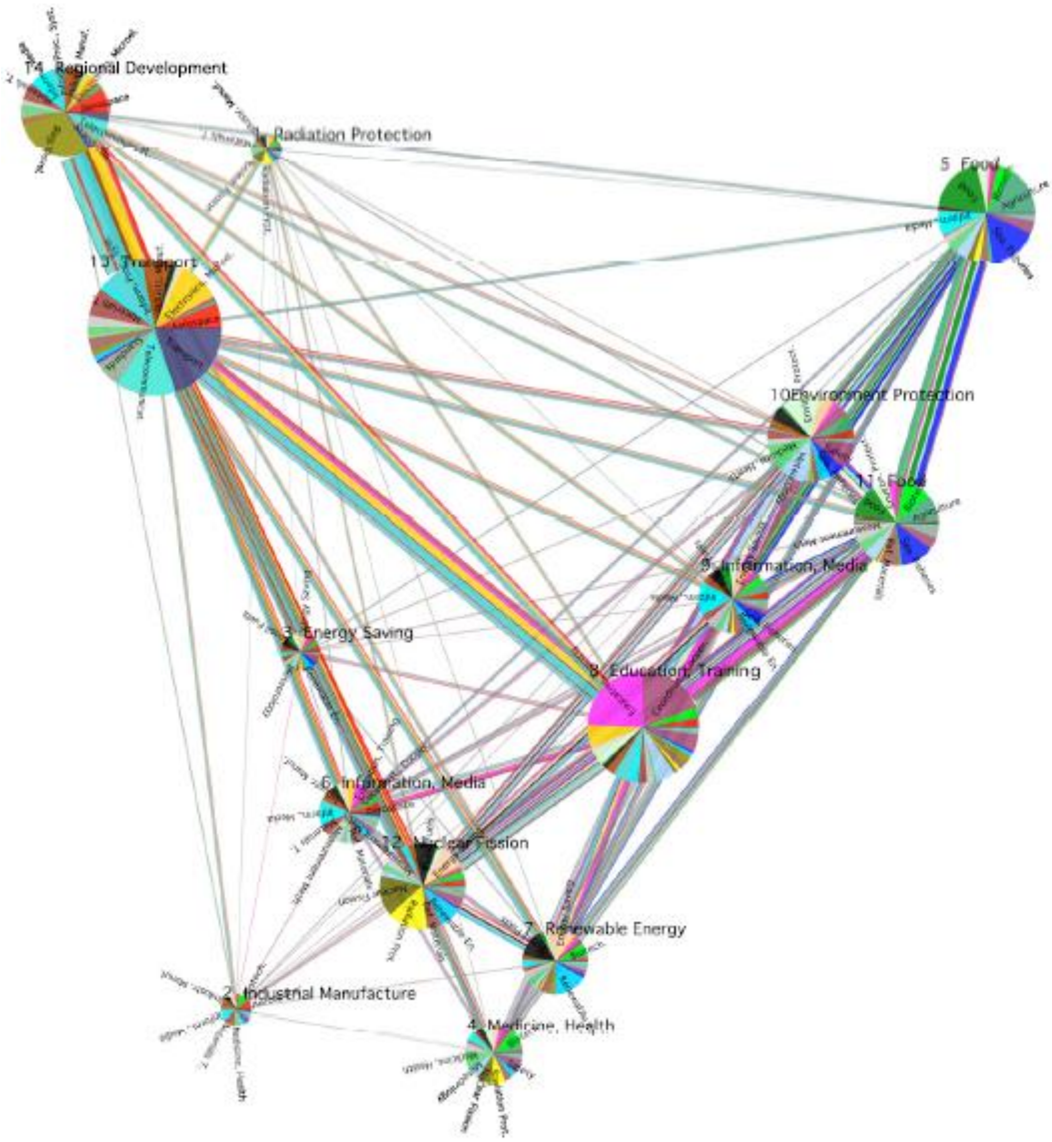


Figure 18. Community groups in the network of projects and organizations for 3th Framework Programme from EU. Source: (Roediger-Schluga & Barber 2008)

- Other example shows the analysis of the knowledge flows in the European R&D network (Figure 19), as inferred from Framework Programme (FP) data, to evaluate knowledge flows between organizations, considering the NUTS2 regional level. Analysing some SNA indicators, the power of a relation was examined and strategically positioned organization identified (Barber & Scherngell 2012).

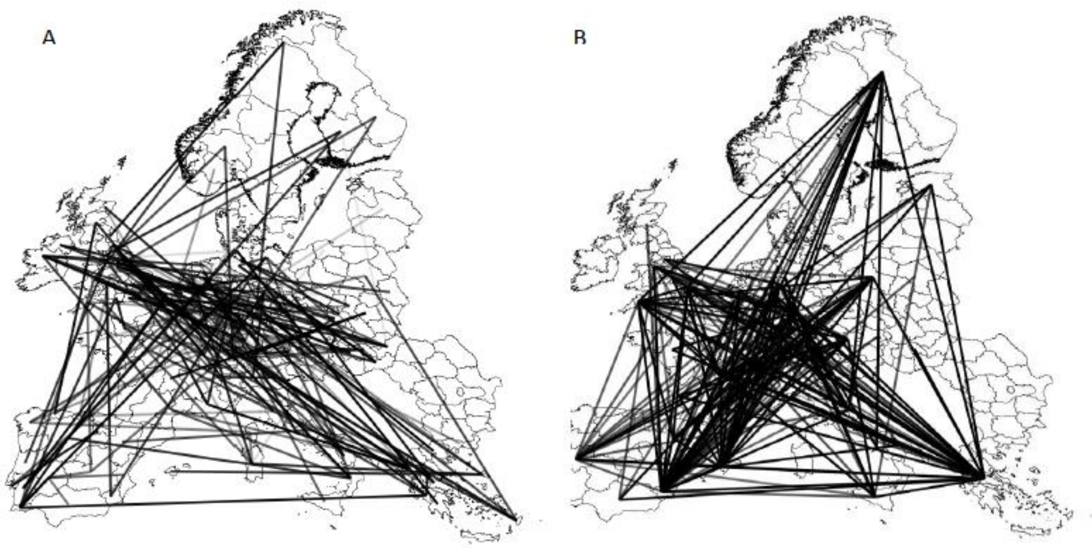


Figure 19. The geographical networks showing the links with high and low ratios of inter-regional betweenness centrality to weight (map A shows the network of the 1% of FP inter-regional links with the lowest ratio and map B the highest ratio of inter-regional betweenness to weight). Source: (Barber & Scherngell 2012)

Even few research works has been carried out about R&D collaborations in emergent sectors, such as RE sector, there is an increasing interest, mainly from the organizational and knowledge and information flows perspective (Ragwitz & Miola 2005; Hain 2013; Kang & Park 2013; Kang & Hwang 2016).

- For example, a detailed analysis of hydrogen & fuel cells and wind energy technological fields in-depth investigation was carried out (Figure 20) using the database provided by Energiforskning.dk and maintained by the Risø National Laboratory for Sustainable Energy of Denmark's Technical University (DTU) as a source for information about public funded research projects, identifying overall 1,807 projects with 1,292 organizations involved (Hain 2013).

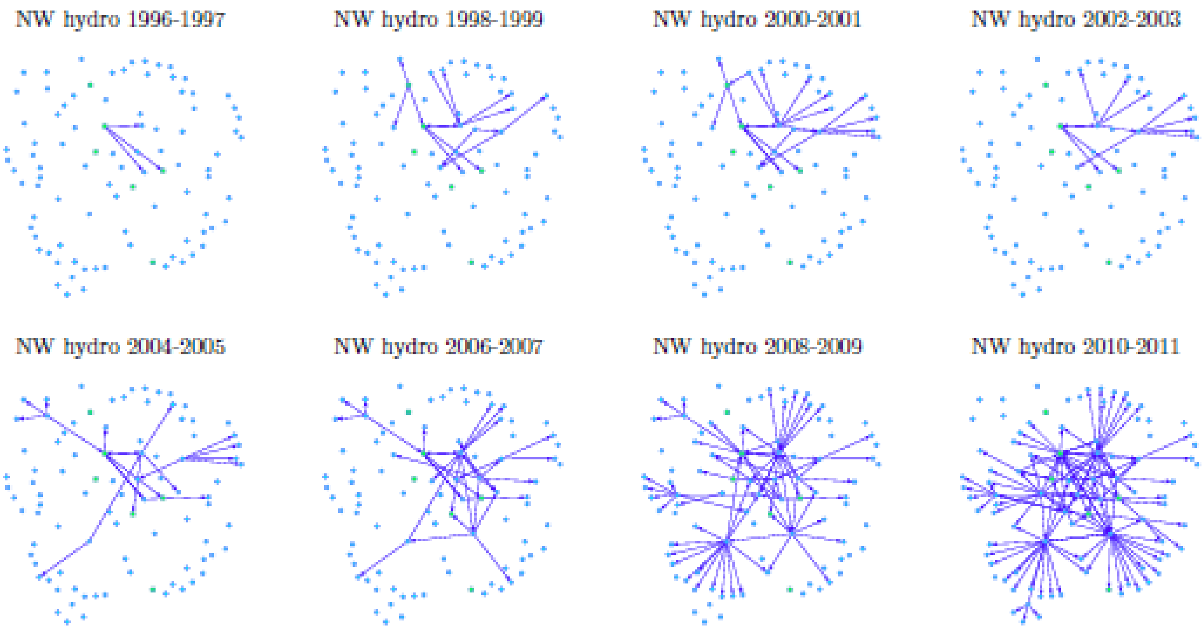


Figure 20. The Network Development in Public Funded R&D in hydrogen and fuel cells, Ties are directed from project-leader to project partner, and circles represent universities while squares all remaining types of organisations. Source: (Hain 2013).

5.6. Crucial concepts when applying SNA to projects

The vast literature about application of SNA suggest following a standard general methodology as a basis to apply SNA in majority of the fields in scientific research works ((Heimeriks et al. 2003; Batagelj & Mrvar 2011; Kang & Hwang 2016). This standard general methodology is based on the following crucial concepts: relational networks construction, choosing the useful approach and identifying key actors.

In this chapter, these crucial concepts are analysed under the aim of applying them to projects' environment.

5.6.1.Relational networks construction

First, researchers must decide what kinds of networks and relations are needed to apply SNA. These needs are encompassed in a methodology which could be summarised in three main steps:

network data dimensions, structural approach modes and types of connections as relational information (Carrington & Scott 2011).

Related to data dimensions, the two main perspectives are: whole networks and ego networks. On the one hand, whole network perspective considers the network focusing on all nodes and their effect in the whole network, as a bird's-eye view of the network. However, ego networks perspective focuses on a particular node and its surrounding nodes (Burt 2001; Burt 1992). In the first perspective, all nodes form the network and the general affects are studied, while in the second one, different networks are created to analyse each node's effect on its neighbours.

Related to structural approaches modes, 1-mode data and 2-mode data are commonly treated. On the one hand, one-mode data contains a single type of node in the network, while on the other hand, 2-mode data contains mainly the type of node and its affiliation information (Carrington & Scott 2011). For example, the following figure (Figure 21) shows a simple understanding of both structures:

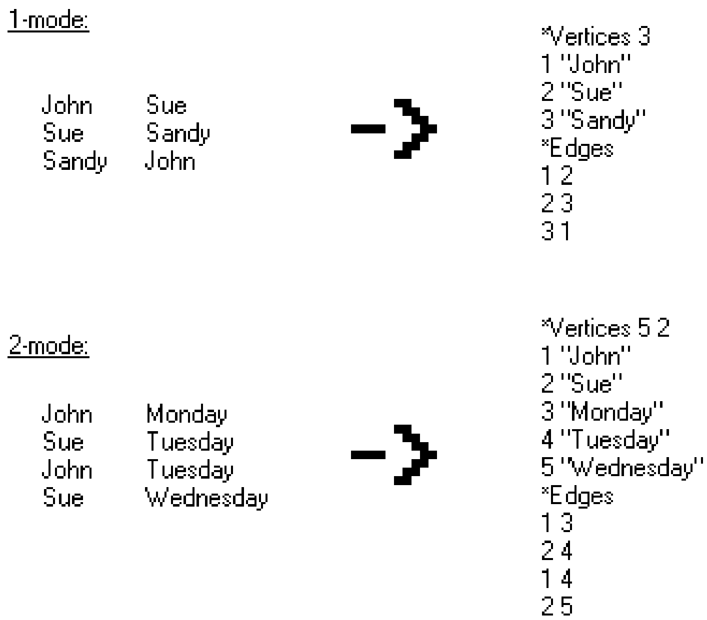


Figure 21.1-mode and 2-mode data structures for networks construction. Source: www.fas-research.com

When analysing the whole network, where any node could be connected to any other node, 1-mode option is mainly used (Carrington & Scott 2011). Generally, these 1-mode networks are created based on affiliation data which could contain two types of nodes. For example, the organizations and the events or projects where they are involved in (Carrington & Scott 2011; Batagelj & Mrvar 2011). In this sense, 1-mode data could be obtained easily from 2-mode data by extracting relations that consist of co-membership, co-attendance or any kind of relation in common (Duncan J Watts & Strogatz 1998).

Finally, according to types of connections, some considerations are necessary based on the purpose of SNA in each network. Here, two perspectives are analysed: directions of ties and values of them.

On the one hand, related to the directions of ties or relations, directed and undirected are considered. While directed ties are those that go from one node to another, undirected have no direction. Directed ties are reciprocated and needed when the action of the relation is mainly done by one of the nodes, while undirected ties do not take into account the direction since both nodes are promoting the tie in the same importance (Carrington & Scott 2011; Batagelj & Mrvar 2011).

On the other hand, and related to the value of ties, two main types are considered. Binary ties give information about the existence of the ties, while the valued ties provide information about how strong or weak is the tie (Carrington & Scott 2011).

However, several authors concluded that the decision to build networks using 1-mode/2-mode, directed/undirected or binary/values ties is a pragmatic choice since sometimes the availability of the data is limited (Borgatti & Halgin 2011; Batagelj & Mrvar 2011; Carrington & Scott 2011; Wieczorek et al. 2013; Heimeriks et al. 2003).

5.6.2.SNA approaches: Coleman and Burt

As detailed in previous chapters, science, technology and innovation networks became an emerging organizational mode in contexts where the path of technological progress is high and knowledge-intensive industries rely on it as well as on the wide range of network types (Cassi et al. 2008a). Although academic works in managerial and sociological fields focused their attention into alliance networks at the beginning of social network analysis, in these days more attention is put into **knowledge networks**, using patents and scientific publications data (Cassi et al. 2008a; Arroyabe et al. 2015; Breschi & Cusmano 2002).

Interaction between nodes in project networks is a structural element and it was defined as "a combination of the duration of the tie itself, emotional intensity, intimacy or mutual confidence, and reciprocal services between the partners" for joint R&D projects networks (Granovetter 1985; Arroyabe et al. 2015).

From the social capital perspective, researchers state on the existence of two main approaches that analyse how this interaction affects both individual 'exchange' and 'transactional behaviour' (Cassi et al. 2008a; Uehara 1990).

On the one hand, the first one is from the **individual exchange perspective** that focus the attention into the quality of the constituent ties, analysing frequency, intensity and multiplexity, as well as into the role that those ties perform as structures of knowledge and information transfer (Arroyabe et al. 2015). Thus, weak ties constitute structures to access novel knowledge and information (Granovetter 1985; Rowley et al. 2000; Arroyabe et al. 2015), while strong ones transfer tacit knowledge (Borgatti & Halgin 2011).

On the other hand, the second approach is focused in **interactions as a transactional behaviour structure**. Taking into account this perspective, Coleman (Coleman 1988) state that being embedded in a very interconnected, close, dense networks enhance the existence of effective norms and strengthen social capital, and encourage the sharing of complex knowledge. However, Burt (Andrews & Burt 1995) has argued that when the aim is to access new information and knowledge, few redundant ties provide greater advantages, because being embedded in a very cohesive network reduce the individual learning process, while placing oneself in a position that enable to connect previously unconnected part of network increase the efficiency of access new knowledge (Arroyabe et al. 2015; Cassi et al. 2008a; Burt 2008).

The "small world" concept was developed by Watts and Strogatz (Duncan J Watts & Strogatz 1998) and is seen as a formal model that integrated those two perspectives. They suggested that there is a possibility to build a network that are dense, cohesive, interconnected and "cliquish" following Coleman's centrality perspective to promote knowledge and information transmission; and additionally, having networks with short average distances between nodes to avoid redundant lies and the drawback of these strength of relations: "more repeated interactions, the exchange become more alike and develop stocks of knowledge" (Arranz & Fdez. de Arroyabe 2008; Andrews & Burt 1995).

Even an increasing number of research works have the impact of each of those perspective approaches separately in the recent years, there is still few research carried out about the way of how they should be integrated to understand the structures of project networks and their impacts in the knowledge and information transmission between organizations and regions in the field of different industrial sectors.

The interest in the tension between "globalisation and "territorialisation" has been widely studied by researchers in the last decades, but it increases again rapidly in the last years due to the emergence of knowledge-based regional clusters as well as the need of understanding the process of the creation of European Research Area which involves complementarities between close and distant interaction of organizations and regions. Furthermore, the latter referring to the policy makers' need to foster effective networks and processes of knowledge and information creation and dissemination. In this sense, the identification of key organizations and regions that are strategically located in those networks under these both perspectives, central and distant, as well as the understanding of their role in this creation and transfer process, has become a major field of research for research community.

5.6.3.Identifying key actors. Efficiency

According the strategic choice theory proposed by (Rychen & Zimmermann 2009), for collaborative networks a gatekeeper configuration is the most suitable for efficiently transferring knowledge and building cohesion networks, since these gatekeepers act as a local-global interface between organizations in the periphery and the core, the latter having better access to knowledge flows (Giuliani & Bell 2005). In recent studies the gatekeeping role would be analyzed mainly under a centrality based approach, focusing on the impact of the actor as its communication activity (degree), its control significance (betweenness) as well as the extent to which an actor is close to all others (closeness) (Kang & Park 2013).

However, the gatekeeping role could not always be assumed by the central leading partner or local region in some sectors (Morrison & others 2004) and their relative position within the overall network must be analysed, understanding the existing lack of collaboration between some areas in the network. Those are defined as structural holes and few or no non-redundancy connections exist between them (Thomas W. Valente & Fujimoto 2010; D J Watts & Strogatz 1998).

The nodes on each side of the hole have access to different sources of information (Hargadon & Sutton 1997), separating set of nodes with a low grade of common information indicating high level of knowledge diversity, radical innovation or control and influence in ties (Kang & Park 2013). Analyzing the structural hole feature of nodes results in a suitable approach for gauging the degree of redundancy of their relations in collaboration networks and measuring their efficiency and effectiveness. Moreover, nodes in structural holes minimize the number of ties needed to access a unique source of information and play a dominant role as brokers between disconnected nodes (Baum et al. 2003), enabling them to be integrated within the core area.

Quantitative research on the existence of unconnected areas and the importance of location as well as the specific role of each partner or local region in the overall structure of R&D project networks seems to be still in its infancy in RE technologies (Matt et al. 2012).

CHAPTER 6

6. Strategic knowledge creation from consortium networks of R&D Projects in Renewable Energy sector

6.1. Introduction

In this chapter, the process applied to this second part of the thesis is described. This part is the most important contribution of this thesis where the outcomes from the theoretical framework are employed and a research methodology is designed and developed, allowing to obtain the main results which achieve our thesis' objectives.

6.2. Research objective and methodology

The **final objective** of the thesis is to present the potential of a booming technique, such as the Social Network Analysis, to obtain strategic knowledge for decision making when creating the research and development space of an emerging, multidisciplinary technological sector. For this, this thesis is based on the applicability of social network theory and the usefulness of the information provided by research and development projects.

The **contribution** of this thesis is divided mainly into two parts, understanding the p**otential of information about projects to create strategic knowledge through Social Network Analysis, and the creation of strategic knowledge in the field of renewable energy in Europe. This part of the thesis is focused in this second contribution.**

While the first part has a theoretical and general character for any emerging sector, this second part presents a theoretical and practical basis oriented to the sector of renewable energies in Europe. In turn, it would group the following sub-objectives:

- **To delimit the renewable energy sector in Europe.** This process would allow us to define in detail the emerging sector under study, through available information on research and development projects, analysing the possibilities and limitations of this information.
- **To create the structure that shows the network of information transfer and conformation between actors of the sector of renewable energies in Europe.** This process would provide us with the vision of the network system that make up the different actors involved in research and development projects from a relational point of view.
- **To identify key players who play a key role in Europe's renewable energy sector in terms of their efficiency in the transfer of information and knowledge.** This identification will provide information on the most influential actors in the sector in terms of their efficiency in transmitting information and knowledge, and can use it as strategic knowledge of the sector for decision-making in structuring the European research and development area. This information could be very useful for policy-makers in charge of designing the policies of the European research and development area.

This second part focuses on the point of view of:

• Organizations: All the organizations participating in the different European research and development projects, which contribute to the creation of the European research and development area, such as research and technological centres, universities, companies, public administrations, associations, etc. ...

• Local Regions: In this case, the focus of analysis would be all the European local regions that are part of the projects.

The research part is divided in three different phases as shown in the bellow figure (Figure 22):

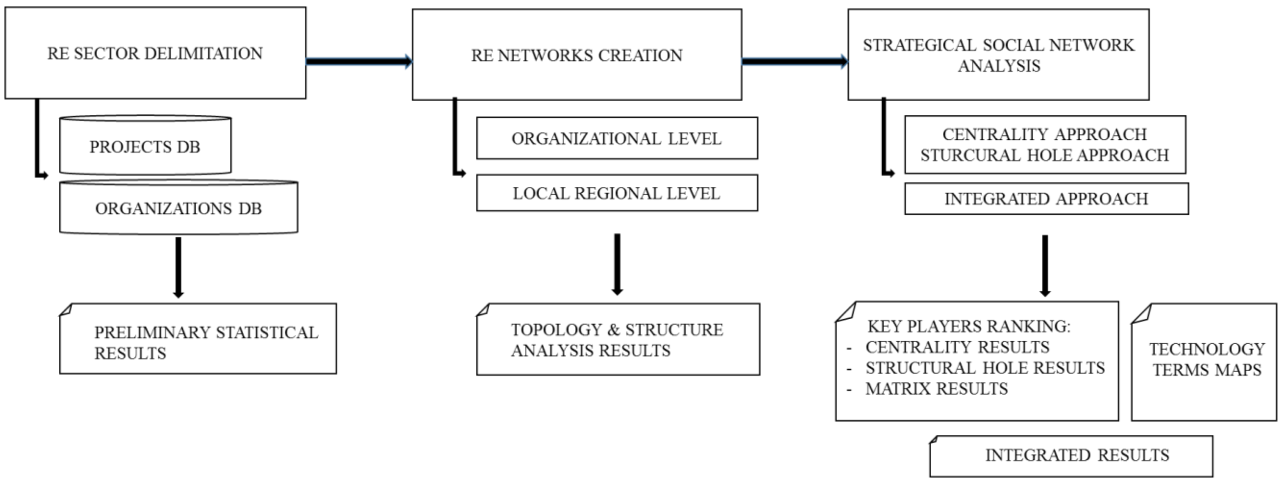


Figure 22. Research process methodology flow chart. Source: own elaboration.

The general methodology for this section will be the practical application of the critical concepts analysed in the theoretical section in a real context: renewable energy sector. The methodology used for each sub-objective is detailed below.

Delimitation of the renewable energy sector in Europe

This is a critical point for the realization of this research work, since it will be the basis for defining and obtaining the necessary project information to address the practical part.

The methodology proposed by the literature in this area will be followed, considering that the limited availability and quality of the information, and will consist of three phases: traditional analysis of the sector, including the description of each sub-sector and characteristics, and current status under the strategic perspective of the European Union; Selection of the database; and definition of the strategy to extract the information. The latter will consist, in turn, of the following phases according to the Text Data Mining literature: selection of the identification fields, elaboration of the strategy of consultations, cleaning and verification of the data, process of fusion of data; and the process of geolocation of the actors.

Descriptive statistics will be used to analyse the network of projects, organizations and local regions.

The development of the methodology is described in more detail in section 6.3. And the results will be explained in section 7.2.

Creation of the structure which shows the network of information transfer and conformation between actors of the renewable energy sector in Europe

The methodology for this section will be based on the theoretical part discussed in section 5.6.1., And applied to the renewable energy sector, using the R & D projects identified in the previous section for the period 2000-2013, from the Point of view of local organizations and regions.

The topological analysis of the structure of each of the networks of each sector will be carried out, as well as a process of visualization of those networks for their better understanding.

The development of the methodology is described in more detail in section 6.4. The description of the indicators, contrasted by the vast majority of the research work consulted by the author, will be shown in section 6.5.1. And the results will be explained in section 7.3.

Identification of key players who play a key role in Europe's renewable energy sector in terms of their efficiency in the transfer of information and knowledge

The methodology for this section will be based, on the one hand, on the practical application of the approaches of analysis of social networks analysed in section 5.6.3., Using the indicators proposed by the recent literature that are described in sections 6.5.2, 6.5.3, 6.5.4 and 6.5.5; On the other hand, in clustering analysis based on the two proposed approaches, adding information extracted from maps of key terms in each of the sectors.

For this process, the development of the methodology is described in more detail in section 6.5, 6.5.2. The description of the indicators, contrasted by the vast majority of the research work consulted by the author, will be shown in section 6.5.1. And the results will be explained in section 7.4.

6.3. Phase 1: Renewable Energy sector delimitation

This section addresses the crucial step of delimitating the sector under study. It starts with the exam of the sector's features and limitations and how the selection of the baseline data could be done. Then, renewable energy sector data capturing strategy is described in depth, including the choosing of fields for filtering, queries strategy, cleaning and verification process, fusion, matching and geolocalization.

6.3.1.RE sector

Being Renewable Energy sector the target of this research, some definitions of Renewable Energy and their technologies are given according to the two main International Organizations in the field of energy.

On the one hand, according to International Energy Agency (IAE) (http://www.iea.org/), **Renewable energy** is "energy that is derived from natural processes (e.g. sunlight and wind) that are replenished at a higher rate than they are consumed. Solar, wind, geothermal, hydropower, bioenergy and ocean power are sources of renewable energy. The role of renewables continues to increase in the electricity, heating and cooling and transport sectors."

On the other hand, International Renewable Energy Agency (IRENA) (http://www.irena.org) provides the following definition: "**renewable energy** means all forms of energy produced from renewable sources in a sustainable manner, which include: bioenergy, geothermal energy, hydropower, ocean energy (including tidal, wave and ocean thermal energy), solar energy, wind energy."

The main renewable energy types, according to their technology and potential, are detailed below:

- **Wind energy:** "Wind energy is kinetic energy of wind exploited for electricity generation in wind turbines" (http://www.iea.org/topics/renewables/subtopics/wind/). The slow-moving turbine rotor is turned into faster-roating gears, converting mechanical energy in electricity (Jacobson & Delucchi 2011). There are two main sub technologies: Land-based (energy generated using wind turbines located in the mainland) and Offshore (using turbines located in the sea). Nowadays, this sector is increasing rapidly its competitiveness and reliability, reducing costs specially in land. Although it is a promising sector, some limitations appeared such as height problems, coast distance of offshore sites as well as insufficient wind velocities and land use (Resch et al. 2008).
- **Solar energy:** "Solar energy is the conversion of sunlight into usable energy forms" (http://www.iea.org/topics/renewables/subtopics/solar/). There are two main sub technologies: Solar photovoltaic (PV) (arrays of cells convert directly solar radiation into electricity) and Concentrated solar power (CSP) devices (a receiver is heated to high temperatures by concentrated energy from the sun's rays, and then, it is transformed into electricity; mirrors or reflective lenses to focus the sunlight are used) (Jacobson & Delucchi 2011). Although having an enormous theoretical potential, its large-scale availability depends directly on sites' geographical locations, weather conditions as well as, related to final energy, on the effectiveness of solar technology applied (Resch et al. 2008).
- **Sea energy**: Electricity energy is generated by "tidal rise and fall (barrages), tidal/ocean currents, waves, temperature gradients, and salinity gradients" (http://www.iea.org/topics/renewables/subtopics/ocean/). Nowadays, this mixture of technology sources are diffuse and pose a challenge for research ways to

commercialisation (Resch et al. 2008). Concerning to wave technology, of device is a buoy which fluctuate in height with the wave, producing electricity; another main device is a surface-following which use a hydraulic motor. Related to tidal turbines, they provide a predictable energy source, being a promising technology (Jacobson & Delucchi 2011).

- **Geothermic energy**: This energy "can provide low-carbon base-load power, heat (and cooling) from high-temperature hydrothermal resources, deep aquifer systems with low and medium temperatures, and hot rock resources" (http://www.iea.org/topics/renewables/subtopics/geothermal/). The technology in this sector could differ substantially depending on the resource needed to power or heat generation. There are four types of geothermal occurrences: hydrothermal sources, hot dry rock, magma and geopressurized sources (Resch et al. 2008). It offers the highest potential among all RE sectors, from both a theoretical and a technical perspective (Resch et al. 2008). However, deep drilling costs needs to be reduced since they represent a primary deficit (http://www.iea.org/topics/renewables/subtopics/geothermal/).
- **Biomass energy**: "Biomass is any organic, i.e. decomposable, matter derived from plants or animals available on a renewable basis". Bioenergy is considered as the single largest renewable energy source nowadays and it provides around 10% of world primary energy supply (http://www.iea.org/topics/renewables/subtopics/bioenergy/). It could include: wood and agricultural crops, herbaceous and woody energy crops, municipal organic wastes as well as manure (Resch et al. 2008). The concept of Bioenergy defines the energy produced from the conversion of biomass, used directly as fuel, or processed into liquids and gases. Although the technical potential of energy crops and plantations is based on the dynamic character of land use-pattern and the limitation to have a larger scale , biomass technology has a promising future (Resch et al. 2008).

Related to industrial and business RE sector, the need to incorporate a greater percentage of different technologies (including not so well-developed ones such as wave, tidal and small wind energies) within the new structures of energy generation and distribution in regions, and specially in cities, makes local participation increasingly important in terms of industrial development.

Investments in this sector will generate a multiplying effect in the economy, and the creation of new organizational structures such as local clusters will become necessary(Marques & Fuinhas 2012; Larruscain, Río-Belver, et al. 2014).

The extensive and speedy evolution of RE enterprises shows that local clusters as well as industry based on knowledge will grow exponentially in the next few years. Clusterization in this emergent RE sector is an industrial hallmark (Larruscain, Río-Belver, et al. 2014). For example, the following table (xxx) shows some European Renewable Energy Local clusters:

Table 5. Some examples of European Renewable Energy Local Clusters (2011). Source (Larruscain, Río-Belver, et al. 2014)

Cluster	Creation year	Phase	Members (companies)	Comments (Employment)
Hamburg (Germany)	2010	Embryonic	163	Local: 14.563; expected growth (2008-2015): 40%
Freiburg (Germany)	2009	Established	107	Region: 12.000
Copenhagen (Denmark)	2010	Embryonic	36	Local expected growth (2010-2013): +1000
San Sebastian (Spain)	2009	Embryonic	85	Local: 1.800

Source: http://en.erneuerbare-energien-hamburg.de/, http://www.greencity-cluster.de/, http://www.cphcleantech.com/, and http://www.fomentosansebastian.org/

In the era of globalization, the tendency to create local clusters is gathering strength as the key factor for the economic development of regions and smart cities. This is particularly true in the renewable energy (RE) sector, not only in order to comply with sustainability requirements imposed by government organizations, but also to generate economic growth (Larruscain, Río-Belver, et al. 2014).

However, sometimes public policies seem diverging for RE subsectors (Kitzing et al. 2012; Darmani et al. 2014) including wind, solar, sea, geothermal and biomass. This is understandable because there is a lack of official and standardized data for the multidisciplinary diversified industrial activities in non-mature RE technologies.

In the next figure (Figure 23), the evolution of European Union's Renewable Energy targets is shown, detailing the name of directive, scope and time frame, targets and units, as well as legal status for mentioned members.

Name of Directive	Scope and time frame	Target(s) and Units	Legal status	No. of Member States
DIRECTIVE 2001/77/EC on the promotion of electricity produced from RES in the internal electricity market	Share of electricity in 2010	• Indicative target of 12% of gross domestic energy consumption by 2010 and 22.1% of electricity from RES in total European Community electricity consumption • The 22.1% target was changed to a target of 21% with the accession of the 10 new Member States	Voluntary	• Originally EU-15 • EU-25 after 2004 enlargement
DIRECTIVE 2009/28/EC on the promotion of the use of energy from RES	Share of energy from RES consumed in transport, electricity and heating/cooling in 2020	• 20% of gross final energy consumption at EU level • 10% for transport • National shares defined in NREAP	Binding at EU level and at national level	• EU- 27 • EU-28 after accession of Croatia in 2013
2030 Climate and Energy Policy Framework as adopted by EU leaders at the European Council held on 23-24 October 2014 (EUCO 169/14)	Share of energy from renewable sources in 2030; no target for transport; heat not mentioned	• At least 27% of gross final energy consumption at EU level • Not deemed appropriate to establish new targets for renewable transport fuels	Binding at EU level but not at national level	• EU-28

Figure 23. Evolution of European Union's Renewable Energy targets. Source: *(IRENA 2015)*

With the aim of promoting and standardizing this sector, within the European Research Area (ERA) strategy, important financial programmes were addressed to RE R&D projects from its creation in 2000 to 2013: 2000/2002 Fifth Framework Programme of Energy, Environment and Sustainable Development Thematic programmes (FP5), 2002/2006 Sixth Framework

Programme, 2003/2006 Intelligent Energy -Europe I (IEE I), Seventh Framework programme, 2007/2013 Intelligent Energy (IIE II) and 2009/2010 European Energy Programme for Recovery (EEPR), before the implementation of current Horizon H2020 programme for 2014-2020 (Helm 2014; Giacomarra & Bono 2015; European Commission 2015).

6.3.2.Data base selection

The lack of official and standardized data for the multidisciplinary diversified industrial activities in non-mature RE technologies showing slower innovation cycles than those from other sectors, long lead time ventures (Stephen M. McCauley & Stephens 2012) and relatively weak position newcomers with a high percentage of public support (Hvelplund 2006), prevents a consensus within the public administration on how to define RE sectors.

Moreover, the difficulty for company managers to provide sensitive information such as their relationships with other companies or organizations is observed for RE sectors.

Additionally, knowing that the European Union finances most collaborative R&D technological projects in Europe, particularly in RE (detailed in point 6.3.1) and being an emergent sector still under research and development, and based on the criteria of amount of information and its availability (Garechana et al. 2012), the Community Research and Development Information Service database (CORDIS) was chosen.

At the date of 17.02.2014, this database stored reliable global information for 97,992 projects (73,993 from European consortiums), involving 163,664 partners from 28 European countries, starting in 1990.

6.3.2.1. CORDIS database structure

Community Research and Development Information Service database (CORDIS) is “the European Commission's primary public repository and portal to disseminate information on all

EU-funded research projects and their results in the broadest sense" (http://cordis.europa.eu/guidance/home_en.html). The website repository stores all the information related to public R&D carried out under the funding of EU, and includes: project factsheets, publishable reports and deliverables, as well as editorial content to support communication and exploitation. It is managed by Publications Office of the European Union, on behalf of the European Commission's research Directorates-General and Agencies. CORDIS provides information from its origin through the online website opened in 1994.

Publication office is improving the structure, access and availability of this repository. However, data from CORDIS is still not 100% accurate and available, since some fields remain still empty or hold inaccurate data.

The website picture is shown in the next figure (Figure 24):

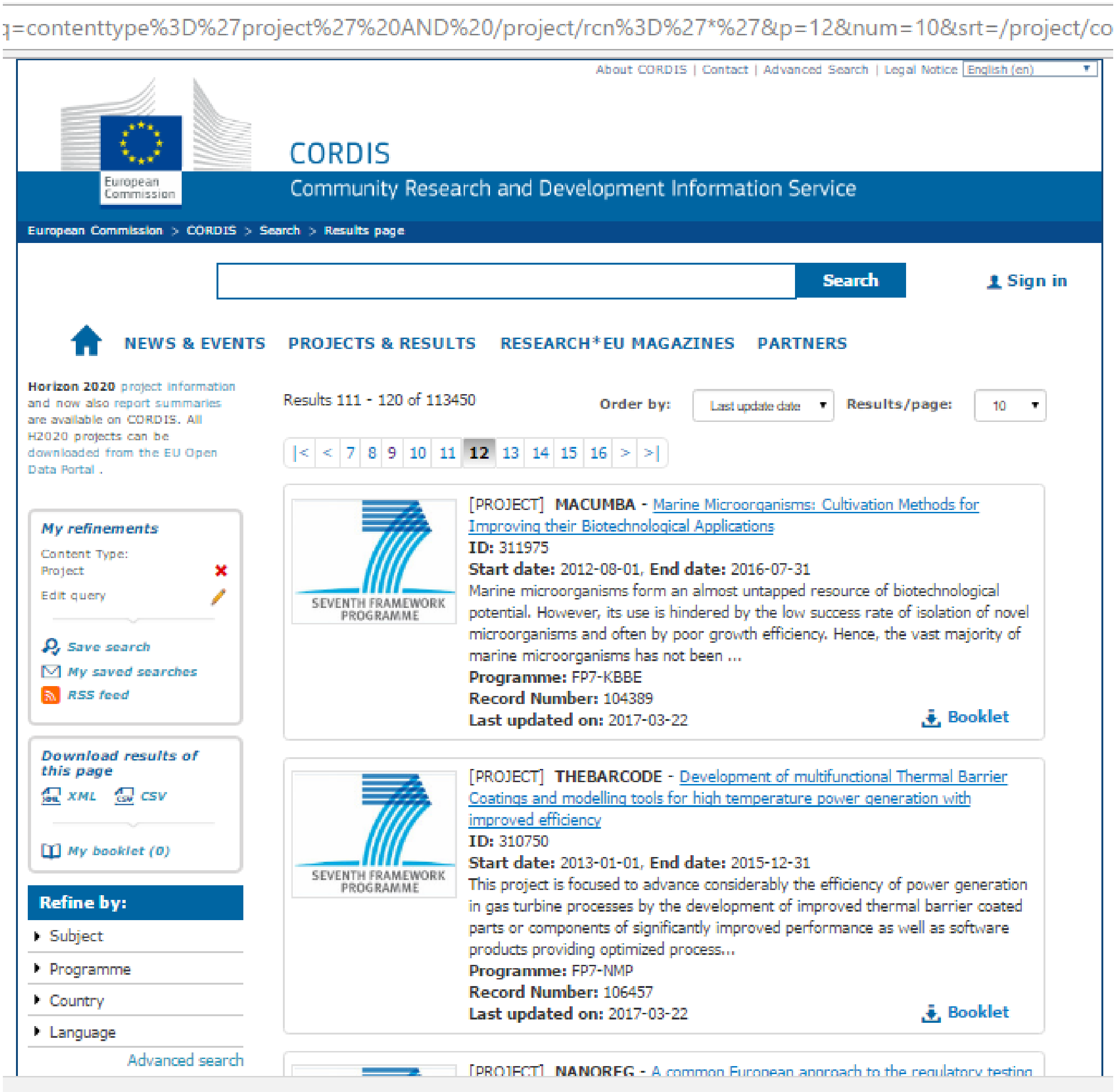


Figure 24. CORDIS website interface. Source: http://www.cordis.europa.eu.

Once having selected one project, the general information provided by EC through CORDIS repository is shown in the next figure (Figure 25).

Project details

Total cost: Not available	**Topic(s):**
EU contribution: Not available	7 - WIND ENERGY
Coordinated in: Belgium	**Funding scheme:** DEM - Demonstration contracts

Objective

The aim of the project is demonstrate the first commercial windfarm application of the high efficiency T400 turbine in a 2MW windfarm in such a manner that the maximum amount of power is generated at the least height. The siting of the turbines aims are to minimise visual intrusion for the more rugged areas that surround the site. In this manner it is expected to increase the public acceptability of wind turbines as usefully contributing to the environment at least impact.

It will use 5 x 400 kW free-yaw turbines to produce electricity. The production output is 48% higher than the T300-28 due to the innovative design and active stall principle. The power curve is flat from 13.5 m/s to 25 m/s. The active stall regulated wind turbine does not need to be braked when not running which decreases the loads on blade and drive train mechanism. The blades can rotate freely when not running; there is adapted appropriate rotor hardware and software to achieve this. When running the windturbine will free-yaw which decreases the load on the complete structure• all other turbines use yaw brakes. The nacelle will not be braked on its tower but smoothly follow the wind; this steady soft free-yaw nacelle system is achieved by using special software. The reduced stress on the tower support enables a more innovative tower of less size and weight to be used.

Context in which the technology is operating : The 2MW windfarm will be located in Burren, Castelbar, Co.Mayo Ireland. The turbines will be located to produce the maximum output consistent with fitting harmoniously into the landscape. The energy efficiency of the electrical system will be optimised by keeping losses to a minimum.

The economic aspects of the technology: the cost of the T400-34 produced in series is expected to be only 5% higher than the T300-28 for a 48% increase in output. The average price of per rotor surface of all, pitch regulated, wind turbines between 300-600 kW is 670 DM/m² • the series price for a T400-34 is 620 DM/m² ie 7% better.

Coordinator

TRECO/TURBOWINDS
PRINS BISSCHOPSSINGEL 50
3500 Hasselt
Belgium
See on map

Subjects

Renewable Sources of Energy

Last updated on 2002-10-21

Retrieved on 2017-03-24

Permalink : http://cordis.europa.eu/project/rcn/50748_en.html

Figure 25. Project information provided by CORDIS website interface. Source: http://www.cordis.europa.eu.

There is a possibility to do a searching using the predetermined refines, such as: content type, subject, programme or country. The following tables show these searches.

Filtering by "content type", the following table (Table 6) shows all the items stored nowadays:

Table 6. Search using "content type" field for projects recorded in CORDIS. Source: http://cordis.europa.eu/home_es.html

Content Type	**Items**
Project	**113450**

News	127059
Event	60806
Result in Brief	106007
Report Summary	44580
Result Pack	2648
Top Story	1994
Programme	20184
Publication	117831
Web item	35069
	629628

Filtering by "projects", the following table (Table 7) shows all the "subjects" in all projects:

Table 7. Search using "subject" field for projects recorded in CORDIS. Source: http://cordis.europa.eu/home_es.html

Subject	**Projects**
Aerospace Technology	7782
Agricultural biotechnology	209
Agriculture	8532
Automation	35
Biofuels	56
Biotechnology	10971
Business aspects	279
Clean coal technologies	7
Climate change and Carbon cycle research	137
Construction Technology	3369
Coordination and Cooperation	27315
Earth Sciences	4150
Economic Aspects	18319
Education and Training	30699
Electronics and Microelectronics	15197
Employment issues	1446
Energy Saving	8475
Energy Storage and Energy Transport	5671
Environmental Protection	21263
Evaluation	10690
Food	5873
Forecasting	4518
Fossil Fuels	7431
Funding Programmes	15
Healthcare delivery/services	290
Hydrogen and fuel cells	31
Industrial Manufacture	16074
Industrial biotech	28
Information Processing and Information Systems	20910

Information and Media	13129
Information and communication technology applications	1168
Innovation and Technology Transfer	16531
Intellectual property rights	7
Legislation and Regulations	13004
Life Sciences	16770
Materials Technology	15042
Mathematics and Statistics	4027
Measurement Methods	7755
Medical biotechnology	453
Medicine and Health	16263
Meteorology	8338
Nanotechnology and Nanosciences	624
Network technologies	1044
Nuclear Fission	5833
Nuclear Fusion	5217
Other	7
Other Energy Topics	8181
Other Technology	4262
Physical sciences and engineering	1914
Policies	21068
Project management methodologies	12
Radiation Protection	5349
Radioactive Waste	4934
Reference Materials	4853
Regional Development	11650
Renewable Sources of Energy	**11965**
Research ethics	77
Resources of the Sea and Fisheries	7216
Robotics	115
Safety	10600
Scientific Research	52018
Security	326
Social sciences and humanities	29567
Space and satellite research	353
Standards	7623
Sustainable development	212
Telecommunications	9320
Transport	8692
Veterinary and animal sciences	50
Waste Management	6927
Water resources and management	98
Total	562366

A detailed description of these "subjects" is available in the section of annexes (Annex C).

Filtering all "projects" using "programme" field as a filter (Table 8):

Table 8. Search using "programme" field for projects recorded in CORDIS. Source: http://cordis.europa.eu/home_es.html

Programme	Projects
FP7	25779
FP6	10096
FP5	17199
FP4	14524
FP3	5527
FP2	3884
FP1	3282
Others	33159
Total	113450

A detailed codification and description of these framework programmes is available in the section of annexes (Annex B).

Filtering all "projects" using "country" field as a filter (Table 9):

Table 9. Search using country field for projects recorded in CORDIS. Source: http://cordis.europa.eu/home_es.html

Country	Projects
United Kingdom	50296
Germany	46085
France	41535
Italy	33062
Spain	27888
Netherlands	24239
Belgium	18339
Greece	13179
Sweden	12752
Denmark	10793
Switzerland	9245
Austria	9028
Portugal	8895
Finland	7796
Ireland	7435
Norway	6119
Poland	5670
Hungary	4080
Czech Republic	3946
Israel	3894

Russia	3767
Romania	2427
Slovenia	2319
Turkey	1859
Bulgaria	1776
Slovakia	1572
Estonia	1443
Ukraine	1246
Luxembourg	1139
United States	1111
Lithuania	1106
Cyprus	1056
Latvia	888
Iceland	812
Croatia	730
China	710
Brazil	516

Note: Extract of the search for countries participating in more than 500 projects.

However, CORDIS interface provides an advanced search option, more suitable when complex search process is needed. The following figure (Figure 26) shows this interface:

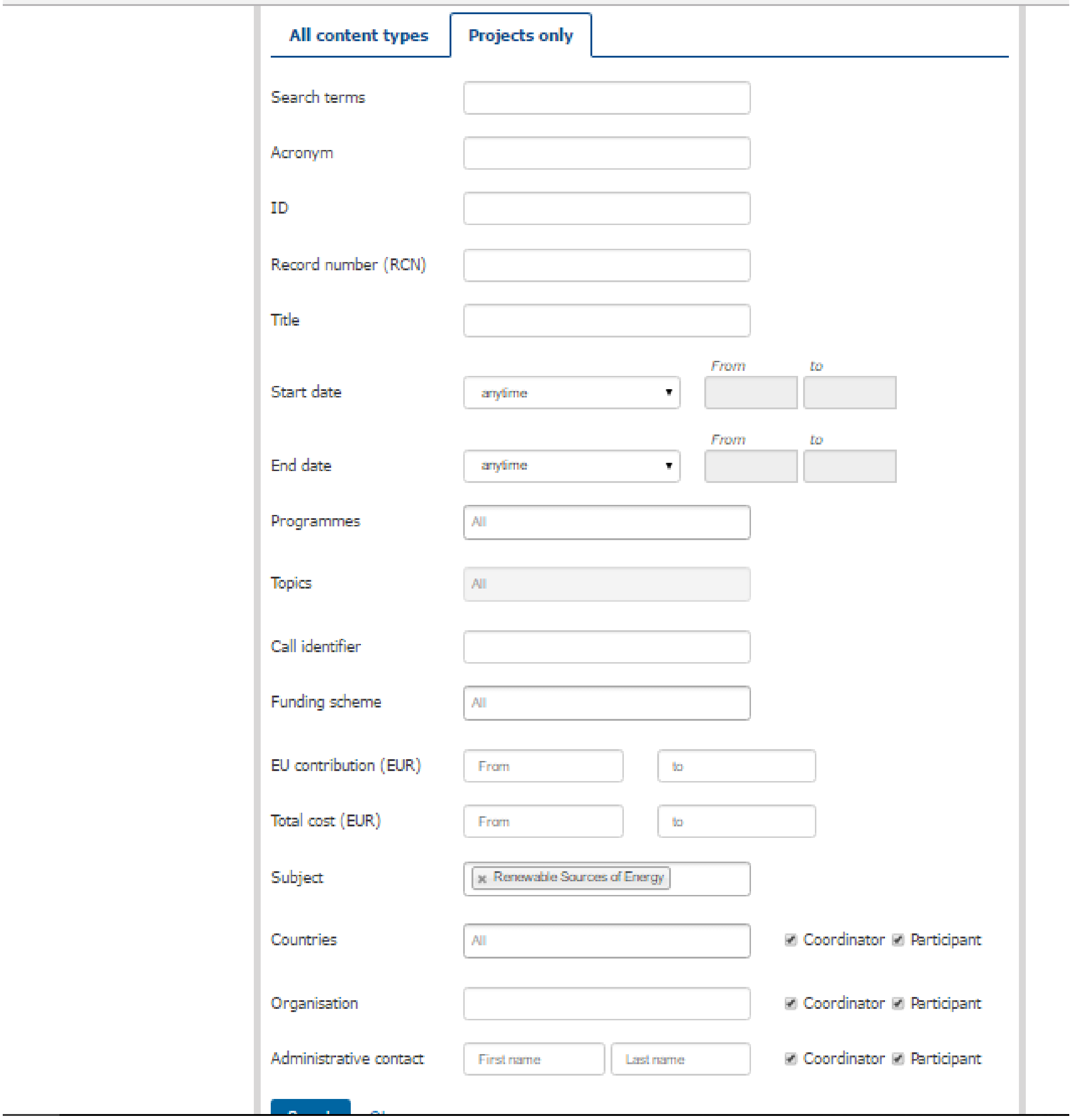


Figure 26. Advanced search interface for projects in CORDIS website. Source: http://www.cordis.europa.eu.

Then, using this "advanced search" interface, the information provided by CORDIS is in a different format which is more useful to handle in a research task.

Related to projects' information, on the one hand, this is the information that CORDIS database provides for one project using "advanced search" (Table 10):

Table 10. Example of information of each project using advanced search in CORDIS. Source: http://cordis.europa.eu/home_es.html

PJ_UID	4261446
RCN	50748
Project Title	A 2 MW WINDFARM WITH ATTENTION TO VISUAL INTRUSION
Start Date	01-jul-98
End Date	30-jun-01
Duration	-
Status	2
Contract Number	WE./00136/98
Keywords	ENERGY (PHYSICS); WIND ENERGY; WINDFARMS; TURBOMACHINERY; ELECTRIC POWER GENERATION; ENVIRONMENT PROTECTION
Date of Signature	-
Total Cost	-
Total Funding	-
Project Website	-
Project Call	-
Project Acronym	-
General Information	It will use 5 x 400 kW free-yaw turbines to produce electricity. The production output is 48% higher than the T300-28 due to the innovative design and active stall principle. The power curve is flat from 13.5 m/s to 25 m/s.
Achievements	
Objectives	The aim of the project is to demonstrate the first commercial windfarm application of the high efficiency T400 turbine in a 2MW windfarm in such a manner that the maximum amount of power is generated at the least height.
Activity Area	WIND ENERGY
Contract Type	32
Subject	Renewable Sources of Energy
Framework Programme	4
PGA	90

On the other hand, this is the information for one organization (Table 11):

Table 11. Information for an organization using advanced search in CORDIS. Source: http://cordis.europa.eu/home_es.html

CC_UID	9605977
PJ_UID	8369942
Role	C
OG_EID	
Organisation name	EUROPEAN SOUTHERN OBSERVATORY
Organisation Department	VLTI GROUP
Organisation Subdepartment	
Organisation Acronym	ESO
Organisation Size	S
Organisation Type	OTH
Address	Karl-Schwarzschild-Strasse
PO Box	
Post Code	
City	GARCHING
Country	DE
Website	http:///http://www.eso.org
Contact Surname	GLINDEMANN
Contact Name	Andreas
Contact Position	
Contact Initials	

Note: The EC administrative reference number for the project (RCN) is also known as the proposal number or grant agreement number (PGA) or project ID (PJ_UID).

6.3.3.RE data capturing strategy

Using CORDIS website is possible only possible to download data related to maximum of 100 projects at the same time in .csv and .xml format.

Then, a special request to European Commission was done by the author of this research with the aim of obtaining the whole database (from 1980 to 2013) in digital format with all the projects' information related only projects for renewable energy sector, but only for example "renewable sources of energy".

However, since the department responsible of maintaining CORDIS database did not have a unified and official delimitation method to identify renewable energy sector, a sub-database which contained all the records related to all projects and all partners for all R&D framework programmes (Annex B) was received.

The only restriction made by EC for the use of this information was that the purpose of the exploitation of the records had to be only academic use.

The initial data was formed by "projects" and "contractors" tables.

Table "Projects" contained 29,728 number of projects related to all possible SIC subjects (Annex C) and table "contractors" contained 163.664 records for the period 1981-2013. It was important to consider that renewable energy sector holds projects from different SIC subjects (not only "energy").

The following table (Table 12) shows the structure of the fields for "Projects" and the ratio of empty fields:

Table 12. Figures of percentage for Projects' fields with data in CORDIS. Source: own elaboration.

Field name	Ratio of empty fields (%)
PJ_UID	0
PGA	0
RCN	0
Project Title	0
Framework Programme	0
Status	0.08
Contract number	0.08
End date	5.08
Start Date	5.16
Contract type	14.31
Objectives	21.2
Activity Area	25.24
Total Funding	30.99
Total Cost	34.67
Duration	42.56
Project acronym	45.68
Subject	48.14
General information	59.24
Project call	70.59
Keywords	76.55
Date of sign	81.36
Achievements	82.16
Project website	92.02

The following table shows the fields structure for Organizations and the percentage without data (Table 13):

Table 13. Figures of percentage for organizations' fields with data. Source: own elaboration.

Field name	Ratio of empty fields (%)
CC_UID	0.00
PJ_UID	0.00
Role	0.00
OG_EID	0.00
Organisation name	0.00
Contact Surname	0.54
Country	0.59
City	2.49
Address	6.77
Contact Name	22.18

Organisation Acronym	28.31
Contact Title	43.32
Post Code	44.27
Organisation Department	53.71
Organisation Type	65.16
Website	66.81
Organisation Size	73.10
PO Box	88.84
Organisation Subdepartment	93.20
Contact Initials	96.62
Contact Position	99.99

Then, a strategy to obtain accurate information related to the only RE sector was defined by the author. There were two main data to be obtained: projects from RE sectors and partners only involved in those projects.

6.3.3.1. Choosing fields for Filtering

In the process of delimiting the RE sector, only the information from "projects" table was suitable to use as a filter, since records from "partners" table did not have any field which relates to sectorial data.

Firstly, as an initial attempt, the Subject field was filtered, according to general Subject Index Classification Codes (SID) provided by CORDIS, including all records for "Energy" group, including "Renewable Sources of Energy", "Energy Storage, Energy Transport", "Energy Savings", "Biofuels", "Hydrogen and Fuel Cells" and "Other Energy Topics", and excluding "Nuclear Fission", "Nuclear Fission" and "Fossil Fuel". But, this process was not implemented as a filter, since the author realized that information about multidisciplinary projects was losing, since some projects could have "subjects" codes not directly related to energy or especially renewable energy. For example: "Industrial biotech", including "bioenergy"; or "Innovation Technology Transfer", including "Development of mechanisms to promote innovation and technology transfer" in RE sector. However, the restriction of excluding "Nuclear Fission", "Nuclear Fission" and "Fossil Fuel" was accepted.

Then, strategy of selecting suitable fields and adequate filter words was developed for this thesis. First, in addition to what has been proposed by Porter (Arora et al. 2013; Porter et al. 2008), Boolean search logic was chosen as a Text Data Mining (TDM) technique, given the partially structured information of the fields of the database.

Next step was how to choose the suitable fields. The percentage of available data criteria was selected, considering the following percentages:

- "Keywords" field: available 23.45%
- "Project Title" field: available 100%
- "Activity area" field: available 74.76%
- "Objective" field: available 78.8%

"Keywords", "Title", "Activity Area" and "Objective" fields were chosen to carry out the research of projects, using the criteria of their percentage of data availability and Boolean search logic to these fields to build new enquiry tables for each sector.

This final selection was accepted after the inestimable advice from the reviewers at Manchester International Summer School on Emerging Technologies (MiSET) 2014 where preliminary results of TDM and filtering were submitted and discussed.

6.3.3.2. Queries strategy

For that purpose, the keyword list proposed by Rizzi for the RE sector (Rizzi et al. 2014) was accepted as general filter approach and modified according to CORDIS structures and records' content. The queries were directly applied to "projects" table under Microsoft Access environment format. An extract of this strategy for wind, solar, sea, geothermal and biomass sectors is shown in Table 14.

Table 14. Boolean search logic to delimit RE sectors in the CORDIS*. List of keywords grouped by each RE sector, including rejected projects after manual check process. Source: own elaboration.*

Sector	Keywords	RCN of Rejected Projects
Wind	"*wind*", not "*window*"	15350,15186,16103,29382,39102,50874,70964,71712, 71721,71748,71754,71763,71782,71818
Solar	"*solar*","*PV*","*photovoltaic*", "*SCP”,"*SHC*","*thermal solar*"	71757,71782,71796,71813,71818,58439,52379,93996, 71194,91278,89658,87771,71236,28498,69330,98769, 100380,103527,104462,108163,107507,96887,107309, 95633,73531,79054,73280,78919,81696,83651,83721, 81108,82229,82383,101963,72919,85121,82929,84501, 85577,88708,90662,90915,89584,93152,103486,78718, 3625,79991,106604,51263,51269,52077,57214,67942, 54217,61600,61617,51190,69263,52067,54162,58521, 64870,67326,67576,70785,64525,58616,64064,24518, 100273,100766,101349,60821,57846,92596,92877, 15933,16397,30375,16083,94044,65938,14890,18717, 97529,106507,97510,99520,88543,92509,100998, 100336,88966,106168,97855,108749,102369,65423, 65448,65476,65945,28558,75502,66122,65545,65561, 65705,65849,66107,105828,91283,24564,78732,101999, 101804,104574,108386,63597,65585,65762,65926, 99802,99805,65841,104337,3219,87870,69386,80035, 292,14053,4037,6503,6504,11515,12878,13061,14118, 24998,25172,30249,53139,54271,60611,65212,67418, 67514,85827,85840,85857,85883,85906,85919,85932, 85937,86032,86093,86110,86111,86172,86818,108913, 108925,85969,2431,12626,15757,22541,51609,65434, 65605,65692,5261,12571,32614,37116,61568,61634, 66097,66102,66159,67402,71809,86185,93219,96712, 101303,102688,60451,83628,105754,48157,48156, 56840,85167,101857,74397,73690,79188,97973,94289, 67578,51776,58679,59941,61411,101659,24910,48280, 48283,106544,946,57982,59187,59566,106542,71714, 71721,71721,85969,2431,12626,15757,22541,51609, 65434,65605,65692,5261,12571,32614,37116,61568, 61634,66097,66102,66159,67402,71809,86185,93219, 96712,101303,102688,60451,83628
Sea	"*see power*", "*wave energ*", "*tidal energ*", "*tidal*","*sea energ*", "*sea current* energ*", "*ocean energ*", "*marine renew* energ*", "*marine current*"	194,3565,38028,44494,60451,61295,83628,83872, 17921,36124,43355,45313,53056,54897,56682,60766, 63162,63206,67910,67911,69327,69341,69996,71818, 72308,72773,74197,82611,84696,89616,91867,93048, 98660,101149,105969
Geothermal	"*geotherm*", “thermal water*"	
Biomass	"*biomass*","bioenergy", “alternative fuel*", "anaerobic digestion","energ*",”biodiesel*", "biofuel*", "biogas*", "biochar*", "bioethanol*", "palm oil*", "soybean oil*"	

6.3.3.3. Cleaning and verification process

Since data in “Project title” and “Objectives” are “free text” format and are not part of a closed list of terms, a manual cleaning and verification process had to be carried out.

This table (Table 14) includes manually rejected projects, especially in wind, solar and sea energies. The main reasons of rejection include the following terms:

- Related to wind sector: “solar wind”, “window”.
- Related to solar sector: “solar system”, “astronomy”, “star energy”, “planets”, “interplanetary”, “solar distillation”, “extra-solar planets”, “direct solar steam”, “Mars space”, “intra-solar planets”, “solar and galactic”, space weather prediction”, “solar eruptive phenomena”, “physics of the solar chromosphere”, “solar eruption”, “astrophysics”.
- Related to sea energy: “intertidal”, “intertidal sediments”, “tidal mechanism of the revolution of the intertidal mass of the earth”, “tidal inlets”; “biological and physical state of intertidal areas”.

For example, this is the SQL query to extract data from “Title” field for Solar sector.

Enquiry name: “Consulta projects EERR ALL 4 TITLE SOLAR“

```
SELECT Projects.PJ_UID, Projects.[Project Title], Projects.[Activity Area],
Projects.Keywords, Projects.RCN

FROM Projects

WHERE (((Projects.[Project Title]) Like "*solar*" Or (Projects.[Project Title]) Like "*PV*" Or
(Projects.[Project Title]) Like "*photovoltaic*" Or (Projects.[Project Title]) Like "*SCP*" Or
(Projects.[Project Title]) Like "*SHC*" Or (Projects.[Project Title]) Like "*thermal solar*")
AND ((Projects.RCN) Not In
(85969,2431,12626,15757,22541,51609,65434,65605,65692,5261,12571,32614,37116,61568,6
1634,66097,66102,66159,67402,71809,86185,93219,96712,101303,102688,60451,83628)));
```

6.3.3.4. Fusion process

Then, after applying this Boolean search logic to these fields (keywords, activity, title, objectives), unification of these tables with filtering results' data was carried out for each sector.

Definitive projects tables were elaborated through the enquiry which uses "Projects" table and each of tables created after filtering, cleaning and verification process, obtaining all the information about the projects with all the fields.

This process details are given below and visual representation is shown in Figure 27.

For **Wind** sector:

"Consulta projects EERR ALL ACTIVITY TITLE KEYWORDS OBJECTIVE WIND"

SELECT PJ_UID FROM [Consulta projects EERR ALL 4 ACTIVITY WIND] UNION SELECT PJ_UID FROM [Consulta projects EERR ALL 5 TITLE WIND] UNION SELECT PJ_UID FROM [Consulta projects EERR ALL 6 KEYWORD WIND] UNION SELECT PJ_UID FROM [Consulta projects EERR ALL 7 OBJECTIVES WIND];

For **Solar** sector:

"Consulta projects EERR ALL ACTIVITY TITLE KEYWORDS OBJECTIVE SOLAR"

SELECT PJ_UID FROM [Consulta projects EERR ALL 4 ACTIVITY SOLAR] UNION SELECT PJ_UID FROM [Consulta projects EERR ALL 5 TITLE SOLAR] UNION SELECT PJ_UID FROM [Consulta projects EERR ALL 6 KEYWORD SOLAR] UNION SELECT PJ_UID FROM [Consulta projects EERR ALL 7 OBJECTIVES SOLAR];

For **Sea** sector:

"Consulta projects EERR ALL ACTIVITY TITLE KEYWORDS OBJECTIVE SEA"

SELECT PJ_UID FROM [Consulta projects EERR ALL 4 ACTIVITY TIDAL WAVE SEA ENERGY] UNION SELECT PJ_UID FROM [Consulta projects EERR ALL 5 TITLE TIDAL WAVE SEA ENERGY] UNION SELECT PJ_UID FROM [Consulta projects EERR ALL 6

KEYWORD TIDAL WAVE SEE ENERGY] UNION SELECT PJ_UID FROM [Consulta projects EERR ALL 7 OBJECTIVES TIDAL WAVE SEE ENERGY];

For **Geotherm** sector:

“Consulta projects EERR ALL ACTIVITY TITLE KEYWORDS OBJECTIVE GEOTHERM”

SELECT PJ_UID FROM [Consulta projects EERR ALL 4 ACTIVITY GEOTHERMIC] UNION SELECT PJ_UID FROM [Consulta projects EERR ALL 5 TITLE GEOTHERMIC] UNION SELECT PJ_UID FROM [Consulta projects EERR ALL 6 KEYWORD GEOTHERMIC] UNION SELECT PJ_UID FROM [Consulta projects EERR ALL 7 OBJECTIVES GEOTHERMIC];

For **Biomass** sector:

“Consulta projects EERR ALL ACTIVITY TITLE KEYWORDS OBJECTIVE BIOMASS”

SELECT PJ_UID FROM [Consulta projects EERR ALL 4 ACTIVITY BIOMASS] UNION SELECT PJ_UID FROM [Consulta projects EERR ALL 5 TITLE BIOMASS] UNION SELECT PJ_UID FROM [Consulta projects EERR ALL 6 KEYWORD BIOMASS] UNION SELECT PJ_UID FROM [Consulta projects EERR ALL 7 OBJECTIVES BIOMASS];

All five sectors together: WIND+SOLAR+SEA+GEOTHERM+BIOMASS:

“Consulta projects EERR ALL ACTIVITY TITLE KEYWORDS OBJECTIVE”

SELECT PJ_UID FROM [Consulta projects EERR ALL 4 ACTIVITY] UNION SELECT PJ_UID FROM [Consulta projects EERR ALL 5 TITLE] UNION SELECT PJ_UID FROM [Consulta projects EERR ALL 6 KEYWORD] UNION SELECT PJ_UID FROM [Consulta projects EERR ALL 7 OBJECTIVES];

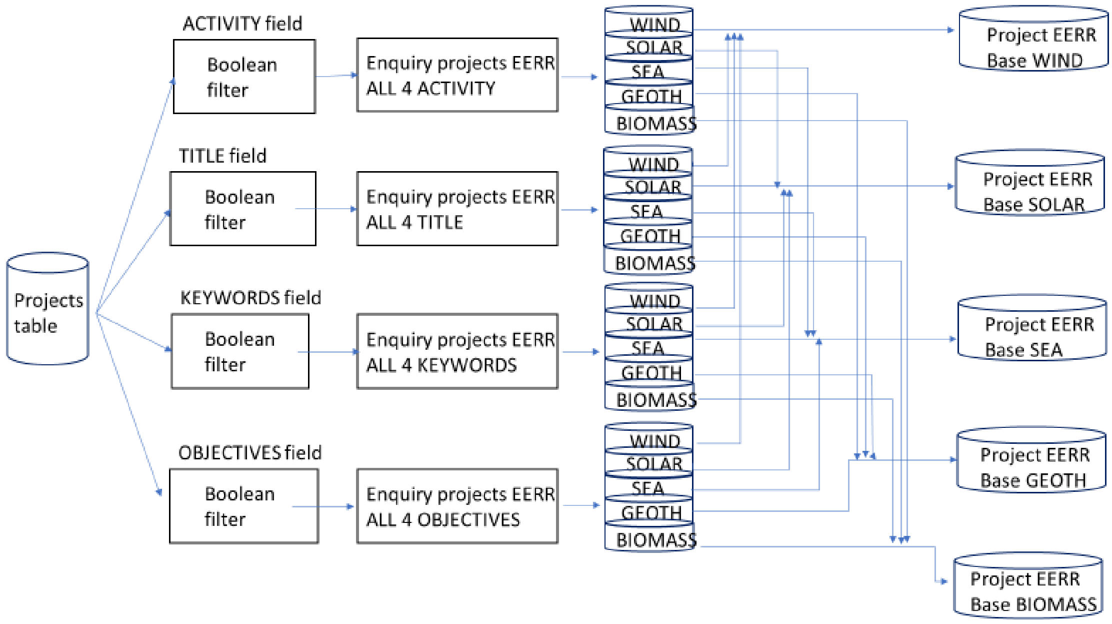


Figure 27. Creation process of the tables "Projects EERR Base" for each sector. Source: own elaboration.

Finally, "Projects EERR Base" table was elaborated using initial "Projects" table and "Consulta projects EERR ALL ACTIVITY TITLE KEYWORDS OBJECTIVE", doing the fusion using the project identification code of "PJ_UID" (Figure 28).

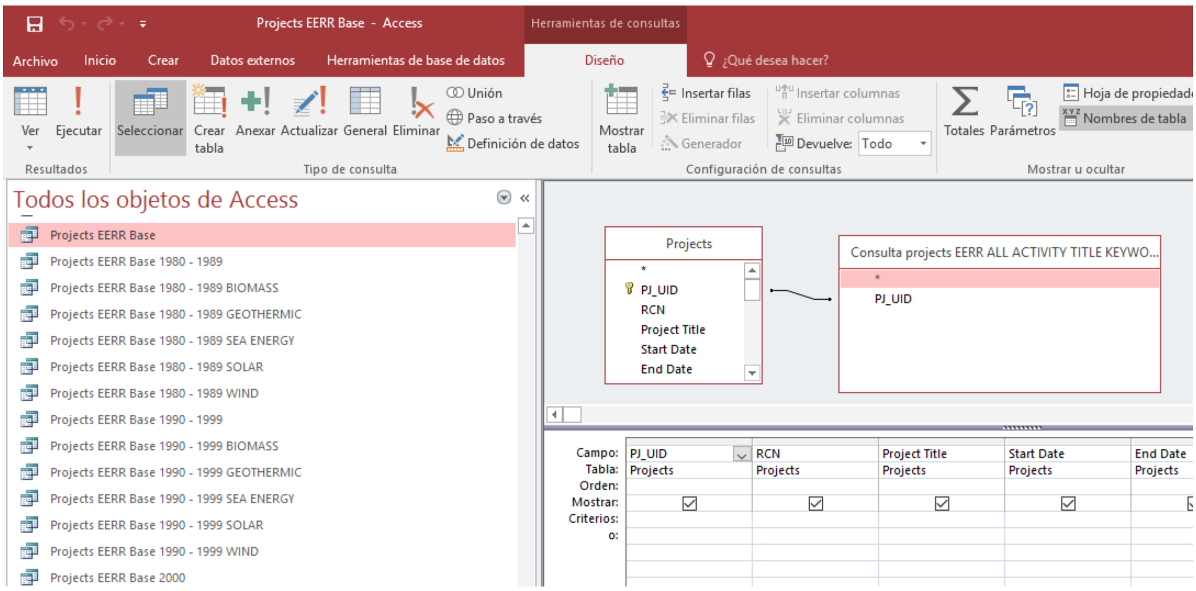


Figure 28. "Projects EERR Base" creation process. Source: own elaboration.

Since our research target needs an analysis of RE projects during 2000-2013 period, different tables were created applying the following time filters: 2000, 20001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013.

Also in an aggregated mode: 1980-1989, 1990-1999, 2000-2001, 2000-2002, 2000-2003, 2000-2004, 2000-2005, 2000-2006, 2000-2007, 2000-2008, 2000-2009, 2000-2010, 2000-2011, 2000-2011, 2000-2012, 2000-2013.

6.3.3.5. Matching organizations

Concerning the identification of organizations involved in RE projects, a match process was carried out between “Projects EERR Base” table and “partners” table, using the field “PJ_UID” as a link and creating a new table “Contractor DEF” with all the fields.

6.3.3.6. Cleaning and unification process

On the one hand, each partner had a unique CC_UID code for each project. This means that the same partner was identified by different CC_UID codes. Then, a unique identification was needed for each partner. The best option was using the official organization name registered in the field “Organization name”.

However, a cleaning and homogenization process during 4 months was necessary to correct the inaccurate, imprecise data of same organizations registered using different names.

For this purpose, OpenRefine open source software (http://openrefine.org/) was used. This program uses clustering processes to find groups of different values that might be alternative representations of the same thing. Our “Contractors DEF” table was uploaded to OpenRefine web interface and several clustering methods were applied to clean and homogenize

"Organization name" field and "City" field. In the next figure (Figure 29) OpenRefine web interface is shown.

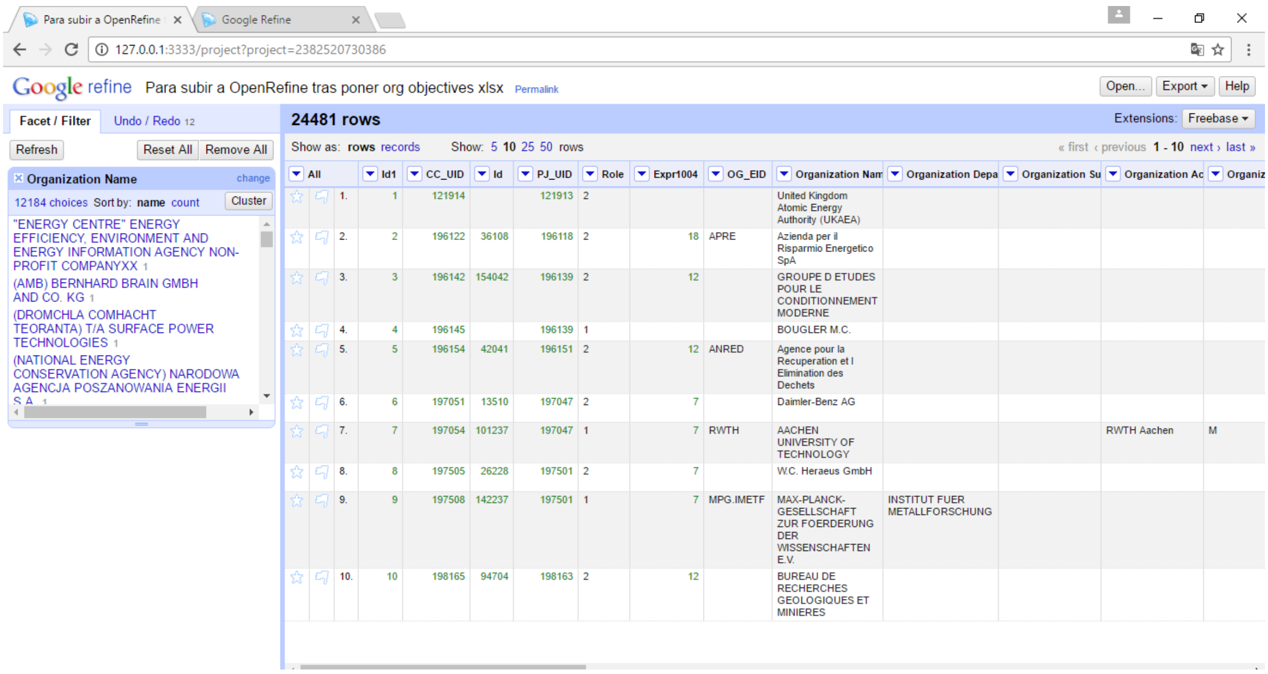


Figure 29. Open Refine software web interface. Source: http://openrefine.org/

"Organization name" field was taken and using "Facet" -> "Text Facet" option, a clusterization window was open. Key collision with Finger print and ngram-fingerprint options was applied, as well as nearest-neighbor with levenshtein. The detailed explanation of these clustering methods is done at http://openrefine.org/.

For example, with Fingerprint option, the following alternatives are given (Figure 30):

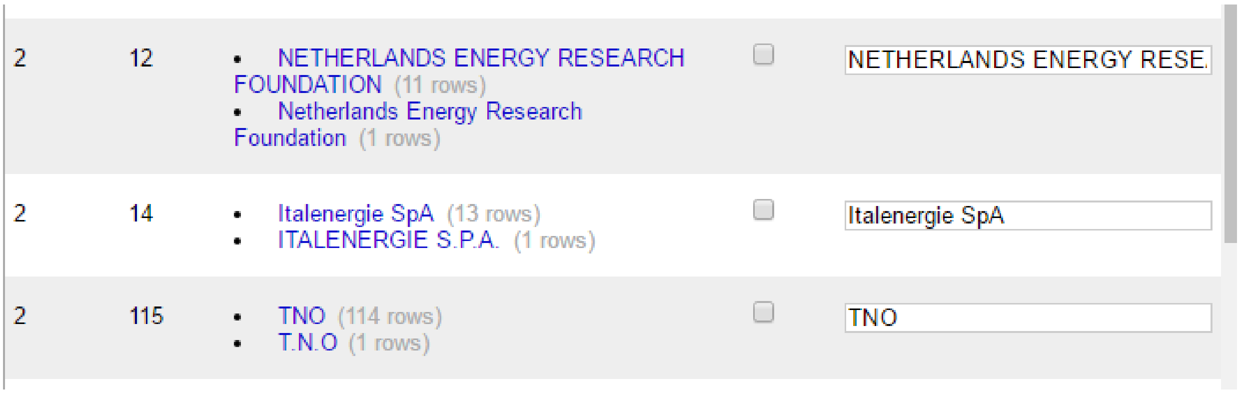


Figure 30. Fingerprint Clusterization option applied to "Organization name" field in Open Refine software web interface. Source: http://openrefine.org/

With "emerge" option, each cluster's items are homogenized according to our choice.

After OpenRefine process, %18.87 of the Organization names were unified and homogenized, obtaining 24,481 CC_UID and 10,390 Organization Names for RE sector.

In the next step, some new data was completed in the following fields:

- Type of organization (university, firm, government, research centre, association, NGO, or others) according to codes shown in Annex D.
- City, according to codification of EU http://ec.europa.eu/eurostat/web/nuts/correspondence-tables/postcodes-and-nuts.
- Country according to codification of EU http://ec.europa.eu/eurostat/web/main/home

6.3.3.7. Geolocalization

The process of geolocalization consisted in adding GPS coordinates and local region code's information to all partners' records.

For the local region codification, European nomenclature of territorial units for statistics (NUTS3) classification system was adopted (Eurostat 2015). For this purpose, Reference And Management Of Nomenclatures (RAMON) Eurostat's metadata server database was used (http://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=LST_CLS_DLD&StrNom=NUTS_2013L&StrLanguageCode=EN&StrLayoutCode=HIERARCHIC).

For GPS coordinates, GPSVisualizer software (http://www.gpsvisualizer.com/) was used, adding Latitude and Longitude data to each contractor according to their city and country.

After obtaining the definite “Contractors DEF” and “Projects EERR Base” tables, “Contractors EERR Base NUTS3” table was created using PJ_UID field as a link (Figure 31):

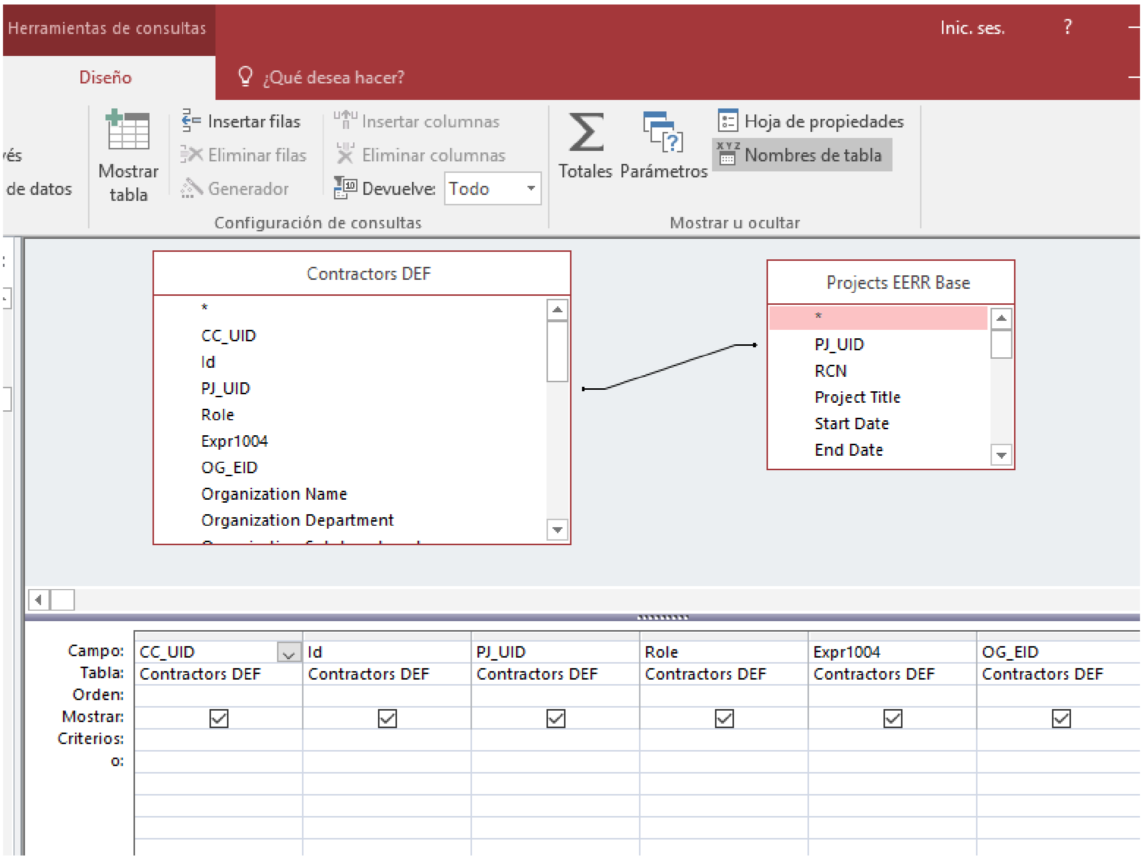


Figure 31. “Contractors EERR Base NUTS3”. Source: own elaboration.

4,324 number of RE projects and 5736 number of partners were identified for 2000-2013 period in Europe as a final scope for this research.

6.4. Phase 2: RE networks creation

In this point, the general considerations developed in point 5.6.1 are applied to specific field of collaborations networks in the RE sector and networks construction was carried out.

6.4.1.Relational data construction

First, a rearranging process of the data of each RE sector, which was collected and extracted previously, was carried out. For this purpose, enquiries were designed in SQL-Microsoft Access (the original format of database received from EC) using the affiliation relationship between partners and projects, taking the partners (Organization name) as nodes and the common projects (PJ_UID) as a relational feature.

This step was carried out for each RE sector and year under study (for 2000 to 2013, in separated and aggregated mode). In the following figure (Figure 32) an example of these enquiries is shown, for biomass sector in 2000-2013:

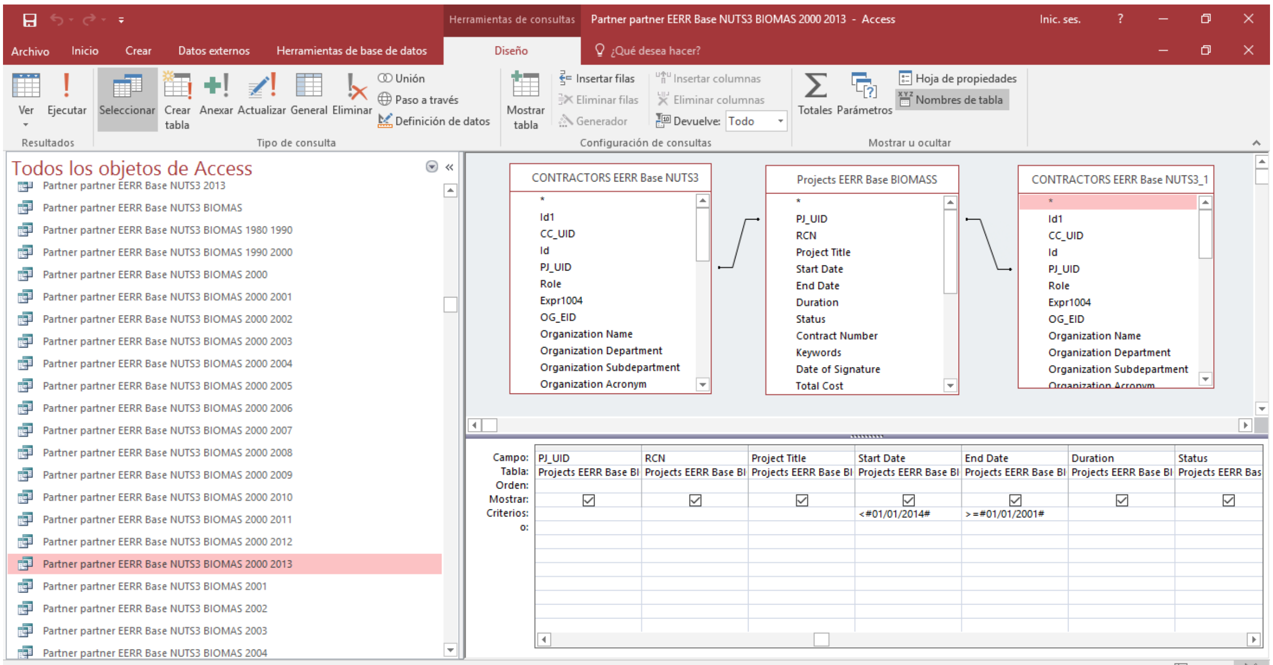


Figure 32. Enquiry for creating Partner-Partner records for biomass sector in 2000-2013. Source: own elaboration.

The following figure (Figure 33) shows the relational data construction process from projects and organizations.

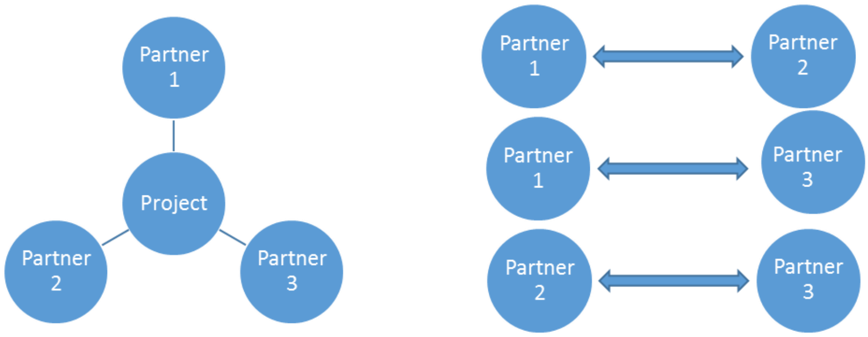


Figure 33. Relational data construction from projects and organizations information. Source: own elaboration.

6.4.2.Relational data transformation into 1-mode networks: Organizations

Then, a transformation process of this data into 1-mode network was carried out (Kang & Park 2013), obtaining collaborations networks (van Rijnsoever et al. 2015). In this step, "Txt2Pajek" program, which was developed by FASresearch company (http://www.fas-research.com) was used, creating network text files in Pajek format (.net).

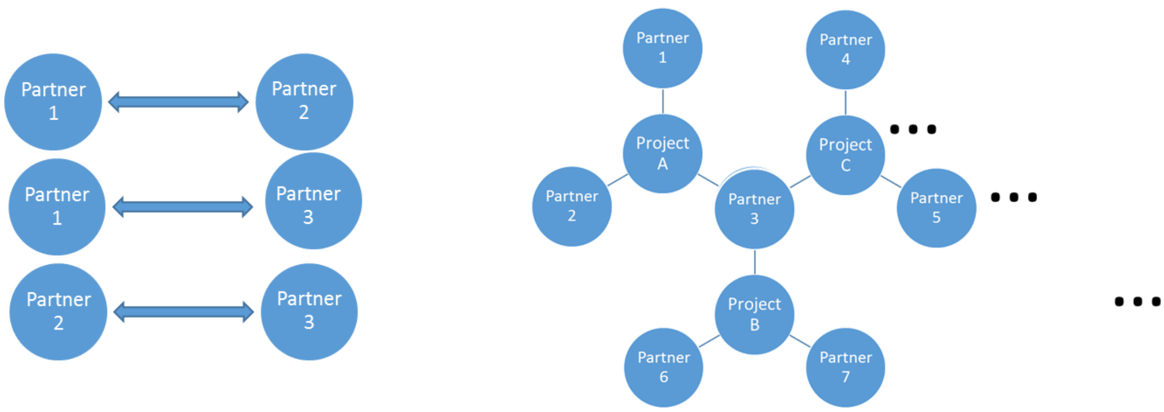


Figure 34. 1-mode network creation process. Source: own elaboration.

An extract of the basic structure of Partner-Partner (PP) in Pajek format for Sea energy for the year 2000 (file "PP SEA ENERGY 2000") is shown below, where vertices are the names of the organizations and edges their relations through projects:

```
*Vertices 46
 1 "INSTITUTE OF OCEANOLOGY - BULGARIAN ACADEMY OF SCIENCES"    0.0000    0.0000    0.5000
 2 "MVV CONSULTANTS AND ENGINEERS GMBH"    0.0000    0.0000    0.5000
 3 "GKSS - Forschungszentrum Geesthacht GmbH"    0.0000    0.0000    0.5000
 4 "UNIVERSITY OF KASSEL"                0.0000    0.0000    0.5000
 5 "IBK INGENIEUR BUERO - DR GUENTER KRETZSCHMAR"    0.0000    0.0000    0.5000
 6 "ENERGY AND ENVIRONMENT CONSULTANCY"    0.0000    0.0000    0.5000
(…)
37 "UNIVERSITY OF GDANSK"                0.0000    0.0000    0.5000
38 "INSTITUTO SUPERIOR TECNICO"           0.0000    0.0000    0.5000
39 "NATIONAL LABORATORY FOR ENGINEERING AND INDUSTRIAL TECHNOLOGY LISBOA"    0.0000    0.0000    0.5000
40 "EFACEC Sistemas de Electronica SA"      0.0000    0.0000    0.5000
41 "ELECTRICIDADE DOS ACORES S.A."         0.0000    0.0000    0.5000
42 "APPLIED TECHNOLOGIES COMPANY LTD."      0.0000    0.0000    0.5000
43 "KRYLOV SHIPBUILDING RESEARCH INSTITUTE"    0.0000    0.0000    0.5000
44 "ITT Flygt Products AB"               0.0000    0.0000    0.5000
45 "UNIVERSITY OF TECHNOLOGY OF CHALMERS"    0.0000    0.0000    0.5000
46 "HAMMARLUND ALTENATIV KONSULT"         0.0000    0.0000    0.5000
*Edges
 1   3 1
 1   8 1
 1   9 1
 1  26 1
 1  37 1
 1  38 1
 2  25 1
 2  42 1
 2  43 1
 (..)
39  45 1
 39  46 1
 40  41 1
 42  43 1
 45     46 1
```

6.4.3. Relational data transformation into 1-mode networks: Local regions

Since our objective is also to analyse the local regions, these networks were transformed into new networks. To transform partner-partner organizational level networks into region-region level collaboration networks, the sum of all the organizations participating in the R&D project and located within a region was calculated.

An extract of the basic structure of NUTS3 local regions-local regions (NN) in Pajek format for Sea energy for the year 2000 (File "NN SEA ND NLM 2000") is shown below, where vertices are the local regions and edges their relations through projects:

```
*Vertices 38
 1 "BG331"        0.0000   0.0000   0.5000
 2 "DE300"        0.0000   0.0000   0.5000
 3 "DEF06"        0.0000   0.0000   0.5000
 4 "DE731"        0.0000   0.0000   0.5000
 5 "DE254"        0.0000   0.0000   0.5000
 6 "DK001"        0.0000   0.0000   0.5000
 7 "DK032"        0.0000   0.0000   0.5000
 8 "ES300"        0.0000   0.0000   0.5000
(…)
36 "SE213"        0.0000   0.0000   0.5000
37 "SE232"        0.0000   0.0000   0.5000
38 "SE224"        0.0000   0.0000   0.5000
*Edges
 1   3 1
 1   8 1
 1   9 1
 1  23 1
 1  31 1
 1  32 1
 2  22 1
 2  35 2
 3   8 1
```

(...)

32 37 2

32 38 2

33 34 1

37 38 1

In the following figure (Figure 35), R&D collaboration network at local regions level for sea sector in 2000-2001 is shown.

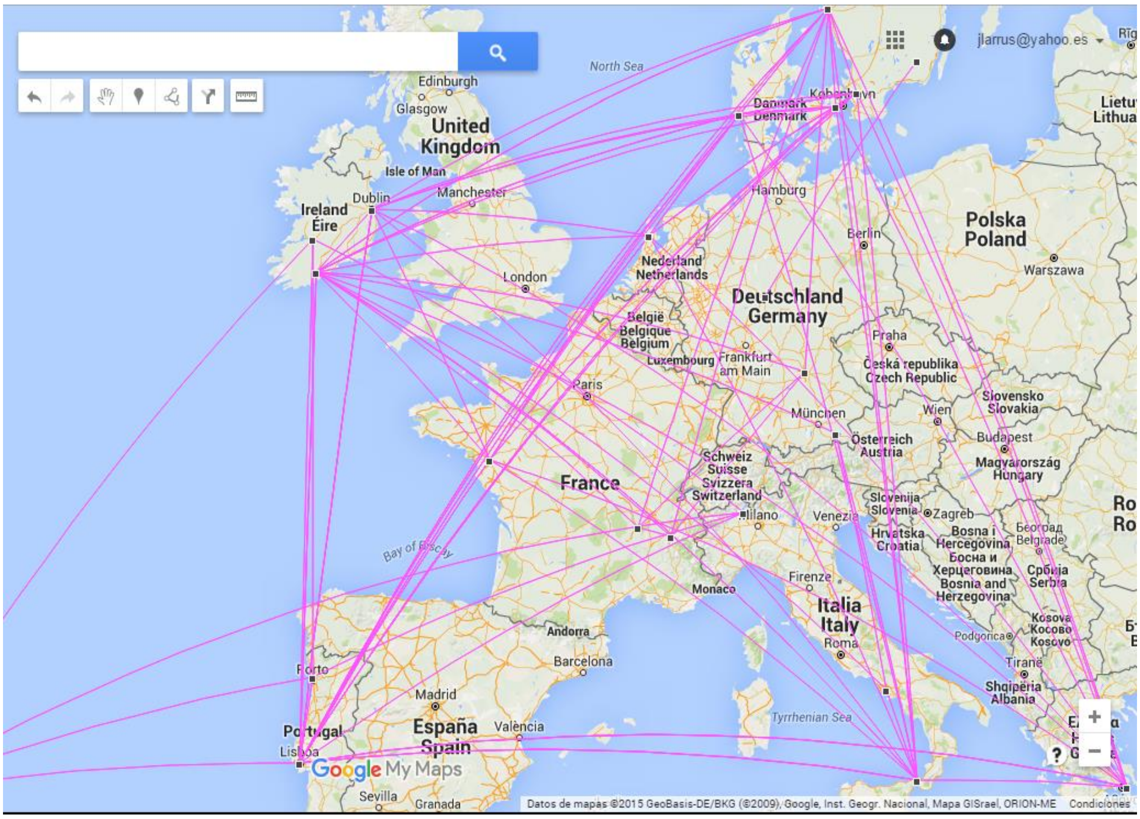


Figure 35. R&D collaboration network at Local regions level for sea sector in 2000-2001. Source: own elaboration.

Summarizing, these undirected networks were used as a basis of our research, where nodes represent organizations or local regions and links (lines between them) the sum of all the collaborations carried out through organizations located within each region.

6.5. Phase 3: Strategical Social Network analysis

6.5.1. Longitudinal SNA

The first step to carry out the strategical SNA to R&D collaboration networks is to analyse the topological structure and basic properties, which will be analysed following measures proposed by Freeman, Borgatti, Valente, Batagelj and Watts (Borgatti et al. 2002; Valente & Fujimoto 2010; Batagelj & Mrvar 2011; D J Watts & Strogatz 1998), and widely used in patents (Choe et al. 2016), publication citation (Montoya et al. 2014; Rizzi et al. 2014; Luz M. Romo-Fernández et al. 2011) and project based networks (Hain 2013; Kang & Hwang 2016; Kang & Park 2013; Ragwitz & Miola 2005).

For this purpose, the following measures are studied for the whole networks (Table 15).

Table 15. Indicators for longitudinal analysis of networks.

Measures	**Definition**
Average Degree	Average total number of lines (edges) incident to each vertex. It is calculated by dividing the sum of all node degrees by the total number of nodes in a network. (1)
Degree Centralization	This is the normalized average degree of the network. (1)
Density	Number of edges divided by the maximum number possible. (2)
Components	Number of weak components in the network. For undirected graph cases, two vertices are members of the same component if there is a path connecting them. Two vertices A and B are in the same strong component if there is a path connecting A to B and a path connecting B to A. The largest component is named as the main component. (2)
Component Ratio	Number of components minus one divided by the number of actors minus one. (2)
Average Distance	The length of a path (geodesic distance) is the number of edges it contains. The distance between two nodes is the length of the shortest path. The average distance is calculated with all path length distances. (2)
Standard Distance	It is the standard deviation of the geodesic distances amongst reachable pairs of nodes. (2)
Diameter	This is the length of the longest geodesic distance. (2)

Fragmentation	Proportion of pairs of vertices that are unreachable (pairs of nodes that cannot reach each other). Fragmentation centrality of a node is calculated as the difference in the total score with the node and the score with the node removed. (2)
Connectedness	1 minus the fragmentation (see below). (1) (3)
Watts-Strogatz Clustering Coef. Local	The local clustering coefficient of a vertex (node) in a graph quantifies how close its neighbours are to being a clique (a set of vertices in which each vertex is directly connected to all other vertices). It could determine whether a graph is a small-world network. (4) (5)
Network Clustering Coefficient (Transitivity)	The overall level of clustering in a network is measured as the average of the local clustering coefficients of all the vertices. (4) (5) [2]
Number of nodes in components	The total number of nodes in the components. (2)

Note: This table was extracted from: (1) (Freeman 1978), (2) (Borgatti et al. 2002), *(3)* (Valente & Foreman 1998), *(4)* (Batagelj & Mrvar 2011), *(5)* (D J Watts & Strogatz 1998).

To obtain the value of these measures, Pajek (Batagelj & Mrvar 2011) and Ucinet (Borgatti et al. 2002) software programmes were used. The results and analysis are done in chapter 7.3.

6.5.2.Centrality and Structural Hole approaches' SNA

On the one hand, for **Centrality approach** (point 5.6.2), different indicators were calculated for the nodes of networks:

- **Degree centrality:**

It counts the number of relations directly related to the given node (Freeman 1978; Abbasi et al. 2011) and has a meaning of local centrality (Choe et al. 2016) analysing the impact of a node on the network. It represents the measure of communication or relation activity of the node.

The following equation (1) is applied to calculate the normalized degree centrality (the number of links of an actor divided by the maximal possible number) of node i (Freeman 1978; Abbasi et al. 2011). "a_{ij}" indicates the existence or none-existence of a relationship/link between node i and node j; "n" indicates the number of nodes; a_{ij} =1 when there is a link between node i and j, and a_{ij} =0 when there is no link.

$$C(i)d = \frac{\sum_j \mathrm{aij}}{(n-1)} \qquad (1)$$

- **Betweenness centrality:**

This indicator, which enables the numbering of shortest paths (geodesic) passing through the respective node (Kang & Park 2013), is measured by the frequency of one node positioned on the shortest path between other groups of nodes arranged in pairs. It measures de degree to which one node plays a role as a bridge or broker in a network (Choe et al. 2016), holding a key position since it controls the flow of information within the network (gatekeeper function).

The following equation is used (2) to calculate the normalized betweenness centrality, where: n indicates the number of nodes; g_{jk} is the number of shortest paths from node j to node k; $g_{jk(i)}$ indicates the number of shortest paths from nod j to k that pass through node i (Freeman 1978; Abbasi et al. 2011).

$$C(i)b = \frac{\sum_{j<k} \frac{\mathrm{gjk(i)}}{\mathrm{gjk}}}{\frac{(n-2)(n-1)}{2}} \qquad (2)$$

- **Closeness centrality**:

The third measure to analyse the centrality is closeness. In this case, the extent to which a node is close to all others in the network is measured (Abbasi et al. 2011) and it is viewed as a global centrality since there are all kind of connections included (Choe et al. 2016). The following equation is used to measure normalized closeness centrality (3), where: n is the number of nodes and e_{ij} represents the number of links in the shortest path from node i to node j (Abbasi et al. 2011).

$$C(i)c = \frac{(n-1)}{\sum_j \mathrm{eij}} \quad (3)$$

On the one hand, for Structural Hole approach (point 5.6.2), there are two approaches. The first one (ego network mode) focuses on each node as an ego and considers this ego network as if the rest of the network did not exist. Here the ties beyond these egonets have no effect. However, the second one (whole network model) includes alter ties outside of egonet (Burt 1992) giving a complete perspective of the network.

Two main steps are needed to describe structural holes' effect: their existence and their value.

To analyse the existence of Structural Holes in networks, the betweenness centrality measure is used, showing the degree to which one node is playing a role of bridging or brokering within the network (Choe et al. 2016). As demonstrated and described in point 5.6.3, areas between the core and the peripheral nodes with almost no collaboration links, called structural holes in SNA (Figure 49) hamper the efficiency of cohesion and knowledge transfer.

To analyze the value of them, from the four possible algorithm measures for analyzing structural hole features of actors in a network (Effect Size, Efficiency, Constraint and Hierarchy) (Negro et al. 2012; Borgatti et al. 2002), Constraint algorithm was used. It uses closeness among nodes as measure targets, dependence among nodes as the evaluation criteria, determining the degree of structural holes.

Network Constraint index is the quantification of structural holes. It measures direct or indirect closeness between a node and other nodes (Cai & Penghua Cai Hong Liu, Rong Pan, Zheng Liu, Hui Li 2010). Then, if this index is higher, the network is considered closer and the structural holes are fewer.

In the way to calculate this index, 3 steps described are widely used for the research community and are summarized by (Cai & Penghua Cai Hong Liu, Rong Pan, Zheng Liu, Hui Li 2010).

First pij value is needed. pij (4) represents the step 1 towards Constraint index calculation (Cai & Penghua Cai Hong Liu, Rong Pan, Zheng Liu, Hui Li 2010). It represents the ratio of the shortest path length between node i and node j to the sum of the shortest path length about all the neighbouring nodes of i. It is calculated using dij which represents the shortest path length between two nodes (i and j).

$$pij = \frac{dij+dji}{\sum_k (dik+dki)} \qquad (4)$$

Once pij us calculated, cij is needed (5) which represents the binding level between node i and j. k node is the adjacent node of node i. This is the step 2 towards Constraint index calculation (Cai & Penghua Cai Hong Liu, Rong Pan, Zheng Liu, Hui Li 2010).

$$cij = (pij + \sum_{k,k\neq i,k\neq j} pik\ pkj)^2 \qquad (5)$$

Finally, Constraint Index is calculated (6) which represents network constraint index of node i (Cai & Penghua Cai Hong Liu, Rong Pan, Zheng Liu, Hui Li 2010):

$$Ci = \sum cij \qquad (6)$$

To obtain these indicators' values, also Pajek (Batagelj & Mrvar 2011) and Ucinet (Borgatti et al. 2002) software were used. To visualize indicators values in geographical maps, "Europe eXplorer" application was used to (Linköping University, http://ncva.itn.liu.se/explorer/europe-explorer?l=en). The results and analysis are available in point 7.4.

6.5.3.Matrix analysis: clustering

Matrix analysis consisted in carrying out k-means clustering process of centrality and structural hole indicators' values for each sector and at organizational and local regional level. The results and analysis are given in point 7.4.3.

6.5.4.Term maps

Term maps related to "keywords" and "Subjects" field was carried out following the methodology detailed in point 7.4.5., considering the clusterization of items according to their similarities in terms of centrality and structural hole approaches.

6.5.5.Integration of results

Finally, to obtain a global understanding of this methodology and results, the integration of two approaches (centrality and structural hole) with matrix and terms maps is done. The results are shown in point 7.4.6.

CHAPTER 7

7. Results and conclusions

7.1. Introduction

In this section, the results and conclusions of the research carried out in this thesis are simultaneously shown. For this purpose, the diagram of the process detailed in Chapter 6 will be followed. In addition, since most of the results are graphs or tables, they will be shown along with their respective analysis, so that the reading and understanding of this chapter should be as simple as possible.

In the first part of the chapter, section 7.2, the results of phase 1 "Delimitation of the renewable energy sector" will be addressed. Statistical descriptive results will be displayed.

In the second part, section 7.3, the results related to the longitudinal analysis of the projects, organizations and networks obtained with the information bounded in the previous section will be shown. It will detail the results of the topological description and properties of the collaborative networks obtained, as well as the visualization of the same ones, for their better understanding and visual analysis.

Finally, in section 7.4., the results of the strategic analysis carried out through the analysis of social networks based on the theoretical framework will be shown, as well as in chapter 6. It will begin with the results of applying the centrality and structural hole approaches to organizations and local regions, first separately and later as a whole, the latter by means of a matrix analysis, section 7.4.3, by means of graphical visualization and tables as well as geographical maps. Section 7.4.4. will show the conclusions of the results obtained so far. From this section on, the mapping of term terms ("keywords" and "subjects" in this case) will be carried out for each of the renewable sectors, concluding with the integrated results after cluster analysis, including different SNA approaches, as well as the information obtained from the term maps, giving an overview of the results. Section 7.4.7. will show the conclusions for these integrated results. Finally, section 7.5. will show a summary of the whole process and the general conclusions.

7.2. Results of Phase 1: Delimitation of RE sector

In this section, the descriptive results will be shown after having narrowed and delimited the five sectors of renewable energies, starting with results related to the own projects, which are the basis of this doctoral thesis study, following with those related to the organizations that are part of These projects, and ending with results from local regions. These results will help to address those shown in the following sections.

7.2.1.Descriptive statistics: projects

In this point, the evolution of the active EU publicly funded RET projects for 2000-2013 is analyzed (Figure 36). Between 2002 and 2012, save for the solar sector, all the sectors have a slow growth rate. The solar sector leads the number of projects (reaching 396 active projects in 2012), with an exponential increase from 2008 to 2012, clearly caused by a strategic public sector move and the proliferation of new partners (mainly firms) joining projects.

However, geothermal and sea projects slightly increased their rate, but well removed from biomass and wind figures.

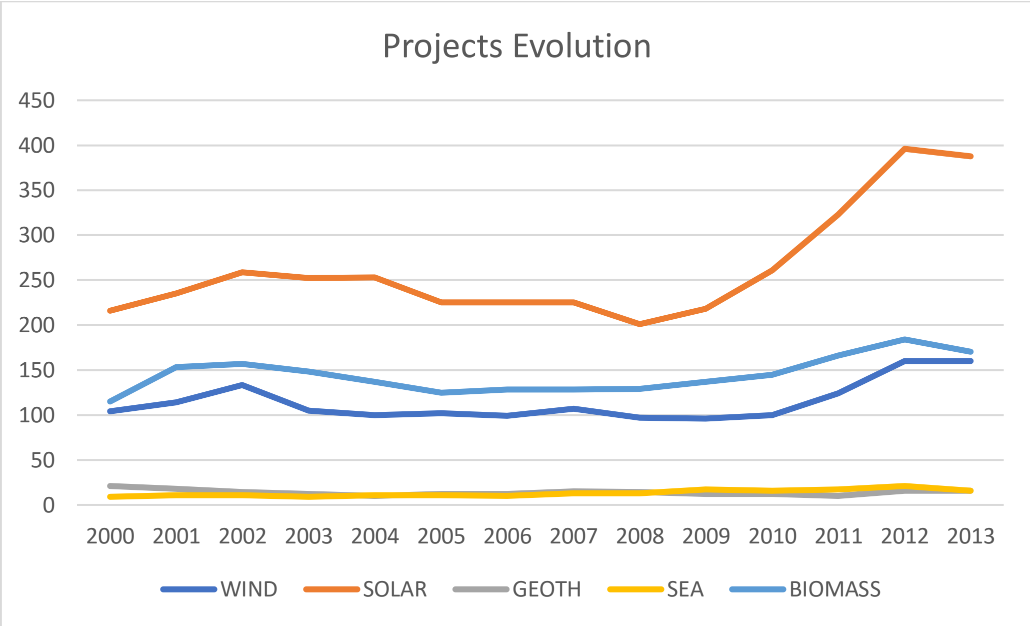


Figure 36. Evolution of the number of projects in RE. Non-aggregated mode. 2000-2013. Source: own elaboration.

7.2.2.Descriptive statistics: partners

Solar, biomass and wind sectors show nearly the same relative speed of growth of partner collaboration numbers (calculated as the number of direct collaborations in projects between two partners) as shown in Figure 37 and Figure 38. However, this seems to be higher for biomass and wind than for the rest of sectors, which perhaps is driven by the maturity of the solar sector compared with the emergent multidisciplinary biomass and wind sectors, in which each project needs higher number of partners.

Additionally, a change in public support for these sectors occurred in 2004-2005, given the significant leap in the number of links for sea (from 619 to 2762) and geothermal (from 569 to 1915), involving more partners in each project.

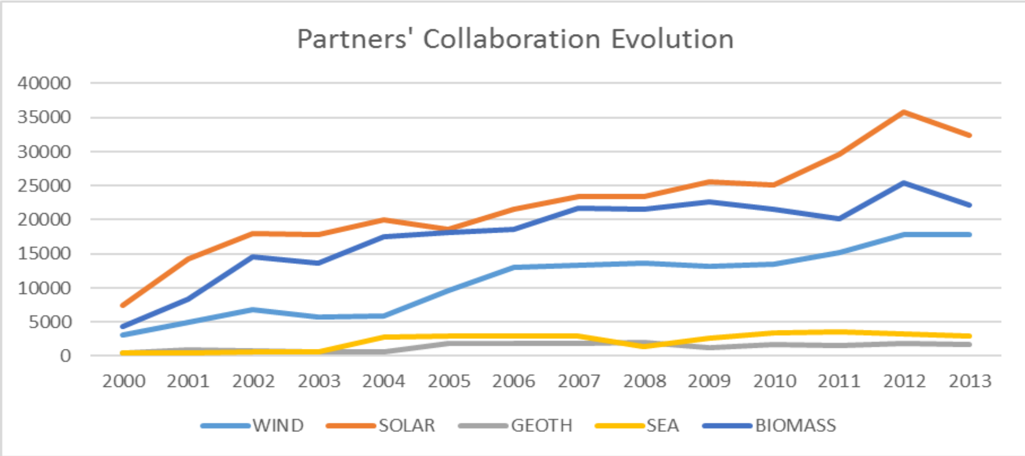


Figure 37. Evolution of relationships between partners in RE projects. Aggregated mode. 2000-2013. Source: own elaboration.

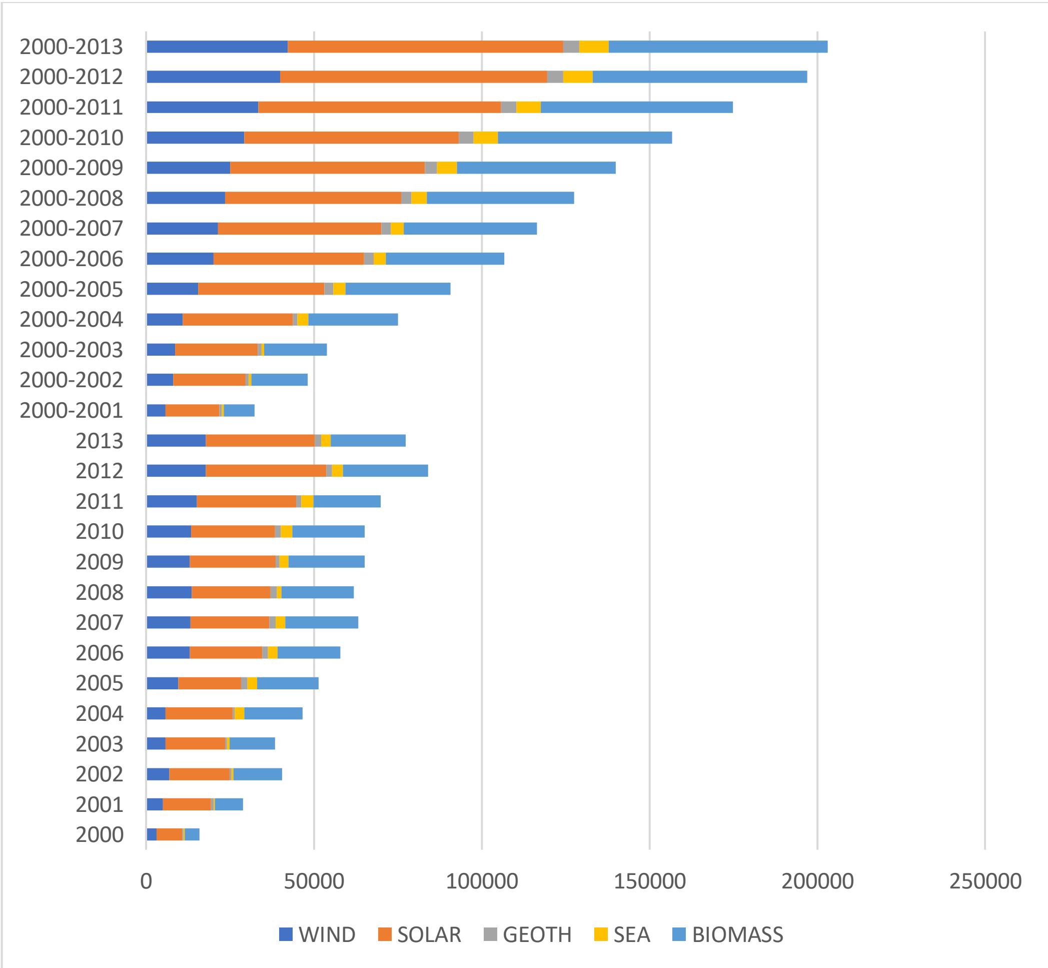


Figure 38. Evolution of relationships between partners in RE projects. Aggregated and simple mode. 2000-2013. Source: own elaboration.

The type of partners involved in RE projects for each sector is reported in Table 16, including the maximum and the average experience (number of projects in which they participate) as well as the average number of partners in a project. Among all the types of partner, firms effectively lead the participation in projects for all the sectors (44% to 59%), followed by Higher Education and Research Centers with 12%-18% (except for geothermal and sea with 25% for Research centers and 21% for Higher Education respectively).

Not surprisingly, both Higher Education and Research Centers hold the higher rates for maximum experience (experience is calculated by the number of projects in which they participate) in R&D projects in all sectors. In terms of the average number of partners in projects, firms have the highest rates (hardly remaining steady for all sectors, from 3.4 to 4.68), followed by Higher Education and Research Centers.

Table 16. Statistical data of partners for all the sectors. Source: own elaboration.

Type of partner	**WIND**				**SOLAR**				**GEOTH**				**SEA**				**BIOMASS**			
	A	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
Higher Educ.	14%	45	2.68	2.3	12%	6	1.08	2.17	14%	3	1.4	1.9	21%	14	2.2	3.44	13%	34	3.33	2.59
Research O.	16%	12	2.19	2.78	16%	19	1.19	2.46	25%	11	1.84	3.13	17%	10	1.89	2.82	18%	29	2.67	2.8
Firms	59%	15	1.45	4.5	59%	15	1.04	4.3	44%	3	1.11	3.4	52%	8	1.28	4.66	55%	22	1.42	4.68
Government	7%	6	1.25	1.8	8%	6	1.05	1.8	11%	4	1.15	1.93	6%	2	1.07	1.41	8%	17	1.58	2
Associations	3%	3	1.15	1.82	5%	2	1.02	1.7	6%	2	1.15	1.57	4%	2	1.09	2	5%	11	1.47	1.7
NGO	0%	1	1	1	0%	2	1.2	1.12	0%	0	0	0	0%	0	0	0	0%	0	0	0
TOTAL	1544				2655				202				266				1834			

Data related to partners in the period of 2000-2013 in each sector. Column A indicates % of partners in sector; Column B, maximum of experience; Column C, average of experience; Column D, average of partners in a project

7.2.3.Descriptive statistics: local regions

Table 17 highlights some peculiarities related to the geographical perspective of projects.

While the Solar sector is leading the number of projects and partners per country (126.25 and 212.75 respectively) as well as projects and partners per NUTS3 (7.55 and 8.63), geothermal presents the lowest rates (8.83, 14.64, 2.01 and 2.31 respectively).

To a certain extent this could suggest the specialization degree of countries and particularly NUTS3, being higher for the mature solar sector compared to geothermal.

Table 17. Average data for number of projects, partners and NUST3 in each sector 2000-2013. Source: own elaboration.

Sector	Projects per country	Partner per country	NUTS3 per country	Projects per NUTS3	Partners per NUTS3
WIND	55.13	95.8	17.67	4.72	5.39
SOLAR	126.25	212.75	24.5	7.55	8.63
GEOTH	8.83	14.65	5.92	2.01	2.31
SEA	11.26	19.67	8.17	2.17	2.4
BIOMASS	87.41	155.89	25.55	5.33	6.13

7.3. Results of Phase 2: Longitudinal analysis of networks

7.3.1. Topological structure and properties

The following tables (Table 18 and Table 19) illustrate the topological structure and basic properties of networks created for each RE sector for organizations and local regions (point 6.4), which will be analyzed following measures proposed by Freeman, Borgatti, Valente, Batagelj and Watts (Borgatti et al. 2002; Thomas W Valente & Fujimoto 2010; Batagelj & Mrvar 2011; D J Watts & Strogatz 1998), and widely used in patents (Choe et al. 2016), publication citation (Montoya et al. 2014; Rizzi et al. 2014; Luz M. Romo-Fernández et al. 2011) and project based networks (Hain 2013; Kang & Hwang 2016; Kang & Park 2013; Ragwitz & Miola 2005). The ideal value for Erdos and Renyi is shown between parentheses.

The explanation of each indicators is described in point 6.5.1 and the main analysis is based on the average values of indicators, calculated though data from in each progressive aggregated period (Annex E).

Related to partner networks (Table 18), focusing on the average degree, calculated dividing the sum of all direct collaborations of each node by the total number of nodes in a network, partners from Sea and Biomass sectors seem to be more active (16.95 and 17.76 respectively) in contrast to Geothermal and Wind (11.52 and 13.90 respectively). Moreover, to be able to compare networks, the normalized average degree of each network was calculated as a degree of centralization: Sea (0.36), Geothermal (0.26), Solar (0.21), Wind (0.17) and Biomass (0.12). The average of cluster coefficient for each partner (calculated as the ratio of the links between the node neighbors and the maximum possible links between those neighbors) (Choe et al. 2016) being higher than overall density (number of edges divided by the maximum number possible) in each sector, leads to clusterization around a few partners.

Moreover, a high number of components (isolated sub-networks in a network) and their very small ratio (compared to the possible number of nodes) implies that central organizations concentrate the influence in the networks in terms of information transfer, involving a majority number of nodes and resulting in a core-periphery model. For example, the main components cover over 90% of partners in Sea, Wind, Solar and Biomass, and 78% in geothermal. However, there is still a wide range of separated ones beyond the core of the network (more central nodes), especially for wind, solar and biomass sectors, resulting in a polysepalous network model (Kang & Park 2013).

On the one hand, since the average value of the geodesic path length between any pair of partners and the longest one (indicated as average distance and diameter respectively) are much higher than for idealized ones, the small-world effect (D J Watts & Strogatz 1998; Newman et al. 2001; Baum et al. 2003) loses strength leading to the knowledge transfer mechanism being less effective between partners.

On the other hand, higher than expected values of clustering coefficients in ideal networks indicate that the distribution of nodes is less well-organized and it is not completely random, as well as their cohesion being more concentrated in few of them (Kang & Park 2013) in terms of knowledge flows possibilities.

Related to the NUTS3 collaboration network (Table 19), all the indicators show the same schema as for partner collaboration networks. However, as the values of average distance between local regions are smaller and clustering coefficients higher, compared with ideal networks, the knowledge transfer mechanism proves to be more effective although they are neither completely random nor homogeneously located in terms of cohesion (D J Watts & Strogatz 1998).

Table 18. Topological analysis of partner network during 2000-2013 period in each sector (average data). Source: own elaboration.

	WIND	SOLAR	SEA	GEOTH	BIOMASS
Avg Degree	13.90	15.15	16.95	11.52	17.76
Deg Centralization	0.16	0.21	0.36	0.26	0.12
Density	0.01 (0.03)	0.01 (0.06)	0.11 (0.07)	0.07 (0.06)	0.01 (0.01)
Components	45.29	69.14	7.93	16.21	47.43
Component Ratio	0.05	0.03	0.04	0.10	0.03
Avg Distance	3.29 (2.24)	3.15 (2.94)	2.30 (2.10)	2.61 (2.29)	3.16 (2.78)
SD Distance	0.92	0.78	0.77	1.07	0.81
Diameter	7.14 (3)	7.64 (4)	4.79 (3)	6.29 (4)	7.00 (4)
Connectedness	0.79	0.85	0.75	0.52	0.84
Watts-Strogatz Clustering Coef. Local	0.89 (0.03)	0.88 (0.06)	0.94 (0.07)	0.94 (0.06)	0.89 (0.01)
Net Clustering Coef. (Transitivity)	0.50	0.34	0.75	0.76	0.51

Table 19. Topological analysis of NUTS3 network during 2000-2013 period in each sector (average data). Source: own elaboration.

	WIND	**SOLAR**	**SEA**	**GEOTH**	**BIOMASS**
Avg Degree	21.50	29.50	18.47	12.27	29.44
Deg Centralization	0.31	0.38	0.40	0.34	0.34
Density	0.05 (0.01)	0.05 (0.02)	0.17 (0.06)	0.11 (0.10)	0.05 (0.03)
Components	5.93	7.14	2.29	7.50	6.57
Component Ratio	0.01	0.01	0.01	0.07	0.01
Avg Distance	2.41 (3.32)	2.30 (2.60)	2.15 (2.38)	2.29 (2.26)	2.29 (2.53)
SD Distance	0.64	0.57	0.77	0.75	0.57
Diameter	4.93 (6)	4.50 (4)	5.00 (4)	4.14 (4)	4.57 (4)
Connectedness	0.97	0.98	0.89	0.76	0.98
Watts-Strogatz Clustering Coef. Local	0.76 (0.001)	0.72 (0.02)	0.88 (0.06)	0.87 (1.68)	0.75 (0.03)
Net Clustering Coef. (Transitivity)	0.38	0.32	0.71	0.63	0.35

7.3.2.Networks Visualization

The following figures (Figure 39 to Figure 48) depict the collaboration networks of partners and NUTS3 for the 2000-2013 period for each RE sector, where dots are partners or NUTS3 and their collaborations are drawn as lines. Nodes with same values of degree indicator have same colors, and their size represent their structural hole values (inverse).

The visualization of these networks of organizations and local regions has been carried out using the Pajek software described in chapter 5.4. Kamada-kawai has been the algorithm chosen for the determination of the spatial configuration of the nodes and allows to generate visualizations in which the distance between them expresses the cognitive relation that they maintain between themselves and with the rest.

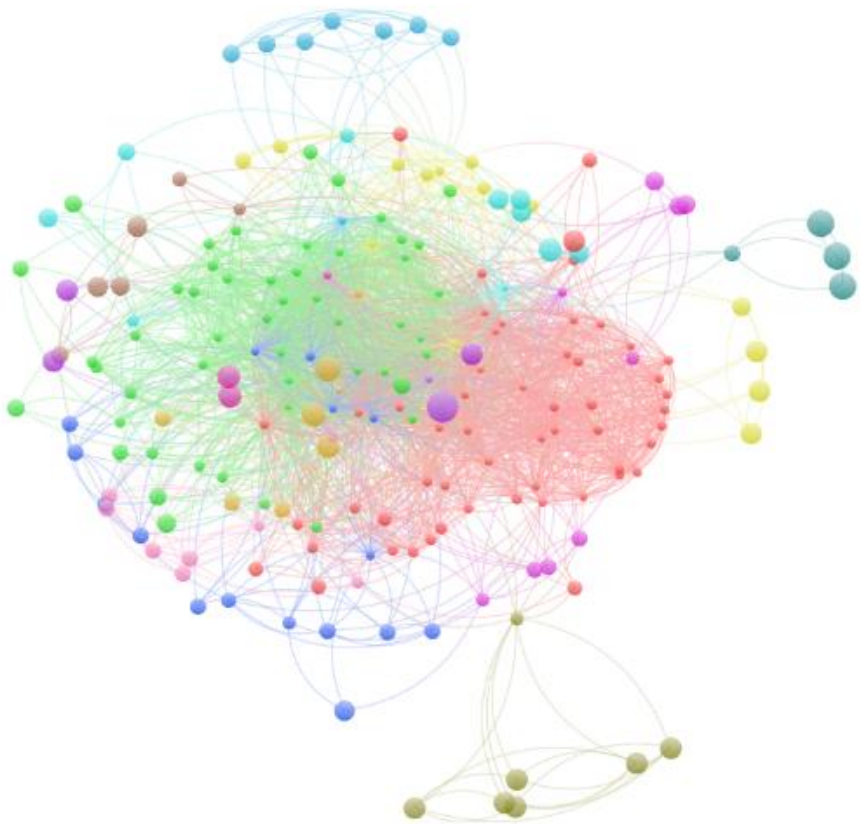


Figure 39. Organizational Network. 2000-2013, wind sector. Source: own elaboration.

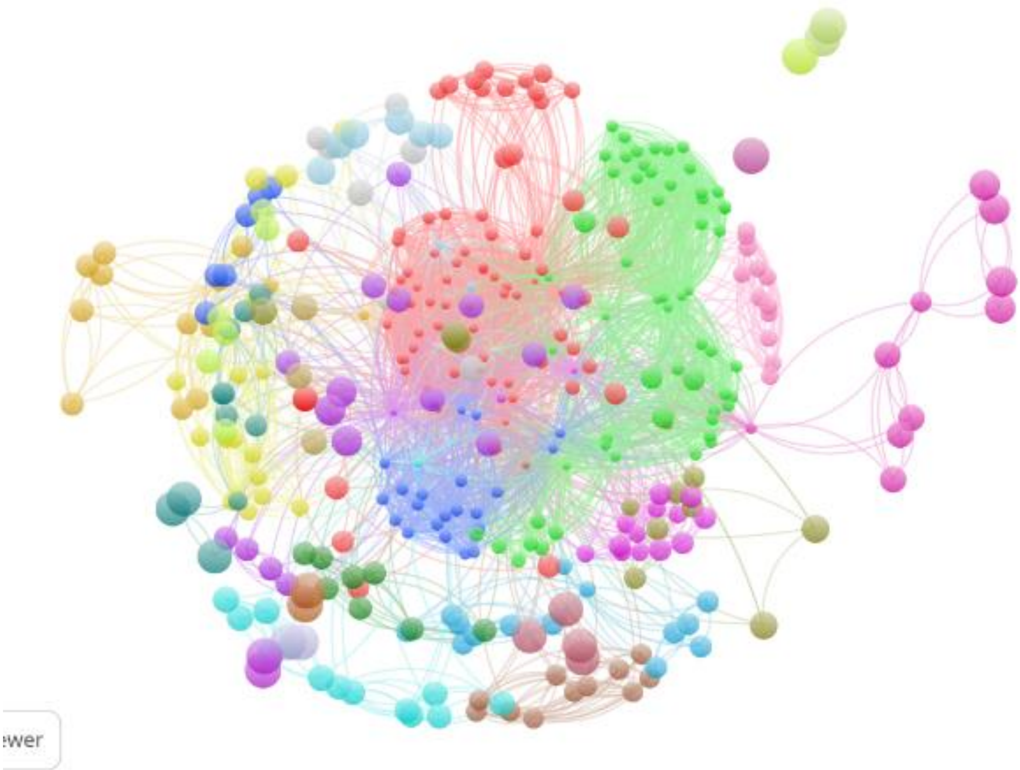


Figure 40. Local regional Network. 2000-2013, wind sector. Source: own elaboration.

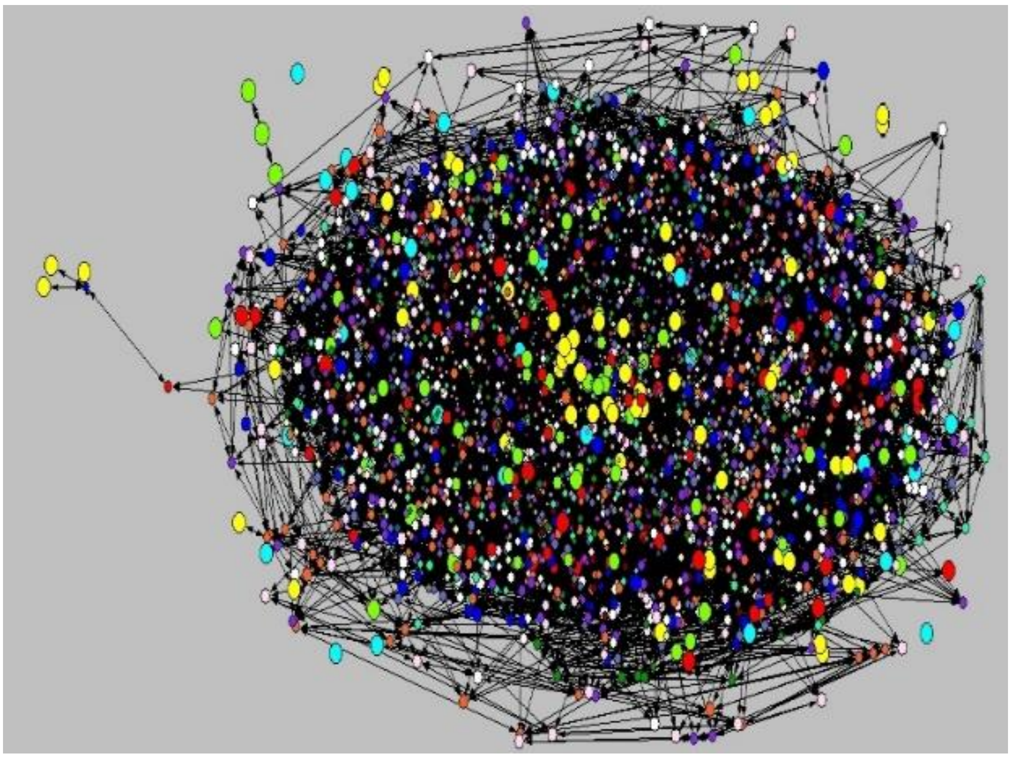


Figure 41. Organizational Network. 2000-2013, solar sector. Source: own elaboration.

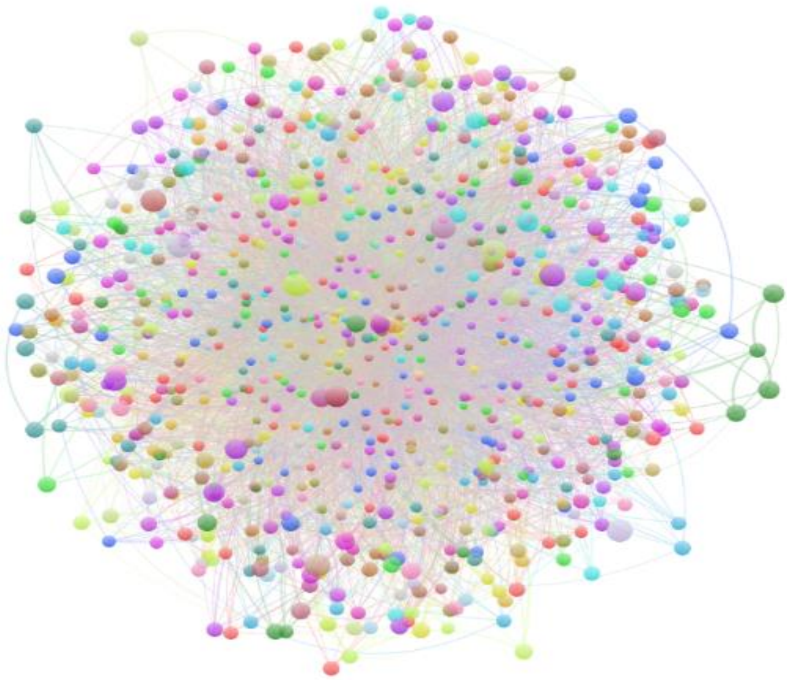


Figure 42. Local regional Network. 2000-2013, solar sector. Source: own elaboration.

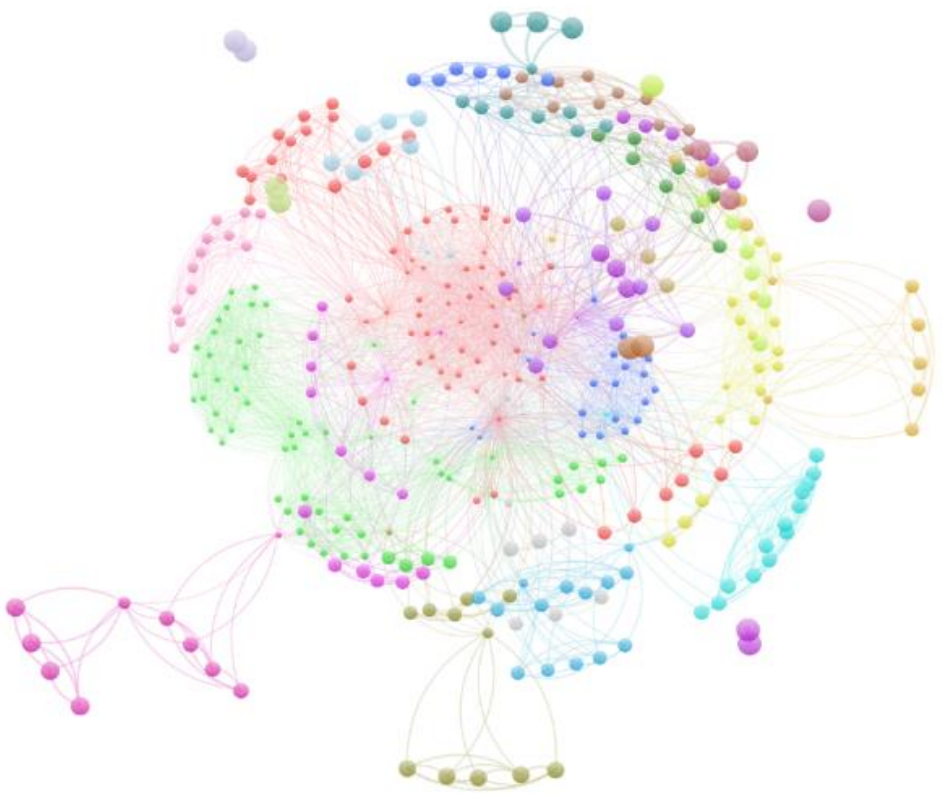


Figure 43. Organizational Network. 2000-2013, sea sector. Source: own elaboration.

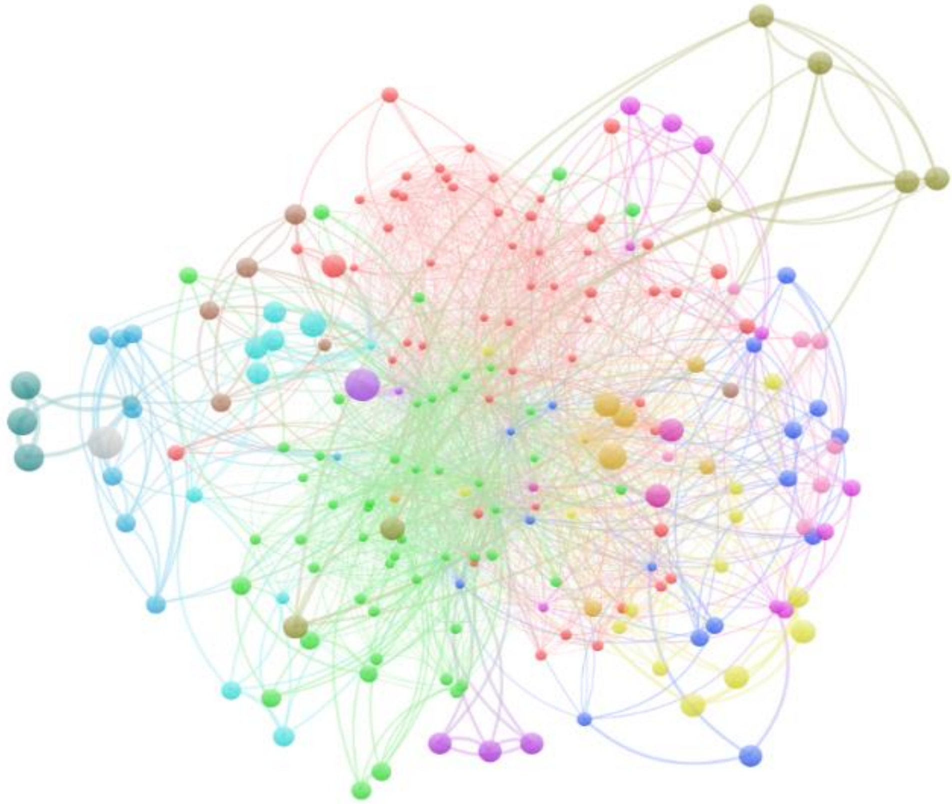


Figure 44. Local regional Network. 2000-2013, sea sector. Source: own elaboration.

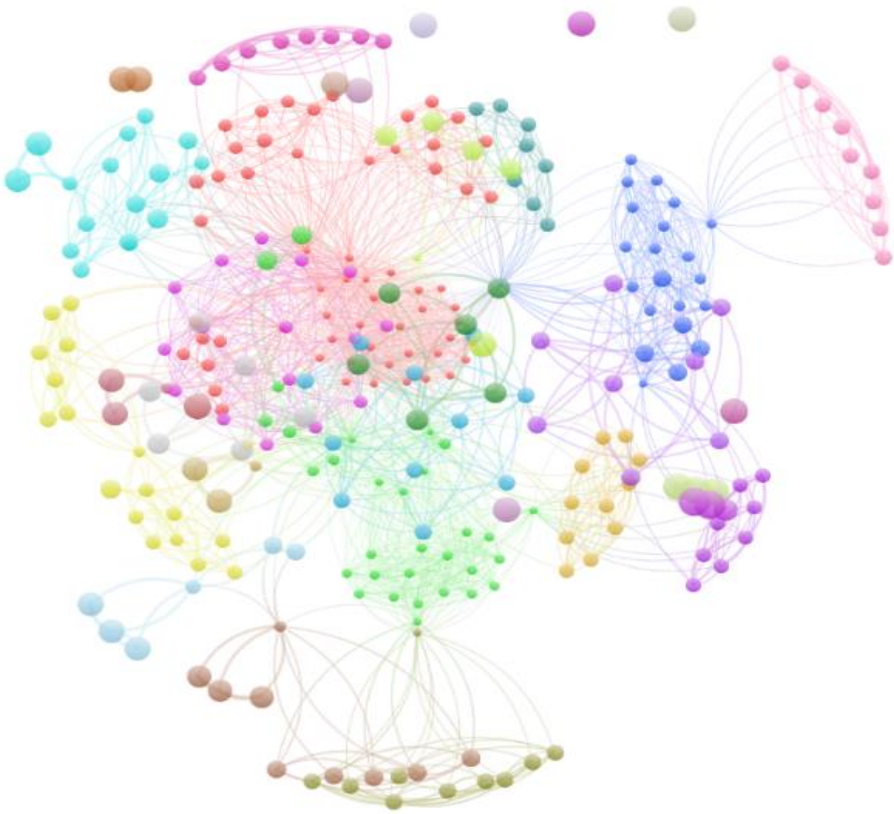


Figure 45. Organizational Network. 2000-2013, geoth. sector. Source: own elaboration.

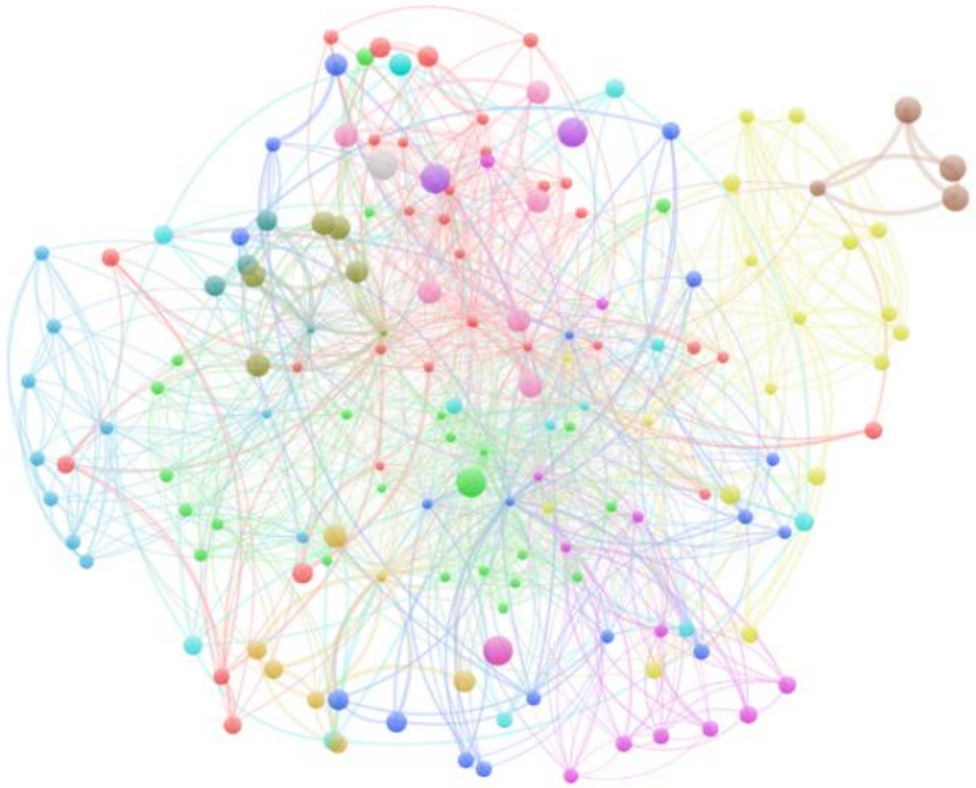


Figure 46. Local regional Network. 2000-2013, geoth. sector. Source: own elaboration.

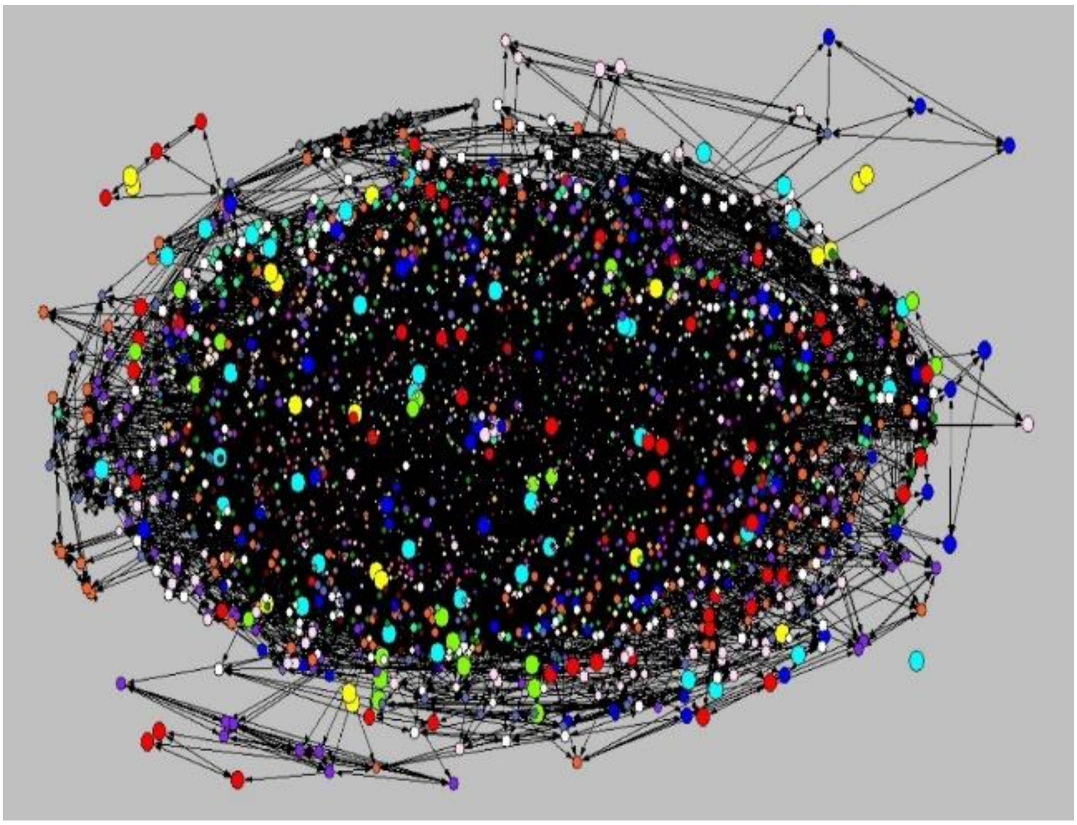


Figure 47. Organizational Network. 2000-2013, biomass sector. Source: own elaboration.

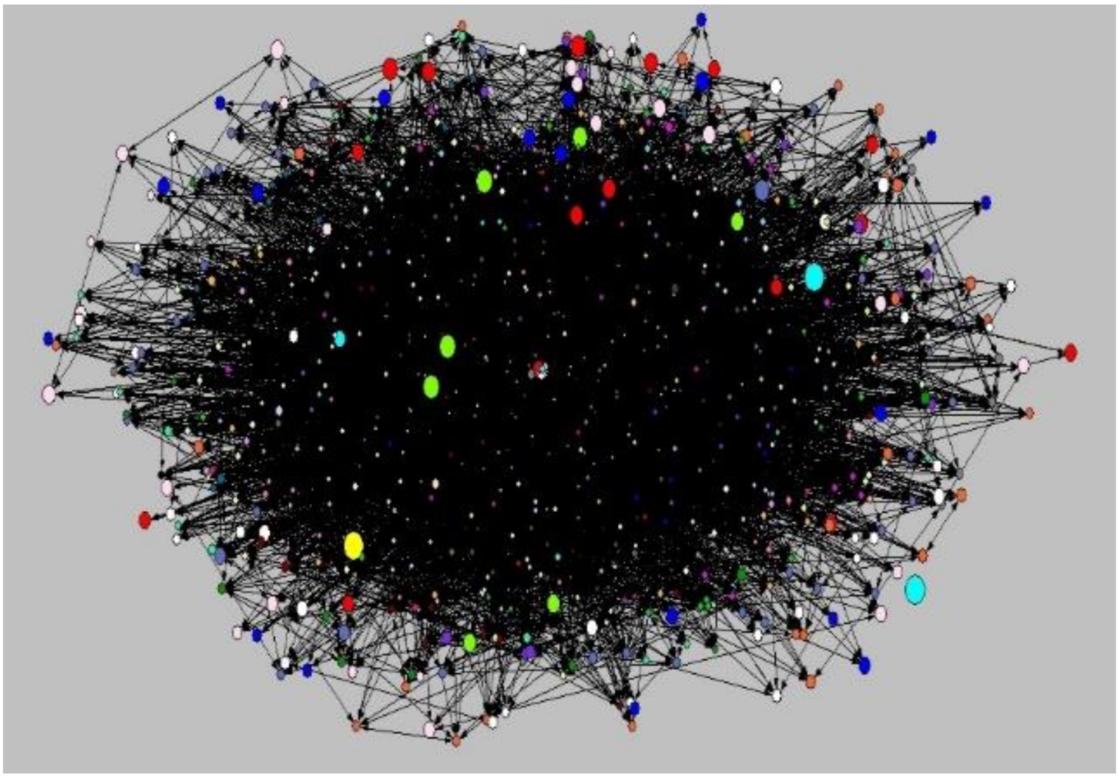


Figure 48. Local regional Network. 2000-2013, biomass sector. Source: own elaboration.

7.4. Results of Phase 3: Social Networks Strategic Analysis

In this section, the results will be obtained after applying the approach of centrality, detailed in section 5.6.2, and analysing through the indicators detailed in section 6.5.2. Results will be obtained at two levels: organizations and local regions.

7.4.1.Centrality Approach

7.4.1.1. Centrality Approach: Organizations

Next, the tables related to the rankings of the organizations according to their centrality value in the project networks that have been visualized in section 7.3. will be obtained (Figure 39-Figure 48).

Apart from the name of the organization, it includes the type according to its activity, the country code, the local region code and the normalized value of the centrality indicator. The ranking is ordered from highest to lowest value, highlighting the importance of the 25 organizations that act as central on the rest. Tables are obtained for each of the 5 renewable energy sectors.

Table 20 shows this ranking for the wind energy sector. The central importance of the technological centers and universities, especially in countries such as Denmark, Germany, Spain and Great Britain, can be observed. Among them, Technological University of Denmark and Fraunhofer research center of Germany are the leaders of the ranking.

Table 20. Ranking of organizations according to their centrality in 2000-2013. Wind sector. Source: own elaboration.

P.	Organization	Type	Country	NUTS_3	Value
1	UNIVERSITY OF TECHNOLOGY OF DENMARK	1	DK	DK012	0.2271
2	FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.	2	DE	DEA32	0.2263
3	CENTER FOR RENEWABLE ENERGY SOURCES - CRES	2	GR	EL305	0.1777
4	ACCIONA S.A.	3	ES	ES220	0.1717
5	Riso National Laboratory	2	DK	DK021	0.1631
6	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	2	FR	FR102	0.1601
7	GARRAD HASSAN AND PARTNERS LTD	3	GB	UKK11	0.1596
8	FUNDACION TECNALIA RESEARCH AND INNOVATION	2	ES	ES212	0.1591
9	DONG ENERGY	3	GB	UKI11	0.1581
10	GAMESA	3	DK	DK042	0.1579
11	UNIVERSITY OF TECHNOLOGY OF DELFT	1	NL	NL333	0.1565
12	EUROPEAN WIND ENERGY ASSOCIATION	5	BE	BE100	0.1558
13	FUNDACION CENER-CIEMAT	2	ES	ES220	0.1547
14	UNIVERSITY OF TECHNOLOGY OF AACHEN	1	DE	DEA21	0.1543
15	UNIVERSITY OF OLDENBURG	1	DE	DE943	0.1542
16	Siemens	3	IT	ITC45	0.1541
17	3E N.V.	3	BE	BE100	0.1523
18	UNIVERSITY OF STUTTGART	1	DE	DE111	0.1518
19	EDF	3	FR	FR105	0.1509
20	NATIONAL TECHNICAL UNIVERSITY OF ATHENS	1	GR	EL303	0.1495
21	UNIVERSITY OF TECHNOLOGY OF MILAN	1	IT	ITC11	0.1490
22	STICHTING ENERGIEONDERZOEK CENTRUM NEDERLAND	2	NL	NL322	0.1472
23	UNIVERSITY OF AALBORG	1	DK	DK050	0.1461
24	CONSIGLIO NAZIONALE DELLE RICHERCHE	2	IT	ITE43	0.1460
25	DEUTSCHES ZENTRUM FUER LUFT UND RAUMFAHRT E.V.	2	DE	DE111	0.1453

Table 21 shows this ranking for the solar energy sector. In this case, on the one hand, the great importance of centrality played by technological centers is observed. As for companies, their position of centrality is still far from the research centers or universities. On the other hand, it should be mentioned that Franhoufer is leading the ranking and followed by two French entities: a research center and a public body.

Table 21. Ranking of organizations according to their centrality in 2000-2013. Solar sector. Source: own elaboration.

P.	Organization	Type	Country	NUTS_3	Value
1	FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.	2	DE	DEA32	0.3317
2	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	2	FR	FR102	0.2217
3	COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES	4	FR	FR824	0.2039
4	Centro de Investigaciones Energeticas Medioambientales y Tecnologicas - CIEMAT	2	ES	ES300	0.1843
5	T.N.O.	2	NL	NL333	0.1768
6	UNIVERSITY OF TECHNOLOGY OF MILAN	1	IT	ITC11	0.1725
7	CENTER FOR RENEWABLE ENERGY SOURCES - CRES	2	GR	EL305	0.1708
8	UNIVERSITY OF STUTTGART	1	DE	DE111	0.1691
9	CONSIGLIO NAZIONALE DELLE RICHERCHE	2	IT	ITE43	0.1654
10	EDF	3	FR	FR105	0.1652
11	DEUTSCHES ZENTRUM FUER LUFT UND RAUMFAHRT E.V.	2	DE	DE111	0.1598
12	FUNDACION TECNALIA RESEARCH AND INNOVATION	2	ES	ES212	0.1559
13	ECOLE POLYTECHNIQUE FEDERALE DE LAUSANNE	1	CH	CH011	0.1548
14	INTERUNIVERSITAIR MICRO-ELECTRONICA CENTRUM VZW	2	BE	BE242	0.1538
15	UNIVERSITY OF TECHNOLOGY OF DENMARK	1	DK	DK012	0.1528
16	Siemens	3	IT	ITC45	0.1517
17	UNIVERSITY OF TECHNOLOGY OF WARSAW	1	PL	PL127	0.1511
18	ACCIONA S.A.	3	ES	ES220	0.1509
19	UNIVERSITY OF ATHENS	1	GR	EL303	0.1494
20	Association pour la Recherche et le Developpement de Methodes et Processus Industriels (ARMINES)	2	FR	FR102	0.1488
21	STICHTING ENERGIEONDERZOEK CENTRUM NEDERLAND	2	NL	NL322	0.1483
22	FORSCHUNGSZENTRUM JUELICH GMBH	2	DE	DE300	0.1465
23	CENTRO RICERCHE FIAT S.C.P.A.	2	IT	ITC11	0.1464
24	AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE	4	IT	ITE43	0.1457
25	UNIVERSITY OF PATRAS	1	GR	EL632	0.1456

Table 22 shows this ranking for the sea energy sector. In this sector, mainly the organizations of Ireland, Netherlands and Great Britain lead the ranking. For example, no Spanish organization is ranked in the top 25. On the other hand, it is observed, being a still very emergent sector, that the universities and then the research centers are those that form the nucleus of the network in function of its centrality.

Table 22. Ranking of organizations according to their centrality in 2000-2013. Sea energy sector. Source: own elaboration.

P.	Organization	Type	Country	NUTS_3	Value
1	UNIVERSITY COLLEGE CORK, NATIONAL UNIVERSITY OF IRELAND, CORK	1	IE	IE025	0.3346
2	UNIVERSITY OF EDINBURGH	1	GB	UKM25	0.3087
3	IT POWER LTD.	3	GB	UKJ37	0.2899
4	UNIVERSITY OF AALBORG	1	DK	DK050	0.2833
5	UNIVERSITY OF TECHNOLOGY OF CHALMERS	1	SE	SE232	0.2799
6	WAVE ENERGY CENTRE - CENTRO DE ENERGIA DAS ONDAS	2	PT	PT114	0.2748
7	UNIVERSITY OF SOUTHAMPTON	1	GB	UKJ32	0.2605
8	INSTITUTO SUPERIOR TECNICO	2	PT	PT172	0.2502
9	FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.	2	DE	DEA32	0.2473
10	UNIVERSITY OF TECHNOLOGY OF DENMARK	1	DK	DK012	0.2247
11	DHI	2	DK	DK013	0.2224
12	WAVE DRAGON APS	3	DK	DK001	0.2210
13	ECOFYS B.V.	3	NL	NL310	0.2179
14	ECOLE CENTRALE DE NANTES	1	FR	FR511	0.2149
15	UNIVERSITY OF STRATHCLYDE	1	GB	UKM34	0.2128
16	UNIVERSITY OF BOLOGNA	1	IT	ITD55	0.2082
17	CENTER FOR RENEWABLE ENERGY SOURCES - CRES	2	GR	EL305	0.2060
18	TEAMWORK TECHNOLOGY BV	3	NL	NL321	0.2045
19	UNIVERSITY OF TECHNOLOGY OF MUNICH	1	DE	DE212	0.2042
20	SPOK APS	3	DK	DK001	0.2016
21	EDF	3	FR	FR105	0.1986
22	UNIVERSITY OF UPPSALA	1	NL	NL221	0.1986
23	INSTITUT FRANCAIS DE RECHERCHE POUR L EXPLOITATION DE LA MER	2	FR	FR105	0.1986
24	STICHTING ENERGIEONDERZOEK CENTRUM NEDERLAND	2	NL	NL322	0.1975
25	Ente Nazionale per l Energia Elettrica SpA (ENEL)	4	IT	ITE43	0.1975

Table 23 shows this ranking for the geothermal energy sector. In this sector, it is observed that the leadership rests in the research centers, followed very behind by the companies and universities.

Table 23. Ranking of organizations according to their centrality in 2000-2013. Geothermal sector. Source: own elaboration.

P.	Organization	Type	Country	NUTS_3	Value
1	CENTER FOR RENEWABLE ENERGY SOURCES - CRES	2	GR	EL305	0.2787
2	T.N.O.	2	NL	NL333	0.2570
3	UNIVERSITY OF ORADEA	1	RO	RO111	0.2462
4	BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES	2	FR	FR246	0.2449
5	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	2	FR	FR102	0.2296
6	CONSIGLIO NAZIONALE DELLE RICHERCHE	2	IT	ITE43	0.1901
7	GROUPEMENT EUROPEEN D INTERET ECONOMIQUE EXPLOITATION MINIERE DE LA CHALEUR	5	FR	DE276	0.1752
8	GEOWATT AG	3	CH	CH040	0.1744
9	GEOFORSCHUNGSZENTRUM POTSDAM	2	DE	DE423	0.1709
10	CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS	2	GR	EL522	0.1659
11	GEOPRODUCTION CONSULTANTS GPC SA	3	FR	FR108	0.1655
12	DEEP HEAT MINING ASSOCIATION	5	CH	CH040	0.1577
13	MESY GEO MESS SYSTEME GMBH	3	DE	DEA51	0.1577
14	COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES	4	FR	FR824	0.1572
15	UNIVERSITY COLLEGE DUBLIN	1	IE	IE021	0.1572
16	SHELL	3	NL	NL333	0.1533
17	NATIONAL CENTER FOR SCIENTIFIC RESEARCH DEMOKRITOS	2	GR	EL301	0.1533
18	VERENIGING VOOR CHRISTELIJK HOGER ONDERWIJS WETENSCHAPPELIJK ONDERZOEK EN PATIENTENZORG	2	NL	NL326	0.1533
19	INSTITUT FUER ENERGETIK UND UMWELT GMBH	2	DE	DED31	0.1533
20	CFG SERVICES SAS	3	FR	FR246	0.1533
21	DANMARKS OG GROENLANDS GEOLOGISKE UNDERSOEGELSE	2	DK	DK001	0.1533
22	EOTVOS LORAND TUDOMANYEGYETEM.	2	HU	HU101	0.1533
23	GEOLOGIJOS IR GEOGRAFIJOS INSTITUTAS	2	LT	LT00A	0.1533
24	INSTITUT FUER GEOWISSENSCHAFTLICHE GEMEINSCHAFTSAUFGABEN	2	DE	DE929	0.1533
25	INSTITUTO GEOLOGICO Y MINERO DE ESPANA	2	ES	ES300	0.1533

Table 24 shows this ranking for the biomass renewable energy sector. This sector is led by research centers, followed by universities. However, only 2 companies lead the table of the 25 most central, in positions 6 and 23.

Table 24. Ranking of organizations according to their centrality in 2000-2013. Biomass sector. Source: own elaboration.

P.	Organization	Type	Country	NUTS_3	Value
1	UNIVERSITY OF STUTTGART	1	DE	DE111	0.1950
2	IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE	1	GB	UKI11	0.1931
3	FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.	2	DE	DEA32	0.1929
4	CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS	2	GR	EL522	0.1906
5	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	2	FR	FR102	0.1866
6	B.T.G. BIOMASS TECHNOLOGY GROUP BV	3	NL	NL213	0.1848
7	UNIVERSITY OF TECHNOLOGY OF DENMARK	1	DK	DK012	0.1837
8	SWEDISH UNIVERSITY OF AGRICULTURAL SCIENCES	1	SE	SE121	0.1827
9	TEKNOLOGIAN TUTKIMUSKESKUS VTT	2	FI	FI181	0.1801
10	CENTER FOR RENEWABLE ENERGY SOURCES - CRES	2	GR	EL305	0.1749
11	T.N.O	2	NL	NL333	0.1744
12	NATIONAL TECHNICAL UNIVERSITY OF ATHENS	1	GR	EL303	0.1741
13	UNIVERSITY OF LUND	1	SE	SE224	0.1729
14	CSIC CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS	2	ES	ES300	0.1695
15	EUROPEAN BIOMASS INDUSTRY ASSOCIATION	5	BE	BE100	0.1694
16	STICHTING DIENST LANDBOUWKUNDIG ONDERZOEK	4	NL	NL221	0.1693
17	VALTION TEKNILLINEN TUTKIMUSKESKUS (TECHNICAL RESEARCH CENTRE OF FINLAND)	2	FI	FI181	0.1683
18	Centro de Investigaciones Energeticas Medioambientales y Tecnologicas - CIEMAT	2	ES	ES300	0.1677
19	INSTITUT NATIONAL DE LA RECHERCHE AGRONOMIQUE	2	FR	FR811	0.1649
20	ENERGY RESEARCH CENTRE OF THE NETHERLANDS	2	NL	NL322	0.1612
21	STICHTING ENERGIEONDERZOEK CENTRUM NEDERLAND	2	NL	NL322	0.1595
22	UNIVERSITY OF TECHNOLOGY OF DELFT	1	NL	NL333	0.1588
23	WIRTSCHAFT UND INFRASTRUKTUR GMBH AND CO PLANUNGS KG	3	DE	DE212	0.1568
24	UNIVERSITY OF ASTON	1	GB	UKG31	0.1562
25	CONSIGLIO NAZIONALE DELLE RICHERCHE	2	IT	ITE43	0.1561

7.4.1.2. Centrality Approach: Local Regions

Next, the tables for the rankings of the local regions will be obtained according to their centrality value in the project networks that have been visualized in section 7.3 (Figure 39 - Figure 48).

Apart from the code of the local region, the country code and the normalized value of the centrality indicator are included. The ranking is ordered from highest to lowest value, highlighting the importance of the 25 local regions that act as central on the rest. Tables are obtained for each of the 5 renewable energy sectors.

Table 25 shows this ranking for the wind sector. The ranking of the first 25 is led by Spain with its various local regions (in terms of frequency of appearance). Moreover, it is the first with its region ES300. It is followed by Germany and Denmark, both with highly distributed regions.

Table 25. Ranking of local regions according to their centrality position in 2000-2013. Country and centrality value are added. Wind sector. Source: own elaboration.

Position	NUTS 3	Country	Centrality value
1	ES300	ES	0.4073
2	BE100	BE	0.3426
3	DE212	DE	0.3384
4	DK012	DK	0.3378
5	FR102	FR	0.3322
6	ITE43	IT	0.3152
7	EL303	GR	0.3044
8	EL305	GR	0.3030
9	UKI11	GB	0.3003
10	ITC45	IT	0.2971
11	ES511	ES	0.2961
12	DE600	DE	0.2954
13	DE111	DE	0.2842
14	DK021	DK	0.2758
15	DEA23	DE	0.2748
16	FI181	FI	0.2740

17	NL333	NL	0.2728
18	ES220	ES	0.2712
19	CZ010	CZ	0.2660
20	UKK11	GB	0.2651
21	FR105	FR	0.2627
22	NL322	NL	0.2617
23	ES213	ES	0.2604
24	SE110	SE	0.2583
25	DK001	DK	0.2558

Regarding the solar sector (Table 26), there is a leadership of Germany with its local region DE212, followed by France with FR102 and Spain with ES300. It is noteworthy that within the first 25 and considering the frequency of appearance, Germany maintains its role of centrality, followed by Spain.

Table 26. Ranking of local regions according to their centrality position in 2000-2013. Country and centrality value are added. Solar sector. Source: own elaboration.

Position	NUTS 3	Country	Centrality value
1	DE212	DE	0.4314
2	FR102	FR	0.4135
3	ES300	ES	0.3961
4	ITE43	IT	0.3787
5	ES511	ES	0.3408
6	BE100	BE	0.3384
7	DE111	DE	0.3300
8	ITC45	IT	0.3175
9	FI181	FI	0.3141
10	DE300	DE	0.3072
11	EL303	GR	0.2986
12	ITC11	IT	0.2963
13	AT130	AT	0.2944
14	UKI11	GB	0.2934
15	DEA23	DE	0.2866
16	CH040	CH	0.2806

17	IE021	IE	0.2752
18	ES212	ES	0.2745
19	DK012	DK	0.2744
20	HU101	HU	0.2669
21	CH011	CH	0.2663
22	CZ010	CZ	0.2656
23	FR105	FR	0.2654
24	BE242	BE	0.2650
25	NL333	NL	0.2622

In relation to the sea renewable energy sector (Table 27), Ireland with IE025, Denmark with DK050 and Great Britain with UKM25 lead the top three positions. However, Great Britain is positioned as the central country in the network with 6 regions in the first 25.

Table 27. Ranking of local regions according to their centrality position in 2000-2013. Country and centrality value are added. Sea energy sector. Source: own elaboration.

Position	NUTS 3	Country	Centrality value
1	IE025	IE	0.3961
2	DK050	DK	0.3671
3	UKM25	GB	0.3588
4	DE212	DE	0.3575
5	PT114	PT	0.3506
6	EL303	GR	0.3487
7	DK001	DK	0.3461
8	DK012	DK	0.3419
9	ITE43	IT	0.3389
10	FR102	FR	0.3337
11	UKJ33	GB	0.3257
12	UKJ32	GB	0.3248
13	PT172	PT	0.3216
14	UKI11	GB	0.3160
15	SE232	SE	0.3157
16	ES130	ES	0.3088
17	BG331	BG	0.2982

18	FR105	FR	0.2975
19	DK013	DK	0.2889
20	UKM34	GB	0.2868
21	UKJ14	GB	0.2832
22	NL333	NL	0.2794
23	EL305	GR	0.2789
24	ITD55	IT	0.2772
25	BE100	BE	0.2739

The geothermal sector (Table 28) presents a distributed ranking in relation to the local regions involved in public R&D projects. In this case, France with its region FR102, Romania with RO111 and Greece with EL305 lead the ranking. However, considering the frequency of occurrence, Germany is the most central with 4 different regions in the top 25.

Table 28. Ranking of local regions according to their centrality position in 2000-2013. Country and centrality value are added. Geothermal sector. Source: own elaboration.

Position	NUTS 3	Country	Centrality value
1	FR102	FR	0.3839
2	RO111	RO	0.3553
3	EL305	GR	0.3489
4	ES300	ES	0.3476
5	BE100	BE	0.3054
6	NL333	NL	0.2835
7	HU101	HU	0.2805
8	FR246	FR	0.2804
9	NL326	NL	0.2763
10	EL303	GR	0.2750
11	ITE43	IT	0.2731
12	DE423	DE	0.2686
13	EL522	GR	0.2673
14	DE929	DE	0.2614
15	ITC45	IT	0.2550
16	PL127	PL	0.2529
17	CH040	CH	0.2502

18	DK001	DK	0.2474
19	EL301	GR	0.2460
20	DEA51	DE	0.2400
21	PT172	PT	0.2346
22	AT224	AT	0.2279
23	FR106	FR	0.2277
24	LT00A	LT	0.2239
25	DE276	DE	0.2213

With respect to the biomass sector (Table 29), the ranking is led by Spain with ES300, Italy with ITE43 and Finland with FI181. However, the Netherlands and Sweden have more local regions in the top 25, followed by Denmark, Austria, Germany and Spain.

Table 29. Ranking of local regions according to their centrality position in 2000-2013. Country and centrality value are added. Biomass sector. Source: own elaboration.

Position	NUTS 3	Country	Centrality value
1	ES300	ES	0.38011
2	ITE43	IT	0.38415
3	FI181	FI	0.37638
4	FR102	FR	0.37000
5	BE100	BE	0.35799
6	DE212	DE	0.35446
7	AT130	AT	0.32727
8	NL221	NL	0.32494
9	UKI11	GB	0.31934
10	DK012	DK	0.31797
11	SE110	SE	0.31188
12	AT221	AT	0.31097
13	PT172	PT	0.30776
14	NL213	NL	0.30684
15	SE121	SE	0.30319
16	NL333	NL	0.30198
17	EL303	GR	0.29883
18	DE111	DE	0.29478

19	EL522	GR	0.29449
20	PL127	PL	0.28399
21	NL322	NL	0.28166
22	DK001	DK	0.27926
23	ITC45	IT	0.27832
24	ES511	ES	0.27366
25	SE232	SE	0.27227

For a better understanding of these tables and contents, in the chapter of annexes (Annex F) the geographic maps can be observed for each of the treated sectors, and visualizing all the local regions of each country with a colour according to their centrality value.

7.4.2.Structural Holes Approach

7.4.2.1. Structural Hole existence

To analyse the existence of Structural Holes in RE networks, the betweenness centrality measure is used, showing the degree to which one node is playing a role of bridging or brokering within the network (Choe et al. 2016). As demonstrated and described in point 5.6.3, areas between the core and the peripheral nodes with almost no collaboration links, called structural holes in SNA (Figure 49), hamper the efficiency of cohesion and knowledge transfer.

This fact is demonstrated by low betweenness centrality for peripheral nodes and high for core nodes, with the existence of key nodes that perform the role of bridging the two edges of structural holes, taking the control of knowledge transfer (the collaboration done through them) and having higher potential influence over whole network than most central players (Kang & Park 2013).

These benefit from structural holes since not only do they have information from their own projects (as peripheral nodes also have) but also a more comprehensive understanding of information flow in the entire network (European Commission 2015).

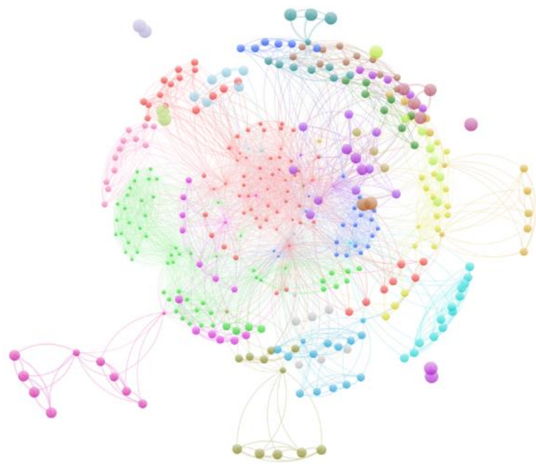


Figure 49. Example of SH existence. Sea organizational network for 2000-2013 with size of the nodes according their structural hole value. *Source: own elaboration.*

To analyze the existence of structural holes, identifying the type of partners obtaining an advantage from Structural Holes and those surrounded by them, a heat map of betweenness scores for partners was produced (European Commission 2015), dividing them in deciles according their scores (Figure 50). The first decile corresponds to the 10% highest scores and the 10th decile to the 10% lowest.

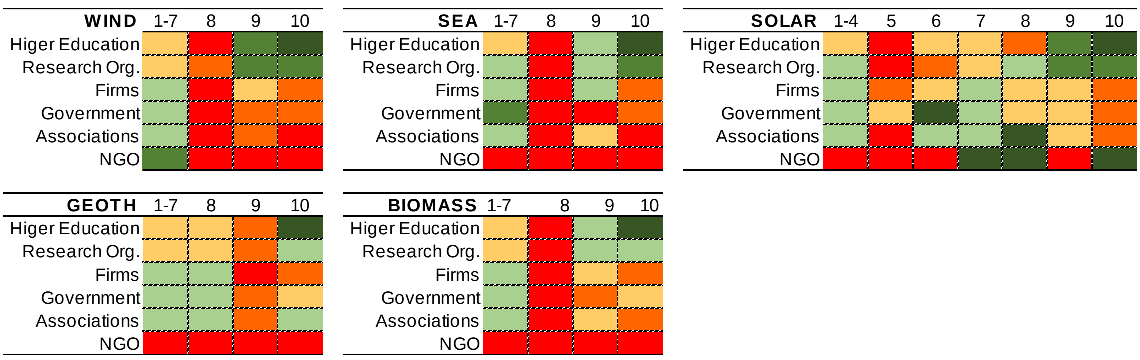


Figure 50. Structural Holes: Identification of type of partners. Those deriving an advantage from Structural Holes and those surrounded by them. Source: own elaboration.

Assuming a uniform distribution of partners in each decile (expected 10%), the following color scale was used in Fig. 14 to show the deviation from ideal 10%: red (<-33%), orange-red (-33%/-66%), orange (-66%/100%), turquoise (100%/+33%), olive (+33%/+66%) and green (>66%).

Wind, Sea and Biomass sectors show a similar pattern. On the one hand, higher education and research organizations are located more in highest values of betweenness and less in lowest ones. This fact means that they take part in multiple projects, gaining in centrality and obtaining an advantage from the existence of structural holes (European Commission 2015). On the other hand, firms, government and associations show the opposite pattern, resulting in organizations surrounded by structural holes. This pattern seems to be more uniform as well as regular, especially for solar and geothermal sectors.

7.4.2.2. Structural Holes: Organizations

To analyze the type of structural hole partner, a heat map of the structural hole feature proposed by Burt (Burt 1992) is used. In our research, as detailed in point 6.5.2, from the four possible measures for analyzing structural hole features of actors (Effect Size, Efficiency, Constraints and Hierarchy) (Negro et al. 2012; Borgatti et al. 2002), we used Constraints.

Following the same methodology as in the previous chapter and distributing partners in deciles (decile 1 corresponds to lowest value of constraint indicator) a heat map is produced. These were colored according to their deviation from the ideal value (10% of the partners distributed in each bin) supposed for homogeneous networks (Figure 51). Only the 1st, 2nd and 3rd deciles are represented as they show the main information.

WIND	D1	D2	D3
Higer Education	56	33	28
Research Org.	49	41	36
Firms	62	99	90
Government	6	5	7
Associations	3	9	3
NGO	0	1	0

SEA	D1	D2	D3
Higer Education	17	21	6
Research Org.	10	14	5
Firms	9	15	12
Government	1	3	3
Associations	1	0	2
NGO	0	0	0

SOLAR	D1	D2	D3
Higer Education	117	69	41
Research Org.	96	64	61
Firms	123	189	182
Government	14	28	45
Associations	10	22	20
NGO	1	1	1

GEOTH	D1	D2	D3
Higer Education	3	4	4
Research Org.	24	6	6
Firms	12	7	15
Government	2	1	1
Associations	3	1	3
NGO	0	0	0

BIOMAS	D1	D2	D3
Higer Education	84	34	42
Research Org.	84	76	40
Firms	70	116	154
Government	16	21	28
Associations	7	15	12
NGO	0	0	0

Figure 51. Identification of type of partners being structural holes. Their absolute number in each decile. Source: own elaboration.

It is concluded that in wind and solar sectors, firms, higher education and research centers respectively show the predominance rate while for the rest of the deciles, the predominance of firms is especially noticeable. For sea and biomass sectors, higher education, research centers and firms respectively represent the key players. The Geothermal sector shows a different pattern: research centers are predominant followed by firms and higher education seems to be in a weaker position.

The following tables show the ranking of the organizations that show the best position with respect to the structural hole category based on the SNA Constraint indicator described in Chapters 5.6.3 and 6.5.2.

Table 30 identifies organizations in the wind sector. It is observed that, although in the first three positions we find research centers, universities and companies, in the total ranking of 25, the companies are those that more appear, followed by universities and research centers. Then, the companies play a bridge role between different groups or areas of actors in the network, enabling efficiently the cohesion and transmission of information and knowledge.

Table 30. Ranking of organizations according to their structural hole position in 2000-2013. Type, country, local region and structural hole value are added. Wind sector. Source: own elaboration.

P.	Organization	Type	Country	NUTS_3	SH value
1	FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.	2	DE	DEA32	0.0171
2	UNIVERSITY OF TECHNOLOGY OF DENMARK	1	DK	DK012	0.0178
3	ACCIONA S.A.	3	ES	ES220	0.0211
4	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	2	FR	FR102	0.0216
5	FUNDACION TECNALIA RESEARCH AND INNOVATION	2	ES	ES212	0.0257
6	UNIVERSITY OF TECHNOLOGY OF AACHEN	1	DE	DEA21	0.0258
7	UNIVERSITY OF TECHNOLOGY OF MILAN	1	IT	ITC11	0.0269
8	3E N.V.	3	BE	BE100	0.0272
9	GAMESA	3	DK	DK042	0.0278
10	Siemens	3	IT	ITC45	0.0287
11	UNIVERSITY OF TECHNOLOGY OF DELFT	1	NL	NL333	0.0288
12	ALSTOM	3	SE	SE123	0.0289
13	E.ON	3	NL	NL335	0.0297
14	CENTER FOR RENEWABLE ENERGY SOURCES - CRES	2	GR	EL305	0.0298
15	UNIVERSITY OF STUTTGART	1	DE	DE111	0.0298
16	DONG ENERGY	3	GB	UKI11	0.0298
17	EUROPEAN WIND ENERGY ASSOCIATION	5	BE	BE100	0.0299
18	KATHOLIEKE UNIVERSITEIT LEUVEN	1	BE	BE242	0.0305
19	Ente Nazionale per l Energia Elettrica SpA (ENEL)	4	IT	ITE43	0.0306
20	CONSIGLIO NAZIONALE DELLE RICHERCHE	2	IT	ITE43	0.0309
21	EDF	3	FR	FR105	0.0309
22	UNIVERSITY OF AALBORG	1	DK	DK050	0.0315
23	GARRAD HASSAN AND PARTNERS LTD	3	GB	UKK11	0.0319
24	UNIVERSITY COLLEGE CORK, NATIONAL UNIVERSITY OF IRELAND, CORK	1	IE	IE025	0.0320
25	STICHTING ENERGIEONDERZOEK CENTRUM NEDERLAND	2	NL	NL322	0.0322

For the organizations of the solar sector (Table 31), it is observed that the research centers are the leaders in the first positions for the total ranking of the first 25. The universities play a minor role, while the companies are virtually non-existent. This shows that, in the solar sector, the research centers are those that efficiently link the network of all the organizations involved in the projects.

Table 31. Ranking of organizations according to their structural hole position in 2000-2013. Type, country, local region and structural hole value are added. Solar sector. Source: own elaboration.

P.	Organization	Type	Country	NUTS_3	SH value
1	FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.	2	DE	DEA32	0.0068
2	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	2	FR	FR102	0.0116
3	COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES	4	FR	FR824	0.0128
4	CENTER FOR RENEWABLE ENERGY SOURCES - CRES	2	GR	EL305	0.0139
5	UNIVERSITY OF TECHNOLOGY OF MILAN	1	IT	ITC11	0.0141
6	UNIVERSITY OF STUTTGART	1	DE	DE111	0.0152
7	T.N.O.	2	NL	NL333	0.0160
8	Centro de Investigaciones Energeticas Medioambientales y Tecnologicas - CIEMAT	2	ES	ES300	0.0160
9	CONSIGLIO NAZIONALE DELLE RICHERCHE	2	IT	ITE43	0.0168
10	EDF	3	FR	FR105	0.0184
11	UNIVERSITY OF TECHNOLOGY OF WARSAW	1	PL	PL127	0.0201
12	UNIVERSITY OF TECHNOLOGY OF DENMARK	1	DK	DK012	0.0212
13	FORSCHUNGSZENTRUM JUELICH GMBH	2	DE	DE300	0.0215
14	ECOLE POLYTECHNIQUE FEDERALE DE LAUSANNE	1	CH	CH011	0.0219
15	DEUTSCHES ZENTRUM FUER LUFT UND RAUMFAHRT E.V.	2	DE	DE111	0.0220
16	FUNDACION TECNALIA RESEARCH AND INNOVATION	2	ES	ES212	0.0222
17	CENTRO RICERCHE FIAT S.C.P.A.	2	IT	ITC11	0.0223
18	NATIONAL TECHNICAL UNIVERSITY OF ATHENS	1	GR	EL303	0.0224
19	UNIVERSITY OF TECHNOLOGY OF WIEN	1	AT	AT130	0.0230
20	EIDGENOESSISCHE MATERIALPRUEFUNGS- UND FORSCHUNGSANSTALT	2	CH	CH040	0.0234
21	TEKNOLOGIAN TUTKIMUSKESKUS VTT	2	FI	FI181	0.0235
22	UNIVERSITY OF ATHENS	1	GR	EL303	0.0240
23	CENERGIA ENERGY CONSULTANTS	3	DK	DK012	0.0243
24	COMMISSION OF THE EUROPEAN COMMUNITIES	4	IT	ITC41	0.0243
25	KUNGLIGA TEKNISKA HOEGSKOLAN	2	SE	SE110	0.0244

Regarding the ranking of organizations for the sea energy sector (Table 32), it is observed that the universities play the role of facilitating and allowing the transmission of information and technological knowledge, enhancing the cohesion of groups of organizations that are not in the central core of the total network. The research centers and companies would have a similar weight in the total ranking. However, the first position of the ranking is for a company.

Table 32. Ranking of organizations according to their structural hole position in 2000-2013. Type, country, local region and structural hole value are added. Sea energy sector. Source: own elaboration.

P.	Organization	Type	Country	NUTS_3	SH value
1	IT POWER LTD.	3	GB	UKJ37	0.0380
2	UNIVERSITY OF SOUTHAMPTON	1	GB	UKJ32	0.0397
3	UNIVERSITY OF TECHNOLOGY OF CHALMERS	1	SE	SE232	0.0398
4	UNIVERSITY COLLEGE CORK, NATIONAL UNIVERSITY OF IRELAND, CORK	1	IE	IE025	0.0401
5	UNIVERSITY OF AALBORG	1	DK	DK050	0.0423
6	UNIVERSITY OF EDINBURGH	1	GB	UKM25	0.0429
7	DHI	2	DK	DK013	0.0470
8	FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.	2	DE	DEA32	0.0474
9	WAVE ENERGY CENTRE - CENTRO DE ENERGIA DAS ONDAS	2	PT	PT114	0.0486
10	ECOFYS B.V.	3	NL	NL310	0.0524
11	UNIVERSITY OF TECHNOLOGY OF DENMARK	1	DK	DK012	0.0528
12	UNIVERSITY OF BOLOGNA	1	IT	ITD55	0.0553
13	INSTITUTO SUPERIOR TECNICO	2	PT	PT172	0.0557
14	UNIVERSITY OF STRATHCLYDE	1	GB	UKM34	0.0576
15	WAVE DRAGON APS	3	DK	DK001	0.0605
16	STICHTING ENERGIEONDERZOEK CENTRUM NEDERLAND	2	NL	NL322	0.0630
17	Ente Nazionale per l Energia Elettrica SpA (ENEL)	4	IT	ITE43	0.0630
18	CENTER FOR RENEWABLE ENERGY SOURCES - CRES	2	GR	EL305	0.0636
19	UNIVERSITY OF TECHNOLOGY OF MUNICH	1	DE	DE212	0.0638
20	ECOLE CENTRALE DE NANTES	1	FR	FR511	0.0642
21	UNIVERSITY OF GENT	1	BE	BE234	0.0643
22	UNIVERSITY OF UPPSALA	1	NL	NL221	0.0649
23	EDF	3	FR	FR105	0.0649

24	INSTITUT FRANCAIS DE RECHERCHE POUR L EXPLOITATION DE LA MER	2	FR	FR105	0.0649
25	TEAMWORK TECHNOLOGY BV	3	NL	NL321	0.0658

The table below shows the ranking for the geothermal sector (Table 33). It is verified that the research centers are the leaders of the whole ranking, even especially the first positions. Companies have little representation. It is possible to emphasize the little representation of universities in the ranking of this sector.

Table 33. Ranking of organizations according to their structural hole position in 2000-2013. Type, country, local region and structural hole value are added. Geothermal sector. Source: own elaboration.

P.	Organization	Type	Country	NUTS_3	SH value
1	T.N.O.	2	NL	NL333	0.0522
2	CENTER FOR RENEWABLE ENERGY SOURCES - CRES	2	GR	EL305	0.0536
3	UNIVERSITY OF ORADEA	1	RO	RO111	0.0553
4	BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES	2	FR	FR246	0.0574
5	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	2	FR	FR102	0.0649
6	CONSIGLIO NAZIONALE DELLE RICHERCHE	2	IT	ITE43	0.0740
7	GEOWATT AG	3	CH	CH040	0.0831
8	CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS	2	GR	EL522	0.0844
9	GROUPEMENT EUROPEEN D INTERET ECONOMIQUE EXPLOITATION MINIERE DE LA CHALEUR	5	FR	DE276	0.0885
10	GEOPRODUCTION CONSULTANTS GPC SA	3	FR	FR108	0.0892
11	GEOFORSCHUNGSZENTRUM POTSDAM	2	DE	DE423	0.0927
12	DEEP HEAT MINING ASSOCIATION	5	CH	CH040	0.0978
13	MESY GEO MESS SYSTEME GMBH	3	DE	DEA51	0.0978
14	NATIONAL CENTER FOR SCIENTIFIC RESEARCH DEMOKRITOS	2	GR	EL301	0.1006
15	SHELL	3	NL	NL333	0.1006
16	VERENIGING VOOR CHRISTELIJK HOGER ONDERWIJS WETENSCHAPPELIJK ONDERZOEK EN PATIENTENZORG	2	NL	NL326	0.1006
17	CFG SERVICES SAS	3	FR	FR246	0.1006
18	DANMARKS OG GROENLANDS GEOLOGISKE UNDERSOEGELSE	2	DK	DK001	0.1006
19	EOTVOS LORAND TUDOMANYEGYETEM.	2	HU	HU101	0.1006

20	FILTECH ENERGY DRILLING CORPORATION	3	PH	PH	0.1006
21	GEOLOGIJOS IR GEOGRAFIJOS INSTITUTAS	2	LT	LT00A	0.1006
22	INSTITUT FUER GEOWISSENSCHAFTLICHE GEMEINSCHAFTSAUFGABEN	2	DE	DE929	0.1006
23	INSTITUTO GEOLOGICO Y MINERO DE ESPANA	2	ES	ES300	0.1006
24	PANSTWOWY INSTYTUT GEOLOGICZNY - POLISH GEOLOGICAL INSTITUTE	2	PL	PL127	0.1006
25	INSTITUT FUER ENERGETIK UND UMWELT GMBH	2	DE	DED31	0.1006

In relation to the biomass sector (Table 34), the total ranking of "structural holes" is led by the research centers, followed by the universities to a lesser extent. However, there is practically no representation of companies in the top 25 of the ranking.

Table 34. Ranking of organizations according to their structural hole position in 2000-2013. Type, country, local region and structural hole value are added. Biomass sector. Source: own elaboration.

P.	Organization	Type	Country	NUTS_3	SH value
1	IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE	1	GB	UKI11	0.0120
2	FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.	2	DE	DEA32	0.0124
3	CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS	2	GR	EL522	0.0128
4	B.T.G. BIOMASS TECHNOLOGY GROUP BV	3	NL	NL213	0.0136
5	TEKNOLOGIAN TUTKIMUSKESKUS VTT	2	FI	FI181	0.0137
6	UNIVERSITY OF STUTTGART	1	DE	DE111	0.0140
7	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	2	FR	FR102	0.0141
8	UNIVERSITY OF TECHNOLOGY OF DENMARK	1	DK	DK012	0.0142
9	SWEDISH UNIVERSITY OF AGRICULTURAL SCIENCES	1	SE	SE121	0.0144
10	T.N.O.	2	NL	NL333	0.0149
11	CENTER FOR RENEWABLE ENERGY SOURCES - CRES	2	GR	EL305	0.0152
12	STICHTING DIENST LANDBOUWKUNDIG ONDERZOEK	4	NL	NL221	0.0153
13	UNIVERSITY OF LUND	1	SE	SE224	0.0161
14	CSIC CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS	2	ES	ES300	0.0162
15	NATIONAL TECHNICAL UNIVERSITY OF ATHENS	1	GR	EL303	0.0163
16	EUROPEAN BIOMASS INDUSTRY ASSOCIATION	5	BE	BE100	0.0167

17	VALTION TEKNILLINEN TUTKIMUSKESKUS (TECHNICAL RESEARCH CENTRE OF FINLAND)	2	FI	FI181	0.0168
18	Centro de Investigaciones Energeticas Medioambientales y Tecnologicas - CIEMAT	2	ES	ES300	0.0173
19	ENERGY RESEARCH CENTRE OF THE NETHERLANDS	2	NL	NL322	0.0183
20	INSTITUT NATIONAL DE LA RECHERCHE AGRONOMIQUE	2	FR	FR811	0.0183
21	CONSIGLIO NAZIONALE DELLE RICHERCHE	2	IT	ITE43	0.0188
22	STICHTING ENERGIEONDERZOEK CENTRUM NEDERLAND	2	NL	NL322	0.0199
23	UNIVERSITY OF WAGENINGEN	1	NL	NL221	0.0201
24	WIRTSCHAFT UND INFRASTRUKTUR GMBH AND CO PLANUNGS KG	3	DE	DE212	0.0209
25	UNIVERSITY OF TECHNOLOGY OF DELFT	1	NL	NL333	0.0210

7.4.2.3. Structural Holes: Local Regions

To conclude this section of analysis, the tables for structural hole rankings for the renewable sectors under study from the point of view of local regions (NUTS3) are shown below.

The following table corresponds to the ranking of the wind sector (Table 35). It is observed that Germany and Italy lead the ranking, although in the first two positions is placed Spain, with its organizations distributed by different local regions.

Table 35. Ranking of local regions according to their structural hole position in 2000-2013. Country and the value of structural hole are added. Wind sector. Source: own elaboration.

P.	NUTS 3	Country	SH value
1	ES511	ES	0.0334
2	ES300	ES	0.0360
3	DE111	DE	0.0376
4	BE100	BE	0.0383
5	ITC33	IT	0.0387
6	FI181	FI	0.0393
7	ITE43	IT	0.0395
8	NL333	NL	0.0403
9	ITC11	IT	0.0413

10	ITC45	IT	0.0413
11	DE21H	DE	0.0416
12	FR102	FR	0.0419
13	NL310	NL	0.0419
14	DEA23	DE	0.0420
15	DE212	DE	0.0427
16	CH040	CH	0.0427
17	CZ010	CZ	0.0428
18	DE600	DE	0.0429
19	UKI11	GB	0.0431
20	AT130	AT	0.0442
21	DK012	DK	0.0443
22	DK050	DK	0.0444
23	PL127	PL	0.0446
24	EL305	GR	0.0450
25	UKD53	GB	0.0454

With respect to the solar sector (Table 36), it is observed that, although the ITC11 region of Italy holds the first position, it is Spain, Germany and Great Britain that lead the whole ranking.

Table 36. Ranking of local regions according to their structural hole position in 2000-2013. Country and the value of structural hole are added. Solar sector. Source: own elaboration.

P.	**NUTS 3**	**Country**	**SH value**
1	ITC11	IT	0.0323
2	DK012	DK	0.0329
3	UKD53	GB	0.0336
4	ES523	ES	0.0337
5	DE212	DE	0.0339
6	ES511	ES	0.0349
7	UKJ14	GB	0.0351
8	HU101	HU	0.0353
9	ITE43	IT	0.0355
10	CH021	CH	0.0356
11	FR102	FR	0.0357

12	UKM34	GB	0.0358
13	ITD55	IT	0.0367
14	DE300	DE	0.0367
15	DE111	DE	0.0371
16	UKI11	GB	0.0373
17	AT221	AT	0.0375
18	AT130	AT	0.0379
19	ITC45	IT	0.0380
20	ES300	ES	0.0381
21	EL632	GR	0.0381
22	CZ010	CZ	0.0384
23	DE600	DE	0.0385
24	FI181	FI	0.0386
25	FR714	FR	0.0386

In the following (Table 37) the ranking for the sea energy sector is shown. Although Spain with the local region ES130 is in the first position, Great Britain leads the total ranking, followed by Denmark, Italy and Greece.

Table 37. Ranking of local regions according to their structural hole position in 2000-2013. Country and the value of structural hole are added. Sea energy sector. Source: own elaboration.

P.	**NUTS 3**	**Country**	**SH value**
1	ES130	ES	0.0604
2	EL303	GR	0.0607
3	FR102	FR	0.0608
4	BG331	BG	0.0618
5	UKJ33	GB	0.0626
6	DK050	DK	0.0638
7	IE025	IE	0.0643
8	DK001	DK	0.0673
9	ITD55	IT	0.0680
10	EL522	GR	0.0686
11	UKM25	GB	0.0688
12	UKI11	GB	0.0693

13	DK012	DK	0.0698
14	DE212	DE	0.0698
15	UKJ32	GB	0.0702
16	FR105	FR	0.0724
17	PT114	PT	0.0727
18	ITE43	IT	0.0740
19	EL305	GR	0.0749
20	PL127	PL	0.0749
21	UKL15	GB	0.0752
22	UKJ14	GB	0.0755
23	SE232	SE	0.0761
24	ITD35	IT	0.0774
25	PT172	PT	0.0775

The table below (Table 38) represents the ranking of the local regions of the geothermal sector, according to their efficiency in connecting almost isolated areas of the total network. In this sector, although the first three positions are for Belgium, Romania and Spain, the leader of the whole table corresponds to Greece, France, Italy, followed by Germany and the Netherlands.

Table 38. Ranking of local regions according to their structural hole position in 2000-2013. Country and the value of structural hole are added. Geothermal sector. Source: own elaboration.

P.	**NUTS 3**	**Country**	**SH value**
1	BE100	BE	0.0707
2	RO111	RO	0.0718
3	ES300	ES	0.0747
4	FR102	FR	0.0777
5	EL305	GR	0.0805
6	NL326	NL	0.0891
7	EL303	GR	0.0911
8	NL333	NL	0.0929
9	ITC45	IT	0.0956
10	EL522	GR	0.0973
11	HU101	HU	0.0983
12	FR246	FR	0.1016

13	PL127	PL	0.1030
14	ITE43	IT	0.1041
15	EL301	GR	0.1087
16	PT172	PT	0.1126
17	AT224	AT	0.1150
18	FR106	FR	0.1157
19	DE423	DE	0.1178
20	DK001	DK	0.1192
21	CH040	CH	0.1199
22	ITC33	IT	0.1236
23	LT00A	LT	0.1241
24	SI021	SI	0.1270
25	DE929	DE	0.1320

With respect to the energy sector of biomass, the table below (Table 39) shows the first 25 local regions that lead the sector in terms of their value of "structural hole". The first three positions are for Finland, Germany and France. However, the leadership of the ranking is for local regions from Netherlands, followed by Sweden and Great Britain. Finally, to a lesser extent, Austria, Germany, Italy and Greece.

Table 39. Ranking of local regions according to their structural hole position in 2000-2013. Country and the value of structural hole are added. Biomass sector. Source: own elaboration.

P.	**NUTS 3**	**Country**	**SH value**
1	FI181	FI	0.0259
2	DE212	DE	0.0270
3	FR102	FR	0.0271
4	NL221	NL	0.0273
5	ITE43	IT	0.0273
6	AT221	AT	0.0273
7	NL213	NL	0.0276
8	BE100	BE	0.0278
9	DK012	DK	0.0291
10	ES300	ES	0.0297
11	UKI11	GB	0.0298

12	NL333	NL	0.0300
13	ITC45	IT	0.0303
14	SE110	SE	0.0304
15	UKJ14	GB	0.0306
16	NL310	NL	0.0309
17	SE121	SE	0.0312
18	AT130	AT	0.0315
19	UKI12	GB	0.0318
20	EL522	GR	0.0318
21	NL326	NL	0.0322
22	EL303	GR	0.0325
23	DE600	DE	0.0325
24	PT172	PT	0.0326
25	SE232	SE	0.0327

The compression of this data is made easier with the help of geographic maps that are available in the annexes chapter (Annex G). There the local regions that are part of projects in these sectors can be visualized for each renewable energy sector under study, showing them with coloured in a scale according to their "structural hole" value.

7.4.3.Matrix analysis, based on SH and Centrality indicators measures

Since a centrality based approach has been widely used to provide information about the importance of node position in networks (see point 7.4.1.), both structural hole and centrality approaches were used in this research work to carry out matrix analysis and understand the overall importance of the connectivity feature of organizations and local regions in RE networks.

Calculating the centrality indicator as the average value of degree, betweenness and closeness of each node, and the structural hole value as a network constraint proposed by Burt (Burt 2008), The following figure (Figure 52) shows the exponential trend lines for each sector. A rapid fall of structural hole rates at higher rates of centrality is observed for Biomass, solar and wind sectors, while Sea and especially Geothermal have a more linear fall rate. This means that emergent sectors are still less effective in terms of knowledge transmission.

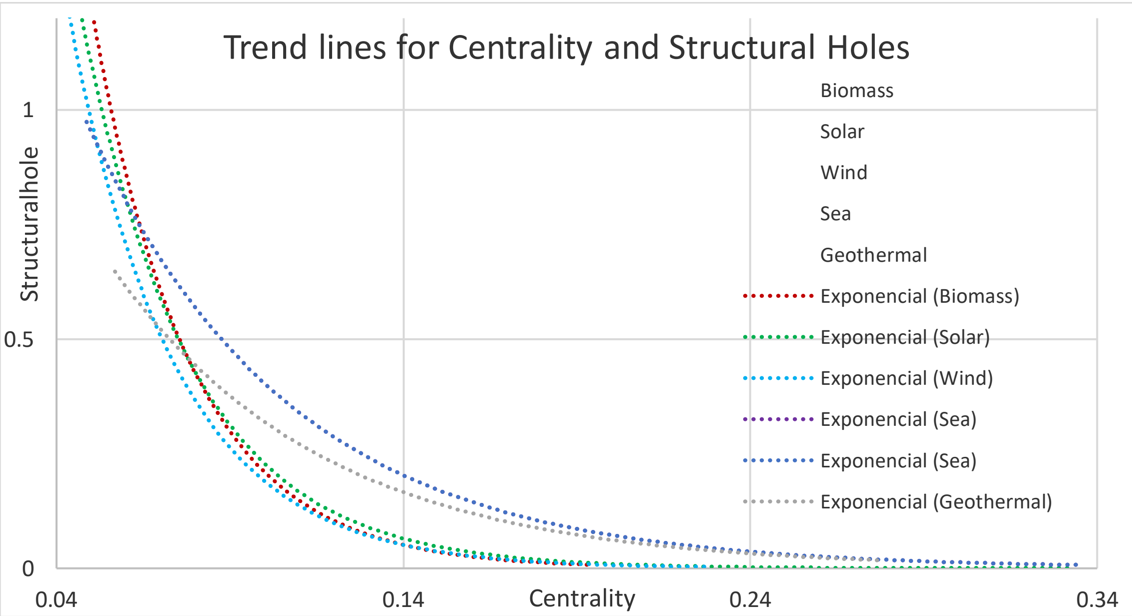


Figure 52. Exponential trend lines for Centrality and Structural Holes at organizational level. R2 factor for each RE sector: Wind (0.7021), Solar (0.5933), Biomass (0.6352), Geothermal (0.7348) and Sea (0.774). Source: own elaboration.

The following tables (Table 40-41) show, for example, the indexes of the correlation that exist between the centrality indicators ("degree", "closeness", "betweenness") and "Structural holes", for organizations and local regions, both from the point of view of the node (ego) and the whole network (Net).

Table 40. Table of correlations for organization networks. Source: own elaboration.

WIND	CENT	SHego	SHNet
CENT	1		
SHego	-0.692606	1	
SHNet	-0.817820	0.906916	1
SOLAR	CENT	SHego	SHNet
CENT	1		
SHego	-0.571489	1	
SHNet	-0.772905	0.857200	1
SEA	CENT	SHego	SHNet
CENT	1		
SHego	-0.776662	1	
SHNet	-0.806483	0.946262	1
GEOTH	CENT	SHego	SHNet
CENT	1		
SHego	-0.660816	1	
SHNet	-0.714839	0.953750	1
BIOMASS	CENT	SHego	SHNet
CENT	1		
SHego	-0.685917	1	
SHNet	-0.779556	0.92634	1

Table 41. Table of correlations for local region networks. Source: own elaboration.

WIND	CENT	SHego	SHNet
CENT	1		
SHego	-0.688685	1	
SHNet	-0.631960	0.898160	1
SOLAR	CENT	SHego	SHNet
CENT	1		
SHego	-0.664001	1	
SHNet	-0.593473	0.872726	1
SEA	CENT	SHego	SHNet
CENT	1		
SHego	-0.761402	1	
SHNet	-0.742472	0.902922	1
GEOTH	CENT	SHego	SHNet
CENT	1		
SHego	-0.778191	1	
SHNet	-0.778048	0.876481	1
BIOMASS	CENT	SHego	SHNet
CENT	1		
SHego	-0.667935	1	
SHNet	-0.609097	0.896916	1

On the one hand, for the network of organizations, these correlation indices show that there is a high degree of negative relationship between network structural hole with centrality (in this case between -0.71 and 0.81), and moderate negative for ego's "structural hole" with centrality (-0.57 to -0.69), except for the sea energy sector which is high (-0.77).

With respect to the network of the local regions, there is a moderate negative relation of both network and ego structural hole with centrality (-0.6 to -0.68). However, this ratio is strong negative for the sea energy sector (-0.74 to -0.77).

The most influential organizations and local regions in each of the sectors can be analysed, considering both the centrality and the "structural hole" values.

The following two tables (Tables 42 and 43) represent the ranking of the first 10 organizations for an integrated ranking of centrality and structural hole.

Table 42. Integrated ranking for centrality and structural holes applied to organization networks. Sectors: wind, solar, sea. Period of 2000-2013. Source: own elaboration.

	Wind		**Solar**		**Sea**	
	Cent	**Shnet**	**Cent**	**Shnet**	**Cent**	**Shnet**
1	Uni.Tec. Denmark	Fraunhofer	Fraunhofer	Fraunhofer	Uni. Cork	IT Power LTD.
2	Fraunhofer	Uni. Techn. Denmark	CNRS	CNRS	Uni. Edinburgh	Uni. Southmpton
3	Center RES	Acciona S.A.	CEAEA	CEAEA	IT Power LTD.	Uni. Tec. Chalmers
4	Acciona S.A.	CNRS	CIEMAT RC	Center RES	Uni. Aalborg	Uni. Cork
5	Riso Nat. Lab.	Tecnalia RC	T.N.O	Uni. Techn. Milan	Uni. Tec. Chalmers	Uni. Aalborg
6	CNRS	Uni. Tec. Aachen	Uni. Tec. Milan	Uni. Stuttgart	Wave Energy Centre	Uni. Edinburgh
7	Garrad H&P Ltd	Uni. Tec. Milan	Center RES	T.N.O	Uni. Southmpton	DHI
8	Tecnalia RC	3E N.V.	Uni. Stuttgart	CIEMAT RC	Inst. Sup. Tecnico	Fraunhofer
9	Dong Energy	Gamesa S.A.	CN Richerche	CN Richerche	Fraunhofer	Wave Energy Centre
10	Gamesa S.A.	Siemens	EDF	EDF	Uni. Tec. Denmark	Ecofys B.V.

Table 43. Integrated ranking for centrality and structural holes applied to organization networks. Sectors: geothermal and biomass. Period of 2000-2013. Source: own elaboration.

	Geothermal		**Biomass**	
	Cent	**Shnet**	**Cent**	**Shnet**
1	Center RES	T.N.O	Uni. Stuttgart	Fraunhofer
2	T.N.O	Center RES	Fraunhofer	Hellas RC
3	Uni. Oradea	Uni. Oradea	Hellas RC	B.T.G. B.V.
4	BR Geo. Minieres	BR Geo. Minieres	CNRS	Tekn. Tutk. VTT
5	CNRS	CNRS	B.T.G. B.V.	Uni. Stuttgart
6	CN Richerche	CN Richerche	Uni. Tec. Denmark	CNRS
7	GEE Min. Chaleur	Geowatt A.G.	Sweedish Uni. Agric.	Uni. Tec. Denmark

8	Geowatt A.G.	Hellas RC	Tekn. Tutk. VTT	Sweedish Uni. Agric.
9	Geof. Zentr. Postdam	GEE Min. Chaleur	Center RES	T.N.O
10	Hellas RC	Geo. Consult. S.A.	Nat. Tec. Uni. Athens	CRES

To analyze and understand better the situation of these organizations, different graph-matrices are made for each sector.

The following figures (Figure 53-Figure 57) represent the 15 organizations which are most central and non-redundant in terms of information and knowledge transmission. Since they are central players, due to their high centrality values, their connections show efficiency and effectiveness by economizing on the number of collaboration links required to transfer unique knowledge and information (low network constraint values). In fact, they act as a broker between disconnected nodes and provide the network with more cohesion (Baum et al. 2003).

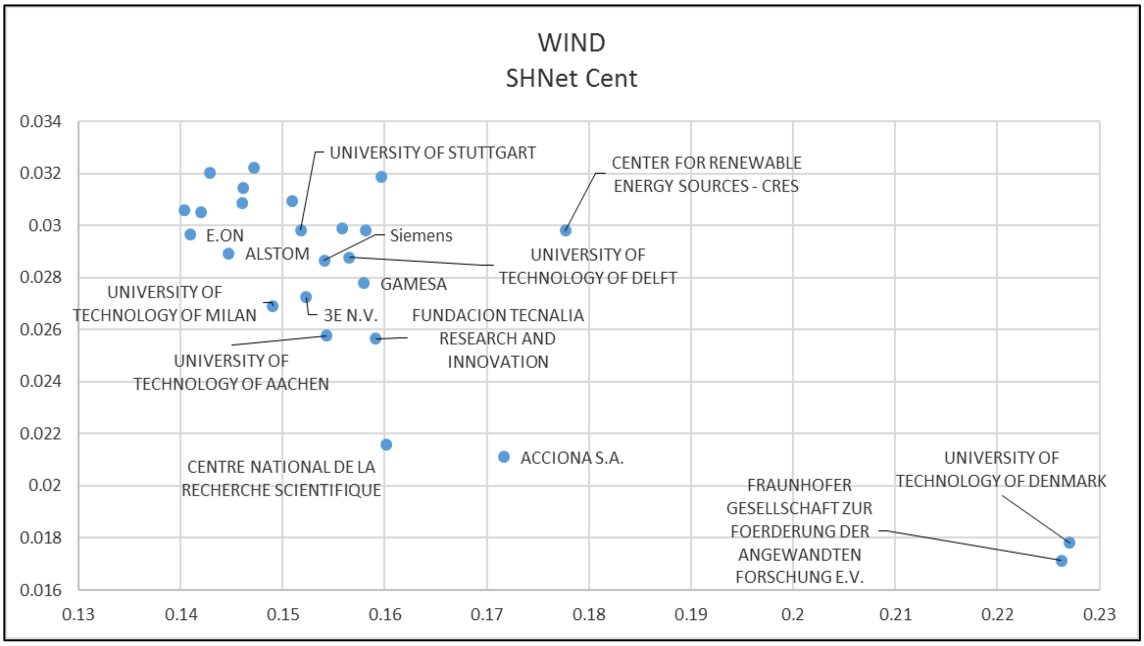


Figure 53. Centrality and Structural hole matrix. Organizations. Wind sector. Source: own elaboration.

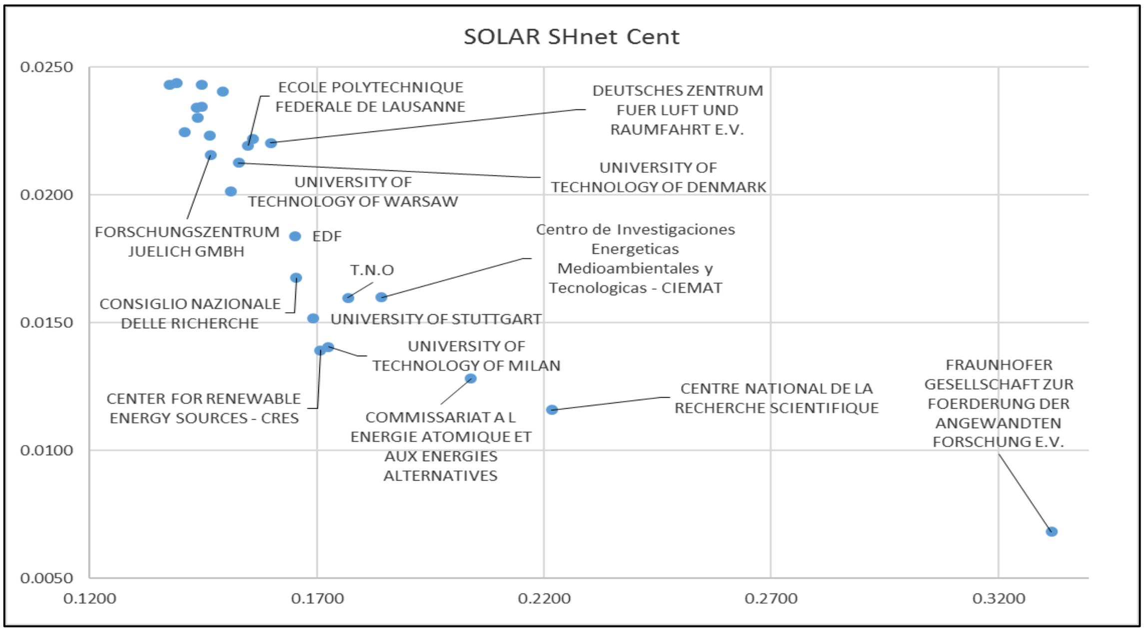


Figure 54. Centrality and Structural hole matrix. Organizations. Solar sector. Source: own elaboration.

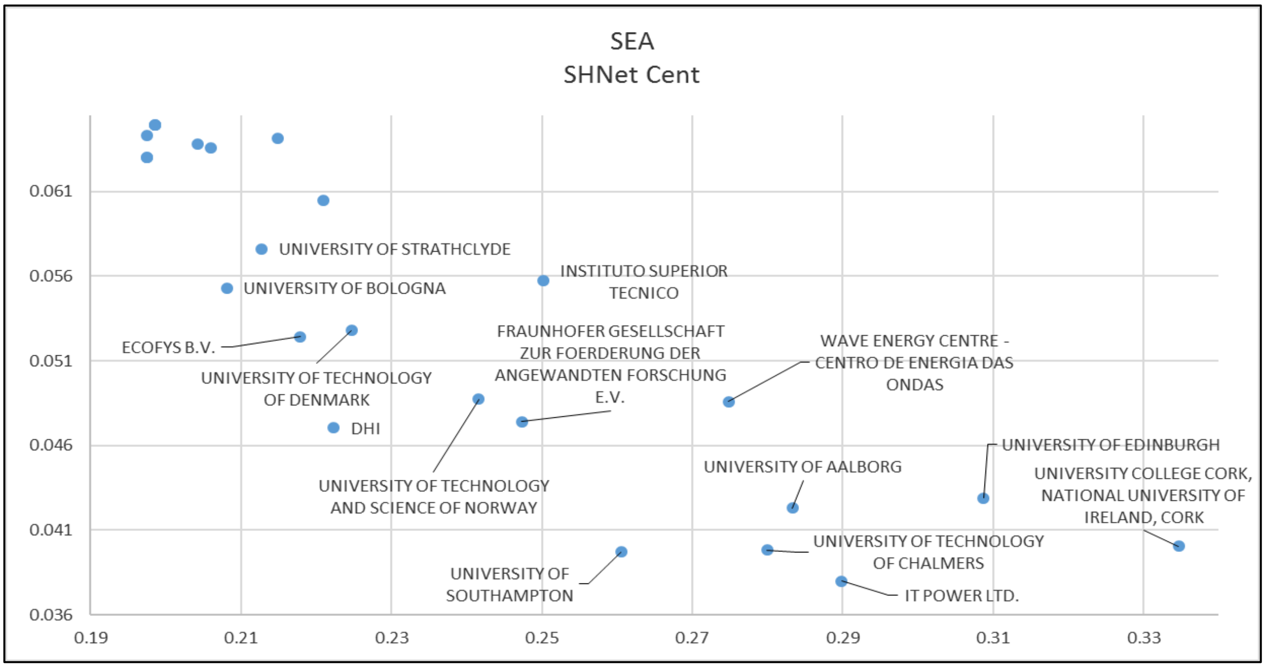


Figure 55. Centrality and Structural hole matrix. Organizations. Sea energy sector. Source: own elaboration.

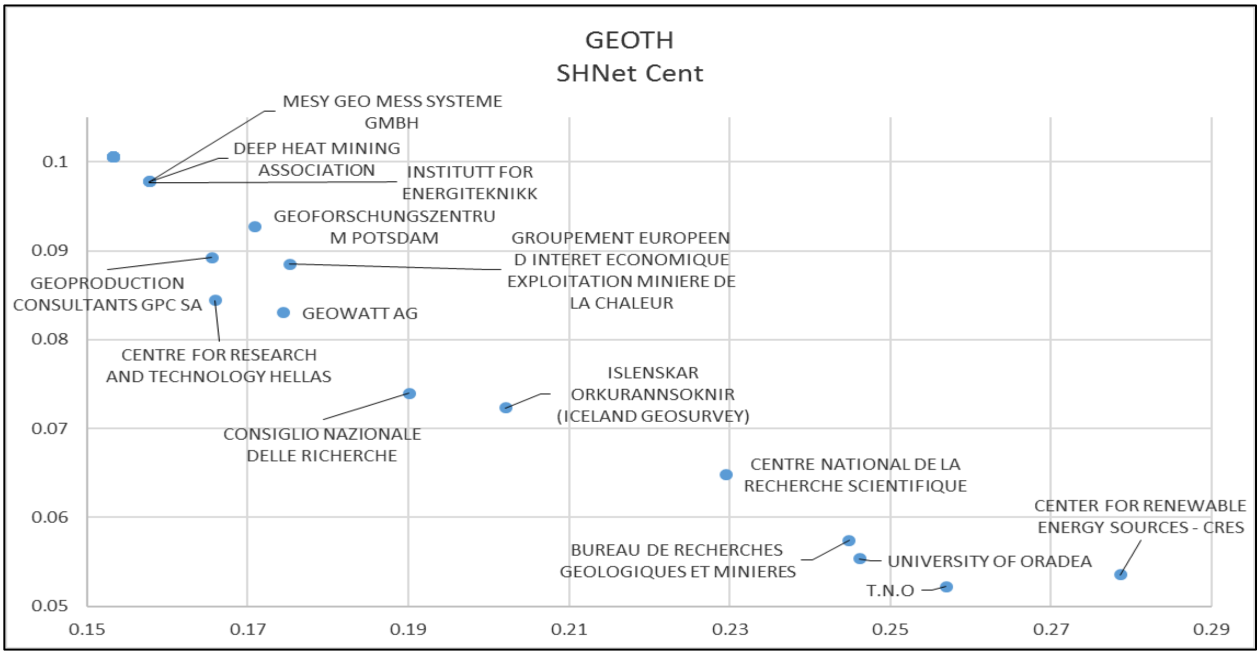


Figure 56. Centrality and Structural hole matrix. Organizations. Geothermal sector. Source: own elaboration.

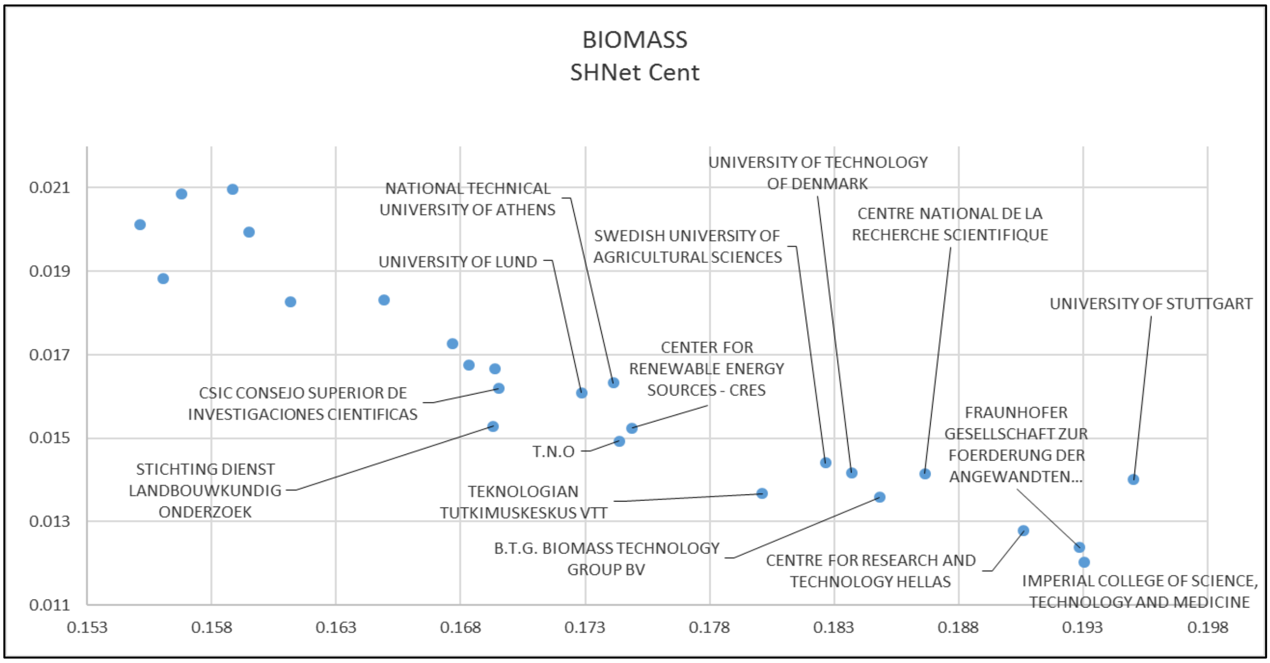


Figure 57. Centrality and Structural hole matrix. Organizations. Biomass sector. Source: own elaboration.

Regarding the organizations matrix, on the one hand, as determined in previous chapters, first evidence from the analysis of the top 15 leading organizations clearly shows the importance of universities as well as research centers, with special attention to University of Technology of Denmark (Denmark) and Fraunhofer Institute (Germany) that appear leading the biomass, solar and wind sectors. On the other hand, it is worth mentioning that a small representation of firms is observed in all sectors, except for wind sector, where a broad number of companies are collaborating in leading positions, such as Acciona S.A., 3E N.V., Siemens, Alstom, E.On, Dong Energy or Gamesa S.A.

What our data have demonstrated is that distribution homogeneity is observed for biomass, sea and geothermal sectors, while dispersed organizations appear for solar and wind sectors. Thus, a small group of organizations, mainly formed by universities and research centers, are leading the central positions and structural hole roles in these sectors, while the Fraunhofer Institute and University of Technology of Denmark together with the Fraunhofer Institute appear as clear leaders in solar and wind sectors respectively, far beyond the rest of organizations.

The following two tables (Table 44 and Table 45) represent the ranking of the first 25 local regions.

Table 44. Integrated ranking for centrality and structural holes applied to local region networks. Sectors: wind, solar and sea. Period of 2000-2013. Source: own elaboration.

	WIND				SOLAR				SEA			
Position	CENT		Shnet		CENT		Shnet		CENT		Shnet	
1	ES300	ES	ES511	ES	DE212	DE	ITC11	IT	IE025	IE	ES130	ES
2	BE100	BE	ES300	ES	FR102	FR	DK012	DK	DK050	DK	EL303	GR
3	DE212	DE	DE111	DE	ES300	ES	UKD53	GB	UKM25	GB	FR102	FR
4	DK012	DK	BE100	BE	ITE43	IT	ES523	ES	DE212	DE	BG331	BG
5	FR102	FR	ITC33	CH	ES511	ES	DE212	DE	PT114	PT	UKJ33	GB
6	ITE43	IT	FI181	FI	BE100	BE	ES511	ES	EL303	GR	DK050	DK
7	EL303	GR	ITE43	IT	DE111	DE	UKJ14	GB	DK001	DK	IE025	IE
8	EL305	GR	NL333	NL	ITC45	IT	HU101	HU	DK012	DK	DK001	DK
9	UKI11	GB	ITC11	IT	FI181	FI	ITE43	IT	ITE43	IT	ITD55	IT
10	ITC45	IT	ITC45	IT	DE300	DE	CH021	CH	FR102	FR	EL522	GR

11	ES511	ES	DE21H	DE	EL303	GR	FR102	FR	UKJ33	GB	UKM25	GB
12	DE600	DE	FR102	FR	ITC11	IT	UKM34	GB	UKJ32	GB	UKI11	GB
13	DE111	DE	NL310	NL	AT130	AT	ITD55	IT	PT172	PT	DK012	DK
14	DK021	DK	DEA23	DE	UKI11	GB	DE300	DE	UKI11	GB	DE212	DE
15	DEA23	DE	DE212	DE	DEA23	DE	DE111	DE	SE232	SE	UKJ32	GB
16	FI181	FI	CH040	CH	CH040	CH	UKI11	GB	ES130	ES	FR105	FR
17	NL333	NL	CZ010	CZ	IE021	IE	AT221	AT	BG331	BG	PT114	PT
18	ES220	ES	DE600	DE	ES212	ES	AT130	AT	FR105	FR	ITE43	IT
19	CZ010	CZ	UKI11	GB	DK012	DK	ITC45	IT	DK013	DK	EL305	GR
20	UKK11	GB	AT130	AT	HU101	HU	ES300	ES	UKM34	GB	PL127	PL
21	FR105	FR	DK012	DK	CH011	CH	EL632	GR	UKJ14	GB	UKL15	GB
22	NL322	NL	DK050	DK	CZ010	CZ	CZ010	CZ	NL333	NL	UKJ14	GB
23	ES213	ES	PL127	PL	FR105	FR	DE600	DE	EL305	GR	SE232	SE
24	SE110	SE	EL305	GR	BE242	BE	FI181	FI	ITD55	IT	ITD35	IT
25	DK001	DK	UKD53	GB	NL333	NL	FR714	FR	BE100	BE	PT172	PT

Table 45. Integrated ranking for centrality and structural holes applied to local region networks. Sectors: geothermal and biomass. Period of 2000-2013. Source: own elaboration.

	GEOTH				BIOMASS			
Position	CENT		Shnet		CENT		Shnet	
1	FR102	FR	BE100	BE	ITE43	IT	FI181	FI
2	RO111	RO	RO111	RO	FI181	FI	DE212	DE
3	EL305	GR	ES300	ES	ES300	ES	FR102	FR
4	ES300	ES	FR102	FR	FR102	FR	NL221	NL
5	BE100	BE	EL305	GR	BE100	BE	ITE43	IT
6	NL333	NL	NL326	NL	DE212	DE	AT221	AT
7	HU101	HU	EL303	GR	AT130	AT	NL213	NL

8	FR246	FR	NL333	NL	NL221	NL	BE100	BE
9	NL326	NL	ITC45	IT	UKI11	GB	DK012	DK
10	EL303	GR	EL522	GR	DK012	DK	ES300	ES
11	ITE43	IT	HU101	HU	SE110	SE	UKI11	GB
12	DE423	DE	FR246	FR	AT221	AT	NL333	NL
13	EL522	GR	PL127	PL	PT172	PT	ITC45	IT
14	DE929	DE	ITE43	IT	NL213	NL	SE110	SE
15	ITC45	IT	EL301	GR	SE121	SE	UKJ14	GB
16	PL127	PL	PT172	PT	NL333	NL	NL310	NL
17	CH040	CH	AT224	AT	EL303	GR	SE121	SE
18	DK001	DK	FR106	FR	DE111	DE	AT130	AT
19	EL301	GR	DE423	DE	EL522	GR	UKI12	GB
20	DEA51	DE	DK001	DK	PL127	PL	EL522	GR
21	PT172	PT	CH040	CH	NL322	NL	NL326	NL
22	AT224	AT	ITC33	CH	DK001	DK	EL303	GR
23	FR106	FR	LT00A	LT	ITC45	IT	DE600	DE
24	LT00A	LT	SI021	SI	ES511	ES	PT172	PT
25	DE276	DE	DE929	DE	SE232	SE	SE232	SE

To analyse and understand better the situation of these organizations, different graph-matrices are made for each sector.

The following figures (Figure 58 - Figure 62) show the matrix analysis applied to local regions networks.

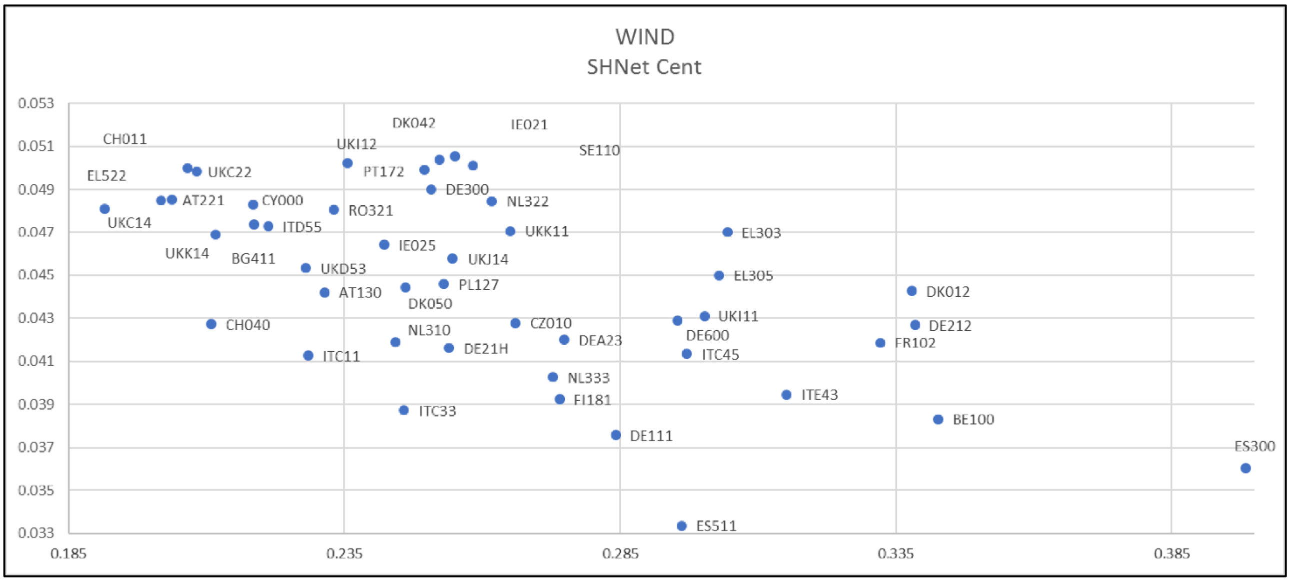


Figure 58. Centrality and Structural hole matrix. Local regions. Wind sector. Source: own elaboration.

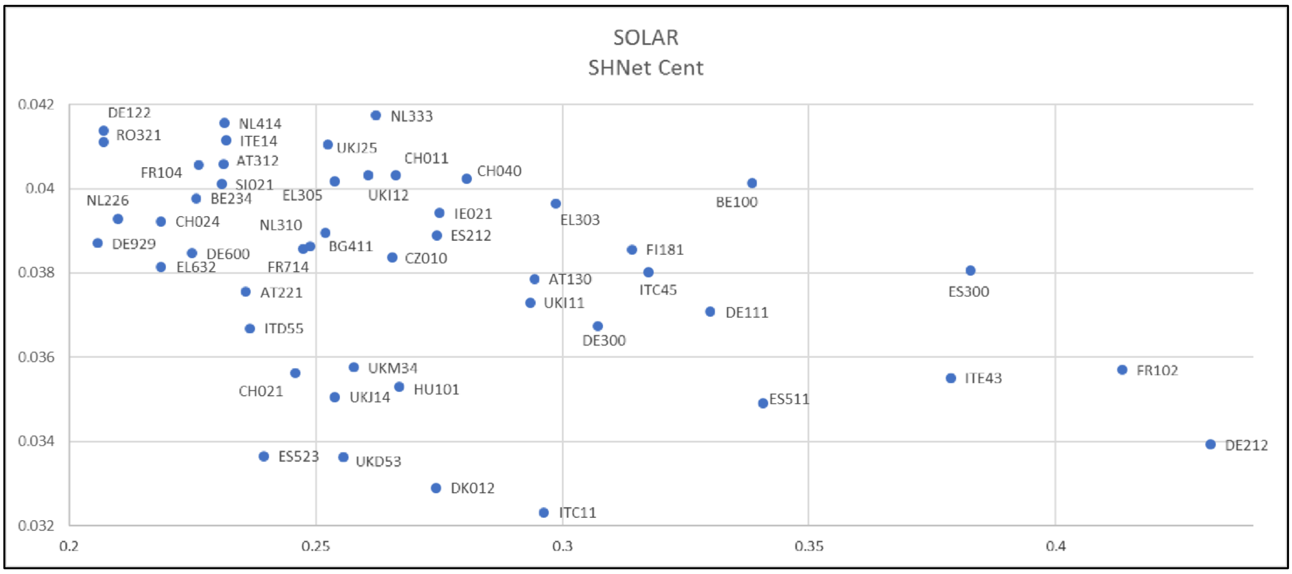


Figure 59. Centrality and Structural hole matrix. Local regions. Solar sector. Source: own elaboration.

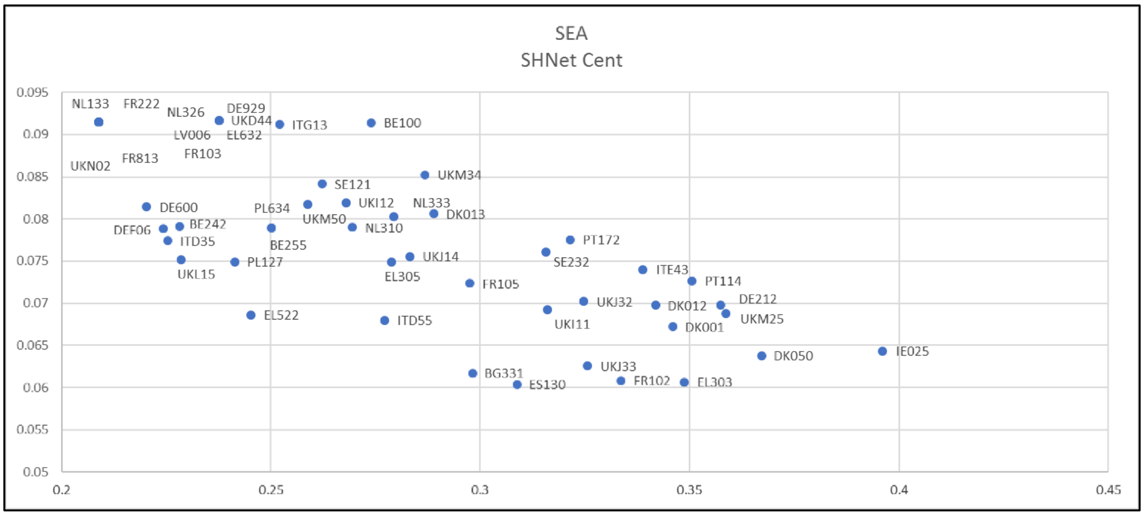


Figure 60. Centrality and Structural hole matrix. Local regions. Sea energy sector. Source: own elaboration.

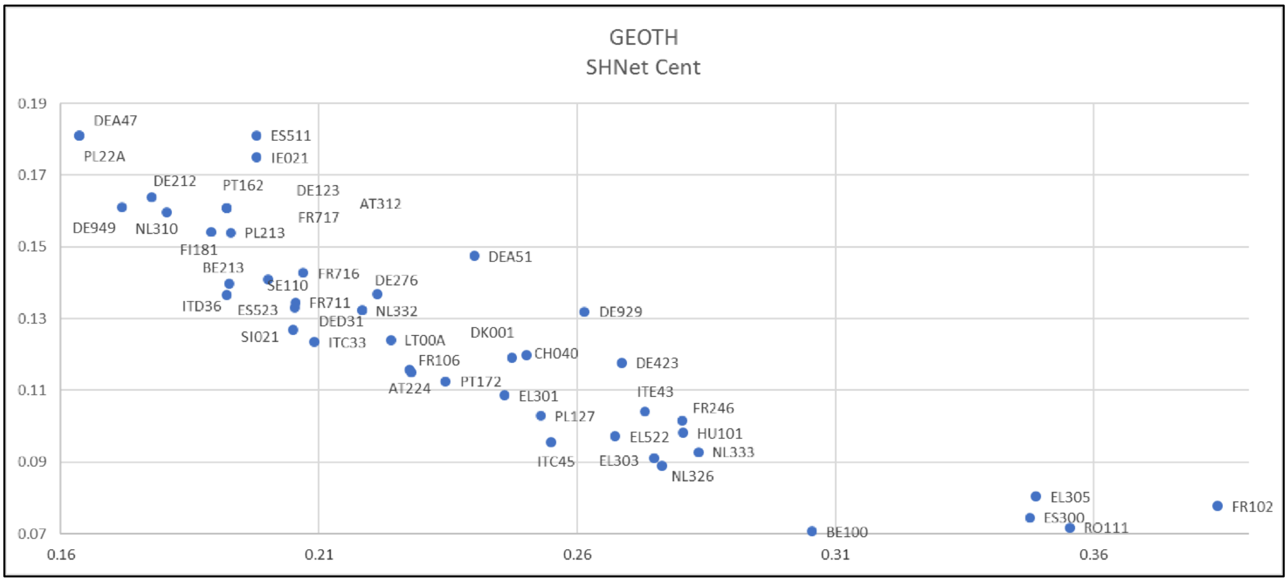


Figure 61. Centrality and Structural hole matrix. Local regions. Geothermal sector. Source: own elaboration.

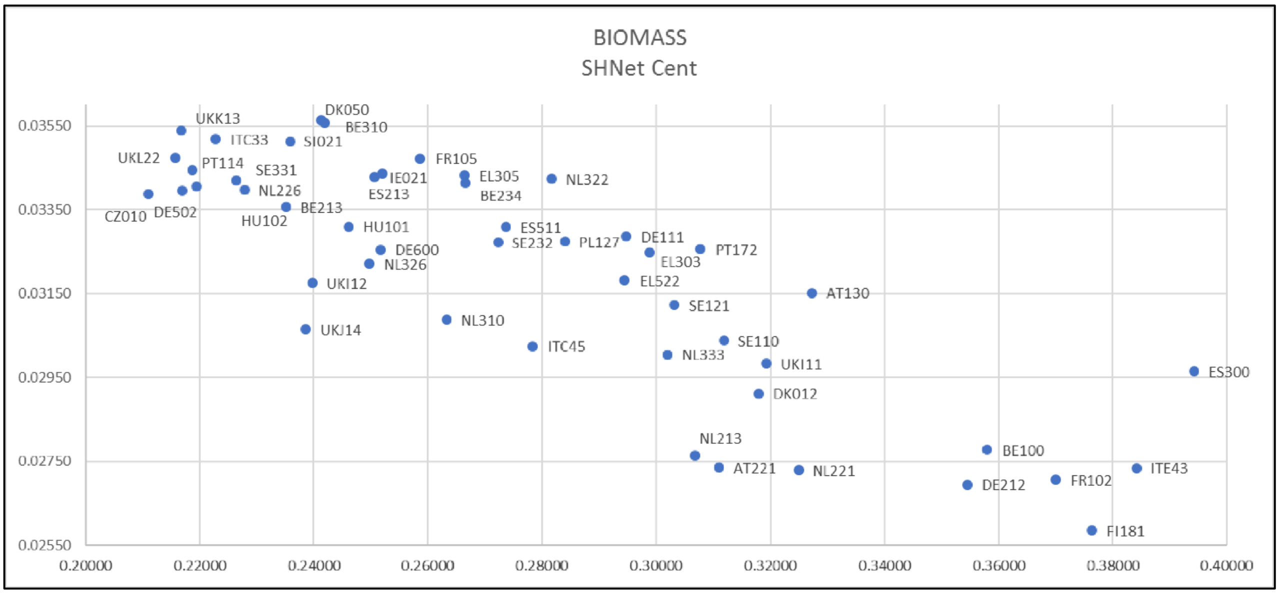


Figure 62. Centrality and Structural hole matrix. Local regions. Biomass sector. Source: own elaboration.

In this case, homogenous exponential distribution of regions is observed for biomass, sea and wind sectors, while more dispersion is shown in geothermal and especially in solar sector. It is worth noting that two main groups are clearly observed leading in the Geothermal sector and three in the solar sector. Additionally, in solar, it is possible to see that the structural hole value does not always increase when centrality decreases. For example, DE212 is the most central actor, but the ITC11 DK012, UKD53 and ES523 regions show better structural hole value, even being less central. This fact would suggest that central actors are not always effectively positioned as brokers between structural holes, avoiding redundant relationships in terms of knowledge and information transmission.

Since each local region is geolocalized, geographical maps are useful tools to show centrality and structural hole values at the same time. The next figures (Figure 63- Figure 67) show the difference between the effectiveness and efficiency of European projects related to the objective of cohering different local regions in renewable energy research and development projects through knowledge and information transmission. The difference of both ranking positions for each NUTS3 is calculated, with a lighter color to indicate regions being better-connected in the network to a darker color for those having less redundant partnership connections between core and periphery groups. These maps highlight similar results for Wind, Solar and Biomass groups as well for sea and geothermal sectors.

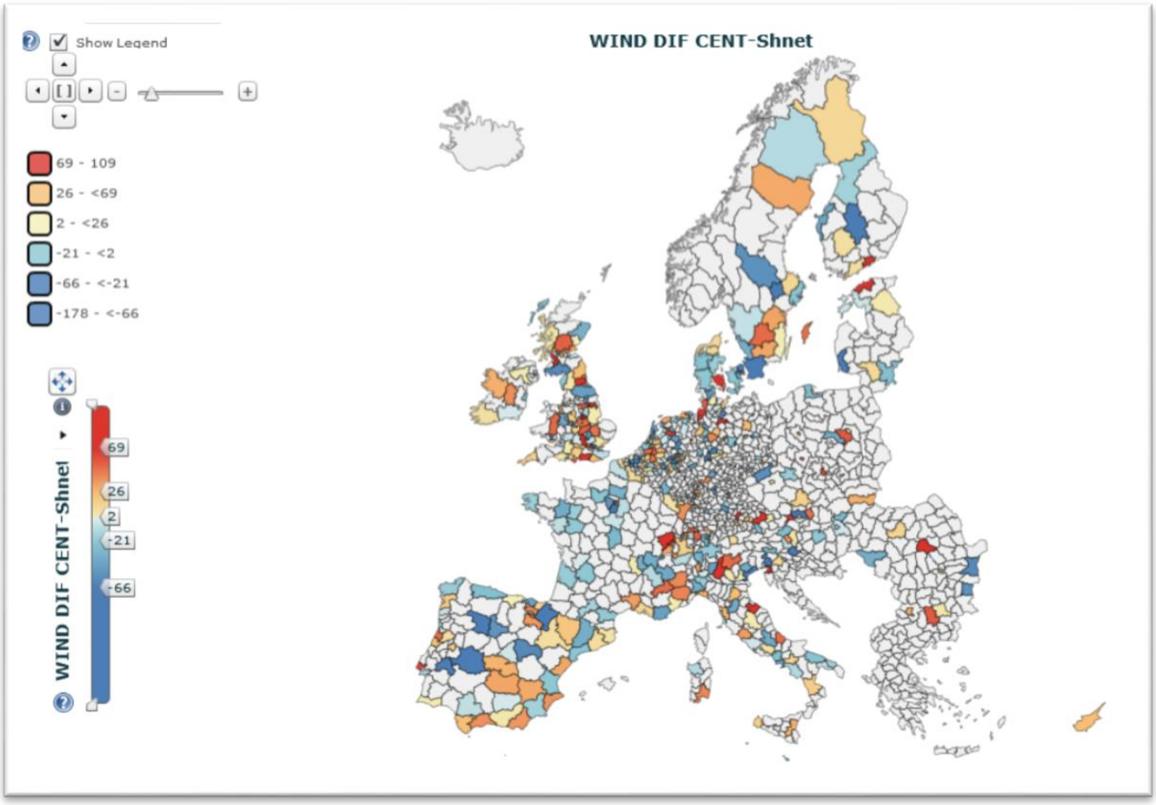


Figure 63. Difference between Centrality and Structural hole rankings. Local regions. Wind sector. Source: own elaboration.

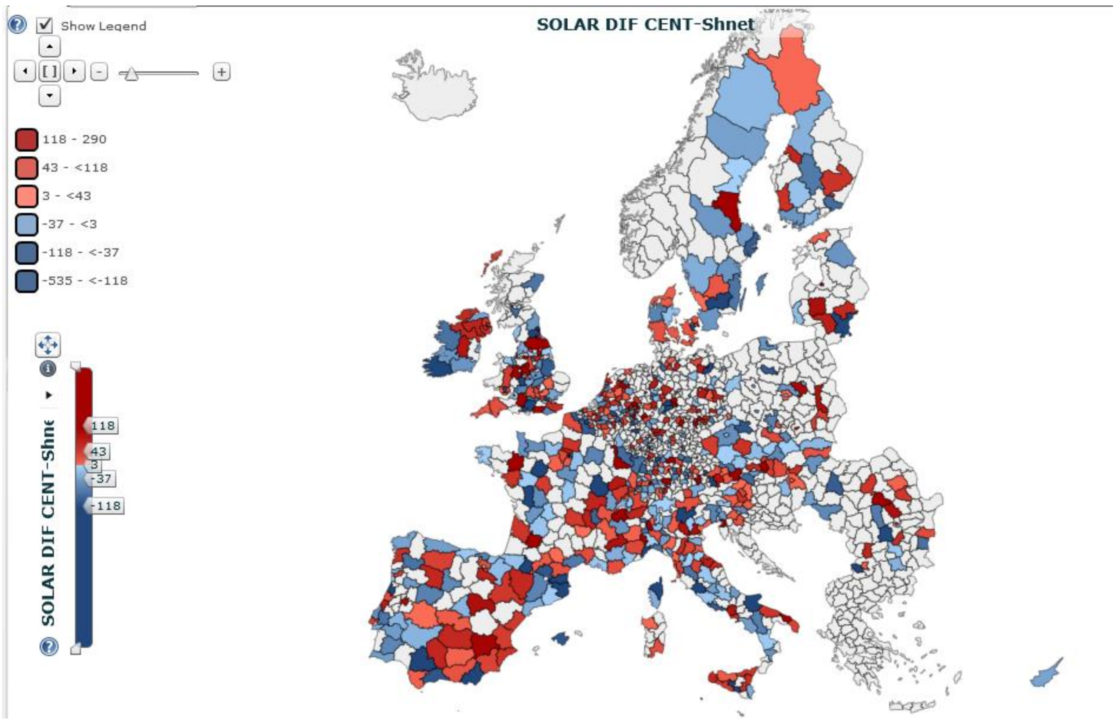


Figure 64. Difference between Centrality and Structural hole rankings. Local regions. Solar sector. Source: own elaboration.

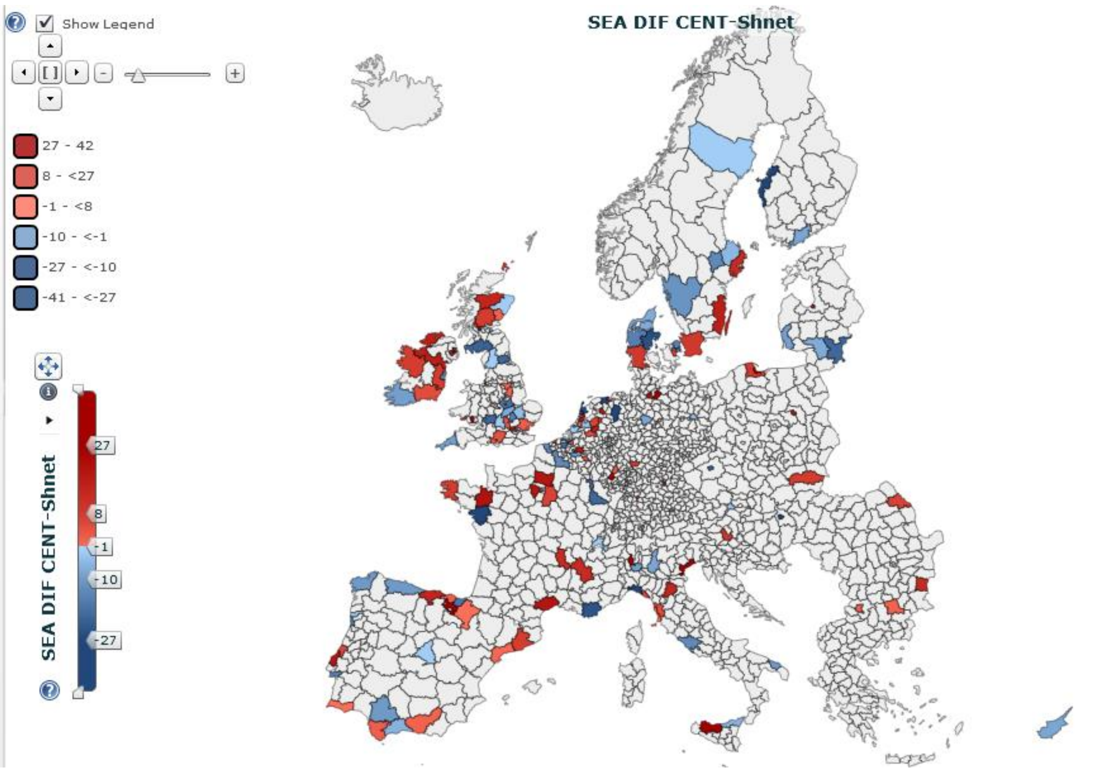


Figure 65. Difference between Centrality and Structural hole rankings. Local regions. Sea energy sector. Source: own elaboration.

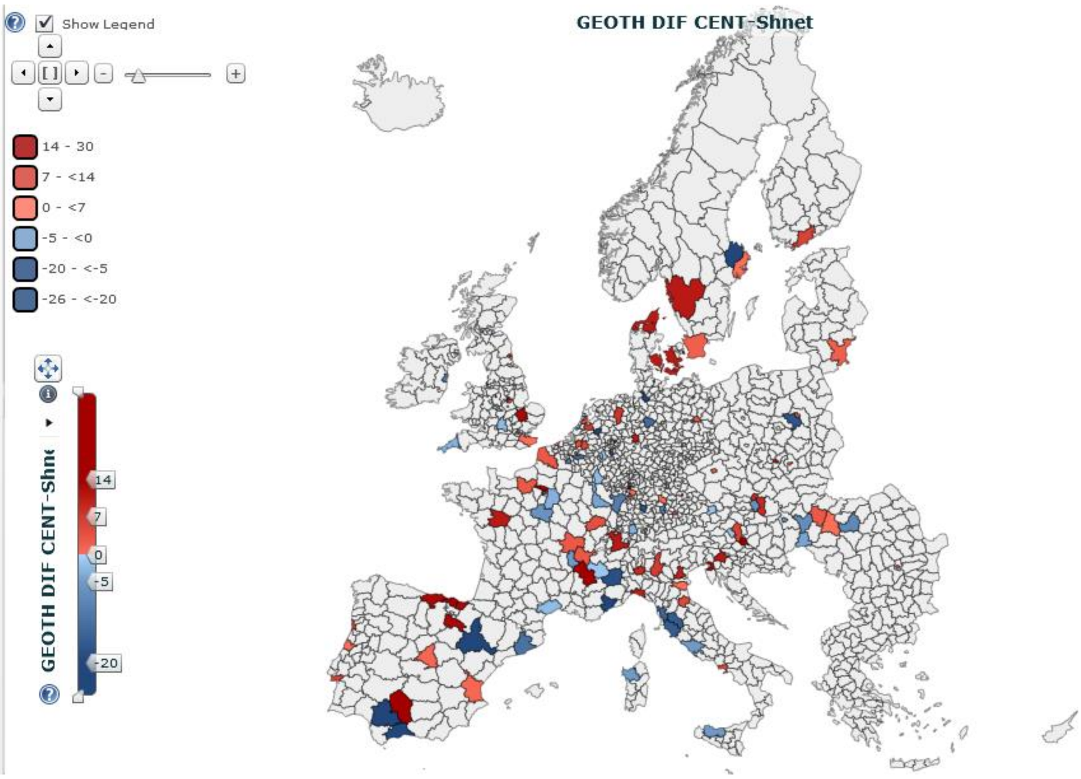


Figure 66. Difference between Centrality and Structural hole rankings. Local regions. Geothermal sector. Source: own elaboration.

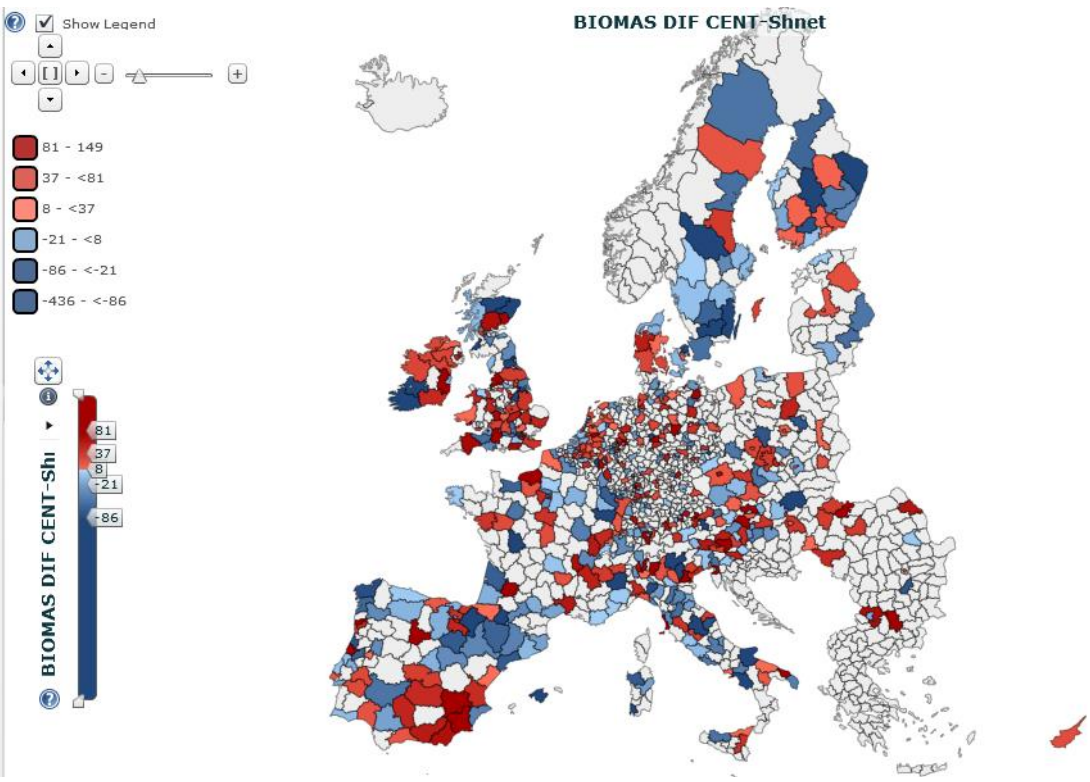


Figure 67. Difference between Centrality and Structural hole rankings. Local regions. Biomass sector. Source: own elaboration.

7.4.4.Conclusions and discussion (Strategic Analysis: part 1)

This first part of results and conclusions present the analysis of the information and knowledge transmission efficiency and effectiveness of organizations and local regions participating in European R&D projects within renewable energy sectors (wind, solar, sea, geothermal and biomass) during 2000-2013 using Social Network Analysis.

This research goes one step further and not only is traditional centrality perspective of actors analyzed, based mainly on their own number and type of collaborations with others, but also their relative position, role and potential as well as their collaboration redundancies from the overall network perspective.

This part furnishes the following main findings:

- Projects in the mature solar sector are carried out with a fewer number of partners, although less mature ones, such as sea and biomass, started increasing their rates progressively. Firms lead the participation in all sectors (from 44% to 59%) and universities and research centers have more experience.
- Knowledge and information transmission is observed to be more effective between local regions than partners, although the small-world effect exist in both network systems and they are neither completely random nor homogenously located in terms of cohesion.
- The existence of areas between the core and the peripheral nodes with almost no collaboration links (called structural holes) is confirmed in both partner and NUTS3 networks. Higher Education and Research Centers take advantage from these (particularly wind, sea, biomass), having a more influential position since they bridge the two edges of these areas, while firms seem to be surrounded by them (specially in solar and geothermal).
- Matrix analysis of centrality and structural hole approach provided connectivity information, concluding that emergent RE sectors (mainly sea and geothermal) are still less effective in terms of knowledge transmission, as well as the top 15 organizations

clearly concerned with the importance to universities and research centers. However, firms appear to be leading more in wind sector than others.

- We noticed that effectiveness is not always better when the centrality position increases, especially for local regions as concluded thanks to the information obtained with geographical maps.

This part should shed some light on the importance of using the overall potential of social network analysis using project information, helping to understand the influence of each partner or local region not only with their closest neighbors but also in the overall network.

7.4.5.Terms maps: “Keywords” and “Subjects”

The objective of this section is to analyse what information or knowledge is used or shared in the projects, based on the information in the fields "keywords" and "subjects" of each of the projects that have been identified for each sector, after the process carried out in section 6.4.

The mapping of the networks of "keywords" and "subjects" of each of the sectors for the period 2000-2013 will be obtained and later, a clustering or grouping will be carried out to facilitate the extraction of how the relationship is between the terms themselves and clusters.

For this purpose, first, the file containing the information of each project (with its RCN code) and its “keywords” or “subjects” is created. For example, the structure for “keywords” case would be as shown in the following table (Table 46):

Table 46. Basic structure for term maps of projects. Case: “keywords”. Source: own elaboration.

RCN	Keyword
P1	K11
P1	K12
P2	K21
P3	K31
…	…
Pn	Kn1

Subsequently, the "keyword-keyword" or “subject-subject” co-occurrence matrix of each sector is constructed, using the information that the projects contain in their corresponding fields. For example, the co-occurrence matrix for “keywords” would have the following structure (Table 47), where the numeric data represents the frequency in which this term appears in the keywords of related projects:

Table 47. Co-occurrence matrix. Case: “keywords”. Source: own elaboration.

	K1	**K2**	**…**	**Kn**
K1	x	x		
K2		x		x
…	x			
Kn			x	

SNA indicators are used that represent, on the one hand, the centrality through the average normalized value of the indicators of centrality "degree", "betweenness" and "closeness" and, on the other hand, the efficiency through the “structural hole” value, obtained by means of the "network constraint" indicator, which indicates how each node can join two groups of nodes efficiently and without redundancy (the value of the indicator is inversely proportional to efficiency).

The construction of the networks is done with Pajek software (Batagelj & Mrvar 2011), creating a partition for centrality (through its "centrality degree" indicator) and a vector to show the efficiency (through its "structural hole" indicator). In the map, each node is positioned spatially maintaining a certain equilibrium, considering the similarity of each node to the rest (in this case, number of relations through centrality, and efficiency through "structural hole") (6.5).

For example, the following figure shows this operation (Figure 68), as well as its visualization done by Pajek (Figure 69) for the wind sector.

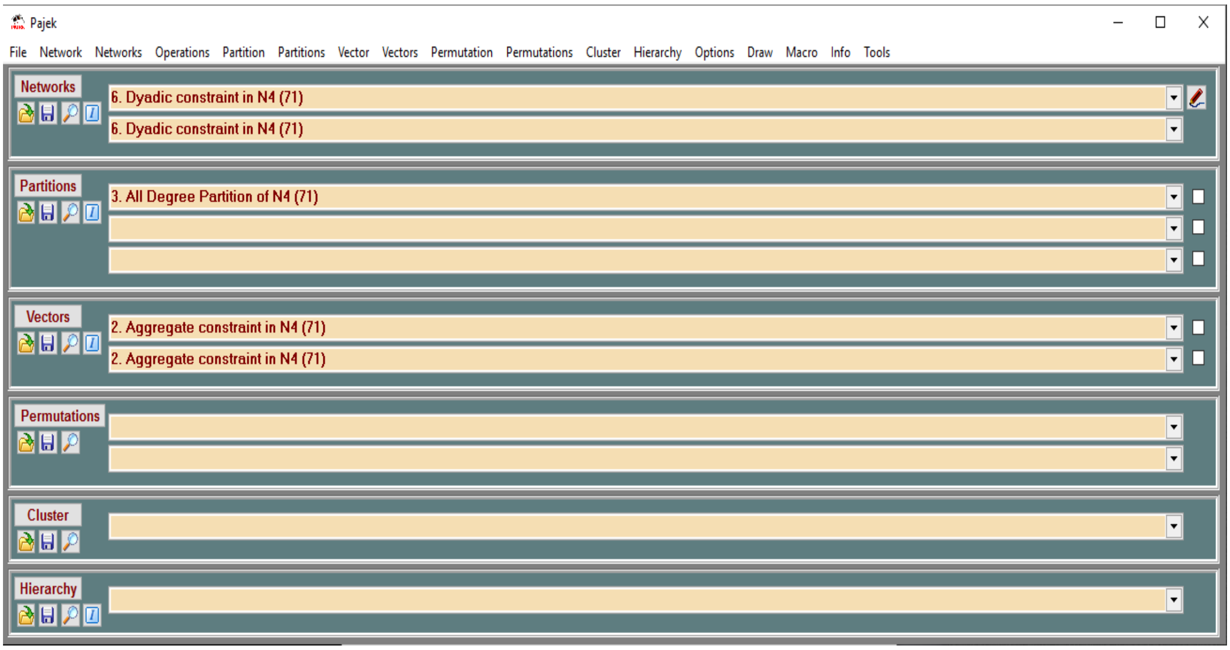


Figure 68. Process of calculating centrality and structural hole values in Pajek. Case: wind sector. Source: own elaboration using Pajek software (Batagelj & Mrvar 2011).

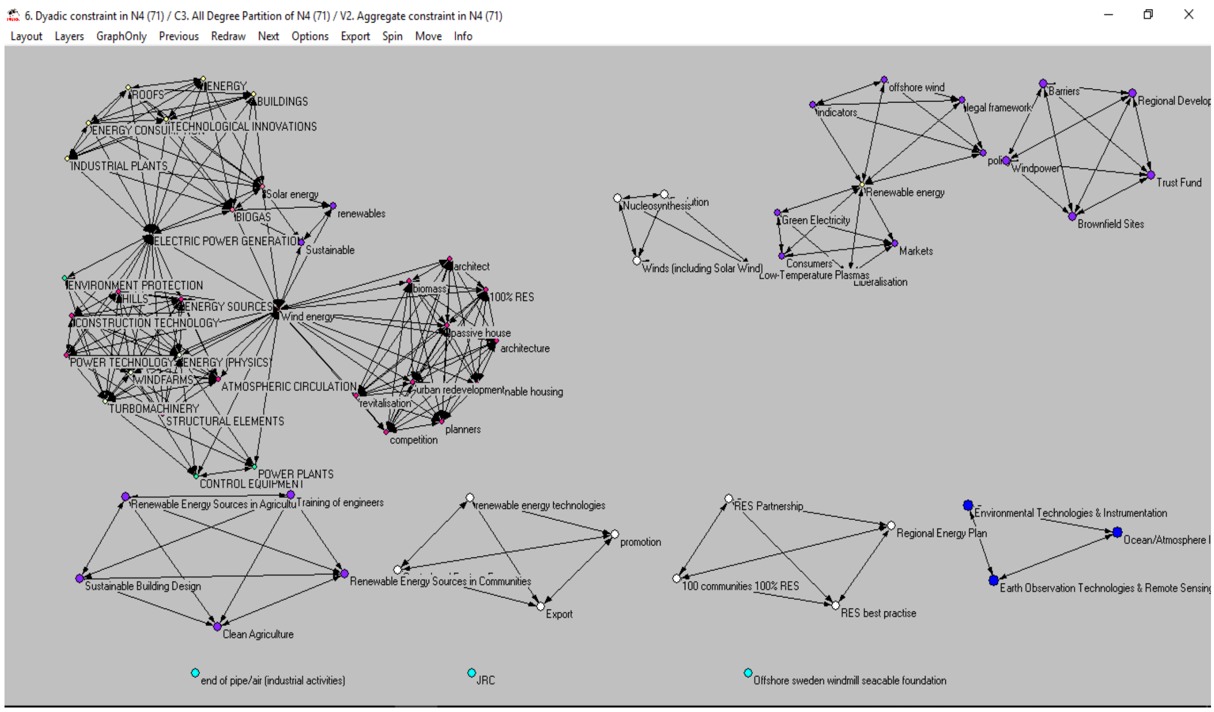


Figure 69. Visualization of "keywords" term map using Pajek. Case: wind sector. Source: own elaboration using Pajek software (Batagelj & Mrvar 2011)

Since the display features in Pajek are not attractive enough, the network is subsequently exported to VosViewer (www.vosviewer.com), maintaining the partition and vector values for each node.

Three types of visualization are generated with VosViewer (www.vosviewer.com):

- Network of terms and their relationship through projects: the colour of each node represents its centrality value and the size, the efficiency level. All relations between nodes are visualized through arcs.
- Cluster density or clustering network: each cluster is represented by one colour. This option is only available if the nodes have been assigned to a cluster. The density of the nodes is displayed separately for each cluster and the colour intensity shows the density of nodes.
- Node density network: in this case, each node has one colour that depends on the density of nodes at that point; initially red and blue. However, the larger the number of nodes in the neighbourhood and the higher the weights of neighbouring nodes, the closer it will be to the red one. And, on the contrary, closer to blue colour.

7.4.5.1. Terms maps: wind sector

In this section, on the one hand, the "keywords" map developed for the wind sector will be shown. There are three types of visualizations: network of nodes and their relationships (Figure 70), cluster density network (Figure 71), node density network (Figure 72).

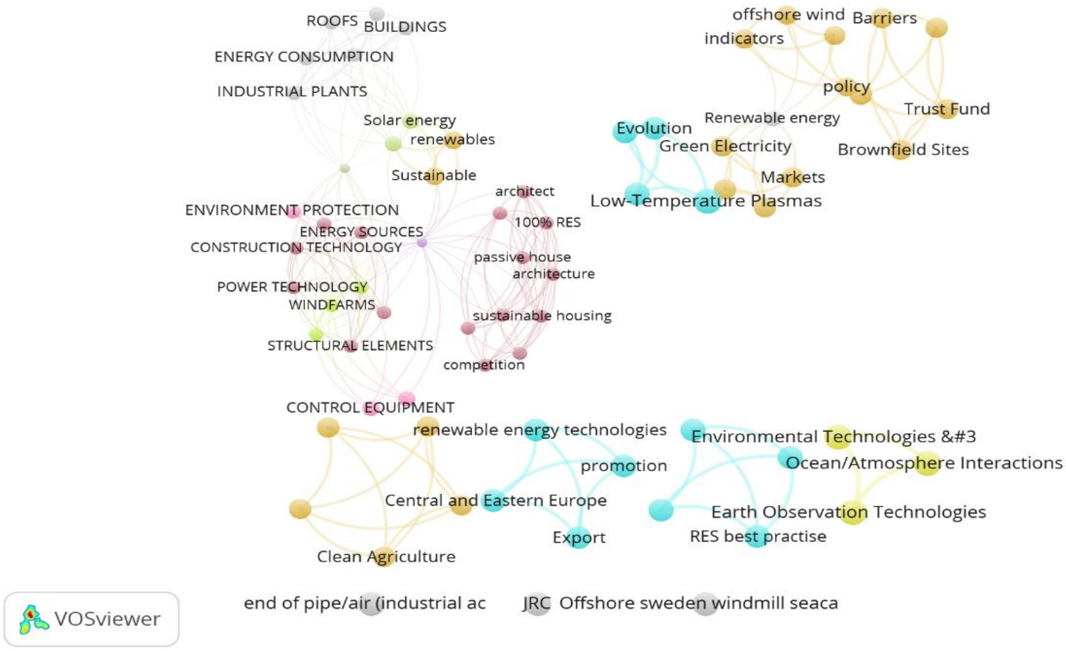


Figure 70. "Keywords" term map. Wind sector. Source: own elaboration.

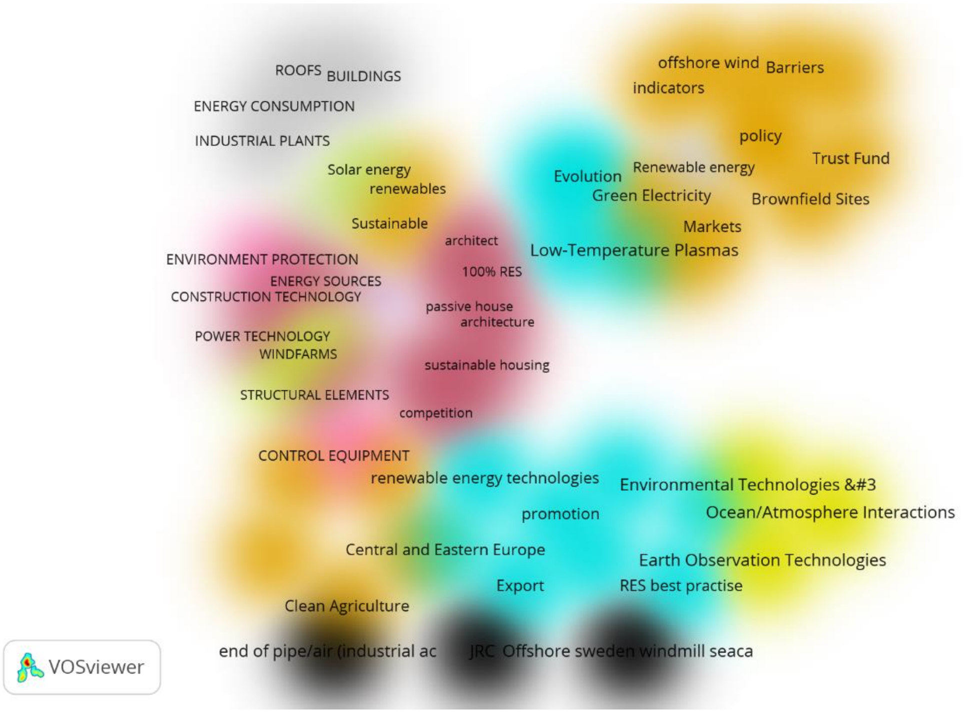


Figure 71. Cluster density "keywords" network term map. Wind sector. Source: own elaboration.

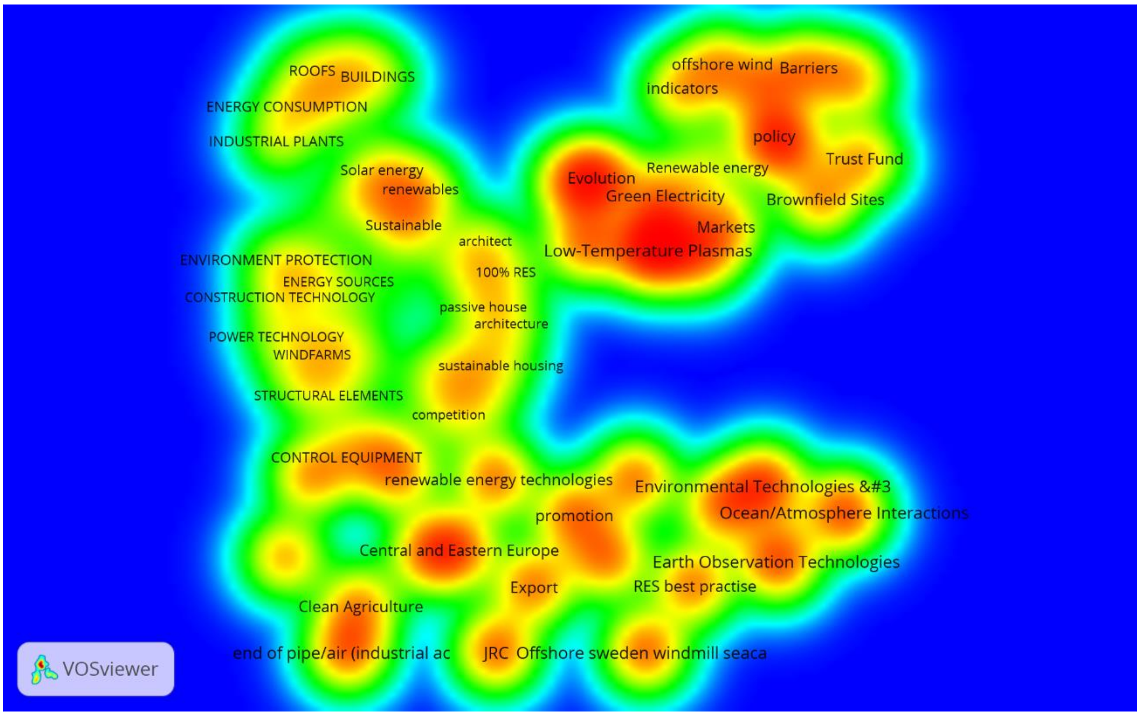


Figure 72. Node density "keywords" network term map. Wind sector. Source: own elaboration.

For the wind energy sector, 10 clusters of “keywords” are identified (Table 48):

Table 48. “Keywords” and “clusters”. Wind sector. Source: own elaboration.

Keywords	**Clusters**
Environmental Technologies & Instrumentation, Ocean/Atmosphere Interactions, Earth Observation Technologies & Remote Sensing	1
100 communities 100% RES, Central and Eastern Europe, Evolution, Low-Temperature Plasmas, Nucleosynthesis, promotion, renewable energy technologies, RES best practise, RES Partnership, Winds (including Solar Wind), Export, Regional Energy Plan	2
Barriers, Brownfield Sites, Clean Agriculture, Consumers, Green Electricity, indicators, legal framework, Liberalisation, Markets, offshore wind, policy, Regional Development, Renewable Energy Sources in Agriculture, renewables, Sustainable Building Design, Training of engineers, Trust Fund, Renewable Energy Sources in Communities, Sustainable, Windpower	3
CONTROL EQUIPMENT, ENVIRONMENT PROTECTION, POWER PLANTS	4
BUILDINGS, ENERGY CONSUMPTION, INDUSTRIAL PLANTS, ROOFS, TECHNOLOGICAL INNOVATIONS, ENERGY, Renewable energy	5
100% RES, architect, architecture, ATMOSPHERIC CIRCULATION, biomass, competition, CONSTRUCTION TECHNOLOGY, ENERGY SOURCES, HILLS, passive house, planners, POWER TECHNOLOGY, STRUCTURAL ELEMENTS, sustainable housing, urban redevelopment, revitalisation	6
BIOGAS, Solar energy	7
TURBOMACHINERY, WINDFARMS, ENERGY (PHYSICS)	8
ELECTRIC POWER GENERATION	9
Wind energy	10
End of pipe/air (industrial activities), JRC, Offshore sweden windmill seacable foundation	No cluster

First, cluster 1 is identified as an area of specialization in environment and natural sciences. It does not relate to any other cluster. As for cluster 2, it focuses on policies, exportation and promotion of renewable energies, in regions and communities-partnerships. Cluster 3 focuses on technical and legal barriers, markets, liberalization, as well as economic aspects of financing renewable energy projects. Cluster 4 focuses on control of equipment, power plants and sustainability. As for clusters 5 and 6, it is observed that the keywords that define them are oriented to the construction area. On the one hand, cluster 5, the construction of plants and structures, and cluster 6 architecture and housing construction (passive, sustainable, ...). In addition, it is observed that clusters 6 and 8 are very integrated, with a high degree of connections between their own nodes. As for clusters 7, 9 and 10, they act as a bridge between the other clusters. In particular, clusters 7 ("Biogas", "Solar energy") and 10 ("Wind energy") link between clusters 5 and 6, focus on building and construction areas; on the other hand, cluster 9 ("Electric Power Generation") also links clusters 5 and 6. This is derived from its high value of centrality and low "structural hole", being the most efficient terms when linking clusters, and in turn, having importance within their clusters.

Then, an extract from the table of Annex H (Table 49) is inserted, showing these numerical values of centrality and "structural hole".

Table 49. Value of Centrality and "Structural hole" for "Keywords". Wind sector. Source: own elaboration.

Keywords WIND 0013	CENT	Keywords WIND 0013	SHnet (constraint)
Wind energy	0.2748	ELECTRIC POWER GENERATION	0.1846
ELECTRIC POWER GENERATION	0.2105	Wind energy	0.2797
TURBOMACHINERY	0.1719	TURBOMACHINERY	0.2843
WINDFARMS	0.1719	WINDFARMS	0.2843

In the following figure (Figure 73) these items are displayed:

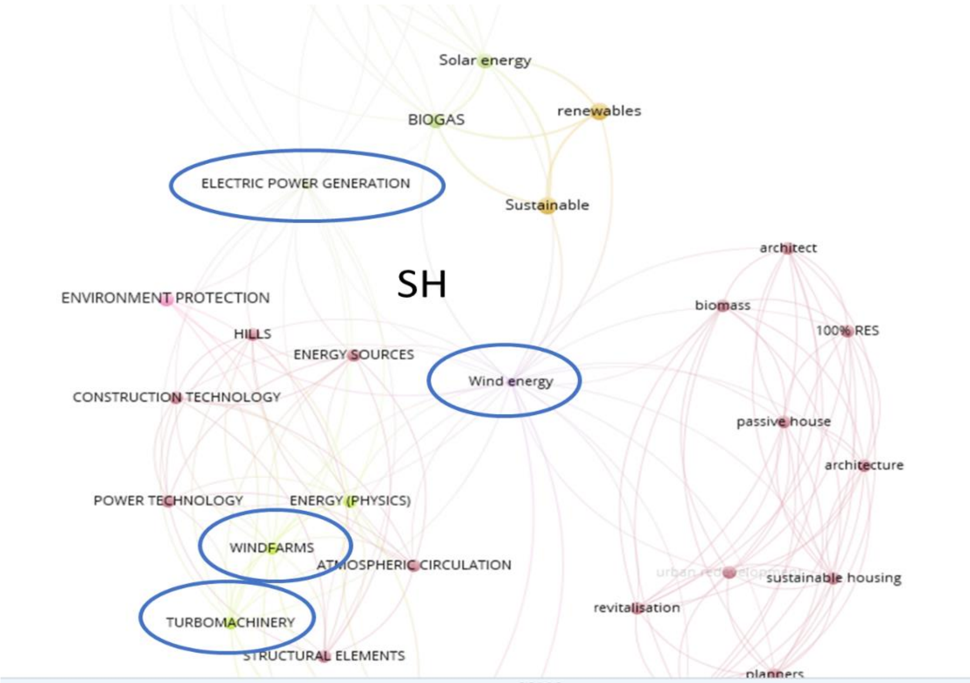


Figure 73. "Structural hole" areas in "keywords" term map. Wind sector. Source: own elaboration.

In conclusion, there is a spatial distribution that is very independent of each cluster, with a clear interconnection between clusters 5 and 6.

On the other hand, the term map for "subjects" drawn up for the wind sector will be shown. There are three types of visualizations: network of nodes and their relationships (Figure 74), cluster density network (Figure 75), node density network (Figure 76).

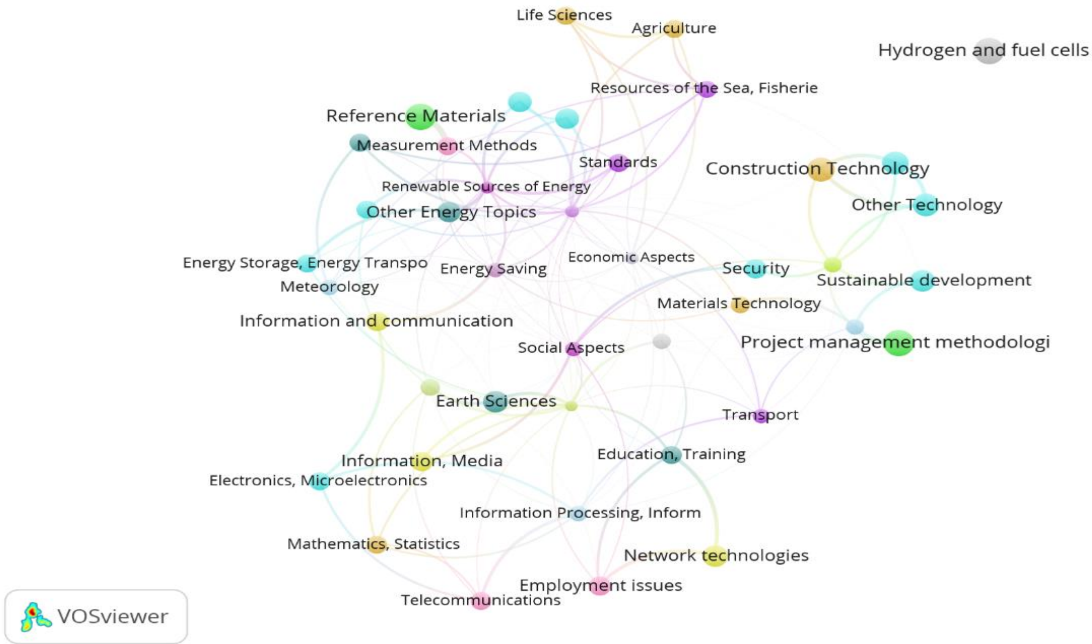


Figure 74. "Subjects" term map. Wind sector. Source: own elaboration.

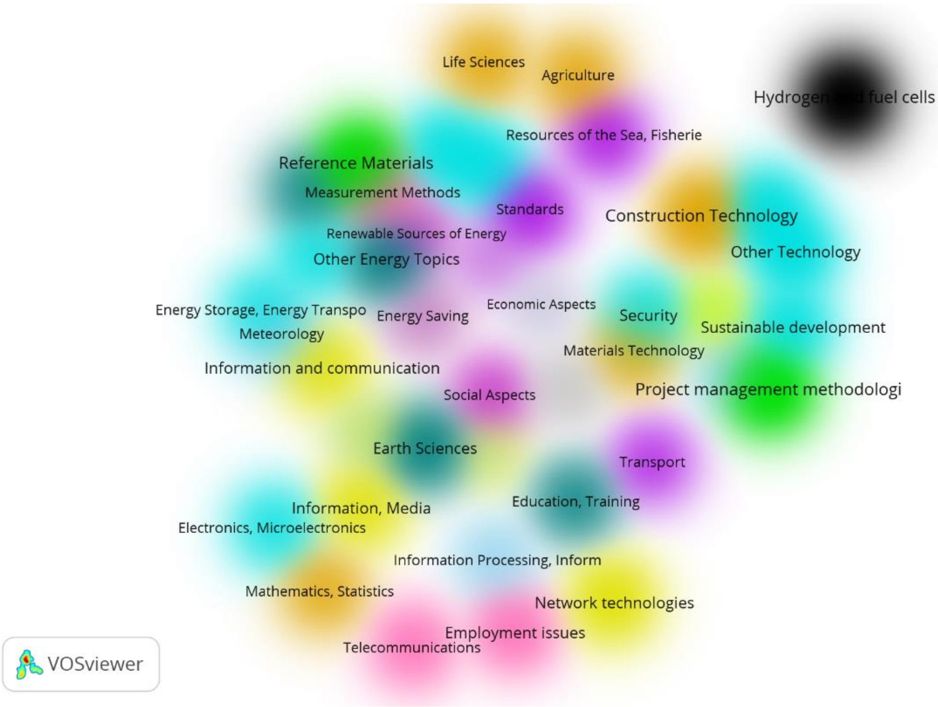


Figure 75. Cluster density "Subjects" network term map. Wind sector. Source: own elaboration.

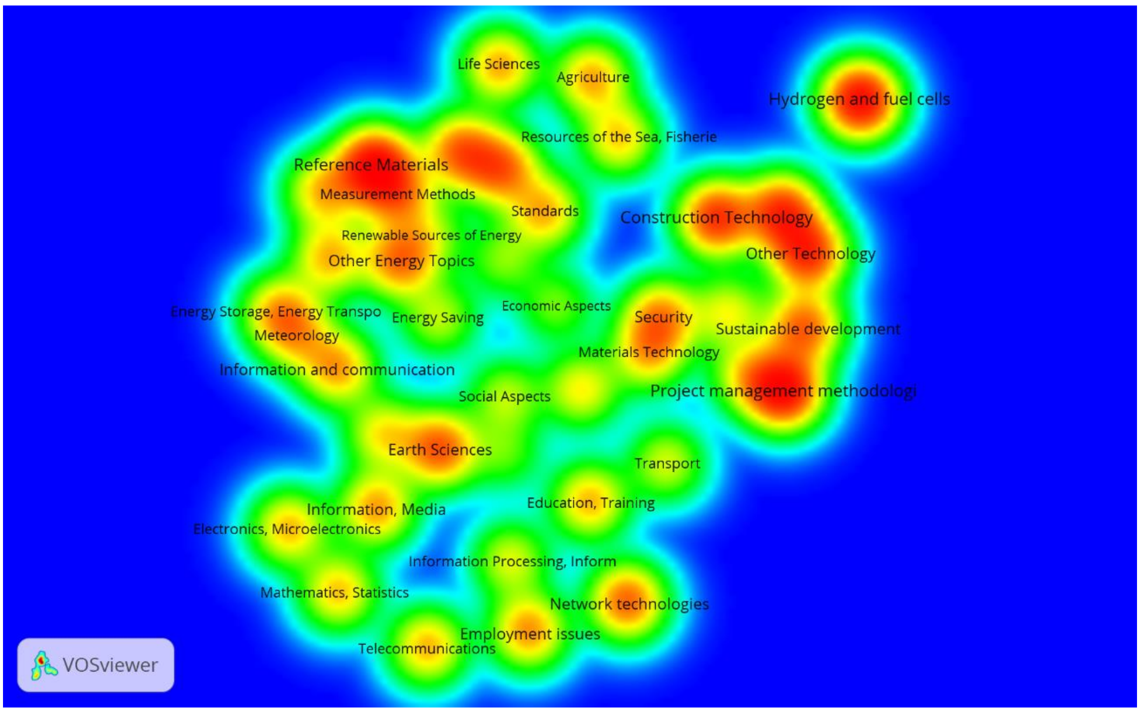


Figure 76. Node density "subjects" network term map. Wind sector. Source: own elaboration.

For the wind energy sector, 16 clusters of "Subjects" (Table 50) are identified:

Table 50. "Subjects" and "clusters". Wind sector. Source: own elaboration.

Subject	**Cluster**
Project management methodologies, Reference Materials	1
Information and communication technology applications, Information, Media, Network technologies	2
Biotechnology, Electronics, Microelectronics, Energy Storage, Energy Transport Other Technology, Security, Waste Management, Medicine, Health, Sustainable development, Policies	3
Agriculture, Construction Technology, Life Sciences, Materials Technology, Mathematics, Statistics	4
Employment issues, Measurement Methods, Telecommunications	5
Earth Sciences, Education, Training, Other Energy Topics, Forecasting	6
Transport, Standards	7
Innovation, Technology Transfer	8
Industrial Manufacture, Information Processing, Information Systems, Meteorology	9
Coordination, Cooperation	10
Safety	11
Energy Saving	12
Renewable Sources of Energy, Social Aspects	13
Economic Aspects	14
Scientific Research	15
Environmental Protection	16
Hydrogen and fuel cells	No cluster

First, each of the clusters will be identified with its main orientation. On the one hand, cluster 1 is focused on project management methodology and material references. Cluster 2, on information, technological communication and media. As for cluster 3, it is roughly related to science, technology, energy storage and transport, while cluster 4 focuses on areas such as construction, agriculture, materials and statistics. On the other hand, clusters 5 and 9 are oriented to different issues such as employment in the wind sector, information systems or methods of measurement, without being able to include them in a specific theme.

In this case, there is no clear independence between the clusters and thematic areas, and an intense interconnection is observed, thanks mainly to terms that have a low "structural hole" value. Among others: Economic Aspects, Scientific Research Social, Aspects, Information Processing, Information Systems and Innovation, and Technology Transfer. Then, an extract (Table 51) is inserted from the table in Annex H, where these numerical values of centrality and structural hole are shown:

Table 51. Value of Centrality and "Structural hole" for "Subjects". Wind sector. Source: own elaboration.

Subject WIND 0013	CENT	Subject WIND 0013	Constraint
Scientific Research	0.4502	Economic Aspects	0.2575
Environmental Protection	0.4274	Scientific Research	0.2616
Economic Aspects	0.3648	Social Aspects	0.2902
Social Aspects	0.3383	Information Processing, Information Systems	0.3135
Safety	0.3375	Innovation, Technology Transfer	0.3252

In the following image (Figure 77) these items are displayed:

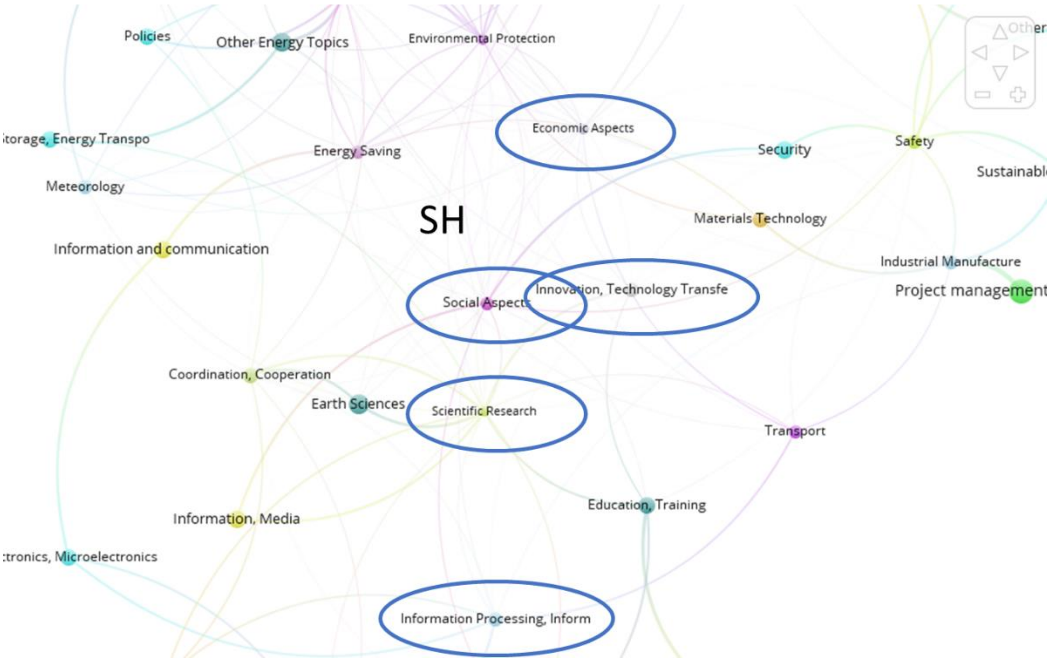


Figure 77. "Structural hole" areas in "subjects" term map. Wind sector. Source: own elaboration.

7.4.5.2. Terms maps: solar sector

On the one hand, the network of "keywords" for the solar sector will be analysed. There are 3 types of visualizations: network of nodes and their relationships (Figure 78), cluster density network (Figure 79), node density network (Figure 80).

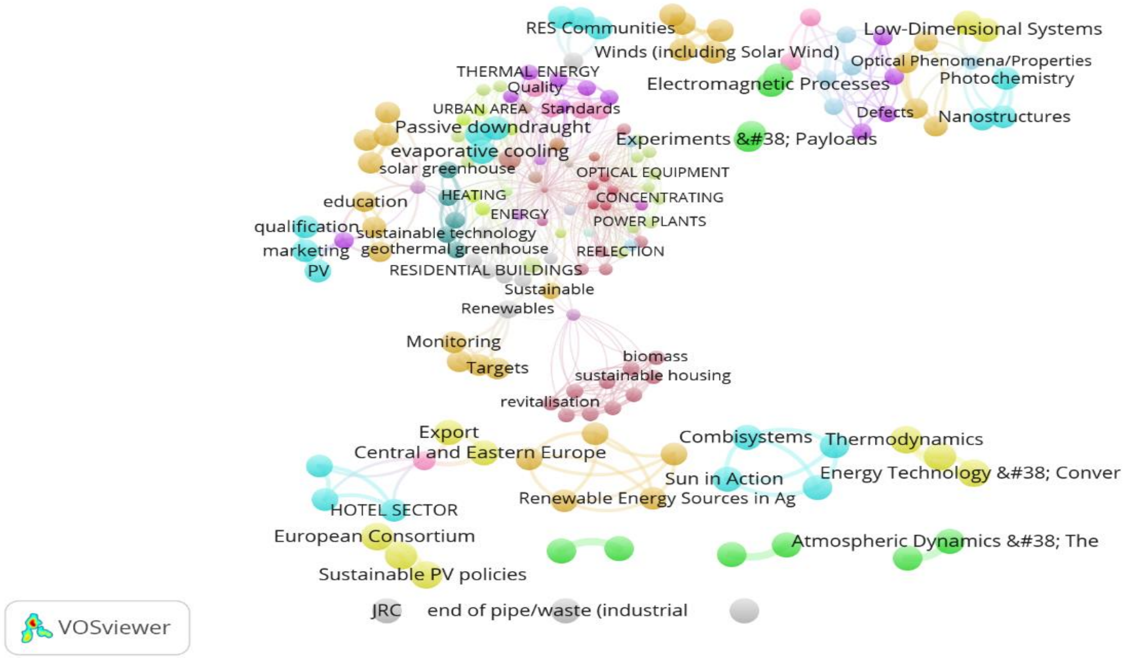


Figure 78. "Keywords" term map. Solar sector. Source: own elaboration.

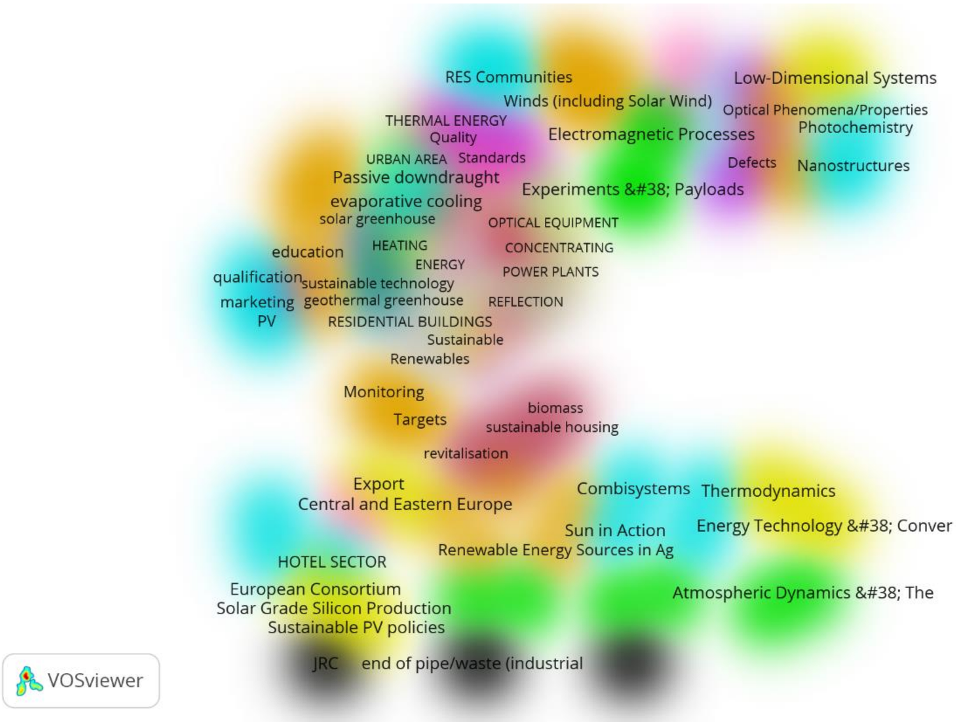


Figure 79. Cluster density "keywords" network term map. Solar sector. Source: own elaboration.

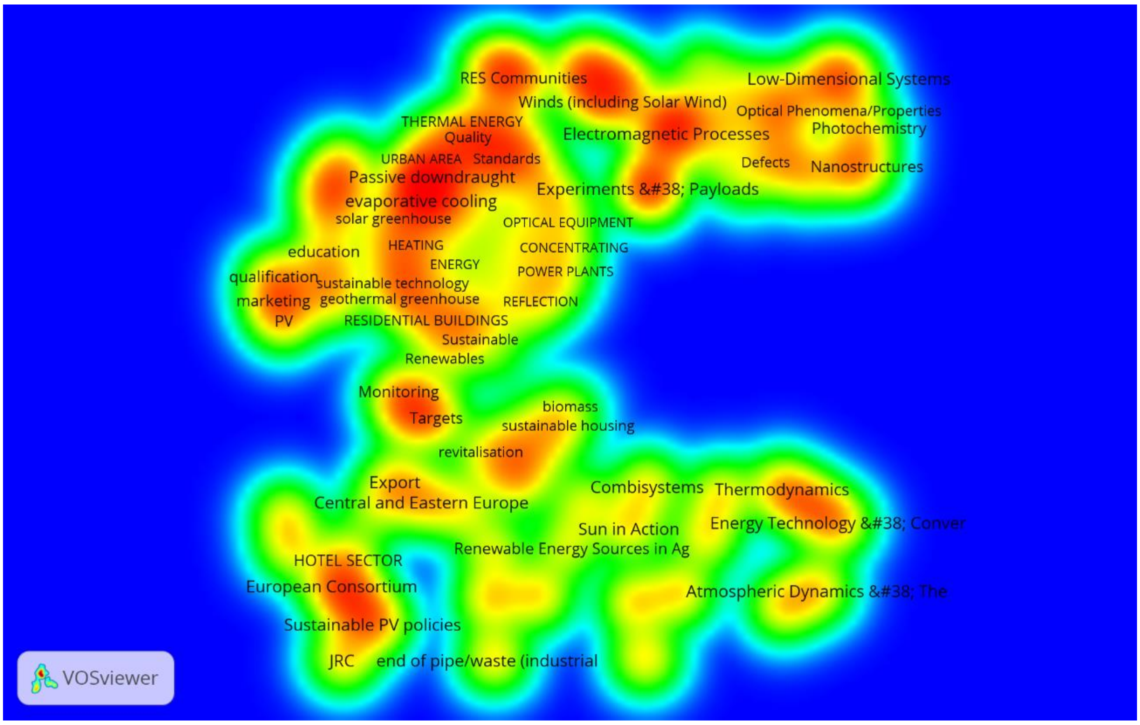


Figure 80. Node density "keywords" network term map. Solar sector. Source: own elaboration.

For the solar energy sector, 27 clusters of “keywords” are identified (Table 52):

Table 52. “Keywords” and “clusters”. Solar sector. Source: own elaboration.

Keywords	**Cluster**
Atmospheric Dynamics & Thermodynamics, Biogas - for rural communities & electricity, Electromagnetic Processes, Experiments & Payloads, Renewable Sources Energy, Domestic, Photovoltaic Systems, Fluid Dynamics, Plasma Instabilities & Non-Linear Phenomena, Meteorology/Climatology, heat and fuel demands	1
Energy Technology & Conversion, European Consortium, Export, Low-Dimensional Systems, Renewable Energy Sources, Electronic Properties & Magnetism, Solar Grade Silicon Production, Central and Eastern Europe, Sustainable PV policies, Thermodynamics	2
ENERGY IN HOTELS, Key Issues in Solar Thermal, Nanostructures, Passive downdraught, RES Communities, evaporative cooling, HOTEL SECTOR, PV, Quantum Dots, Sun in action, District energy system, qualification, Solar Keymark, Combisystems, Europe, Low energy buildings, marketing, Photochemistry, TOURISM INDUSTRY	3
Physical Optics, Renewable Energy Sources in Communities, Schools, Sustainable, Markets, Monitoring, Nonlinear Optics, Renewable Energy Sources in Agriculture, Winds (including Solar Wind), education, Green Electricity, Laser, Nucleosynthesis, Targets, Training of engineers, Evolution, Liberalisation, Photonics, photovoltaics (PV), Statistics, Sustainable Building Design, Clean Agriculture, Consumers, Legislation, Low-Temperature Plasmas, Plasma Chemistry & Applications	4
renewable energy technologies, Surfaces, Interfaces & Microstructures, Quality, Standards, Training, Certification	5
energy substitution, sustainable technology, geothermal energy, geothermal greenhouse, solar greenhouse	6
Crystalline Strucure, solar thermal, ENERGY RESOURCES, Structural Phase Transitionsn, Defects, Mechanical Properties, THERMAL ENERGY, LARGE-SCALE OPERATION, COST DECREASES, POWER PLANT, TURBOMACHINERY	7
Photovoltaic, Renewables, URBAN PLANNING, AIR CONDITIONING, INDUSTRIAL PLANTS, RESIDENTIAL BUILDINGS, DEMONSTRATION, ENVIRONMENT MANAGEMENT, TECHNOLOGICAL INNOVATIONS	8
Semiconductors, Optical Phenomena/Properties, Films, Coating, Wires & Fibres, ISLANDS, MEDITERRANEAN COUNTRIES	9
PUBLIC TRANSPORT, RAILWAY TRANSPORT, TRAINS, CONTROL EQUIPMENT, REMOTE CONTROL, revitalisation, urban redevelopment, sustainable housing, solar, 100% RES, competition, architecture, architect, planners, biomass.	10
BIOGAS, CHP, ENERGY MANAGEMENT SYSTEM, POWER PLANTS, CONCENTRATING, NATURAL RESOURCES, SCHOOL BUILDINGS, LOW COST HOUSING, OPTICAL EQUIPMENT, WATER CONSUMPTION, REFLECTION, VENTILATION, HORIZONTAL AXIS, PREFABRICATED CONSTRUCTION	11
SOLAR CELLS	12
HOUSING, URBAN AREA, HEATING, TECHNOLOGICAL INNOVATION, COOLING	13
Renewable Energy, Wind energy	14
PASSIVE SOLAR SYSTEMS	15
ENERGY CONSERVATION URBAN AREAS	16

WALLS	17
ARCHITECTURAL DESIGN	18
PUBLIC BUILDINGS	19
ROOFS	20
ENERGY, ELECTRIC POWER GENERATION	21
GRID CONNECTION	22
ENERGY CONSUMPTION	23
ENERGY SOURCES, ELECTRICAL TECHNOLOGY, ELECTRIC GENERATORS, SOLAR GENERATORS, PHOTOELECTRIC DEVICES	24
buildings	25
ENERGY (PHYSICS)	26
Solar Energy	27
end of pipe/waste (industrial activities), JRC, Nanotechnology	No cluster

First, the identified clusters will be described.

Cluster 1 and 2, containing items of different nature, could represent the most extensive area of science and technology associated with the solar energy sector. For example, cluster 1 groups terms such as "Atmospheric Dynamics & Thermodynamics", "electricity", "Electromagnetic Processes", "Non-Linear Phenomena", "Renewable Sources Energy" or "Domestic Photovoltaic Systems"; while Cluster 2 includes "Energy Technology & Conversion", "Low-Dimensional Systems", "Electronic Properties & Magnetism" and "Solar Grade Silicon Production" Export ", "Central and Eastern Europe" and "Sustainable PV policies" as representatives of the area of policy management and promotion of solar energy.

Cluster 3 encompasses terms that generally refer to the solar energy sector for the building area, communities and districts, hotel sector and tourism, as well as energy-efficient buildings, including solar thermal and photovoltaic.

Cluster 4 is the cluster with the most diversity of thematic areas. Some of them may be: education, markets and liberalization, consumers or legislative issues.

It should also be noted that cluster 10 encompasses terms referring to the area of public transport, railroad, as well as control and sustainable architecture teams, having a link with the area of biomass.

Next, the thematic areas that have been identified are analysed, which in some cases coincide spatially with the clusters identified according to the degree of centrality of the items. To visualize it better, some image magnifications of the clusters are made (Figure 81).

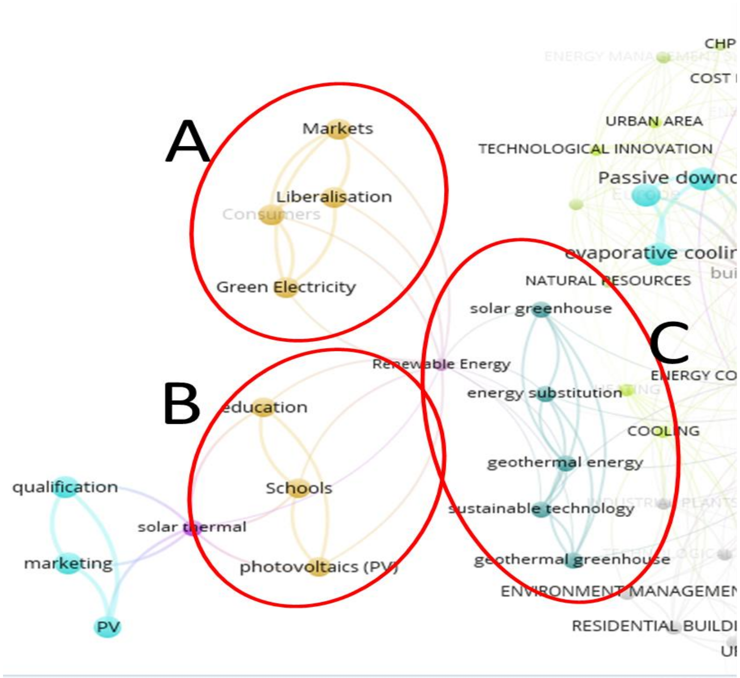


Figure 81. A, B and C areas in "keywords" term map. Solar sector. Source: own elaboration.

An area would correspond to the issue of markets, liberalization and green electricity. B would correspond to the thematic area of education. And C area would correspond to greenhouse and the link with geothermal sector. As can be seen, these three areas are located adjacent to the central zone of the map, having as intermediary the term "Renewable energy" that would act as "structural hole" (Figure 81 and Figure 82).

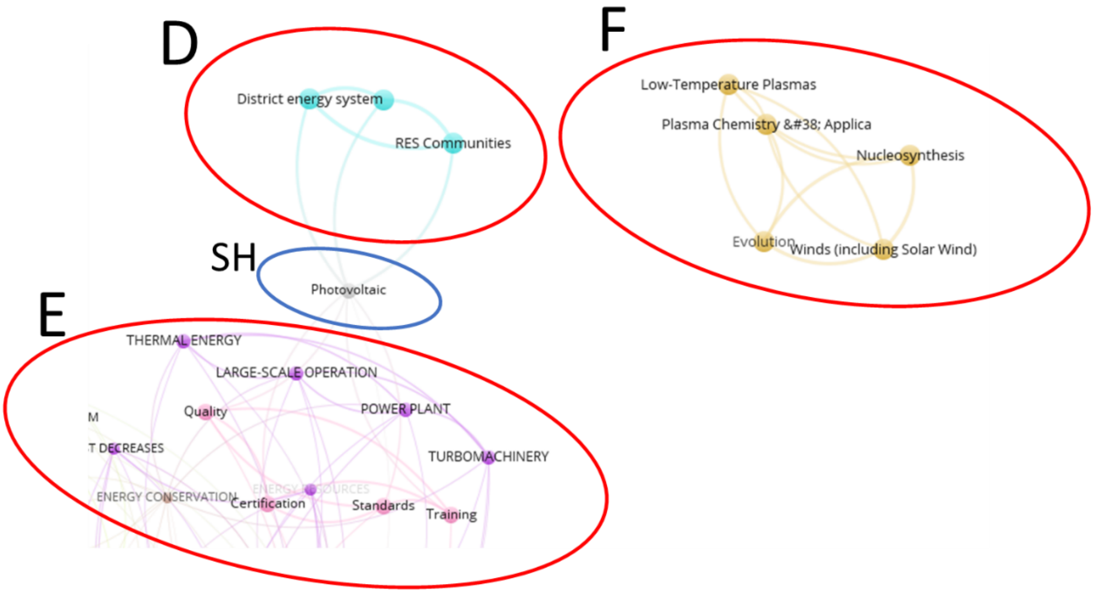


Figure 82. D, E and F, and "structural hole" areas in "keywords" term map. Solar sector. Source: own elaboration.

On the one hand, D area would correspond to the energy area for communities. E would generally cover operations, quality, standardization and certification. D and E would be connected by the "structural hole" "photoelectric" that would act as a bridge between the two zones. D and E areas are located at the top of the central core of the map. On the other hand, zone F would be the one corresponding to more scientific terms (Figure 83).

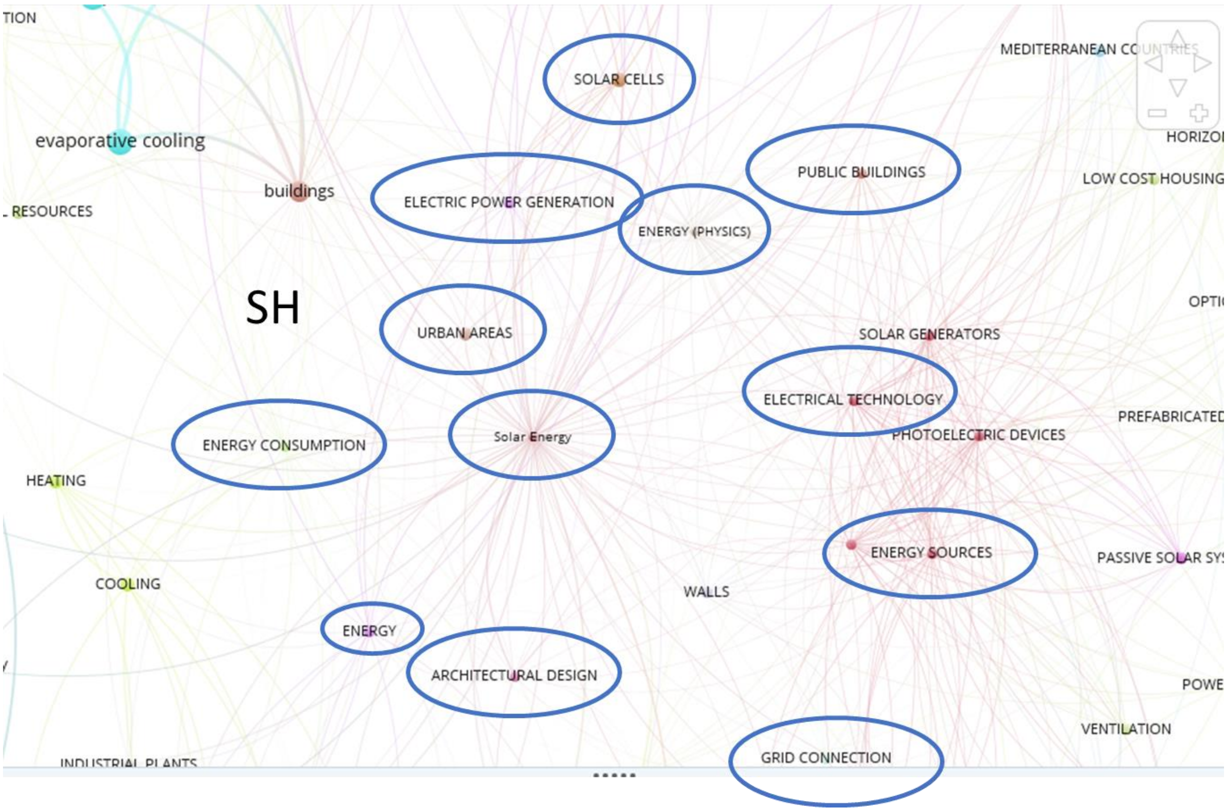


Figure 83. "Structural hole" areas in "keywords" term map. Solar sector. Source: own elaboration.

The central nucleus of the map would include very different terms, but it would be the one that concentrated most of the items that play the role of bridge between different zones. The large number of structural holes in this area can be seen in the Figure 83 (the numerical values can be obtained in Annex H). In addition, it should be noted that most of these items also have a high value of centrality, which makes them efficient terms when integrating the network in a cohesive way.

Next, the network of "subjects" for the solar sector will be analysed. There are three types of visualizations: network of nodes and their relationships (Figure 84), cluster density network (Figure 85), node density network (Figure 86 and Figure 87).

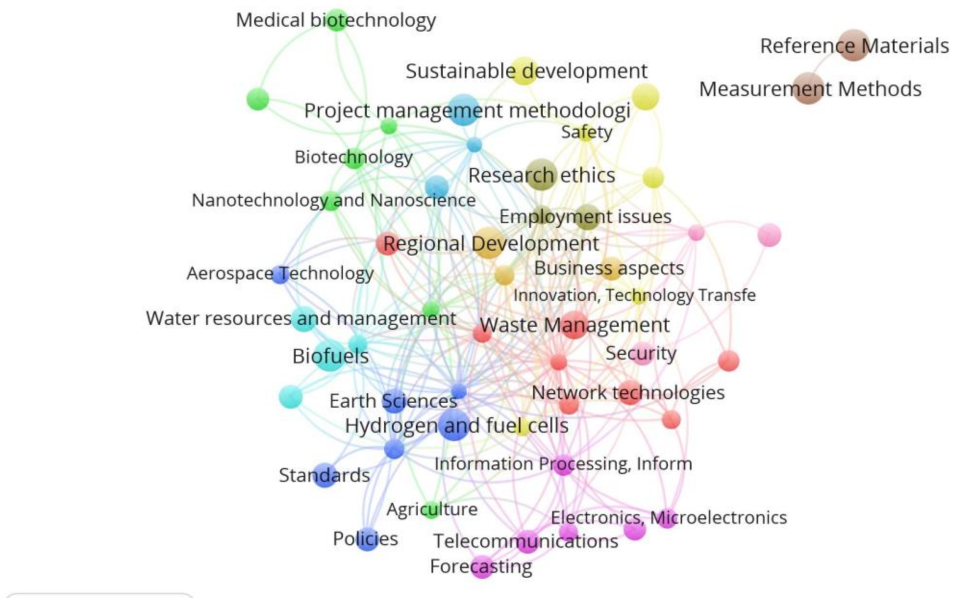


Figure 84. "Subjects" term map. Solar sector. Source: own elaboration.

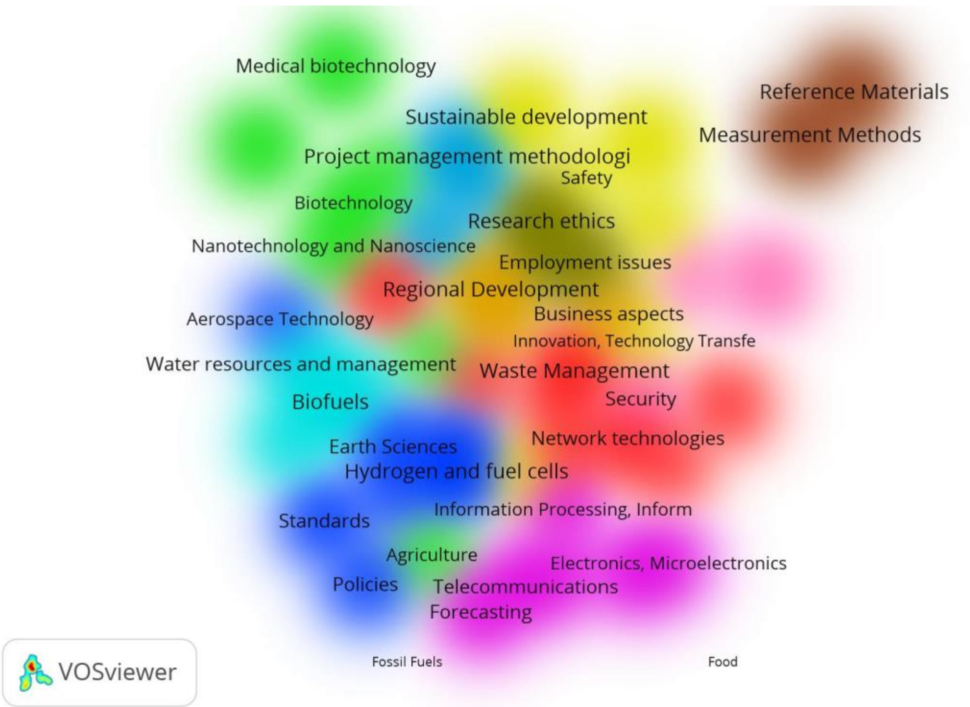


Figure 85. Cluster density "subjects" network term map. Solar sector. Source: own elaboration.

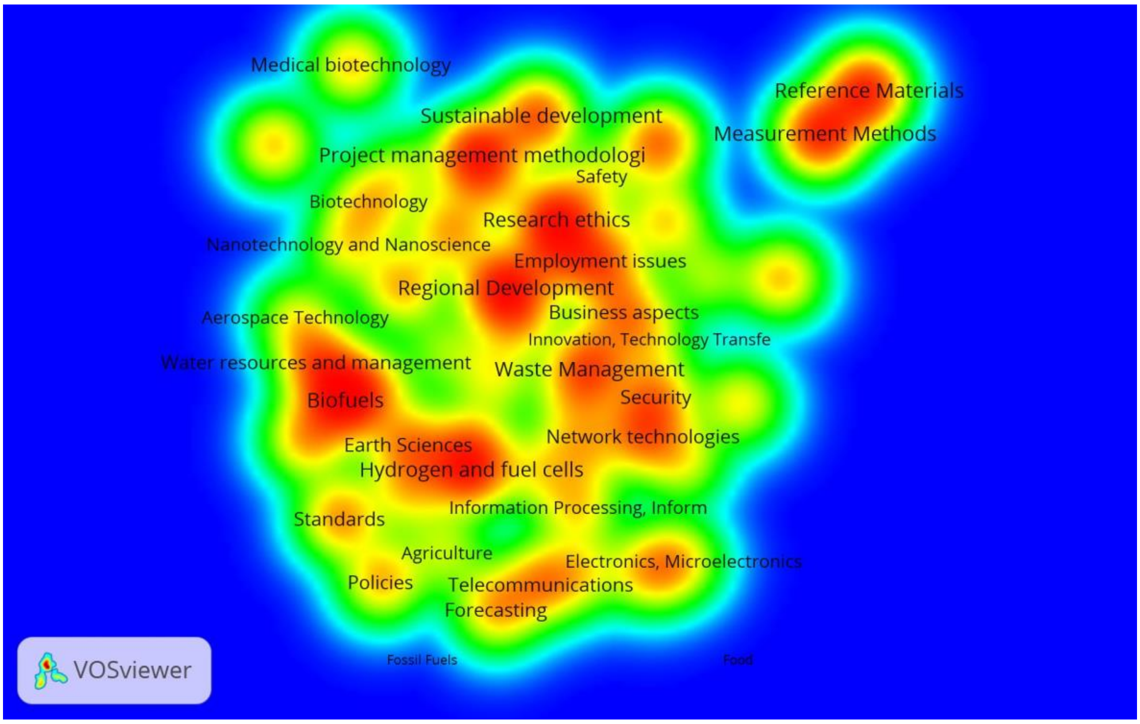


Figure 86. Node density "subjects" network term map. Solar sector. Source: own elaboration.

For the solar energy sector, clusters of "Subject" (Table 53) are identified:

Table 53. "Subjects" and "clusters". Solar sector. Source: own elaboration.

Subject	**Cluster**
Construction Technology, Education, Training, Energy Saving, Environmental Protection, Information and communication technology applications, Information, Media, Network technologies, Waste Management	1
Biotechnology, Life Sciences, Medical biotechnology, Medicine, Health, Nanotechnology and Nanosciences, Agricultural biotechnology, Agriculture	2
Coordination, Cooperation, Earth Sciences, Hydrogen and fuel cells, Policies, Scientific Research Standards	3
Energy Storage, Energy Transport, Innovation, Technology Transfer, Radiation Protection, Safety, Sustainable development	4
Forecasting, Information Processing, Information Systems, Meteorology, Telecommunications, Electronics, Microelectronics	5
Other Energy Topics, Renewable Sources of Energy, Water resources and management, Biofuels	6
Industrial Manufacture, Materials Technology, Project management methodologies	7
Economic Aspects, Regional Development, Business aspects	8
Employment issues, Social Aspects, Research ethics	9
Security, Transport	10
Reference Materials, Measurement Methods	11

On the one hand, cluster 1 is made up of items from various thematic areas, such as construction, education, information and communication. As for cluster 2, the items are generally related to biotechnology, science and agriculture. Cluster 3 is oriented towards coordination, energy policies or scientific research. With respect to cluster 4, there is a clear orientation towards energy transport, sustainable development, storage or technology transfer. On the other hand, cluster 5 focuses on communications, information systems, as well as electronics for the wind sector. Cluster 6 is geared towards other renewable resources. Cluster 7 includes items related to production processes, materials and methodologies for project management in the field of wind energy. As for clusters 8 and 9, one can observe the focus on economic, regional, business, as well as social and ethical aspects of this energy sector. Security and transport are encompassed in Cluster 10, and measurement methods and material references in cluster 11. It is observed that cluster 11 is completely independent of the rest.

The extract of table in annex H (Table 54) breaks down the values of the items corresponding to centrality and efficiency:

Table 54. Value of Centrality and "Structural hole" for "Subjects". Solar sector. Source: own elaboration.

Subjects SOLAR 0013	CENT	Subjects SOLAR 0013	Constraint
Environmental Protection	0.4843	Scientific Research	0.2480
Scientific Research	0.4337	Industrial Manufacture	0.2514
Renewable Sources of Energy	0.3344	Innovation, Technology Transfer	0.2648
Social Aspects	0.3342	Life Sciences	0.2653
Economic Aspects	0.3324	Environmental Protection	0.2683

The following figure (Figure 87) shows these structural holes:

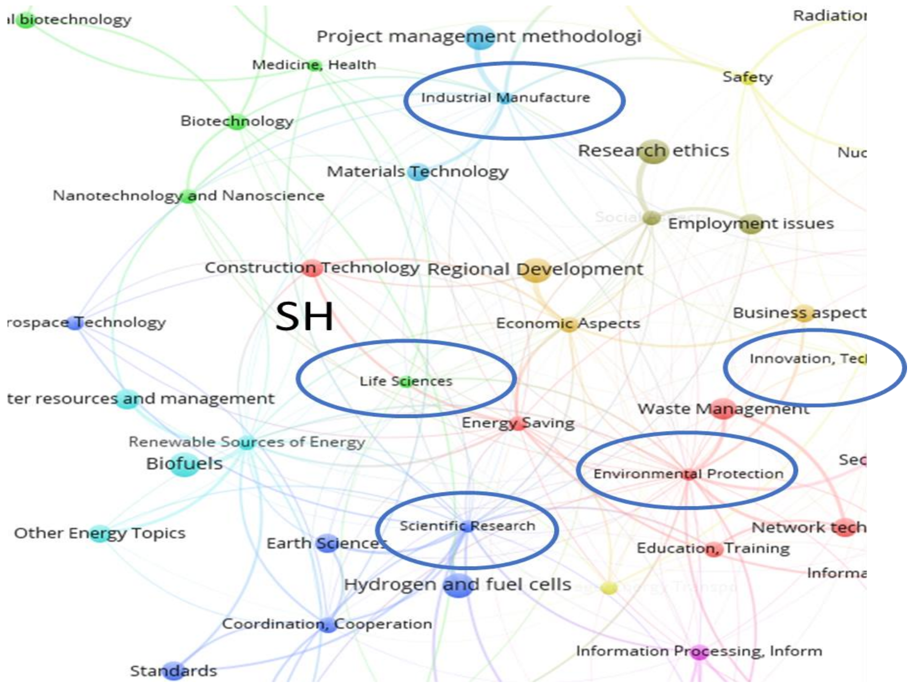


Figure 87. "Structural hole" areas in "subjects" term map. Solar sector. Source: own elaboration.

7.4.5.3. Terms maps: sea energy sector

Next, the network of "subjects" for the sea energy sector will be analysed. There are 3 types of visualizations: network of nodes and their relationships (Figure 88), cluster density network (Figure 89), node density network (Figure 90).

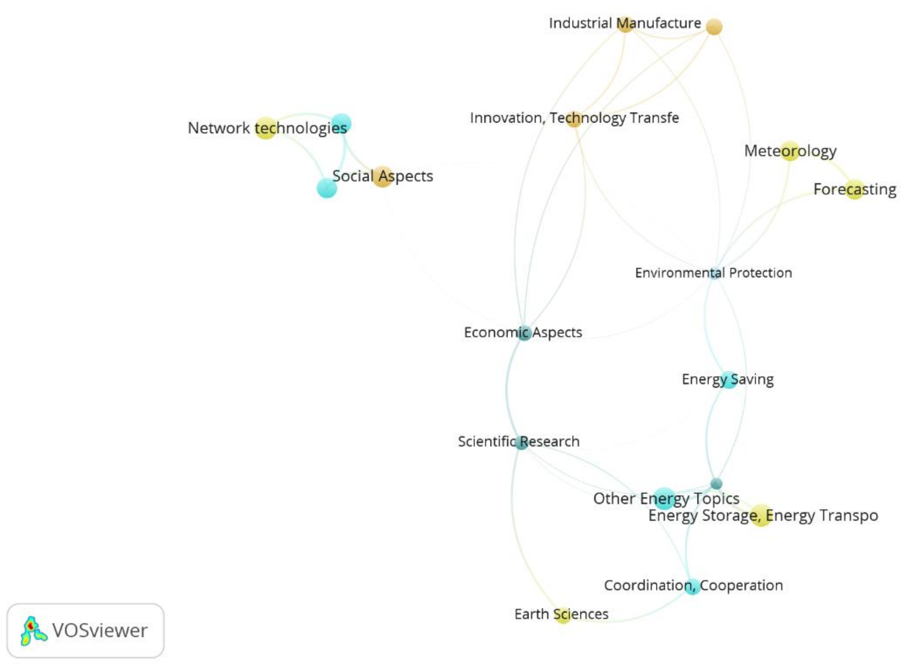


Figure 88. "Subjects" term map. Sea energy sector. Source: own elaboration.

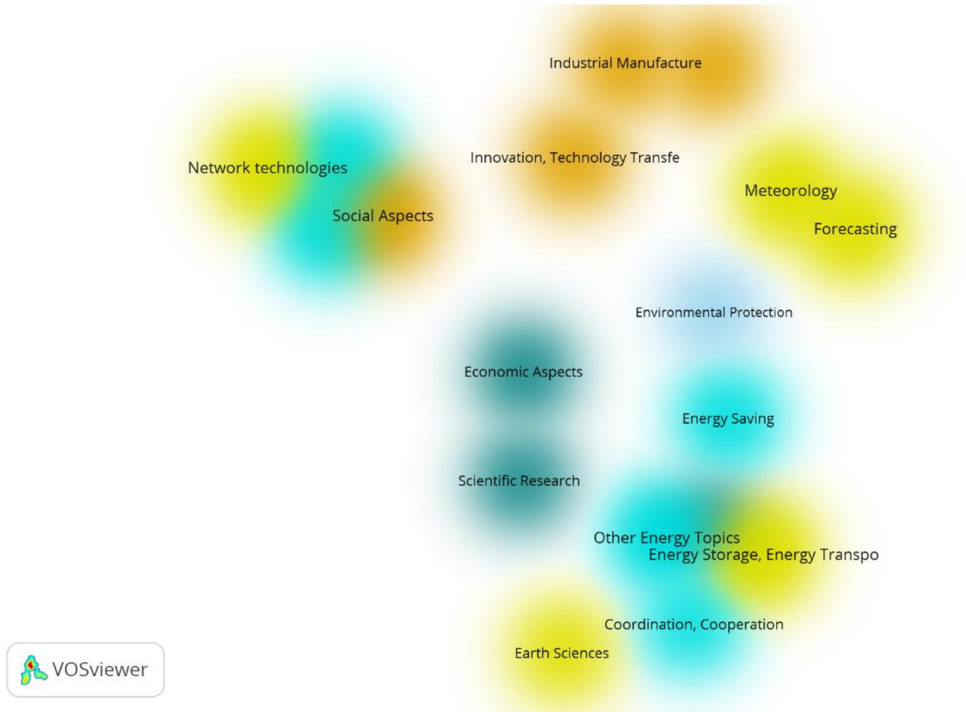


Figure 89. Cluster density "subjects" network term map. Sea energy sector. Source: own elaboration.

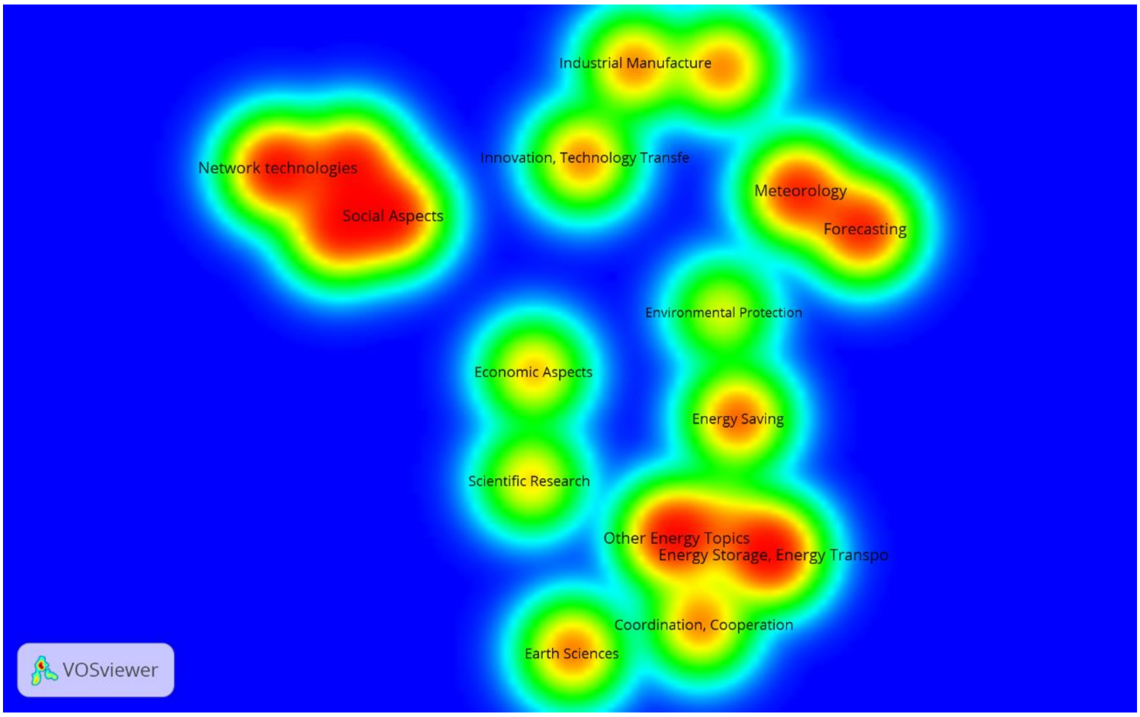


Figure 90. Node density "subjects" network term map. Sea energy sector. Source: own elaboration.

For the sea energy sector, the following 5 clusters of "Subject" are identified (table 55):

Table 55. "Subjects" and "clusters". Sea energy sector. Source: own elaboration.

Subject	Cluster
Energy Saving, Environmental, rotection, Forecasting, Meteorology	1
Education, Training, Social Aspects, Employment issues, Network technologies	2
Economic Aspects, Industrial Manufacture, Innovation, Technology Transfer, Safety	3
Coordination, Cooperation, Scientific Research, Earth Sciences	4
Energy Storage, Energy Transport, Other Energy Topics, Renewable Sources of Energy	5

Cluster 1 focuses on environmental and energy reduction items in the marine sector. Cluster 2 encompasses areas such as education, social aspects, employment, as well as networking technologies. Cluster 3 focuses on the economic area, industrial production, technology transfer and innovation. Cluster 4 includes terms related to coordination, cooperation and scientific research. Finally, cluster 5 refers to other sectors of renewable energies, transport and storage.

In the following table (Table 56) corresponding to an extract from Annex H, the numerical values of the two indicators are shown:

Table 56. Value of Centrality and "Structural hole" for "Subjects". Sea energy sector. Source: own elaboration.

Subjects SEA 0013	**CENT**	**Subjects SEA 0013**	**Constraint**
Environmental Protection	0.5930	Renewable Sources of Energy	0.3064
Renewable Sources of Energy	0.3816	Scientific Research	0.4414
Economic Aspects	0.3810	Industrial Manufacture	0.5143
Social Aspects	0.3573	Innovation, Technology Transfer	0.5143

And in the following figure (Figure 91) the two areas and the items that join the network are shown visually:

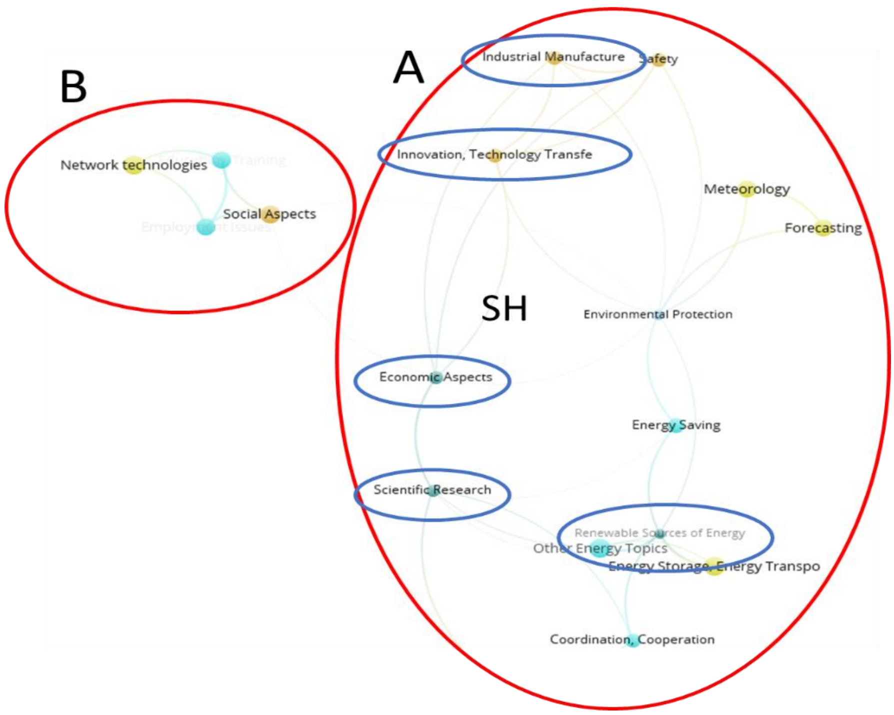


Figure 91. A and B, and "structural hole" areas in "subjects" term map. Sea energy sector. Source: own elaboration.

7.4.5.4. Terms maps: geotermal sector

In this section, we will analyse the networks for "keywords" and "subjects" for the geothermal sector. First, the "keywords" network will be analysed. There are 3 types of visualizations: network of nodes and their relationships (Figure 92), cluster density network (Figure 93), node density network (Figure 94).

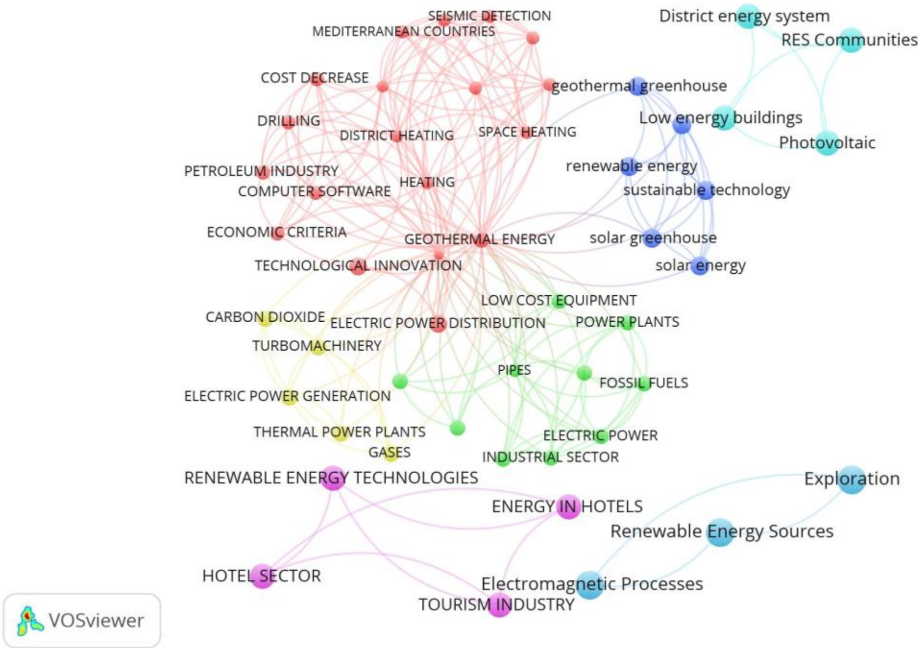


Figure 92. "Keywords" term map. Geothermal sector. Source: own elaboration.

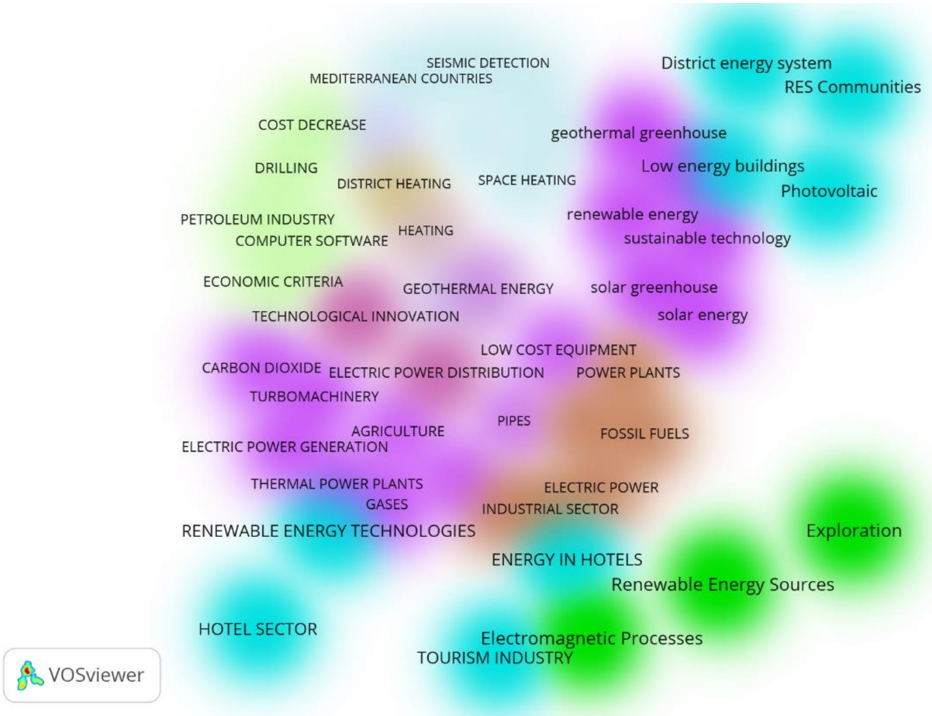


Figure 93. Cluster density "keywords" network term map. Geothermal sector. Source: own elaboration.

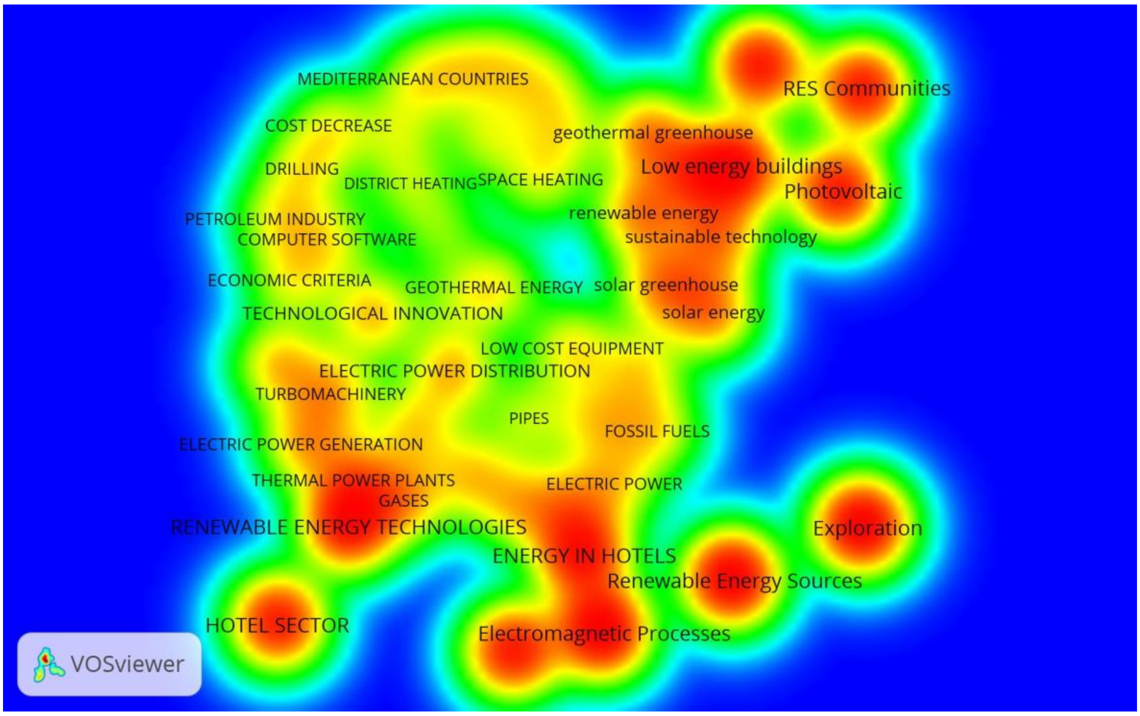


Figure 94. Node density "keywords" network term map. Geothermal sector. Source: own elaboration.

For the geothermal energy sector, the following 7 clusters of "keywords" (Table 57) are identified:

Table 57. "Keywords" and "clusters". Geothermal sector. Source: own elaboration.

Keywords	Cluster
ENERGY (PHYSICS), ENERGY CONSUMPTION, GEOTHERMAL ENERGY, TECHNOLOGICAL INNOVATION, DISTRICT HEATING, HEATING, ELECTRIC POWER DISTRIBUTION, DRILLING, SPACE HEATING, COST DECREASE, MEDITERRANEAN COUNTRIES, COMPUTER SOFTWARE, ENVIRONMENTAL TECHNOLOGY, PETROLEUM INDUSTRY, POLLUTION CONTROL, ECONOMIC CRITERIA, SEISMIC DETECTION, HEAT EXCHANGERS, HEAT TRANSFER	1
ENERGY RESOURCES, INDUSTRIAL SECTOR, ELECTRIC POWER, PIPES AGRICULTURE, POWER PLANTS, LOW COST EQUIPMENT, WATER TRANSPORT, ENVIRONMENT PROTECTION	2
renewable energy, energy substitution, sustainable technology, solar energy, geothermal greenhouse, solar greenhouse	3
ELECTRIC POWER GENERATION, GASES, TURBOMACHINERY, CARBON DIOXIDE, THERMAL POWER PLANTS	4
ENERGY IN HOTELS, HOTEL SECTOR, RENEWABLE ENERGY TECHNOLOGIES, TOURISM INDUSTRY	5
RES Communities, Photovoltaic, District energy system, Low energy buildings	6
Electromagnetic Processes, Exploration, Renewable Energy Sources	7

Cluster 1 focuses on several thematic areas, including: geothermal technology (with district heating), technological innovation, as well as economic aspects and costs. As for cluster 2 and 4, they include items such as: power plants, power, machinery, thermal plants, as well as industrial sector. With respect to cluster 3 and 6, they focus on the "Green House" housing or communities, including solar sector terms. Specifically, cluster 5 refers to the hotel services and tourism sector. Finally, cluster 7 includes items related to exploration and renewable energy sources.

It is observed that clusters 5, 6 and 7 are totally separated from the rest, which make up the integrated and cohesive nucleus of the "keywords" network. In this nucleus, the items that act as a link between clusters efficiently would be indicated in the following table (Table 58) (Annex H extract):

Table 58. Value of Centrality and "Structural hole" for "Keywords". Geothermal sector. Source: own elaboration.

Keywords Geotherm 0013	**CENT**	**Keywords Geotherm 0013**	**Constraint**
GEOTHERMAL ENERGY	0.2392	ENERGY (PHYSICS)	0.1499
ENERGY (PHYSICS)	0.1216	HEATING	0.1984
HEATING	0.0347	DISTRICT HEATING	0.2159
DISTRICT HEATING	0.0281	ENERGY CONSUMPTION	0.2245
ENERGY CONSUMPTION	0.0214	PIPES	0.2593

In the following image (Figure 95) you can see the detail:

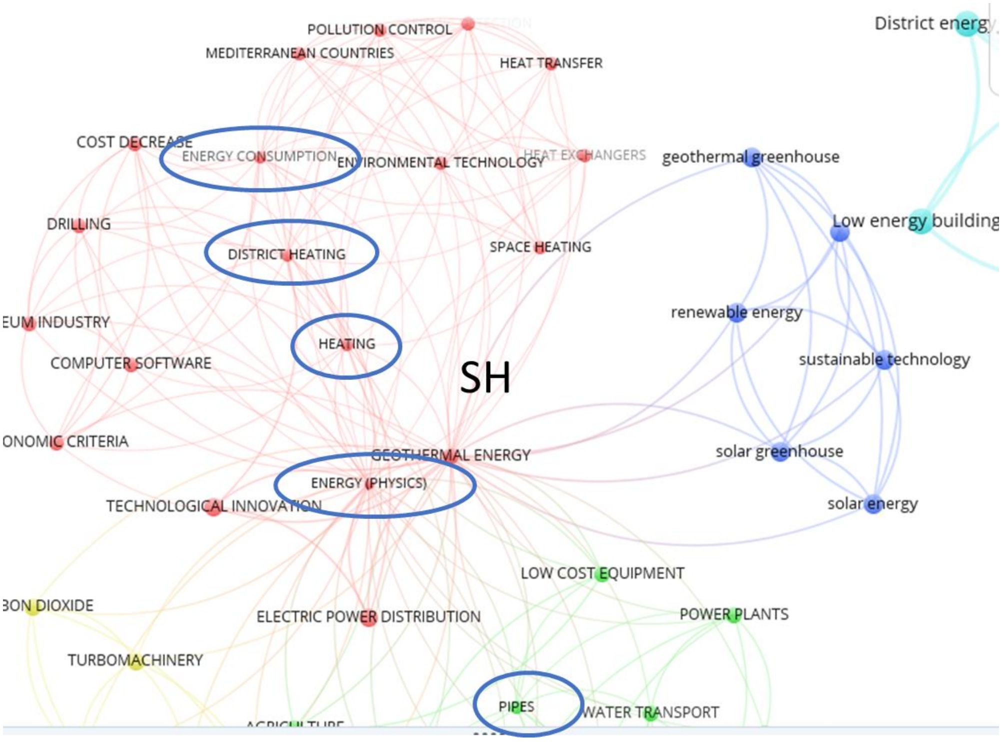


Figure 95. "Structural hole" areas in "keywords" term map. Geothermal sector. Source: own elaboration.

Second, the network of "subjects" will be analysed. There are three types of visualizations: network of nodes and their relationships (Figure 96), cluster density network (Figure 97), node density network (Figure 98).

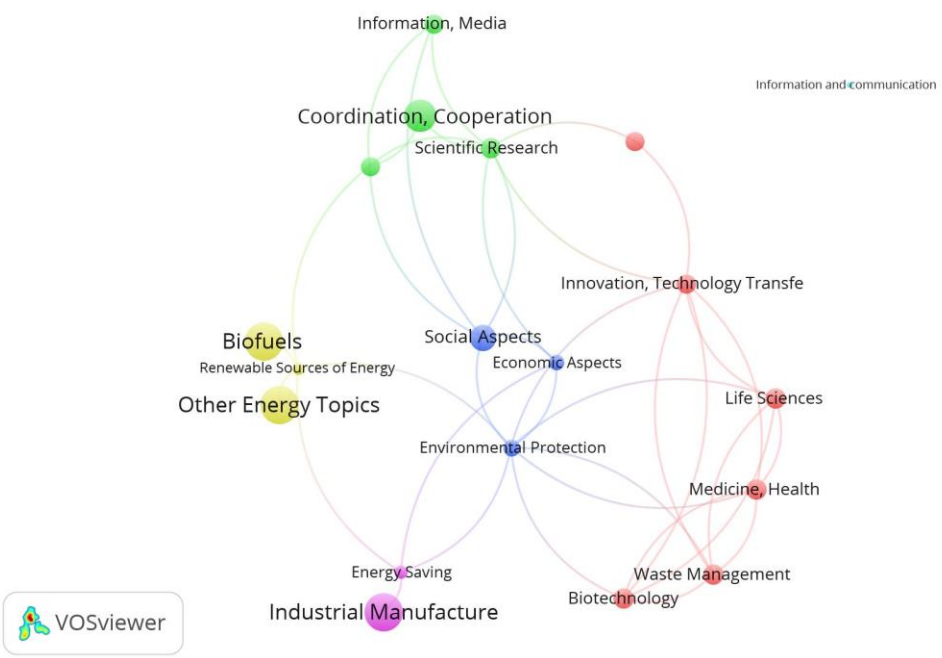


Figure 96. "Subjects" term map. Geothermal sector. Source: own elaboration.

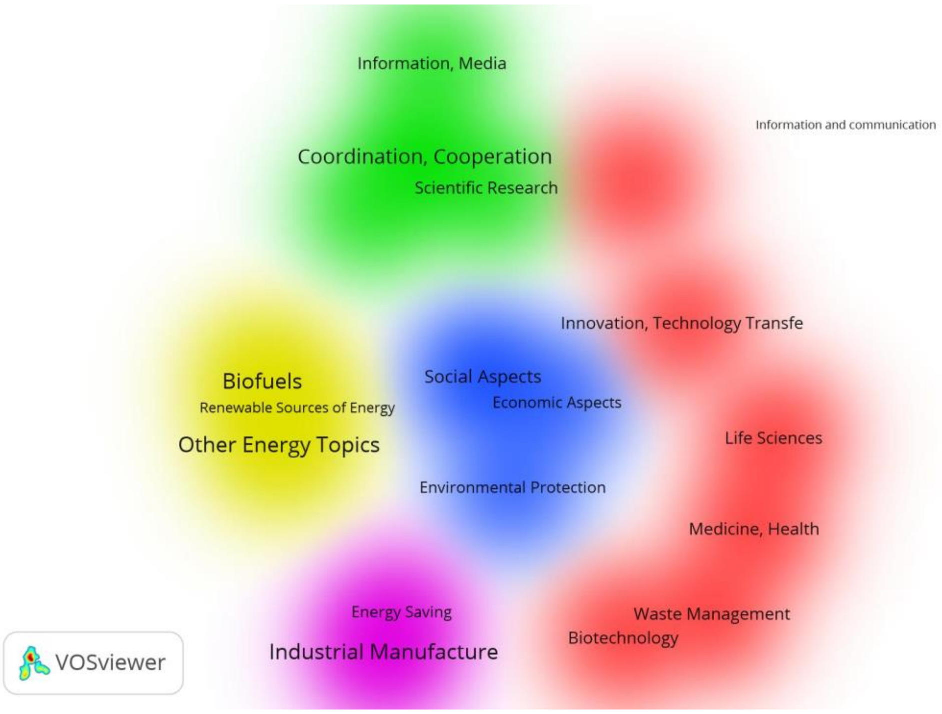


Figure 97. Cluster density "subjects" network term map. Geothermal sector. Source: own elaboration.

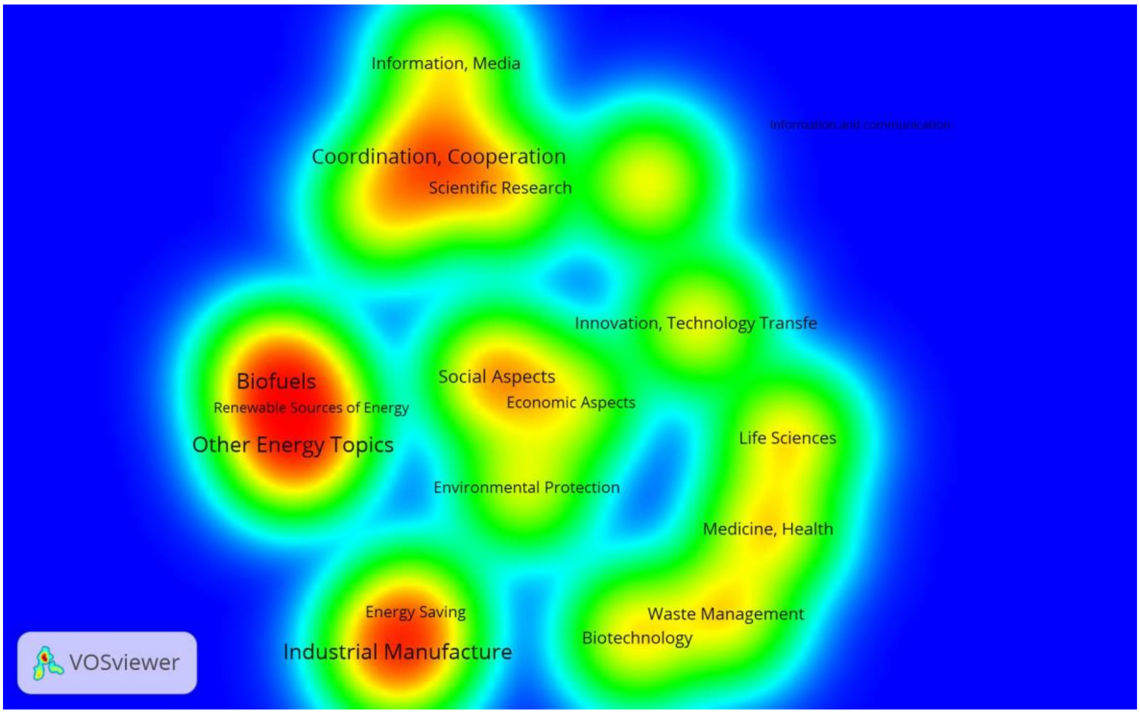


Figure 98. Node density "subjects" network term map. Geothermal sector. Source: own elaboration.

For the geothermal energy sector, the following 6 clusters of "Subject" (Table 59) are identified:

Table 59. "Subjects" and "clusters". Geothermal sector. Source: own elaboration.

Subject	**Cluster**
Biotechnology, Education, Training, Life Sciences, Innovation, Technology Transfer, Medicine, Health, Waste Management	1
Coordination, Cooperation, Earth Sciences, Scientific Research, Information, Media	2
Economic Aspects, Social Aspects, Environmental Protection	3
Biofuels, Other Energy Topics, Renewable Sources of Energy	4
Energy Saving, Industrial Manufacture	5
Information and communication technology applications	6

In this sector, all clusters identified in relation to "subjects" are fully integrated into the total network. Cluster 1 focuses on biotechnology, innovation, technology transfer and social sciences. As for cluster 2, the focus is on information, scientific research, coordination and cooperation. Regarding cluster 3, the focus is on environmental protection, economic and social aspects.

Cluster 4 focuses on other sources of renewable energy. Cluster 5 encompasses the issues of industrial production and energy saving. It should be noted that cluster 6 is thematically related to cluster 3 because it focuses on technological applications for information and communication.

The following table (Table 60) (extract from Annex H) details the numerical values of these items according to their centrality and efficiency:

Table 60. Value of Centrality and "Structural hole" for "Subjects". Geothermal sector. Source: own elaboration.

Subjects GEOTH 0013	**CENT**	**Subjects GEOTH 0013**	**Constraint**
Environmental Protection	0.4782	Renewable Sources of Energy	0.3137
Scientific Research	0.3717	Energy Saving	0.3612
Renewable Sources of Energy	0.3621	Economic Aspects	0.4170
Innovation, Technology Transfer	0.3618	Environmental Protection	0.4411
Earth Sciences	0.2974	Information, Media	0.4980

The identification of the structural holes is done in the following figure (Figure 99):

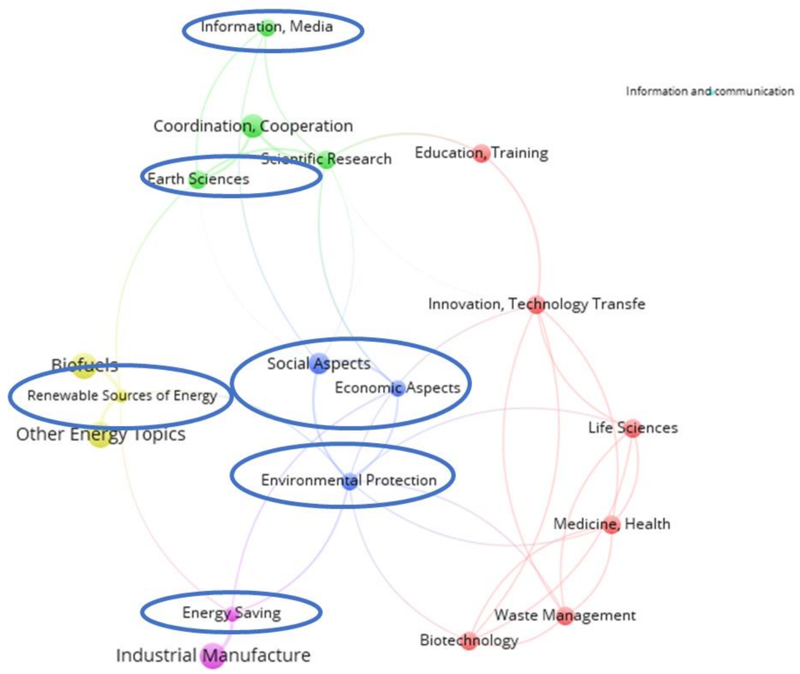


Figure 99. "Structural hole" areas in "subjects" term map. Geothermal sector. Source: own elaboration.

7.4.5.5. Terms maps: biomass sector

Finally, to finish showing the results and conclusions of the "keywords" and "subjects" term maps of the different sectors under study, on the one hand, the "keywords" network for the biomass sector will be analysed first. There are 3 types of visualizations: network of nodes and their relationships (Figure 100), cluster density network (Figure 101), node density network (Figure 102).

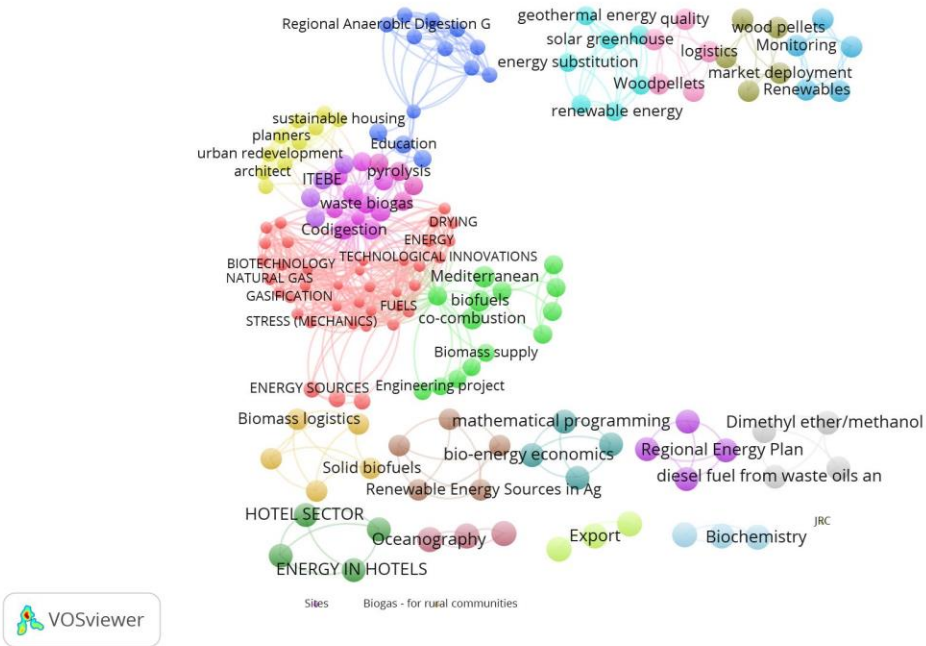


Figure 100. "Keywords" term map. Biomass sector. Source: own elaboration.

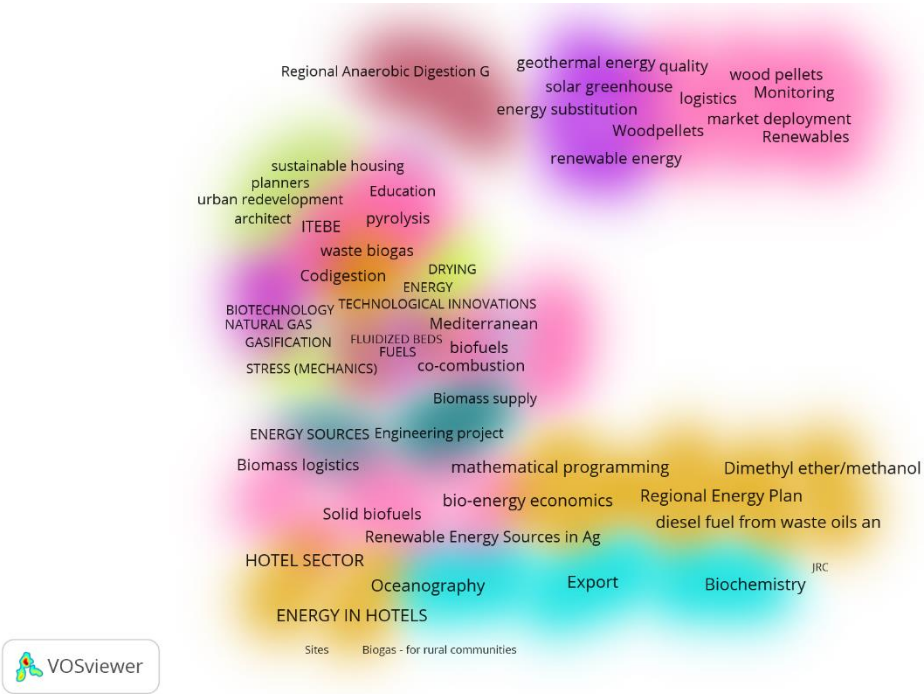


Figure 101. Cluster density "keywords" network term map. Biomass sector. Source: own elaboration.

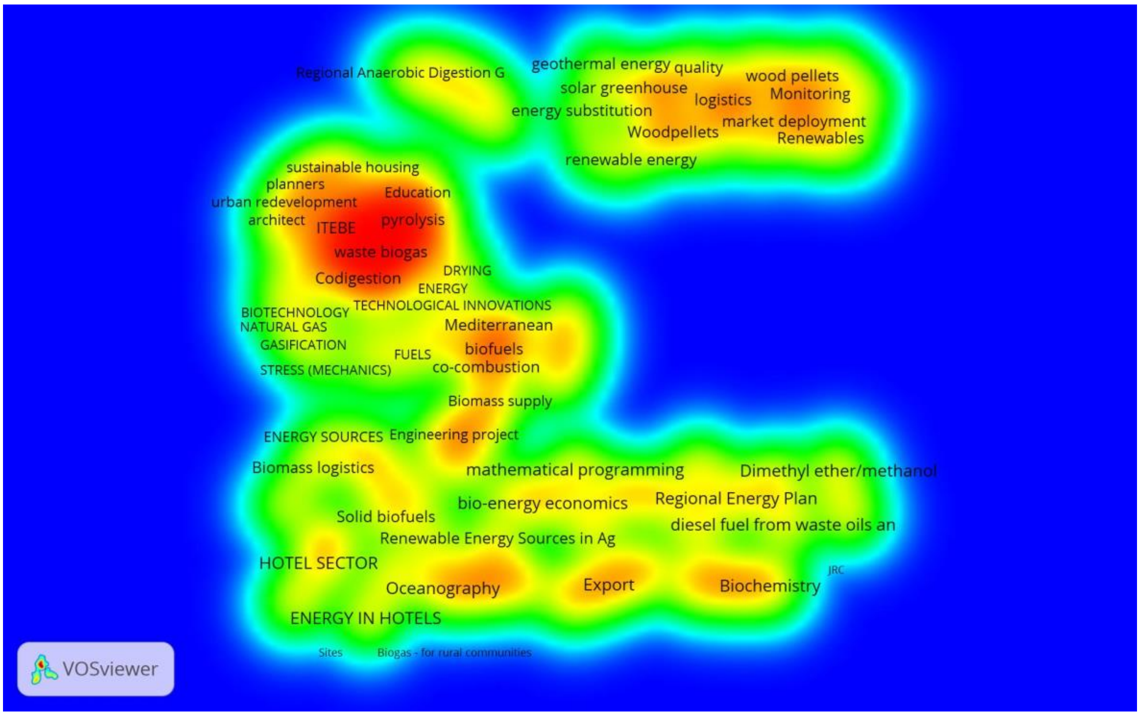


Figure 102. Node density "keywords" network term map. Biomass sector. Source: own elaboration.

For the biomass energy sector, the following 23 clusters of "Keywords" (Table 61) are identified:

Table 61. "Keywords" and "clusters". Biomass sector. Source: own elaboration.

Keywords	**Cluster**
ENERGY, ENERGY (PHYSICS), ENERGY CONSUMPTION, ENERGY RESOURCES, ENERGY SOURCES, FUELS, RESOURCES SUBSTITUTION, BIOTECHNOLOGY, GAS PLANTS, SOLID FUELS, COAL, COMBUSTION, COST DECREASE, FLUIDIZED BEDS, DRYING, HEATING, WASTE TREATMENT, DOMESTIC WASTES, POLLUTION CONTROL, POWER PLANTS, BURNING, ENVIRONMENTAL TECHNOLOGY, GASIFICATION, CARBON DIOXIDE, POWER GENERATION, STRESS (MECHANICS), TURBOMACHINERY, COMBUSTION GASES, CORROSION PROTECTION, TECHNOLOGICAL INNOVATIONS, BOILERS, ENVIRONMENTAL EFFECTS, HEAT EXCHANGERS, HEAT RECOVERY, HEAT TRANSFER, NATURAL GAS, ELECTRIC POWER GENERATION, GRID CONNECTION	1
Biomass supply, Energy crops, Mediterranean, CHP, Forest and agro-industrial wastes, biofuels, Engineering project, co-combustion, Financial mechanisms, Power plant, liquid biofuels, integration, multiplecriteria model, spatial decision-making system	2
Local planning, Wood Energy Business Toolbox, Education, Regional Anaerobic Digestion Groups, Advisory Service, Information, Codes of Practice, Centralised anaerobic digestion plant, Wood, On-farm anaerobic digestion plant, National anaerobic digestion network, National heating network, Biogas	3
Revitalisation, urban redevelopment, sustainable housing, solar, 100% RES, competition, architecture, architect, planners, wind energy	4
Biomass, Codigestion, district heating, small-scale plants, waste biogas, co-generation, hydropower, wood fuel investment, network design, cost benefit analyses	5
renewable energy, energy substitution, sustainable technology, geothermal energy, solar energy, geothermal greenhouse, solar greenhouse	6
Renewables, Monitoring, Targets, Statistics, Legislation	7
Solid biofuels, Biomass CHP technologies, Biomass logistics, Training course material, Wood fuel information	8
Wood fuels, market deployment, biomass combustion, wood pellets, heat market	9
energy wood procurement, logistics, quality, training	10
Renewable Energy Sources in Communities, Renewable Energy Sources in Agriculture, Training of engineers, Sustainable Building Design, Clean Agriculture	11
bio-energy economics, mathematical programming, public policy in agriculture, multi-criteria analysis	12
Pyrolysis, standards, markets, liquid fuels	13
Regional Energy Plan, RES Partnership, RES best practise, 100 communities 100% RES	14
Revue, wood-energy, magazine, ITEBE	15
diesel fuel from waste oils and fats, biodiesel/biogas, Dimethyl ether/methanol, heating from used frying oil	16
ENERGY IN HOTELS, HOTEL SECTOR, RENEWABLE ENERGY TECHNOLOGIES, TOURISM INDUSTRY	17
Biochemistry, Bacteriology, Biophysics	18
Export, renewable energy technologies, promotion, Central and Eastern Europe	19
Oceanography, Aquatic Ecology, Bio-Energetics	20
Biogas - for rural communities & electricity, heat and fuel demands	21
JRC	22
Sites	23

The identified clusters will then be described. Cluster 1 is the densest according to the number of terms it encompasses generally related to technical items in the areas of biotechnology, gasification and combustion. Cluster 2 focuses primarily on terms related to combustion and raw materials. As for cluster 3, it encompasses terms linked to local and regional planning, national energy networks, advice, as well as timber and power plants. With respect to cluster 4, it includes terms from the area of architecture, urban development and sustainable buildings. Cluster 5 focuses on, among others, cogeneration, small power plants, district heating and biogas waste. Cluster 13 focuses on technical aspects of biomass processes such as pyrolysis and standards.

It is observed that clusters 1, 2, 3, 4, 5 and 13 form the central core of the "Keywords" network that is integrated and cohesive.

The rest of the clusters are not related to each other. In this way, cluster 6 focuses on "Green" dwellings; cluster 7 on statistics, monitoring and legislation; cluster 8 and 9 encompass areas of solid biomass sources, pellets and market, as well as cluster logistics and quality of supply; cluster 11 focuses on housing communities and the area of agriculture; cluster 12 in analytical aspects; cluster 14 encompasses areas such as regional planning, good practices and partnership; cluster 15 includes the term ITEBE (European Technical Institute for Wood Energy); clusters 16 and 18 encompass chemical technical terms from the biomass area; cluster 17 focuses on the hotel services sector; cluster 19 to the areas of export and promotion of biomass; cluster 20 to biomass issues related to the sea; cluster 21 to the rural sector and its biomass needs.

At the core of the network, the items that make up the links between the clusters are detailed in the following table (Table 62) and shown in the figure immediately following (Figure 103):

Table 62. Value of Centrality and "Structural hole" for "Keywords". Biomass sector. Source: own elaboration.

Keywords Biomass 0013	**CENT**	**Keywords Biomass 0013**	**Constraint**
Biomass	0.3368	ENERGY (PHYSICS)	0.1187
CHP	0.2012	FLUIDIZED BEDS	0.1266
ENERGY (PHYSICS)	0.1766	POLLUTION CONTROL	0.1339
POLLUTION CONTROL	0.1636	ENERGY RESOURCES	0.1348
FLUIDIZED BEDS	0.1576	HEATING	0.1348

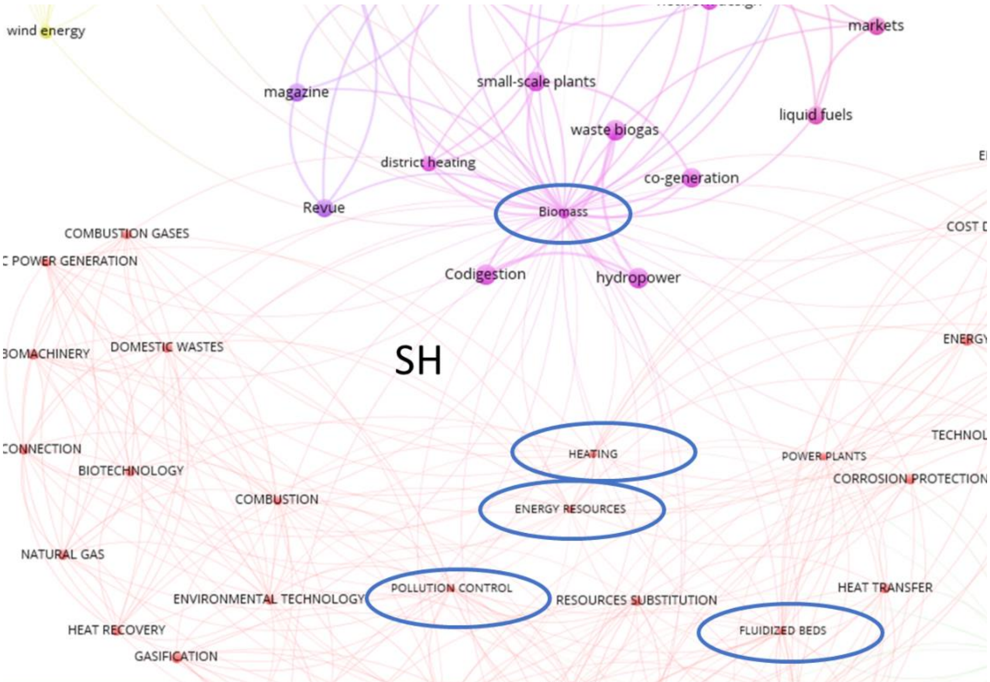


Figure 103. "Structural hole" areas in "keywords" term map. Biomass sector. Source: own elaboration.

Secondly, the network of "subjects" for the biomass sector will be analysed. There are 3 types of visualizations: network of nodes and their relationships (Figure 104), cluster density network (Figure 105), node density network (Figure 106).

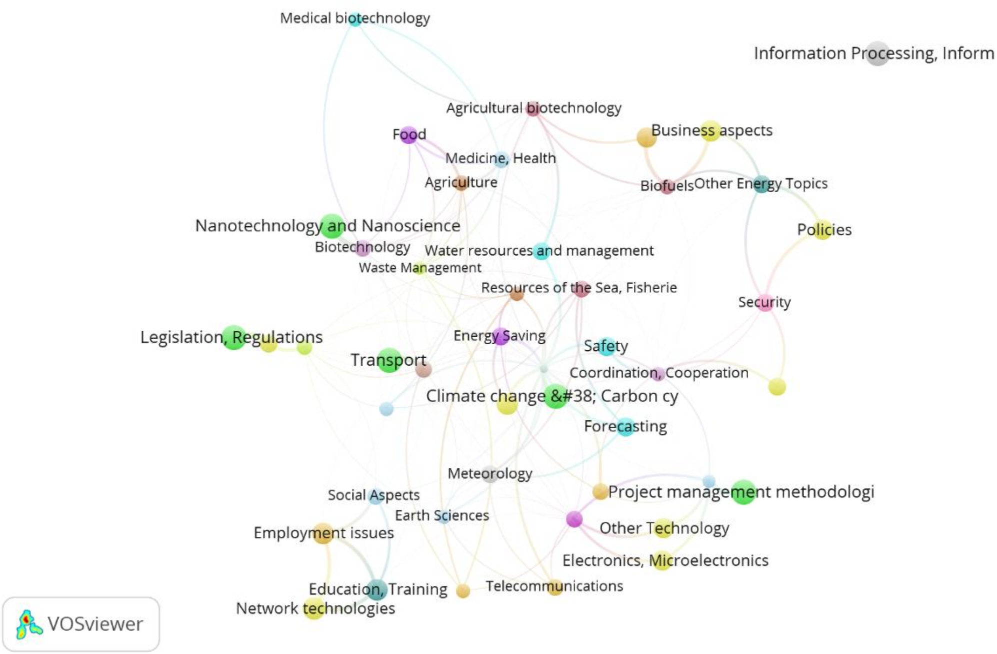


Figure 104. "Subjects" term map. Biomass sector. Source: own elaboration.

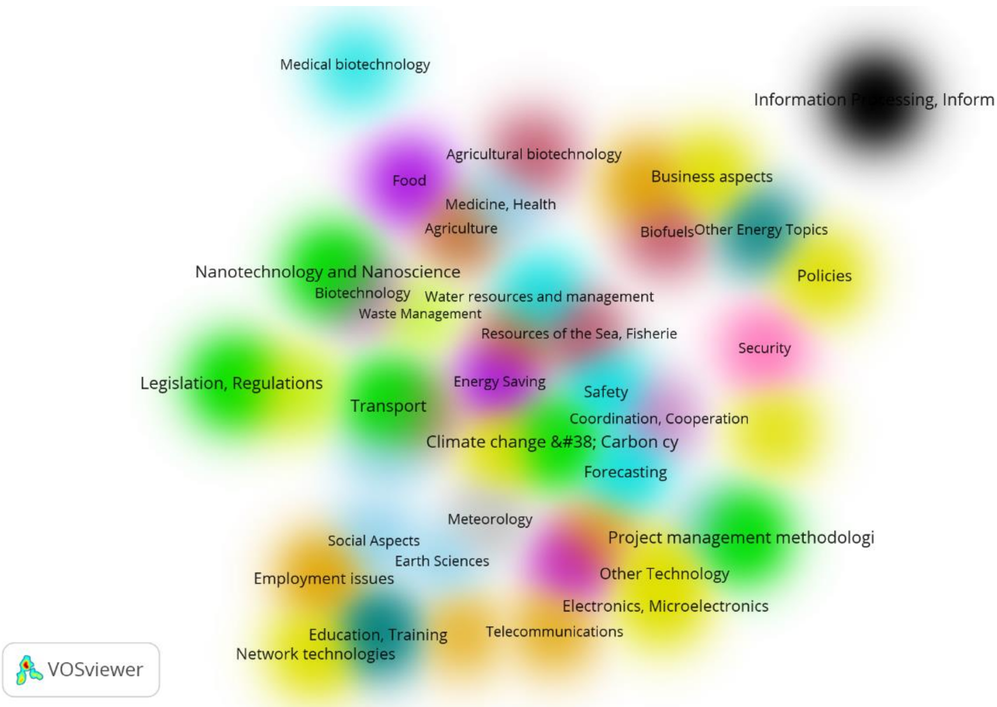


Figure 105. Cluster density "subjects" network term map. Biomass sector. Source: own elaboration.

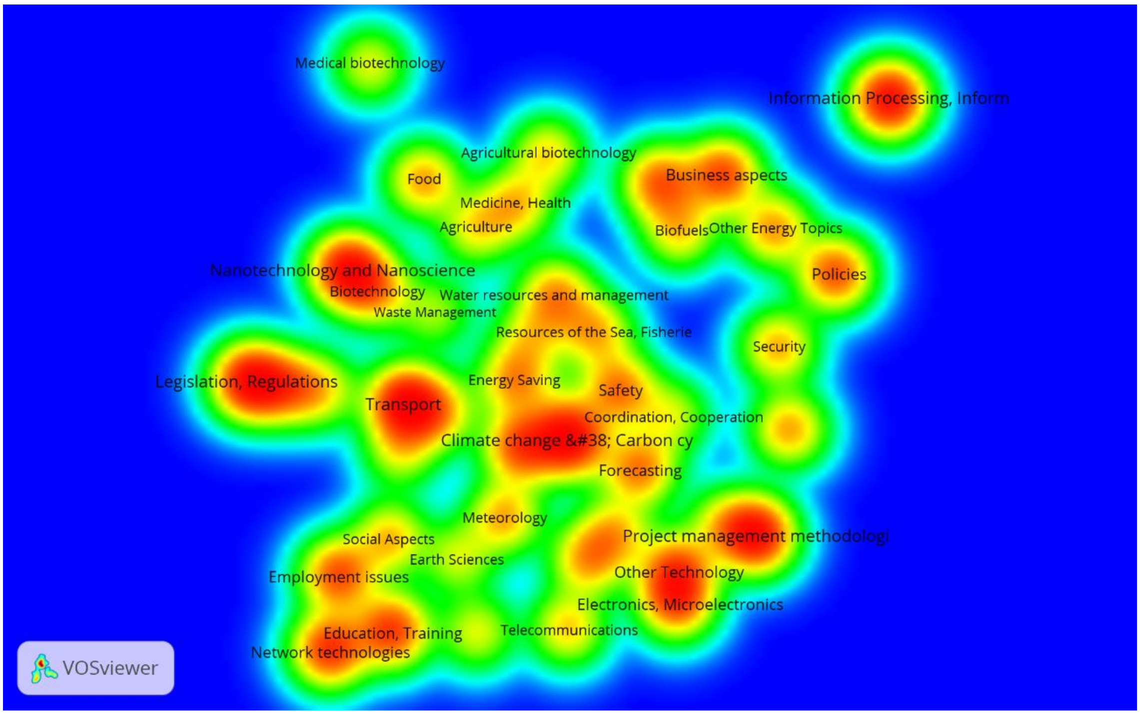


Figure 106. Node density "subjects" network term map. Biomass sector. Source: own elaboration.

For the biomass energy sector, the following clusters of "subjects" (Table 63) are identified:

Table 63. "Subjects" and "clusters". Biomass sector. Source: own elaboration.

Subject	Cluster
Climate change & Carbon cycle research, Legislation, Regulations, Transport Nanotechnology and Nanosciences, Project management methodologies	1
Electronics, Microelectronics, Policies, Regional Development, Business aspects, Energy Storage, Energy Transport, Network technologies, Other Technology	2
Water resources and management, Forecasting, Safety, Medical biotechnology	3
Employment issues, Materials Technology, Sustainable development, Standards, Telecommunications	4
Security	5
Education, Training, Other Energy Topics	6
Energy Saving, Food	7
Meteorology	8
Earth Sciences, Industrial Manufacture, Life Sciences, Social Aspects, Medicine, Health	9
Agricultural biotechnology, Biofuels	10
Agriculture, Renewable Sources of Energy	11
Economic Aspects, Waste Management	12
Biotechnology, Coordination, Cooperation	13
Innovation, Technology Transfer	14

Scientific Research	15
Environmental Protection	16
Information Processing, Information Systems	No cluster

In this sector, the network of "subjects" is fully integrated and there are no isolated clusters. However, it is not possible to generalize the thematic area of each cluster since the terms that form them are not related to each other.

Thus, an approximation of the possible thematic areas is made based on the position of each item in the network and its proximity to the rest. In the following figure (Figure 107) the different areas are displayed:

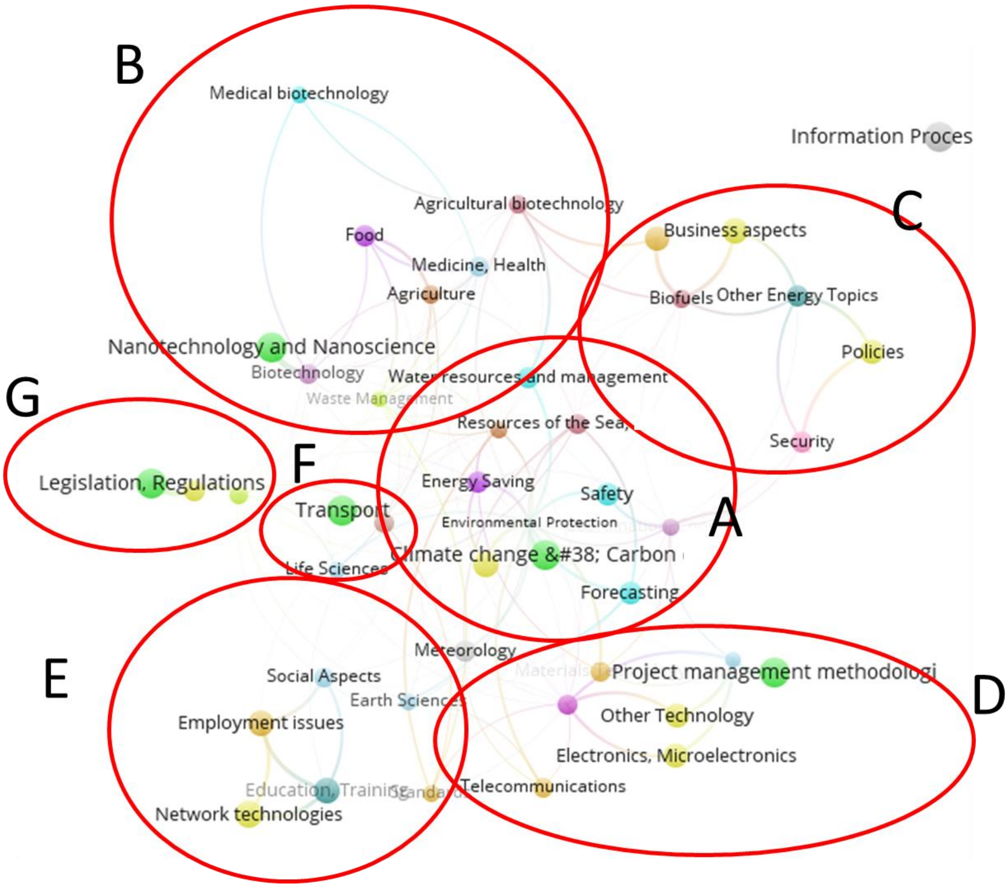


Figure 107. A, B, C, D, E, F, F and G areas in "subjects" term map. Biomass sector.

Area A would correspond with terms referred to climate change, diverse biomass resources as well as energy saving. Area B would correspond to nano, bio technologies for biomass and agriculture. The area C, generally to energy, political and business. As for the area D, it is observed that roughly encompasses activities in electronics and management. Area E focuses on social aspects, employment, education and networks. Area F would focus on biomass aspects relating to the transport sector. Finally, area G would encompass the legislation and regulation of the biomass sector.

The following figure (Figure 108) identifies the items that act as efficient links between the mentioned different areas:

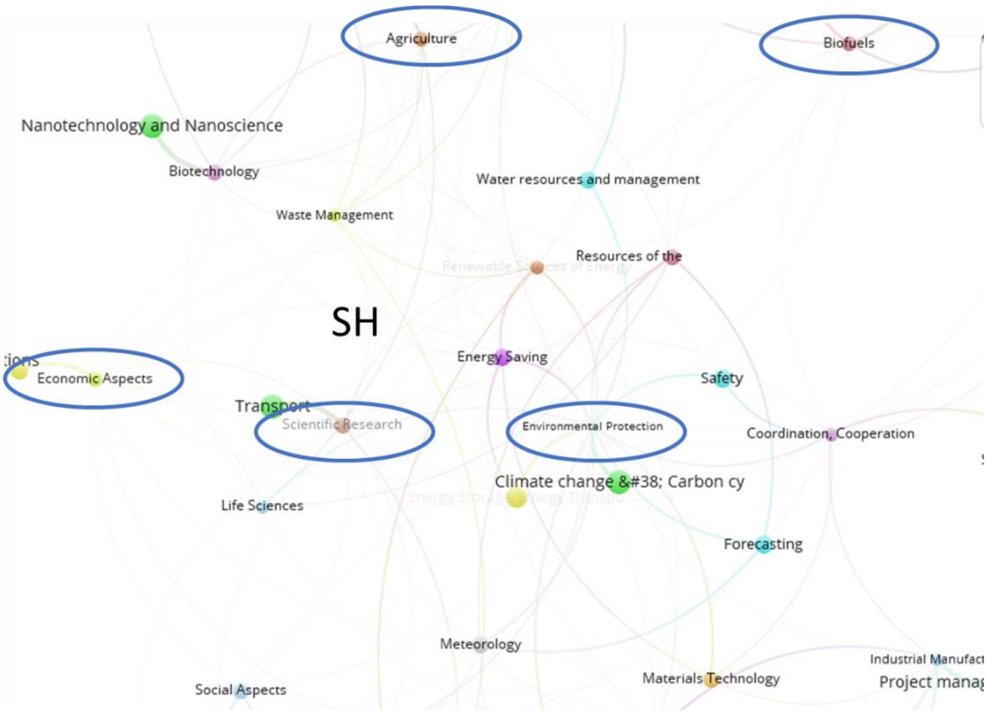


Figure 108. "Structural hole" areas in "subjects" term map. Biomass sector. Source: own elaboration.

The following table (Table 64) (extracted from Annex H) shows the centrality and efficiency value for these items:

Table 64. Value of Centrality and "Structural hole" for "Subjects". Biomass sector. Source: own elaboration.

Subjects Biomass 0013	**CENT**	**Subjects Biomass 0013**	**Constraint**
Environmental Protection	0.4780	Environmental Protection	0.2494
Scientific Research	0.3318	Agriculture	0.2803
Coordination, Cooperation	0.3206	Biofuels	0.2934
Innovation, Technology Transfer	0.3115	Economic Aspects	0.2981
Biotechnology	0.2954	Scientific Research	0.3013

7.4.6.Integrated results

As an added value, this section shows a possible integration of all the data obtained during the development of this doctoral thesis (the tables are shown in Annex I).

For each renewable energy sector, the classification of local regions (NUTS 3) according to their degree of efficiency (structural hole value measured by the Constraint indicator) and their centrality (measured by their degree) when facilitating the transmission of information and knowledge through the network of collaborations of R&D projects. For each sector, a possible clustering is performed by the k-means algorithm.

For each local region, the ranking of the organizations that participate in projects based on their centrality value is shown, by means of the centrality indicators, which are degree, betweenness and closeness, as well as network structural hole and ego structural hole. For each organization, the type (university, research center, company, public administration or association) is included. In addition, information of the terms with the highest degree of use is added for the fields "activity", "subject" and "keywords", indicating their weight of centrality with respect to the total of all the terms.

7.4.7.Conclusions and discussion (Strategic Analysis: part 2)

Thanks to the "keywords" and "subjects" term maps, it has been possible to describe each of the renewable energy sectors with more precision, focusing the interest on the technological and scientific field.

The analysis of these maps (section 6.5.4) can be done with respect to three fundamental ideas: clusters formed by nodes with similar centrality values, relations of cognitive proximity and the "structural hole" values of nodes.

It is observed that, in the wind sector, on the one hand, the focus has been on researching and developing technology for generator machinery, wind farms and in parallel, how to achieve integration with sustainable architecture. On the other hand, another focus of interest emerges that represents the area of offshore wind farms, working concepts such as barriers, policies and financing. It is the local regions of Spain and Germany that lead the efficiency in the transmission of information and knowledge, and technological and research centers lead the ranking more than the companies. This sector focuses mainly on scientific research, environmental protection, economic and social aspects of wind energy, with economic aspects being the focus of transversal efficiency.

For the solar sector, there is a strong core of “keywords”, focused mainly on research and development of generation-consumption technology, as well as integration with the architecture and electricity networks. In parallel, concepts such as market liberalization and heat-cold technologies by integrating geothermal energy and district heating are treated. They lead the efficiency in the transmission of information and knowledge to local regions of Italy, Denmark, Germany and Spain, working mainly on issues related to environmental protection, scientific research, as well as economic and social aspects. And within these regions, companies and universities lead the ranking.

Regarding the sea energy sector, the area of work is focused on environmental and economic aspects as well as renewable energy resources. It is important to highlight the importance of scientific research and innovation and technology transfer, justified due to its emerging technology situation and still in research and development stage, rather than commercialization. In this case, the efficiency of local regions in linking information and knowledge is distributed between regions located in Spain, Greece, France, Belgium, Denmark and Ireland, among others, through their centers of research and universities, rather than by companies.

For the geothermal energy sector, the research and development activity focuses on concepts such as heating, district heating, pipelines and energy as facilitators of the cohesion of the entire network of terms. Belgium, Romania, Spain and France would act as facilitators of union between the different countries for the transmission of information and knowledge, especially working in areas such as: environmental protection, scientific research, energy resources or technological innovation. According to the indicators, in this sector, the distribution of companies, technological centers and universities is similar, due essentially to the maturity of the sector, although it is still emerging.

Finally, with respect to the biomass energy sector, concepts such as biotechnology, gasification and combustion, and more in detail, cogeneration, pollution control and biomass-related technologies with water aspects are treated. The local regions of Finland, Germany, France, Netherlands and Austria are those that exert an efficient link in the transmission of information and knowledge, especially their research and development centers, as well as companies. This fact is related to promotion of their governments of this technology, as well as the natural resources existing in these regions. The map of thematic areas of this sector shows how environmental protection, scientific research, cooperation and technology transfer are central, being environmental protection, agriculture, biofuels and economic aspects the areas that show greater efficiency when it comes to cohesion of the network.

7.5. Summary and general conclusions

This thesis has presented the potential of the technique of Social Network Analysis to obtain strategic information for decision making in creating the space for research and development of an emerging and multidisciplinary technological sector, as is the case of renewable energies sector.

The contribution of this thesis is divided into two main parts.

On the one hand, the potential of the information about participants of R&D projects or the information of databases of projects to create strategic knowledge through the Analysis of Social Networks has been analysed. It has been studied the basis of Network Theory and the linking of networks of inter-organizational relationships with the transfer of information and knowledge, taking it to the context of public research and development projects. In addition, it has been analysed the application of Social Network Analysis to different areas, such as scientific publications, patents and projects, identifying different approaches as a basis for the creation of strategic knowledge in identifying key actors, both organizations and local regions.

The first conclusion obtained from this doctoral thesis is the possible use of R&D projects databases as a source to create, represent and know the structures of information and knowledge transmission networks that are formed among the consortia of participants.

The second conclusion is the importance of the crucial steps that need to be taken to analyse an emerging sector through R&D projects, namely: relational information creation, the need to integrate the centrality perspective and structural holes, and its application to obtain information on the participating actors, depending on their efficiency in the transmission of the possible information and knowledge acquired during the project. To do this, it is necessary to use social network analysis tools, such as Pajek and Ucinet, as well as methods of clustering and data integration.

On the other hand, strategic organizational knowledge of the renewable energy sector (including wind, solar, sea, geothermal and biomass) has been obtained for the period 2000-2013 at European level.

To this end, on the one hand, the use of the CORDIS database containing all R&D projects financed by the European Union has been justified. On the other hand, a process of delimitation of each of the five renewable sectors has been carried out, describing the developed strategy composed of search, capture, merger, filtering and cleaning techniques, as well as adding geolocation information, type of participating organizations and local classification of their regions. Subsequently this information has been transformed into "relational", thus creating the networks of structure of information transfer and knowledge of the network of participants and their local regions. Once this structure has been created for each sector, its topology and properties have been analysed, quantitatively and visually. Finally, the integrated approach of Coleman's centrality and Burt's structural holes has been implemented, obtaining the results sought in relation to efficiency at the level of organizations and local regions. This analysis is carried out considering the value of these two approaches, first separately and then jointly, for each actor and local region.

As a third conclusion, the real usefulness of R&D projects databases to delineate an emerging and multidisciplinary sector is identified, identifying actors that would otherwise be difficult to identify, since there is no official record of such wind, solar, sea, geothermal and biomass sectors. Nowadays the sectors are increasingly multidisciplinary and if this is added the emergent characteristic, this process is effective as complementary to the information obtained from databases of publications (scientific perspective) or patents (technological context). In this way, it can be observed that for the more mature sectors within the renewable ones (as it is the solar) the projects are realized with less participants, whereas for the less mature ones (as they are the sea energy) the consortiums are more extensive. It is also observed that in general there is greater participation of companies, while the experience is still belonging to research centers/universities and universities. This fact is directly related to the characteristic of emerging technologies that are still under investigation and development, prior to its commercialization.

As a fourth conclusion, this thesis shows the usefulness of Social Network Analysis to describe the topology and structure of information and knowledge transfer networks between local actors and regions involved in R&D projects. Thus, it is concluded that the networks of local regions show greater cohesion than those of organizations, although the "small world" effect exists in both, showing a structure not completely random or homogeneous in terms of cohesion.

On the other hand, as a fifth conclusion, it confirms the existence of multiple zones of "structural holes" in the networks of both organizations and local regions at European level, which shows that there are actors who have a more efficient role in transmitting information and knowledge among the other actors. A separate analysis of social network indicators shows that research/technological centers and universities benefit from these areas, especially in the wind, sea and biomass sectors, and their position is influential when linking the network. While companies are surrounded by these areas especially in the solar and geothermal sectors. A joint analysis of the centrality and structural hole indicators show that the sea and geothermal sectors are less efficient when it comes to creating networks for the transmission of information and knowledge, being mainly research and technological centers and universities in the top positions of the rankings in all sectors. On the other hand, it is observed that the companies are taking position in the wind sector, since they lead the first positions, unlike in the other sectors.

Regarding the limitations, firstly, this doctoral thesis is based on the database of research and development projects of the European Union for renewable energy sectors, and the results should be considered complementary, since not all projects of these sectors are covered. Secondly, this study has been based on an aggregate model from 2000 to 2013 (up to the last closed European framework) and, to some extent, once aggregated results have been obtained, future research should focus, for example, on information of annual report on the evolution of the actors and their relationships in each sector, to obtain more detail of their structures of transmission of information and knowledge.

As a general conclusion, and in line with the results of this doctoral thesis, the importance of supplementing information obtained from traditional resources used up to now (such as economic indicators, scientific publications, as well as patents created as a result of research activities) with the information obtained from the application of Social Network Analysis to the databases of R&D projects is remarkable, as a source of strategic knowledge for its use by policy makers in charge of designing policies for European Research and Development Areas. In this way, added value is extracted from projects' information, since in today's multidisciplinary and interconnected society, it is no longer enough to have data from individual organizations and local regions, but how they are related. This means that it is necessary to know how they influence the rest of the actors in the collaboration networks, as well as those who are efficient or who have a facilitating role of cohesion of the network of information transfer and knowledge acquired through the R&D projects applicable to any sector, level and scope, normally subsidized by public bodies when they are emerging sectors.

CHAPTER 8

8. Future research lines

In this chapter, new research directions stemming from this thesis are presented. The future lines of research could be related to the limitations mentioned in the section of general conclusions, such as the availability and the type of data that is taken as base, the different levels and approaches of the application of the network theory, especially in Social Network Analysis, and finally how to complement it with other data depending on its use.

- On the one hand, it has been concluded that the main limitation of this doctoral thesis is to focus on European R&D projects, publicly funded by the European Union, stored specifically in CORDIS database, which is currently the only database that can be obtained publicly. However, even today, their records are neither homogenized nor standardized, so it is difficult to obtain an accurate relational information without a complex treatment of Text Data Mining or implementing a search and data capture strategy for the sector under study. So, on the one hand, future research could make use of possible databases at country, region or even local level so that the results could be better approximated to the reality of collaborative project networks. On the other hand, and although it is now difficult to obtain data on private projects, this information would provide a more detailed knowledge of the total research and development activity of the sector.
- On the other hand, considering the possibilities offered by Social Network Analysis, and even with the rapid development and advancement of available softwares for the calculation of complex indicators in the academic world, research community could go further at analysis level. For example, and following the recommendations of experts in Social Network Analysis applied to emerging technology sectors, future lines of research could analyse not only organizations and local regions, but also delve into analysis at

departmental levels within organizations, with which the structure of the research and development activity would be more accurately understood, since more and more collaborations are carried out directly between the different departments of the organizations. On the other hand, it should be possible to analyse the fields available in the project databases that this thesis has not contemplated, such as: the financing and the cost of the projects, to obtain an economic map associated with the participants, being a perfect complement for an analysis of the items used in the creation of the European research and development area. Another line could be to analyse each ego network (each actor with his close and immediate collaborations) to see the consortiums that are created, their role in the whole network and their influence from the point of view of efficiency and centrality. Although this thesis is based on the approaches proposed by Coleman and Burt, as well as the "Small World" effect proposed by Watts (section 5.6.2), analysis focused on the use of new approaches beyond the one of centrality (based on indicators of Degree, intermediation and closeness) and "structural hole" (based on the Constraint indicator) for more complete information could be interesting. In this case, there are authors (Biggiero & Angelini 2015; Wanzenböck et al. 2014; Arroyabe et al. 2015; Choe et al. 2016) who are beginning to study how other indicators, such as "eigenvector", to understand the efficiency of the different actors within a network, for the moment, more focused on publications and patents. Finally, the results obtained from the study of the sectors in the aggregate period 2000-2013 could be used as a basis, adding an evolutionary analysis of the networks in each year. This could provide a dynamic longitudinal approach to network structures.

- Finally, it is worth highlighting the added value that could be obtained by using the project databases, together with the publications databases, for example: Web of Science (http://www.webofknowledge.com), Scopus (http: //www.scopus.com), Science Direct (http://www.sciencedirect.com), Plos (https://www.plos.org), CSIC (http://bddoc.csic.es); Patents, for example: Spanish Patent and Trademark Office (OEPM) (http://www.oepm.es), US Patent and Trademark Office (USPTO) (http://www.uspto.gov) or the Japanese Office Of Patents (JPO) (http://www.jpo.go.jp/). In this way, the analysis would deepen the technological results of the collaboration networks; or registers of industrial clusters, to be able to relate the networks to local level; also, using energy policy databases from the countries under study, which would generate a complete strategic knowledge, including technological and political foresight.

References

Abbasi, A., Altmann, J. & Alireza Abbasi, J.A., 2011. On the Correlation between Research Performance and Social Network Analysis Measures Applied to Research Collaboration Networks. *System Sciences (HICSS), 2011 44th Hawaii International Conference on*, p.66.

Adler, P.S. & Kwon, S.W., 2002. Social capital: Prospects for a new concept. *Academy of Management Review*, 27(1), pp.17–40.

Agrawal, H., Thakur, A. & Slathia, R., 2015. A Comparative Analysis of Social Networking Analysis Tools. *Journal of Information Technology & Software Engineering*, 5(3). Available at: http://www.omicsgroup.org/journals/information-technology-software-engineering-abstract.php?abstract_id=61687.

Ahuja, G., Soda, G. & Zaheer, A., 2012. The Genesis and Dynamics of Organizational Networks. *Organization Science*, 23(July 2015), pp.434–448.

Andrews, S.B. & Burt, R.S., 1995. Structural Holes: The Social Structure of Competition. *Administrative Science Quarterly*, 40(2), p.355. Available at: http://www.jstor.org/stable/2393644?origin=crossref.

Antivachis, N.A. & Angelis, V.A., 2015. Network Organizations : The Question of Governance. *Procedia - Social and Behavioral Sciences*, 175, pp.584–592. Available at: http://dx.doi.org.idpproxy.reading.ac.uk/10.1016/j.sbspro.2015.01.1241.

Apostolato, I.-A., 2013. An overview of Software Applications for Social Network Analysis. *International Review of Social Research*, 3(3), pp.71–77.

Appleyard, M.M., 1996. How does knowledge flow? Interfirm patterns in the semiconductor industry. *Strategic Management Journal*, 17(S2), pp.137–154. Available at: http://doi.wiley.com/10.1002/smj.4250171112 [Accessed February 13, 2017].

Argote, L., McEvily, B. & Reagans, R., 2003. Managing Knowledge in Organizations: An Integrative Framework and Review of Emerging Themes. *Management Science*, 49(4), pp.571–582. Available at: http://pubsonline.informs.org/doi/abs/10.1287/mnsc.49.4.571.14424.

Arora, S. et al., 2013. Capturing new developments in an emerging technology: an updated search strategy for identifying nanotechnology research outputs. *Scientometrics*, 95(1), pp.351–370. Available at: http://dx.doi.org/10.1007/s11192-012-0903-6.

Arranz, N. & Fdez. de Arroyabe, J.C., 2012. Can innovation network projects result in efficient performance? *Technological Forecasting and Social Change*, 79(3), pp.485–497. Available at: http://www.sciencedirect.com/science/article/pii/S0040162511002022.

Arranz, N. & Fdez. de Arroyabe, J.C., 2008. The choice of partners in R&D cooperation: An empirical analysis of Spanish firms. *Technovation*, 28(1–2), pp.88–100. Available at: http://www.sciencedirect.com/science/article/pii/S0166497207000958.

Arranz, N. & Fernández de Arroyabe, J.C., 2006. Joint R&D projects: Experiences in the context of European technology policy. *Technological Forecasting and Social Change*, 73(7), pp.860–885. Available at: http://www.sciencedirect.com/science/article/pii/S004016250500168X.

Arranz Peña, A.N. & Fernández de Arroyabe, J.C.F. de, 2002. Business Cooperation: From Theory to Practice. , p.208. Available at: http://www.amazon.com/dp/0333986695.

Arroyabe, M.F. et al., 2015. R&D partnerships: An exploratory approach to the role of structural variables in joint project performance. *Technological Forecasting and Social Change*, 90(PB), pp.623–634. Available at: http://dx.doi.org/10.1016/j.techfore.2014.01.007.

Bachmann, R. & van Witteloostuijn, A., 2009. Analysing Inter-Organizational Relationships in the Context of Their Business Systems. *European Societies*, 11(1), pp.49–76.

Barber, M.J., Paier, M. & Scherngell, T., 2009. Analyzing and Modeling European R&D Collaborations: Challenges and Opportunities from a Large Social Network. *Analysis of Complex Networks: From Biology to Linguistics*, pp.401–423.

Barber, M.J. & Scherngell, T., 2012. Inter-regional betweenness centrality in the European R & D network : Empirical investigation using European Framework data. *ERSA conference papers*, (August), pp.21–25. Available at: http://ideas.repec.org/p/wiw/wiwrsa/ersa12p460.html.

Barringer, B.R. & Harrison, J.S., 2000. Walking a Tightrope: Creating Value Through Interorganizational Relationships. *Journal of Management*, 26(3), pp.367–403. Available at: http://dx.doi.org/10.1177/014920630002600302.

Batagelj, V. & Mrvar, A., 2011. Pajek : Program for Analysis and Visualization of Large Networks. Reference Manual. , p.96.

Baum, J. a. C., Shipilov, A. V. & Rowley, T.J., 2003. Where do small worlds come from? *Industrial and Corporate Change*, 12(4), pp.697–725. Available at: http://icc.oupjournals.org/cgi/doi/10.1093/icc/12.4.697%5Cn

Bergman, E. & Feser, E.J., *Industrial and regional Clusters: Concepts and Comparative Applications*, Regional Research Institute, West Virginia University. Available at: http://econpapers.repec.org/RePEc:rri:wholbk:19.

Biggiero, L. & Angelini, P.P., 2015. Hunting scale-free properties in R&D collaboration networks: Self-organization, power-law and policy issues in the European aerospace research area. *Technological Forecasting and Social Change*, 94, pp.21–43. Available at: http://www.sciencedirect.com/science/article/pii/S0040162514001309.

Blanco, M.I. & Rodrigues, G., 2009. Direct employment in the wind energy sector: An EU study. *Energy Policy*, 37(8), pp.2847–2857.

Bodin, Ö. & Crona, B.I., 2009. The role of social networks in natural resource governance: What relational patterns make a difference? *Global Environmental Change*, 19(3), pp.366–374. Available at: http://www.sciencedirect.com/science/article/pii/S0959378009000405.

Boie, I. et al., 2014. Efficient strategies for the integration of renewable energy into future energy infrastructures in Europe – An analysis based on transnational modeling and case studies for nine European regions. *Energy Policy*, 67(0), pp.170–185. Available at: http://www.sciencedirect.com/science/article/pii/S030142151301121X.

Borgatti, S.P. et al., 2009. Network Analysis in the Social Sciences. *Science*, 323(April), pp.892–896.

Borgatti, S.P., Everett, M.G. & Freeman, L.C., 2002. Ucinet for Windows: Software for Social Network Analysis.

Borgatti, S.P. & Foster, P.C., 2003. The network paradigm in organization research: A review and typology. *Journal of Management*, 29(6), pp.991–1013.

Borgatti, S.P. & Halgin, D.S., 2011. On Network Theory. *Organization Science*, 22(5), pp.1168–1181. Available at: http://dx.doi.org/10.1287/orsc.1100.0641.

Borrás, S. & Haakonsson, S.J., 2012. *Global Innovation Networks*, European Commission.

Brass, D.J. et al., 2004. Taking stock of networks and organizations: A multilevel perspective. *Academy of Management Journal*, 47(6), pp.795–817.

Breschi, S. & Cusmano, L., 2002. Unveiling the texture of a European Research Area: emergence of oligarchic network under EU Frameworks Programmes. *International Journal of Technology* …. Available at: ftp://ftp.unibocconi.it/pub/RePEc/cri/papers/wp130.pdf.

Burt, R.S., 2008. Industry Performance and Indirect Access to Structural Holes. *Advances in Strategic Management*, 25, pp.315–360.

Burt, R.S., 1992. Structural holes: The social structure of competition. *Harvard University Press, Cambridge Massachussetts*, pp.38–40.

Burt, R.S., 2004. Structural Holes and Good Ideas. *American Journal of Sociology*, 110(2), pp.349–399. Available at: http://dx.doi.org/10.1086/421787.

Burt, R.S., 2001. Structural Holes versus Network Structure as Social Capital. *Social Capital: Theory and Research*, (May 2000), pp.31–56.

Burt, R.S., 1997. The Contingent Value of Social Capital. *Administrative Science Quarterly*, 42(2), pp.339–365. Available at: http://search.ebscohost.com/login.aspx?direct=true&db=bah&AN=9710080067&site=ehost-live.

Cai, P. & Penghua Cai Hong Liu, Rong Pan, Zheng Liu, Hui Li, H.Z., 2010. Research and Analysis of Structural Hole and Matching Coefficient. *Journal of Software Engineering and Applications*, 3(11), pp.1080–1087. Available at: http://www.scirp.org/journal/PaperInformation.aspx?PaperID=3207.

Cainarca, G.C., Colombo, M.G. & Mariotti, S., 1992. Agreements between firms and the technological life cycle model: Evidence from information technologies. *Research Policy*, 21(1), pp.45–62. Available at: http://www.sciencedirect.com/science/article/pii/004873339290026Z.

Carrington, P.J. & Scott, J., 2011. The SAGE Handbook of social network analysis. Introduction. *The SAGE Handbook of social network analysis*, pp.1–9.

Cassi, L. et al., 2008a. Research Networks As Infrastructure for Knowledge Diffusion in European Regions. *Economics of Innovation and New Technology*, 17(7–8), pp.663–676.

Available at: http://dx.doi.org/10.1080/10438590701785603.

Cassi, L. et al., 2008b. The impact of EU-funded research networks on knowledge diffusion at the regional level. *Research Evaluation*, 17(4), pp.283–293. Available at: http://www.tandfonline.com/doi/abs/10.1080/10438590701785603%5Cn

Choe, H. et al., 2013. Patent citation network analysis for the domain of organic photovoltaic cells: Country, institution, and technology field. *Renewable and Sustainable Energy Reviews*, 26, pp.492–505. Available at: http://www.sciencedirect.com/science/article/pii/S1364032113003407.

Choe, H. et al., 2016. Structural properties and inter-organizational knowledge flows of patent citation network: The case of organic solar cells. *Renewable and Sustainable Energy Reviews*, 55, pp.361–370. Available at: http://www.sciencedirect.com/science/article/pii/S1364032115012290.

Choi, J. & Hwang, Y.S., 2014. Patent keyword network analysis for improving technology development efficiency. *Technological Forecasting and Social Change*, 83(1), pp.170–182. Available at: http://dx.doi.org/10.1016/j.techfore.2013.07.004.

Cohen, W.M. & Levinthal, D., 1990. Absorptive Capacity: a new Perspective on Learning and Innovation. *Administrative Science Quarterly*, 35, pp.128–152. Available at: http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Absorptive+Capacity:+A+New+Perspective+on+Learning+and+Innovation#1.

Coleman, J.S., 1988. Social Capital in the Creation of Human Capital. *American Journal of Sociology*, 94(1988), p.S95.

Commission, E., 2012. Renewable Energy: a major player in the European energy market. *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions*, p.2.

Commission, E., 2000. Towards a European Research Area: Communication from the Commission to the Council, the European Parliament, the Economic and Social Committee and the Committee of the Regions. Available at: http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Towards+a+European+Research+Area#0.

Copenhagen Cleantech Cluster, Quartz+CO & MEC Intelligence, 2012. The Global Cleantech Report 2012. , 46(0). Available at: http://www.cphcleantech.com/media/1944576/20120629 the global cleantech report 2012 assembled final3.pdf.

Costa-Campi, M.T., Duch-Brown, N. & García-Quevedo, J., 2014. R&D drivers and obstacles to innovation in the energy industry. *Energy Economics*, 46(0), pp.20–30. Available at: http://www.sciencedirect.com/science/article/pii/S0140988314002138.

Cowan, R., 2005. Network models of innovation and knowledge diffusion. *Clusters, networks and innovation*, pp.29–53.

Cropper, S. et al., 2009. Introducing Inter-organizational Relations. *The Oxford Handbook of Inter-Organizational Relations*, (January 2017), pp.1–26.

Cross, R., Borgatti, S.P. & Parker, A., 2002. Making invisible work visible: Using social network analysis to support strategic collaboration. *California Management Review*, 44(2), pp.25–46. Available at: http://www.scopus.com/inward/record.url?eid=2-s2.0-0036882179&partnerID=40&md5=572d4c49b30da51b96c1939e5386adcc.

Darmani, A. et al., 2014. What drives the development of renewable energy technologies? Toward a typology for the systemic drivers. *Renewable and Sustainable Energy Reviews*, 38(0), pp.834–847. Available at: http://www.sciencedirect.com/science/article/pii/S1364032114004754.

Dimos, C. & Pugh, G., 2016. The effectiveness of R&D subsidies: A meta-regression analysis of the evaluation literature. *Research Policy*, 45(4), pp.797–815. Available at: http://www.sciencedirect.com/science/article/pii/S0048733316000032.

Doeringer, P.B. & Terkla, D.G., 1995. Business Strategy and Cross-Industry Clusters. *Economic Development Quarterly*, 9(3), pp.225–237.

Emirbayer, M. & Goodwin, J., 1994. Network analysis, culture, and the problem of agency. *American journal of sociology*, 99(6), pp.1411–1454.

European, C., 2011. Impact assessment. Communication from the Commission Horizon 2020 - The framework programme for research and innovation. , (2011), p.112. Available at: http://ec.europa.eu/research/horizon2020/pdf/proposals/horizon_2020_impact_assessment_report.pdf.

European Commission, 2012. A reinforced European Research Area partnership for excellence and growth. *European Comission*. Available at: http://ec.europa.eu/information_society/newsroom/cf/itemdetail.cfm?item_id=9167%5Cn

European Commission, 2015. *Study on Network Analysis of the 7 th Framework Programme Participation Final Report*,

Eurostat, 2015. *Regions in the European Union: Nomenclature of territorial units for statistics NUTS 2013 / EU-28*,

Everett, M. & Borgatti, S.P., 2005. Ego network betweenness. *Social Networks*, 27(1), pp.31–38. Available at: http://www.sciencedirect.com/science/article/pii/S037887330400067X.

van Fenema, P.C. & Loebbecke, C., 2014. Towards a framework for managing strategic tensions in dyadic interorganizational relationships. *Scandinavian Journal of Management*, 30(4), pp.516–524. Available at: http://www.sciencedirect.com/science/article/pii/S0956522114000426.

Freeman, L.C., 1978. Centrality in social networks conceptual clarification. *Social Networks*, 1(3), pp.215–239.

Garechana, G. et al., 2012. Tracking the evolution of waste recycling research using overlay maps of science. *Waste Management*, 32(6), pp.1069–1074. Available at: http://www.sciencedirect.com/science/article/pii/S0956053X12000311.

Gavilanes-Trapote, J. et al., 2015. Patent overlay maps: Spain and the Basque Country. *International Journal of Technology Management*, 69(3–4), pp.261–274.

Geum, Y. et al., 2013. Identifying and evaluating strategic partners for collaborative R&D: Index-based approach using patents and publications. *Technovation*, 33(6–7), pp.211–224. Available at: http://www.sciencedirect.com/science/article/pii/S0166497213000503.

Giacomarra, M. & Bono, F., 2015. European Union commitment towards RES market penetration: From the first legislative acts to the publication of the recent guidelines on State aid 2014/2020. *Renewable and Sustainable Energy Reviews*, 47, pp.218–232. Available at: http://www.sciencedirect.com/science/article/pii/S1364032115001513.

Gilsing, V. et al., 2008. Network embeddedness and the exploration of novel technologies: Technological distance, betweenness centrality and density. *Research Policy*, 37(10), pp.1717–1731. Available at: http://www.sciencedirect.com/science/article/pii/S004873330800190X.

Gilsing, V. & Nooteboom, B., 2006. Exploration and exploitation in innovation systems: The case of pharmaceutical biotechnology. *Research Policy*, 35(1), pp.1–23. Available at: http://www.sciencedirect.com/science/article/pii/S0048733305001332.

Gittell, J.H. & Weiss, L., 2004. Coordination Networks within and across Organizations: A Multi-level Framework. *Journal of Management Studies*, 41(1), pp.127–153.

Giuliani, E. & Bell, M., 2005. The micro-determinants of meso-level learning and innovation evidence from a Chilean wine cluster. *Research policy*, 34(1), pp.47–68.

da Graça Carvalho, M., 2012. EU energy and climate change strategy. *Energy*, 40(1), pp.19–22. Available at: http://www.scopus.com/inward/record.url?eid=2-s2.0-84859106214&partnerID=40&md5=612ea3cff89501908d3836cdebe53bcc.

Granovetter, M., 1985. Economic action and social structure - the problem of embeddedness. *American Journal of Sociology*, 91(3), pp.481–510.

Granovetter, M., 1992. Economic Institutions as Social Constructions: A Framework for Analysis. *Acta Sociologica*, 35(1), pp.3–11.

Grant, R. & Baden-Fuller, C., 2004. A Knowledge Accessing Theory of Strategic Alliances Robert M. Grant and Charles Baden-Fuller. *Journal of Management Studies*, 41(1), pp.61–85.

Gribkovskaia, I., Halskau, Ø. & Laporte, G., 2007. The bridges of königsberg - A historical perspective. *Networks*, 49(3), pp.199–203.

Guan, J. & Liu, N., 2015. Invention profiles and uneven growth in the field of emerging nano-energy. *Energy Policy*, 76, pp.146–157. Available at: http://www.sciencedirect.com/science/article/pii/S0301421514006326.

Gulati, R., Lavie, D. & Madhavan, R., 2011. How do networks matter? The performance effects of interorganizational networks. *Research in Organizational Behavior*, 31, pp.207–224.

Gulati, R., Nohria, N. & Zaheer, A., 2000. Strategic networks. *Strategic Management Journal*, 21(3), pp.203–215. Available at: http://dx.doi.org/10.1002/(SICI)1097-0266(200003)21:3%3C203::AID-SMJ102%3E3.0.CO.

Hagedoorn, J., Link, A.N. & Vonortas, N.S., 2000. Research partnerships. *Research Policy*, 29(4–5), pp.567–586. Available at:

http://apps.webofknowledge.com/full_record.do?product=UA&search_mode=GeneralSearch&qid=2&SID=T2nZ48CIavRCMFXtUr2&page=1&doc=9&cacheurlFromRightClick=no.

Hain, D.S., 2013. The Evolution of R & D Networks in Public funded Renewable. , pp.1–28.

Håkansson, H. & Snehota, I., 1989. No business is an island: The network concept of business strategy. *Scandinavian Journal of Management*, 5(3), pp.187–200. Available at: file://www.sciencedirect.com/science/article/pii/0956522189900262.

Hampton, K. & Wellman, B., 2003. Neighboring in Netville : *City & Community*, 2(4), pp.277–311.

Hansen, M.T. & Hansen, M.T., 1999. The search-transfer problem: The role of weak ties in sharing knowledge across organization subunits. *Administrative Science Quarterly*, 44(1), pp.82–111.

Hargadon, A. & Sutton, R.I., 1997. Technology brokering and innovation in a product development firm. *Administrative science quarterly*, pp.716–749.

He, J. & Fallah, M.H., 2011. The typology of technology clusters and its evolution — Evidence from the hi-tech industries. *Technological Forecasting and Social Change*, 78(6), pp.945–952. Available at: http://www.sciencedirect.com/science/article/pii/S0040162511000084.

Heimeriks, G., Hörlesberger, M. & Van Den Besselaar, P., 2003. Mapping communication and collaboration in heterogeneous research networks. *Scientometrics*, 58(2), pp.391–413. Available at: http://dx.doi.org/10.1023/A:1026296812830.

Hekkert, M.P. et al., 2007. Functions of innovation systems: A new approach for analysing technological change. *Technological Forecasting and Social Change*, 74(4), pp.413–432. Available at: http://www.sciencedirect.com/science/article/pii/S0040162506000564.

Heller-Schuh, B. et al., 2011. Analysis of Networks in European Framework Programmes (1984-2006). *European Commission, Joint Research Centre, Institute for Prospective Technological Studies.*, pp.1–138.

Helm, D., 2014. The European framework for energy and climate policies. *Energy Policy*, 64(0), pp.29–35. Available at: http://www.sciencedirect.com/science/article/pii/S0301421513004151.

Hervás Soriano, F. & Mulatero, F., 2011. EU Research and Innovation (R&I) in renewable energies: The role of the Strategic Energy Technology Plan (SET-Plan). *Energy Policy*, 39(6), pp.3582–3590. Available at: http://www.sciencedirect.com/science/article/pii/S0301421511002485.

Hoekman, J., Frenken, K. & van Oort, F., The geography of collaborative knowledge production in Europe. *The Annals of regional science*, 43(3), pp.721–738. Available at: http://cat.inist.fr/?aModele=afficheN&cpsidt=21656720 [Accessed November 1, 2016].

Hossain, L., 2009. Effect of organisational position and network centrality on project coordination. *International Journal of Project Management*, 27(7), pp.680–689. Available at: http://www.sciencedirect.com/science/article/pii/S0263786308001701.

Huisman, M. & van Duijn, M.A.J., 2011. A readers' guide to SNA software. In SAGE Publications Inc., p. 578–600 BT–The SAGE Handbook of Social Network A.

Hvelplund, F., 2006. Renewable energy and the need for local energy markets. *Energy*, 31(13), pp.1957–1966. Available at: http://www.scopus.com/inward/record.url?eid=2-s2.0-33746373813&partnerID=40&md5=8a5a32d19117710829c6c41400ba6eba.

Iammarino, S. & McCann, P., 2006. The structure and evolution of industrial clusters: Transactions, technology and knowledge spillovers. *Research Policy*, 35(7), pp.1018–1036. Available at: http://www.sciencedirect.com/science/article/pii/S0048733306000990.

International Renewable Energy Agency, 2013. International Standardisation in the Field of Renewable Energy. , (March), p.74. Available at: http://www.irena.org/DocumentDownloads/Publications/International_Standardisation_in_the_Field_of_Renewable_Energy.pdf.

IRENA, 2015. Renewable Energy Target Setting. *Irena*, (June), p.80.

Jacobson, M.Z. & Delucchi, M.A., 2011. Providing all global energy with wind, water, and solar power, Part I: Technologies, energy resources, quantities and areas of infrastructure, and materials. *Energy Policy*, 39(3), pp.1154–1169. Available at: http://www.sciencedirect.com/science/article/pii/S0301421510008645.

Jaegersberg, G. & Ure, J., 2011. Barriers to knowledge sharing and stakeholder alignment in solar energy clusters: Learning from other sectors and regions. *The Journal of Strategic Information Systems*, 20(4), pp.343–354. Available at: http://www.sciencedirect.com/science/article/pii/S0963868711000187.

Jaffee, D., 2001. *Organization theory: Tension and change.*, Singapore: McGraw Hill.

Johannisson, B., 1995. Paradigms and entrepreneurial networks: some methodological challenges. *Entrepreneurship and Regional Development*, 7(3), pp.215–232.

Kang, M.J. & Hwang, J., 2016. Structural dynamics of innovation networks funded by the European Union in the context of systemic innovation of the renewable energy sector. *Energy Policy*, 96, pp.471–490. Available at: http://www.sciencedirect.com/science/article/pii/S0301421516303007.

Kang, M.J. & Park, J., 2013. Analysis of the partnership network in the clean development mechanism. *Energy Policy*, 52, pp.543–553. Available at: http://dx.doi.org/10.1016/j.enpol.2012.10.005.

Kitzing, L., Mitchell, C. & Morthorst, P.E., 2012. Renewable energy policies in Europe:

Converging or diverging? *Renewable Energy in China*, 51(0), pp.192–201. Available at: http://www.sciencedirect.com/science/article/pii/S030142151200746X.

Klessmann, C. et al., 2011. Status and perspectives of renewable energy policy and deployment in the European Union—What is needed to reach the 2020 targets? *Clean Cooking Fuels and Technologies in Developing Economies*, 39(12), pp.7637–7657. Available at: http://www.sciencedirect.com/science/article/pii/S0301421511006355.

Knoben, J., Oerlemans, L.A.G. & Rutten, R.P.J.H., 2006. Radical changes in inter-organizational network structures: The longitudinal gap. *Technological Forecasting and Social Change*, 73(4), pp.390–404.

Koza, M. & Lewin, A., 2000. Managing partnerships and strategic alliances: raising the odds of success. *European Management Journal*, 18(2), pp.146–151. Available at: http://www.sciencedirect.com/science/article/pii/S0263237399000869.

Larruscain, J. et al., 2015. Analysing the Influence of Renewable Energy R&D Projects on Local Clusters in Europe. In 2nd Manchester Forum on Data Science, Tech Mining and Innovation. MIOIR.

Larruscain, J., Rio-Belver, R., Cilleruelo, E., Garechana, G., et al., 2014. Analysis of the R&D Collaboration Network in the European Renewable Energy Sector. In Málaga (Spain): 8th International Conference on Industrial Engineering and Industrial Management.

Larruscain, J., Río-Belver, R., et al., 2014. Applying Cluster Analysis to Renewable Energy Emergent Sector at Local Level. In C. Hernández, A. López-Paredes, & J. M. Pérez-Ríos, eds. *Managing Complexity: Challenges for Industrial Engineering and Operations Management*. Cham: Springer International Publishing, pp. 293–300. Available at: http://dx.doi.org/10.1007/978-3-319-04705-8_34.

Larruscain, J., Rio-Belver, R., Cilleruelo, E. & Garechana, G., 2014. Structural analysis of

European renewable energy R&D Network from 2000 to 2013. In Leiden (Netherlands): 4th Global Techmining Conference.

Larruscain, J., Rodriguez, A., et al., 2014. Understanding of European Sea Energy sector structure through R&D social network analysis. In Oporto: Book of Proceedings of International Congress Water, Waste and Energy Management. Available at: isbn: 9789508965.

Larruscain, J., Rio-Belver, R. & Garechana, G., 2016. Structural Analysis of redundancy influence of local regions in renewable energy R&D Project in Europe. In 21st International Conference on Science and Technology Indicators (STI).

Laumann, E.O., Marsden, P. V & Prensky, D., 1983. The Boundary Specification Program in Network Analysis. In *Applied Network Analysis*. pp. 18–34.

Lavie, D. & Rosenkopf, L., 2006. BALANCING EXPLORATION AND EXPLOITATION IN ALLIANCE FORMATION. *Academy of Management Journal*, 49(4), pp.797–818. Available at: http://amj.aom.org/content/49/4/797.full [Accessed February 23, 2017].

Lepak, D.P., Smith, K.G. & Taylor, M.S., 2007. VALUE CREATION AND VALUE CAPTURE: A MULTILEVEL PERSPECTIVE. *Academy of Management Review*, 32(1), pp.180–194. Available at: http://amr.aom.org/cgi/doi/10.5465/AMR.2007.23464011.

Loebbecke, C., van Fenema, P.C. & Powell, P., 2016. Managing inter-organizational knowledge sharing. *Journal of Strategic Information Systems*, 25(1), pp.4–14. Available at: http://dx.doi.org/10.1016/j.jsis.2015.12.002.

Lundvall, B. & Pavitt, K., 1995. National Systems of innovation: Towards a theory of innovation and interactive learning. *Research Policy*, 24(2), p.320. Available at: http://orton.catie.ac.cr/cgi-bin/wxis.exe/?IsisScript=CIENL.xis&method=post&formato=2&cantidad=1&expresion=

mfn=002923%5Cnpapers2://publication/uuid/719EE451-FB79-47D0-8E30-F2FD6674D753.

March, J.G., 1991. Exploration and Exploitation in Organizational Learning. *Organization Science*, 2(1), pp.71–87. Available at: http://dx.doi.org/10.1287/orsc.2.1.71.

Markusen, A., 1996. Sticky Places in Slippery Space: A Typology of Industrial Districts. *Economic Geography*, 72(3), pp.293–313. Available at: https://ssrn.com/abstract=1505247.

Marques, A.C. & Fuinhas, J.A., 2012. Is renewable energy effective in promoting growth? *Energy Policy*, 46, pp.434–442. Available at: http://www.scopus.com/inward/record.url?eid=2-s2.0-84861221692&partnerID=40&md5=c3a88f0af13f385ebec9d1bf1760fffc.

Marra, A. et al., 2015. A network analysis using metadata to investigate innovation in clean-tech - Implications for energy policy. *Energy Policy*, 86, pp.17–26. Available at: http://dx.doi.org/10.1016/j.enpol.2015.06.025.

Marra, M. et al., 2015. The value of indirect ties in citation networks: SNA analysis with OWA operator weights. *Information Sciences*, 314, pp.135–151. Available at: http://dx.doi.org/10.1016/j.ins.2015.02.017.

Matt, M., Robin, S. & Wolff, S., 2012. The influence of public programs on inter-firm R&D collaboration strategies: Project-level evidence from EU FP5 and FP6. *Journal of Technology Transfer*, 37(6), pp.885–916.

Matusik, S.F. & Hill, C.W.L., 1998. The Utilization of Contingent Work, Knowledge Creation, and Competitive Advantage. *The Academy of Management Review*, 23(4), pp.680–697. Available at: http://www.jstor.org/stable/259057.

McCauley, S.M. & Stephens, J.C., 2012. Green energy clusters and socio-technical transitions:

analysis of a sustainable energy cluster for regional economic development in Central Massachusetts, USA. *Sustainability Science*, 7(2), pp.213–225. Available at: http://dx.doi.org/10.1007/s11625-012-0164-6.

McCauley, S.M. & Stephens, J.C., 2012. Green energy clusters and socio-technical transitions: Analysis of a sustainable energy cluster for regional economic development in Central Massachusetts, USA. *Sustainability Science*, 7(2), pp.213–225.

Menegaki, A.N., 2011. Growth and renewable energy in Europe: A random effect model with evidence for neutrality hypothesis. *Energy Economics*, 33(2), pp.257–263. Available at: http://www.sciencedirect.com/science/article/pii/S0140988310001829.

Michalena, E. & Hills, J.M., 2012. Renewable energy issues and implementation of European energy policy: The missing generation? *Energy Policy*, 45, pp.201–216.

Miotti, L. & Sachwald, F., 2003. Co-operative R&D: why and with whom?: An integrated framework of analysis. *Research Policy*, 32(8), pp.1481–1499. Available at: http://www.sciencedirect.com/science/article/pii/S0048733302001592.

Mitchell, W. & Singh, K., 1992. Incumbents' use of pre-entry alliances before expansion into new technical subfields of an industry. *Journal of Economic Behavior and Organization*, 18(3), pp.347–372.

Montoya, F.G. et al., 2014. The research on energy in spain: A scientometric approach. *Renewable and Sustainable Energy Reviews*, 29(0), pp.173–183. Available at: http://www.sciencedirect.com/science/article/pii/S1364032113006345.

Morrison, A. & others, 2004. *Gatekeepers of knowledge within industrial districts: who they are, how they interact*, Universit{à} commerciale Luigi Bocconi.

Mote, J.E., 2005. R&D ecology: using 2-mode network analysis to explore complexity in R&D environments. *Research on Social Networks and the Organization of Research and*

Development, 22(1–2), pp.93–111. Available at: http://www.sciencedirect.com/science/article/pii/S0923474804000700.

Negro, S.O., Alkemade, F. & Hekkert, M.P., 2012. Why does renewable energy diffuse so slowly? A review of innovation system problems. *Renewable and Sustainable Energy Reviews*, 16(6), pp.3836–3846. Available at: http://www.sciencedirect.com/science/article/pii/S1364032112002262.

Negro, S.O., Hekkert, M.P. & Smits, R.E.H.M., 2013. Stimulating renewable energy technologies by innovation policy. , 35(6), pp.403–416.

Newman, M.E.J., 2001. Scientific collaboration networks. I. Network construction and fundamental results - art. no. 016131. *Physical Review E*, 64(1 pt 2), p.6131–+. Available at: http://linkseeker.lanl.gov/lanl?genre=article&issn=1063-651X&date=2001.

Newman, M.E.J., Strogatz, S.H. & Watts, D.J., 2001. Random graphs with arbitrary degree distributions and their applications. *Phys. Rev. E*, 64(2), p.26118. Available at: http://link.aps.org/doi/10.1103/PhysRevE.64.026118.

Nooy, W. de, Mrvar, A. & Batagelj, V., 2005. *Exploratory Social Network Analysis with Pajek (Google eBook)*, Available at: http://books.google.com/books?hl=en&lr=&id=s5tLJoCWEjQC&pgis=1.

Pacesila, M., Burcea, S.G. & Colesca, S.E., 2016. Analysis of renewable energies in European Union. *Renewable and Sustainable Energy Reviews*, 56, pp.156–170. Available at: http://www.sciencedirect.com/science/article/pii/S1364032115012319.

Parsons, T., 1956. Suggestions for a Sociological Approach to the Theory of Organizations-I. *Administrative Science Quarterly*, 1(1), pp.63–85. Available at: http://www.jstor.org/stable/2390840.

Paulsson, E., 2009. A review of the CDM literature: from fine-tuning to critical scrutiny?

International Environmental Agreements: Politics, Law and Economics, 9(1), pp.63–80. Available at: http://dx.doi.org/10.1007/s10784-008-9088-0.

Perrow, C., 1991. A society of organizations. *Theory and Society*, 20(6), pp.725–762. Available at: http://dx.doi.org/10.1007/BF00678095.

Popp, J.K. et al., 2013. Inter-organizational networks. A criticial review of the literature to inform practice. , p.123.

Porter, M.E., 1998. Clusters and the new economics of competition. *Harvard business review*, 76(6), pp.77–90. Available at: http://www.scopus.com/inward/record.url?eid=2-s2.0-0032199551&partnerID=40&md5=050f72ead152c10c63c4544f290a4c3f.

Porter, M.E., 2000. Location, Competition, and Economic Development: Local Clusters in a Global Economy. *Economic Development Quarterly*, 14(1), pp.15–34. Available at: http://journals.sagepub.com/doi/abs/10.1177/089124240001400105.

Porter, M.E. et al., 2008. THE AUSTRALIAN RENEWABLE ENERGY CLUSTER. Microeconomics of Competitiveness.

Portes, A., 1998. Social Capital: Its Origins and Applications in Modern Sociology. *Annual Review of Sociology*, 24(1), pp.1–24.

Powell, W., 1990. Neither Market nor Hierarchy: Network Forms of Organization. *Research in Organizational Behavior, vol. 12*, pp.295–336.

Prem Sankar, C., Asokan, K. & Satheesh Kumar, K., 2015. Exploratory social network analysis of affiliation networks of Indian listed companies. *Social Networks*, 43, pp.113–120. Available at: http://www.sciencedirect.com/science/article/pii/S0378873315000465.

Provan, K.G., Fish, A. & Sydow, J., 2007. Interorganizational Networks at the Network Level: A Review of the Empirical Literature on Whole Networks. *Journal of Management*, 33(3), pp.479–516. Available at: http://dx.doi.org/10.1177/0149206307302554.

Provan, K.G. & Kenins, P., 2007. modes of network governance - structure management and effectiveness.pdf. *Journal of Public Administration Research and Theory*, 18, pp.229–252.

Provan, K.G. & Lemaire, R.H., 2012. Core concepts and key Iideas for understanding public sector organizational networks: Using research to inform scholarship and practice. *Public Administration Review*, 72(5), pp.638–648.

Provan, K.G. & Milward, H., 2001. Do networks really work? A framework for evaluating public-sector organizations networks. *Public Administration Review*, 61(4), pp.414–423. Available at: http://doi.wiley.com/10.1111/0033-3352.00045.

Provan, K.G. & Milward, H.B., 1995. A Preliminary Theory of Interorganizational Network Effectiveness: A Comparative Study of Four Community Mental Health Systems. *Administrative Science Quarterly*, 40(1), pp.1–33. Available at: http://www.jstor.org/stable/10.2307/2393698.

Putnam, R.D., 1993. The Prosperous Community: Social Capital and Public Life. *The American Prospect*, 13(13), pp.35–42. Available at: http://www.citeulike.org/group/1702/article/1032759.

Ragwitz, M. & Miola, A., 2005. Evidence from RD&D spending for renewable energy sources in the EU. *Renewable Energy*, 30(11), pp.1635–1647. Available at: http://www.scopus.com/inward/record.url?eid=2-s2.0-18144397416&partnerID=40&md5=89ab84b182bf1e9091e4aa5783939899.

Reagans, R. & McEvily, B., 2003. Network Structure and Knowledge Transfer: The Effects of Cohesion and Range. *Administrative Science Quarterly*, 48(2), pp.240–267.

Resch, G. et al., 2008. Potentials and prospects for renewable energies at global scale. *Energy Policy*, 36(11), pp.4048–4056.

van Rijnsoever, F.J. et al., 2015. Smart innovation policy: How network position and project composition affect the diversity of an emerging technology. *Research Policy*, 44(5), pp.1094–1107. Available at: http://www.sciencedirect.com/science/article/pii/S0048733314002224.

Rizzi, F., van Eck, N.J. & Frey, M., 2014. The production of scientific knowledge on renewable energies: Worldwide trends, dynamics and challenges and implications for management. *Renewable Energy*, 62(0), pp.657–671. Available at: http://www.sciencedirect.com/science/article/pii/S0960148113004321.

Robertson, T.S. & Gatignon, H., 1998. Technology development mode: a transaction cost conceptualization. *Strategic Management Journal*, 19(6), pp.515–531. Available at: http://dx.doi.org/10.1002/(SICI)1097-0266(199806)19:6%3C515::AID-SMJ960%3E3.0.CO%5Cn2-F.

Roediger-Schluga, T. & Barber, M.J., 2008. R&D collaboration networks in the European Framework Programmes: data processing, network construction and selected results. *International Journal of Foresight and Innovation Policy*, 4(31), p.321. Available at: http://inderscience.metapress.com/index/h1337472726u163l.pdf%5Cn

Romo-Fernández, L.M. et al., 2011. Analysis of Europe’s scientific production on renewable energies. *Renewable Energy*, 36(9), pp.2529–2537. Available at: http://www.sciencedirect.com/science/article/pii/S0960148111000772.

Romo-Fernández, L.M. et al., 2011. Analysis of Europe’s scientific production on renewable energies. *Renewable Energy*, 36(9), pp.2529–2537. Available at: http://dx.doi.org/10.1016/j.renene.2011.02.001.

Rowley, T., Behrens, D. & Krackhardt, D., 2000. Redundant governance structures: an analysis of structural and relational embeddedness in the steel and semiconductor industries. *Strategic Management Journal*, 21(3), pp.369–386. Available at:

http://dx.doi.org/10.1002/(SICI)1097-0266(200003)21:3%3C369::AID-SMJ93%3E3.0.CO.

Rychen, F. & Zimmermann, J.-B., 2009. Industrial Clusters and the Knowledge Based Economy: from open to distributed structures?

Sagar, a. D. & Holdren, J.P., 2002. Assessing the global energy innovation system: some key issues. *Energy Policy*, 30(6), pp.465–469.

Sakakibara, M., 2001. The Diversity of R&D Consortia and Firm Behavior: Evidence from Japanese Data. *The Journal of Industrial Economics*, 49(2), pp.181–196. Available at: http://dx.doi.org/10.1111/1467-6451.00145.

Schilling, M.A. & Phelps, C.C., 2007. Interfirm Collaboration Networks: The Impact of Large-Scale Network Structure on Firm Innovation. *Management Science*, 53(7), pp.1113–1126. Available at: http://www.jstor.org/stable/20122273.

Schwartz, M. et al., 2012. What drives innovation output from subsidized R&D cooperation?—Project-level evidence from Germany. *Technovation*, 32(6), pp.358–369. Available at: http://www.sciencedirect.com/science/article/pii/S0166497212000338.

Scott, J., 2017. Social network analysis: A handbook. *SAGE Publications*, p.208. Available at: http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Social+Network+Analysis+A+Handbook#6.

Siokas, E., 2008. *The Nature of EU Funded R & D Collaboration Networks in the Area of Information Society Technologies*,

Smith, S.S., 2005. "Don't Put My Name on It": Social Capital Activation and Job-Finding Assistance among the Black Urban Poor. *The American Journal of Sociology*, 111(1), p.1.

Smith, W.K. & Lewis, M.W., 2011. Toward a theory of paradox: A dynamic equilibrium model of organizining. *Academy of Management Review*, 36(2), pp.381–403. Available at: http://ezproxy.library.capella.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=59330958&site=ehost-live&scope=site.

Stejskal, J. & Hajek, P., 2012. Competitive advantage analysis: a novel method for industrial clusters identification. *Journal of Business Economics and Management*, 13(2), pp.344–365. Available at: http://dx.doi.org/10.3846/16111699.2011.620154.

Step, N., Thelwall, M. & Stuart, D., 2009. The use of webometrics for the analysis of knowledge flows within the European Research Area. , (October), pp.1–178.

Stern, M.J., 2008. HOW LOCALITY, FREQUENCY OF COMMUNICATION AND INTERNET USAGE AFFECT MODES OF COMMUNICATION WITHIN CORE SOCIAL NETWORKS. *Information, Communication & Society*, 11(5), pp.591–616. Available at: http://dx.doi.org/10.1080/13691180802126778.

Su, Y.-S. & Hung, L.-C., 2009. Spontaneous vs. policy-driven: The origin and evolution of the biotechnology cluster. *Two Special Sections: Advances in Evolution and Genetics: Implications for Technology Strategy The Digital Economy in Asia*, 76(5), pp.608–619. Available at: http://www.sciencedirect.com/science/article/pii/S0040162508001686.

Tang, F., Xi, Y. & Ma, J., 2006. Estimating the effect of organizational structure on knowledge transfer: A neural network approach. *Expert Systems with Applications*, 30(4), pp.796–800.

Turker, D., 2014. Analyzing relational sources of power at the interorganizational communication system. *European Management Journal*, 32(3), pp.509–517. Available at: http://dx.doi.org/10.1016/j.emj.2013.06.007.

Uehara, E., 1990. Dual Exchange Theory, Social Networks, and Informal Social Support. *American Journal of Sociology*, 96(3), pp.521–557. Available at:

http://dx.doi.org/10.1086/229571.

Uzzi, B., 1997. Social Structure and Competition in Interfirm Networks: The Paradox of Embeddedness. *Administrative Science Quarterly*, 42(1), pp.35–67.

Uzzi, B., 1996. The sources and consequences of embeddedness for the economic performance of organizations:The network effect. *American Sociological Review*, 61, pp.674–698.

Valente, T.W. & Foreman, R.K., 1998. Integration and radiality: Measuring the extent of an individual's connectedness and reachability in a network. *Social Networks*, 20, pp.89–105.

Valente, T.W. & Fujimoto, K., 2010. Bridging: Locating critical connectors in a network. *Social Networks*, 32(3), pp.212–220.

Valente, T.W. & Fujimoto, K., 2010. Bridging: Locating critical connectors in a network. *Social Networks*, 32(3), pp.212–220. Available at: http://www.sciencedirect.com/science/article/pii/S0378873310000146.

van der Valk, T., Chappin, M.M.H. & Gijsbers, G.W., 2011. Evaluating innovation networks in emerging technologies. *Technological Forecasting and Social Change*, 78(1), pp.25–39. Available at: http://dx.doi.org/10.1016/j.techfore.2010.07.001.

Vantoch-Wood, A. & Connor, P.M., 2013. Using network analysis to understand public policy for wave energy. *Energy Policy*, 62(0), pp.676–685. Available at: http://www.sciencedirect.com/science/article/pii/S030142151300709X.

Verspagen, B., 2006. 13 Small worlds and technology networks. *Knowledge flows in European industry*, 35, p.299.

Vlaar, P.W.L., Van Den Bosch, F.A.J. & Volberda, H.W., 2007. Towards a dialectic perspective on formalization in interorganizational relationships: How alliance managers capitalize on the duality inherent in contracts, rules and procedures. *Organization Studies*, 28(4), pp.437–466. Available at: http://www.scopus.com/inward/record.url?eid=2-s2.0-34247247721&partnerID=40&md5=19243623ffcc818cef4ea9a14838b053.

Wanzenböck, I., Scherngell, T. & Lata, R., 2014. Embeddedness of European Regions in European Union-Funded Research and Development (R&D) Networks: A Spatial Econometric Perspective. *Regional Studies*, 3404(June), pp.1–21. Available at: http://www.tandfonline.com/doi/abs/10.1080/00343404.2013.873119.

Watts, D.J. & Strogatz, S.H., 1998. Collective dynamics of “small-world” networks. *Nature*, 393(6684), pp.440–442.

Watts, D.J. & Strogatz, S.H., 1998. Collective dynamics of “small world” networks. *Nature*, 393(6684), pp.440–442.

Weber, E.P. & Khademian, A.M., 2008. Wicked problems, knowledge challenges, and collaborative capacity builders in network settings. *Public administration review*, 68(2), pp.334–349.

Whetten, D.A., 1981. Interorganizational Relations: A Review of the Field. *Journal of Higher Education*, 52(1), pp.1–28.

Wieczorek, A.J. et al., 2013. A review of the European offshore wind innovation system. *Renewable and Sustainable Energy Reviews*, 26, pp.294–306. Available at: http://dx.doi.org/10.1016/j.rser.2013.05.045.

Yin Krogmann Ulrich Schwalbe, N.R., 2013. Inter-firm R&D Networks in Pharmaceutical Biotechnology: What Determines Firm’s Centrality-based Partnering Capability?, Discussion (Universität Hohenheim, Forschungszentrum Innovation und Dienstleistung). Available at: https://fzid.uni-hohenheim.de/71978.html.

Zey, M.A., 2015. Rational Choice and Organization Theory. In *International Encyclopedia of the Social & Behavioral Sciences*. pp. 892–895.

Zheng, X. et al., 2016. Review of the application of social network analysis (SNA) in construction project management research. *International Journal of Project Management*, 34(7), pp.1214–1225.

Annexes

Annex A: List of SNA softwares

The most complete list was created by the researchers Mark Huisman and Marijtje van Duijn (Huisman & van Duijn 2011), as a chapter of the reference book “The SAGE Handbook of Social Network Analysis” (Carrington & Scott 2011):

General Software Packages

Academic/Free

- Agna: Applied Graph and Network Analysis
- DyNet (SE and LS): Data-driven visualizations
- GUESS: The Graph Exploration System
- MultiNet: Exploratory analysis
- NetVis: Dynamic Visualization of Social Networks
- Network Workbench: Analysis, modeling, and visualization
- ORA: Dynamic network analysis
- Pajek: Program for large network analysis
- Sentinel Visualizer: Link analysis and visualization
- SocNetV: Social Networks Visualiser
- UCINET 6: Comprehensive social network analysis software
- visone: Analyis and visualization of social networks

- igraph (R, Python, C): Creating and manipulating graphs
- JUNG (Java): Java Universal Network/Graph framework
- libSNA (Python): Open-source library for social network analysis
- NetworkX (Python): Package for complex networks
- NodeXL (Excel): Viewing and analyzing network graphs
- SNA (R): Social Network Analysis tools

Commercial/Non-free

- Blue Spider: Network analysis
- InFlow: Network mapping
- mdlogix solutions: VisuaLyzer, LinkAlyzer, EgoNet
- NetMiner 3: Exploratory analysis and visualization of network data

- SNAP (Gauss): Social Network Analysis Procedures
- yFiles (Java): Visualization of networks

No longer updated (often DOS-based)

- GRADAP: Graph Definition and Analysis Package
- STRUCTURE: Structural analysis

Specialized Software Packages

Academic/Free

- Blanche: Network dynamics
- CID-ABM: Competing Idea Diffusion Agent Based Model
- CFinder: Finding and visualizing dense groups
- C-IKNOW: Knowledge networks
- CiteSpace: Visualizing patterns and trends in scientific literature
- Commetrix: Dynamic network visualization and analysis
- E-Net: Ego-NETwork analysis
- EgoNet: Egocentric networks
- Financial Network Analyzer: Financial networks
- KeyPlayer: Identifying nodes
- KliqFinder: Cohesive subgroups
- Network Genie: Network surveys
- PGRAPH: Kinship networks
- PNet: Exponential random graph models (ERGMs)
- Puck: Kinship networks
- ReferralWeb: Referral chains
- SIENA: Statistical analysis
- SONIVIS: Analyzing and visualizing virtual information spaces
- StOCNET: Statistical Analysis

- UNISoN: Download messages
- VennMaker: Actor-centered interactive network mapping tool

- statnet suite (R): Statistical analysis
- tnet (R): Analysis of weighted and longitudinal networks
- UrlNet (Python): Web mining

Commercial/Non-free

- MetaSight: Knowledge and e-mail networks
- Network Genie: Network surveys
- ONA surveys: Organizational Network Analysis survey tool

- MatMan (Excel): Structural analysis

No longer updated (often DOS-based)

- FATCAT: Contextual analysis
- NEGOPY: Cohesive subgroups
- PermNet: Permutation tests
- Snowball: Hidden populations

Visualization Software

Academic/Free

- aiSee: Graph visualization
- Apache Agora: Visualizing virtual communities
- Cytoscape: Visualizing molecular interaction networks
- Gephi: Visualization and exploration platform
- Graphviz: Graph visualization
- Jacob's Ladder: Multidimensional Data Animation, Visualization and Intonation
- KrackPlot: Social network visualization program
- Mage: 3D vector display program (showing kinemage graphics)
- NetDraw: Program associated with UCINET
- OGDF (successor of AGD): Open Graph Drawing Framework
- Otter: Tool for topology display
- SoNIA: Visualizing longitudinal network data

- Tulip: Visualization of large graphs
- uDraw(Graph) (successor of daVinci): Graph drawing
- Zoomgraph Visualizing zoomable data driven graphs

Commercial/Non-free

- KeyHubs: Mapping informal networks
- TouchGraph: Information visualization

Other than Social Networks

Academic/Free

- AutoMap: Network text analysis
- Ecosystem Network Analysis: Ecosystem trophic networks
- EveSim: Simulation of Evolutionary Environments
- WAND: Ecological network analysis

Annex B: Numeration and details of European Programmes

Numeration of Framework Programmes:

1	First Framework Programme
2	Second Framework Programme
3	Third Framework Programme
4	Fourth Framework Programme
5	Fifth Framework Programme
6	Sixth Framework Programme
7	Seventh Framework Programme
8	Education and Training
9	Energy Programmes
10	Environment
11	Euratom Framework Programme
12	Health and Safety
13	Information Society
14	International Cooperation
15	Joint Research Centre programmes
16	Pre-1984 programmes
17	Regional programmes
18	Research Programme of the Research Fund for Coal and Steel

Details of Framework Programmes:

http://collections.internetmemory.org/haeu/20161215121151/http://cordis.europa.eu/archive/home_en.html

Fourth Framework Programme (FP4, 1994-1998)

- ACTS Information Window - Multimedia Information Window for National Hosts
- ACTSLINE - ACTS guideline consolidation/channeling and streaming towards market applications
- BIOMED 2 - Biomedicine and Health
- BIOTECH 2 - Biotechnology
- BRITE-EURAM 3 - Industrial and Materials Technologies
- ELSA - Ethical, Legal and Social Aspects
- ENV - Environment and Climate
- ESPRIT 4 - Specific research and technological development programme in the field of information technologies
- FAIR - Agriculture and Fisheries
- INCO - Specific RTD programme in the field of international cooperation
- INFOSEC - Security of Telecommunications and Information Systems
- LIBRARIES - Creating a European library space, Telematics for libraries
- MAST III - Marine Science and Technology
- SMT - Specific RTD programme in the field of standards, measurements and testing
- TELEMATICS 2C - Specific RTD programme in the field of telematics applications
- TMR - Specific RTD programme in the field of training and mobility of researchers
- TRANSPORT RTD – Research for Sustainable Mobility
- TSER - Specific RTD programme in the field of targeted socio-economic research

Fifth Framework Programme (FP5, 1998-2002)

- EESD - Energy, Environment and Sustainable Development
- FIFTH FRAMEWORK - Preparation and Adoption
- FITFH FRAMEWORK - Candidates for temporary research posts
- FITFH FRAMEWORK - Expert Candidature
- FITFH FRAMEWORK - Monitoring Experts
- FITFH FRAMEWORK - Project Technical Assistants
- FITFH FRAMEWORK -Temporary Research Posts
- FP5-EAECTPC - Euratom thematic programme, Nucelear Energy (Euratom Framework Programme)
- GROWTH - Competitive and Sustainable Growth
- IMPROVING - Improving the Human Research Potential and the Socio-economic Knowledge Base
- INCO 2 - Confirming the international role of community research
- IST - User-friendly information society
- LIFE QUALITY - Quality of life and management of living resources

Sixth Framework Programme (FP6, 2002-2006)

- CITIZENS - Citizens and governance in a knowledge-based society
- Co-ordination of Research Activities
- FOOD-Food Quality and Safety
- INCO - International co-operation activities
- IST - User-friendly information society
- Life sciences, genomics and biotechnology for health
- Marie-Curie Actions - Human resources and mobility
- NANOTECHNOLOGY
- NEST-New and emerging science and technology
- NMP - Nanotechnologies and nano-sciences, knowledge-based multifunctional materials and new production processes and devices
- Nuclear Fission and Radiation Protection
- RESEARCH INFRASTRUCTURES
- Science and Society
- SUSTDEV - Sustainable development, global change and ecosystems

Seventh Framework Programme (FP7, 2007-2013)

- Article 185 Initiatives (ex Article 169 TEC)
- Coordination of Research Activities
- Energy
- Euratom
- Euratom Fission
- Euratom Fusion
- FET House - Architects of Future Emerging Technologies (FP7, 2007-2013)
- ICT - Information and Communication Technologies
- Transport (including Aeronautics)

ERA - European Research Area

- ERA - European Research Area
- FORESIGHT - Science and Technology Foresight
- STI-ERA-Science and technology Indicators for the European Research Area

Focus on Innovation

- AWARENESS - Increasing Awareness of Innovation (1994-1998)
- EASW - European Awareness Scenario Workshop (1994)
- EIMS - European Innovation Monitoring System (SPRINT Committee 1989-1994)
- ENS - European Networks and Services (Innovation Programme, 1994-1998)
- FINANCE - Financing Innovation (1994-1998)
- IMT - Promotion of Innovation Management Techniques in SME's (1994-1998)
- INCUBATORS - European Database on Business Incubators (2001)
- INNOVATION - Innovation programme in FP4 (1994-1998)

- INNOVATION POLICY- Innovation Policy Studies (until 2006)
- INNOVATION PORTAL - European Innovation Portal (2002-2006)
- INTERFACES - Interfaces, Science, Technology, Society (1994-1998)
- IPR - Intellectual Property Rights (1998-2004)
- PATINNOVA '99 - Patinnova '99 Conference (Thessaloniki, 1999)
- PAXIS - Supporting innovative start-ups (2002-2006)
- RI-Research and Innovation Support for SME's
- SCOREBOARD - Innovation Scoreboard (2001-2005)
- TDSP - Training and Dissemination Schemes Projects (1994-1998)
- TVP - Technology Transfer& Technology Validation Projects (1994-1998)

Annex C: Subject Index Classification (SIC) Codes in CORDIS

- Industry and Technology
- Energy
- Physical and Exact Sciences
- Biological Sciences
- Agriculture and Marine Resources and Products
- Measurements and Standards
- Protecting Man and his Environment
- Social and Economic Concerns
- RTD Horizontal Topics

For example, SIC "Energy" is formed by:

FIS	NUCLEAR FISSION	Reactor operation; decommissioning; reactor physics; pressure vessels; safeguarding techniques; fuel fabrication and reprocessing; irradiation facilities; uranium; plutonium and thorium ores; trans-uranium elements/actinides; fissile materials (excluding radioactive waste management).
FUS	NUCLEAR FUSION	Tokamaks'; plasma physics; electron dynamics and confinement; components and materials; instabilities and turbulence; MHD equilibrium; safeguarding techniques; electric and magnetic fields; impurities; ignition; modelling.

RSE	RENEWABLE SOURCES OF ENERGY	Tidal wave and wind energy; geothermal energy; energy from biomass; solar energy; photovoltaic cells; unconventional and alternative energies.
EST	ENERGY STORAGE, ENERGY TRANSPORT	The storage, transmission and conversion of energy; use of hydrogen for energy transport; cells; secondary energy vectors.
ESV	ENERGY SAVING	Energy conservation; increased efficiency of energy use; energy audits; heat transmission and storage; heat pumps; thermal insulation; use of waste heat.
BIF	BIOFUELS	Prospects for widespread use; applicability in rural societies and needs; food or fuel arguments; agricultural requirements.
HFC	HYDROGEN AND FUEL CELLS	Hydrogen production; hydrogen delivery; hydrogen storage; fuel cells.
OET	OTHER ENERGY TOPICS	Demand analysis and utilization strategies; energy statistics; general energy topics not included elsewhere.

Annex D: “Type of organisation” codification

Organization	**Type**
UNIVERSITY	1
RESEARCH	2
FIRM	3
GOVERNMENT	4
ASSOCIATION	5
NGO	6
NA	7

Annex E: Progressive aggregated Longitudinal SNA analysis for 2000-2013

Organisations. Wind Sector.

ID	**2000**	**2000-2001**	**2000-2002**	**2000-2003**	**2000-2004**	**2000-2005**	**2000-2006**	**2000-2007**	**2000-2008**	**2000-2009**	**2000-2010**	**2000-2011**	**2000-2012**	**2000-2013**
Avg Degree	7.7297	9.5159	10.5776	10.6101	11.0170	13.1230	15.1099	15.1517	15.6927	15.5866	16.3521	17.1691	18.3506	18.5651
Deg Centralization	0.2364	0.1762	0.1869	0.1791	0.1666	0.1581	0.1593	0.1511	0.1436	0.1333	0.1350	0.1258	0.1703	0.1643
Density	0.0262	0.0202	0.0177	0.0167	0.0144	0.0138	0.0137	0.0131	0.0129	0.0119	0.0112	0.0108	0.0103	0.0101
Components	19	32	40	40	43	42	43	45	46	48	55	59	60	62
Component Ratio	0.0610	0.0660	0.0652	0.0614	0.0550	0.0432	0.0382	0.0380	0.0370	0.0359	0.0370	0.0365	0.0332	0.0331
Avg Distance	3.3016	3.4534	3.3071	3.3081	3.3488	3.3879	3.3133	3.2916	3.2359	3.3005	3.2460	3.2162	3.1964	3.1914
SD Distance	1.0557	1.0539	0.9935	0.9859	0.9463	0.9506	0.9146	0.8833	0.8501	0.8814	0.8543	0.8276	0.8450	0.8346
Diameter	7	7	7	7	7	7	7	7	7	7	7	7	8	8
Connectedness	0.7662	0.7079	0.6677	0.6877	0.7161	0.7937	0.8269	0.8274	0.8396	0.8605	0.8227	0.8331	0.8761	0.8792
Fragmentation	0.2338	0.2921	0.3323	0.3123	0.2839	0.2063	0.1731	0.1726	0.1604	0.1395	0.1773	0.1669	0.1239	0.1208
Watts-Strogatz Clustering Coefficient	0.8673	0.8927	0.8900	0.8887	0.8876	0.8910	0.8951	0.8891	0.8824	0.8839	0.8866	0.8848	0.8804	0.8825
Network Clustering Coefficient (Transitivity)	0.4347	0.5875	0.5183	0.4960	0.4927	0.5445	0.5639	0.5491	0.5183	0.5067	0.4811	0.4733	0.4363	0.4357

Local regions. Wind Sector.

ID	**2000**	**2000-2001**	**2000-2002**	**2000-2003**	**2000-2004**	**2000-2005**	**2000-2006**	**2000-2007**	**2000-2008**	**2000-2009**	**2000-2010**	**2000-2011**	**2000-2012**	**2000-2013**
Avg Degree	10.1149	12.9355	14.7703	15.0204	15.9695	19.1359	22.7273	23.3864	24.3781	24.8985	26.3185	28.2510	31.1047	31.9894
Deg Centralization	0.2859	0.2778	0.2687	0.2577	0.2493	0.2654	0.2874	0.3010	0.3225	0.3437	0.3482	0.3782	0.4063	0.4085
Density	0.0585	0.0524	0.0524	0.0513	0.0488	0.0521	0.0545	0.0549	0.0557	0.0539	0.0532	0.0546	0.0562	0.0566
Components	5	6	6	7	8	6	6	6	6	5	5	6	6	5
Component Ratio	0.0231	0.0202	0.0177	0.0205	0.0214	0.0136	0.0120	0.0117	0.0114	0.0087	0.0081	0.0097	0.0090	0.0071
Avg Distance	2.6123	2.5951	2.4885	2.4853	2.4880	2.4303	2.3870	2.3729	2.3463	2.3565	2.3380	2.3100	2.2757	2.2673
SD Distance	0.7609	0.7397	0.6632	0.6589	0.6609	0.6464	0.6286	0.6221	0.6136	0.6133	0.6044	0.5948	0.5723	0.5676
Diameter	5	6	5	5	5	5	5	5	5	5	5	5	4	4
Connectedness	0.9544	0.9521	0.9580	0.9529	0.9518	0.9730	0.9762	0.9767	0.9773	0.9828	0.9839	0.9808	0.9820	0.9859
Fragmentation	0.0456	0.0479	0.0420	0.0471	0.0482	0.0270	0.0238	0.0233	0.0227	0.0172	0.0161	0.0192	0.0180	0.0141
Watts-Strogatz Clustering Coefficient	0.7565	0.7769	0.7765	0.7731	0.7683	0.7666	0.7772	0.7675	0.7593	0.7544	0.7534	0.7491	0.7474	0.7541
Network Clustering Coefficient (Transitivity)	0.3969	0.4233	0.3923	0.3819	0.3654	0.3706	0.4061	0.3977	0.3855	0.3752	0.3632	0.3611	0.3570	0.3598

Organisations. Solar Sector.

ID	**2000**	**2000-2001**	**2000-2002**	**2000-2003**	**2000-2004**	**2000-2005**	**2000-2006**	**2000-2007**	**2000-2008**	**2000-2009**	**2000-2010**	**2000-2011**	**2000-2012**	**2000-2013**
Avg Degree	8.1692	11.9287	12.7868	13.1656	14.6870	15.2367	16.1652	16.4652	16.7444	17.1729	17.1735	17.5054	17.5945	17.3252
Deg Centralization	0.1766	0.1669	0.1764	0.1970	0.2090	0.1990	0.2009	0.1999	0.2113	0.2166	0.2247	0.2329	0.2453	0.2503
Density	0.0113	0.0109	0.0094	0.0087	0.0082	0.0076	0.0072	0.0068	0.0066	0.0062	0.0057	0.0053	0.0049	0.0047
Components	47	57	64	62	67	74	75	77	80	83	86	79	59	58
Component Ratio	0.0639	0.0512	0.0462	0.0404	0.0367	0.0364	0.0329	0.0315	0.0309	0.0297	0.0280	0.0235	0.0162	0.0154
Avg Distance	3.4624	3.2446	3.2506	3.2195	3.1554	3.1670	3.1277	3.0910	3.0657	3.0549	3.0707	3.0716	3.0573	3.0616
SD Distance	1.0624	0.9069	0.8596	0.8427	0.8040	0.7911	0.7634	0.7122	0.7002	0.6907	0.6957	0.7153	0.7000	0.7010
Diameter	9	8	7	7	7	7	7	7	7	7	7	9	9	9
Connectedness	0.6932	0.7560	0.7912	0.8114	0.8261	0.8370	0.8589	0.8702	0.8736	0.8820	0.8906	0.9001	0.9280	0.9298
Fragmentation	0.3068	0.2440	0.2088	0.1886	0.1739	0.1630	0.1411	0.1298	0.1264	0.1180	0.1094	0.0999	0.0720	0.0702
Watts-Strogatz Clustering Coefficient	0.8817	0.8865	0.8851	0.8844	0.8815	0.8837	0.8827	0.8809	0.8814	0.8800	0.8778	0.8634	0.8515	0.8449
Network Clustering Coefficient (Transitivity)	0.3714	0.4516	0.4263	0.3865	0.3813	0.3805	0.3554	0.3407	0.3212	0.3075	0.2887	0.2710	0.2467	0.2349

Local regions. Solar Sector.

ID	2000	2000-2001	2000-2002	2000-2003	2000-2004	2000-2005	2000-2006	2000-2007	2000-2008	2000-2009	2000-2010	2000-2011	2000-2012	2000-2013
Avg Degree	13.2125	20.8116	22.0694	23.6041	26.7542	27.9212	30.5865	31.6557	33.0046	34.3752	35.5519	37.2542	38.0344	38.1752
Deg Centralization	0.3116	0.3119	0.2990	0.3047	0.3536	0.3564	0.3630	0.3669	0.3963	0.4139	0.4231	0.4552	0.4833	0.4857
Density	0.0414	0.0504	0.0480	0.0483	0.0495	0.0479	0.0491	0.0496	0.0502	0.0497	0.0486	0.0486	0.0468	0.0465
Components	8	8	8	8	9	8	8	8	8	7	6	6	4	4
Component Ratio	0.0219	0.0169	0.0152	0.0143	0.0148	0.0120	0.0112	0.0110	0.0106	0.0087	0.0068	0.0065	0.0037	0.0037
Avg Distance	2.5803	2.3981	2.3881	2.3663	2.3239	2.3156	2.2878	2.2736	2.2492	2.2358	2.2244	2.2079	2.2042	2.2006
SD Distance	0.6966	0.6269	0.6052	0.5959	0.5840	0.5751	0.5634	0.5561	0.5453	0.5356	0.5256	0.5174	0.5101	0.5073
Diameter	5	5	5	5	5	5	5	4	4	4	4	4	4	4
Connectedness	0.9506	0.9664	0.9698	0.9716	0.9706	0.9762	0.9777	0.9782	0.9789	0.9827	0.9864	0.9870	0.9926	0.9927
Fragmentation	0.0494	0.0336	0.0302	0.0284	0.0294	0.0238	0.0223	0.0218	0.0211	0.0173	0.0136	0.0130	0.0074	0.0073
Watts-Strogatz Clustering Coefficient	0.7154	0.7388	0.7374	0.7260	0.7292	0.7325	0.7322	0.7269	0.7228	0.7223	0.7166	0.7131	0.7068	0.6985
Network Clustering Coefficient (Transitivity)	0.3000	0.3605	0.3462	0.3364	0.3357	0.3268	0.3245	0.3224	0.3168	0.3115	0.3042	0.3005	0.2877	0.2844

Organisations. Sea Sector.

ID	**2000**	**2000-2001**	**2000-2002**	**2000-2003**	**2000-2004**	**2000-2005**	**2000-2006**	**2000-2007**	**2000-2008**	**2000-2009**	**2000-2010**	**2000-2011**	**2000-2012**	**2000-2013**
Avg Degree	8.2609	7.7959	8.0260	8.1176	23.1333	20.5526	19.8765	18.7586	19.9791	19.9688	20.7138	20.4145	20.8324	20.8324
Deg Centralization	0.4818	0.4605	0.2833	0.3521	0.4262	0.3520	0.3341	0.3172	0.3831	0.3519	0.3445	0.3441	0.3103	0.3103
Density	0.1836	0.1624	0.1056	0.0966	0.1944	0.1361	0.1235	0.1084	0.1052	0.0783	0.0700	0.0674	0.0584	0.0584
Components	2	4	5	5	6	7	8	10	10	12	12	12	9	9
Component Ratio	0.0222	0.0625	0.0526	0.0476	0.0420	0.0397	0.0435	0.0520	0.0474	0.0431	0.0372	0.0363	0.0224	0.0224
Avg Distance	2.1140	2.1129	2.4522	2.4598	1.9727	2.1977	2.2126	2.2369	2.2473	2.3769	2.3486	2.3612	2.5424	2.5424
SD Distance	0.7563	0.7568	0.8692	0.8346	0.7302	0.8218	0.8163	0.8161	0.7609	0.7374	0.6704	0.6664	0.7722	0.7722
Diameter	4	4	5	5	4	5	5	5	5	5	4	4	6	6
Connectedness	0.9150	0.8061	0.7187	0.7426	0.7542	0.7029	0.6591	0.6084	0.6886	0.7081	0.7450	0.7504	0.8762	0.8762
Fragmentation	0.0850	0.1939	0.2813	0.2574	0.2458	0.2971	0.3409	0.3916	0.3114	0.2919	0.2550	0.2496	0.1238	0.1238
Watts-Strogatz Clustering Coefficient	0.9302	0.9302	0.9373	0.9426	0.9597	0.9587	0.9541	0.9523	0.9323	0.9402	0.9404	0.9409	0.9189	0.9189
Network Clustering Coefficient (Transitivity)	0.7076	0.7076	0.7288	0.7022	0.8887	0.8626	0.8520	0.8489	0.7620	0.7427	0.6887	0.6826	0.6397	0.6397

Local regions. Sea Sector.

ID	**2000**	**2000-2001**	**2000-2002**	**2000-2003**	**2000-2004**	**2000-2005**	**2000-2006**	**2000-2007**	**2000-2008**	**2000-2009**	**2000-2010**	**2000-2011**	**2000-2012**	**2000-2013**
Avg Degree	8.6842	8.3000	8.2000	8.2813	21.7241	20.0196	19.7383	19.0089	21.0880	23.6770	25.1954	24.7151	24.9754	24.9754
Deg Centralization	0.5225	0.5047	0.3296	0.3722	0.4198	0.3735	0.3582	0.3453	0.4418	0.3754	0.3789	0.3766	0.4251	0.4251
Density	0.2347	0.2128	0.1390	0.1314	0.2526	0.1982	0.1862	0.1697	0.1701	0.1480	0.1456	0.1388	0.1236	0.1236
Components	1	2	2	2	3	3	3	2	3	3	2	2	2	2
Component Ratio	0.0000	0.0256	0.0169	0.0159	0.0233	0.0198	0.0189	0.0089	0.0161	0.0125	0.0058	0.0056	0.0050	0.0050
Avg Distance	2.0427	2.0412	2.3788	2.3630	1.8592	2.0585	2.0776	2.2116	2.1128	2.1297	2.1832	2.1996	2.1881	2.1881
SD Distance	0.7754	0.7759	0.9197	0.8925	0.7340	0.7897	0.7729	0.8235	0.7512	0.6962	0.7313	0.7296	0.6899	0.6899
Diameter	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Connectedness	1.0000	0.9026	0.7904	0.8021	0.7690	0.8002	0.8089	0.8827	0.8783	0.9044	0.9885	0.9888	0.9901	0.9901
Fragmentation	0.0000	0.0974	0.2096	0.1979	0.2310	0.1998	0.1911	0.1173	0.1217	0.0956	0.0115	0.0112	0.0099	0.0099
Watts-Strogatz Clustering Coefficient	0.8912	0.8912	0.8946	0.8913	0.9308	0.9227	0.9177	0.9052	0.8850	0.8673	0.8517	0.8544	0.8429	0.8429
Network Clustering Coefficient (Transitivity)	0.6924	0.6924	0.6768	0.6394	0.8730	0.8465	0.8261	0.8176	0.7298	0.6801	0.6317	0.6271	0.5796	0.5796

Organisations. Geothermal Sector.

ID	**2000**	**2000-2001**	**2000-2002**	**2000-2003**	**2000-2004**	**2000-2005**	**2000-2006**	**2000-2007**	**2000-2008**	**2000-2009**	**2000-2010**	**2000-2011**	**2000-2012**	**2000-2013**
Avg Degree	6.3175	7.3265	7.2793	7.0156	7.6757	13.6416	13.4000	13.0957	13.0352	14.5488	14.6792	14.6792	14.3310	14.2818
Deg Centralization	0.2446	0.1649	0.1455	0.1519	0.2298	0.3374	0.3424	0.3454	0.3263	0.3323	0.2684	0.2684	0.2462	0.2455
Density	0.1019	0.0755	0.0662	0.0552	0.0522	0.0793	0.0749	0.0700	0.0658	0.0680	0.0556	0.0556	0.0496	0.0492
Components	15	17	17	18	16	13	15	16	16	15	17	17	17	18
Component Ratio	0.2258	0.1649	0.1455	0.1339	0.1020	0.0698	0.0782	0.0802	0.0758	0.0654	0.0606	0.0606	0.0554	0.0586
Avg Distance	1.6935	2.0566	2.6924	2.6967	3.3860	2.6748	2.6634	2.6840	2.7078	2.6437	2.6462	2.6462	2.6569	2.6569
SD Distance	0.7188	1.0163	1.4790	1.4148	1.5243	1.0856	1.0778	1.0736	1.0489	0.9615	0.9461	0.9461	0.8688	0.8688
Diameter	3	4	7	7	8	7	7	7	7	7	7	7	5	5
Connectedness	0.2222	0.2045	0.2695	0.2442	0.5199	0.6592	0.6353	0.6319	0.6498	0.7495	0.6274	0.6274	0.6178	0.6136
Fragmentation	0.7778	0.7955	0.7305	0.7558	0.4801	0.3408	0.3647	0.3681	0.3502	0.2505	0.3726	0.3726	0.3822	0.3864
Watts-Strogatz Clustering Coefficient	0.9492	0.9520	0.9449	0.9455	0.9306	0.9296	0.9284	0.9288	0.9320	0.9271	0.9372	0.9372	0.9423	0.9423
Network Clustering Coefficient (Transitivity)	0.8555	0.8492	0.8283	0.8156	0.7263	0.7754	0.7575	0.7398	0.7341	0.7173	0.7044	0.7044	0.6968	0.6968

Local regions. Geothermal Sector.

ID	**2000**	**2000-2001**	**2000-2002**	**2000-2003**	**2000-2004**	**2000-2005**	**2000-2006**	**2000-2007**	**2000-2008**	**2000-2009**	**2000-2010**	**2000-2011**	**2000-2012**	**2000-2013**
Avg Degree	5.7447	6.5075	6.3590	6.4944	7.7083	14.4151	14.3853	14.0696	13.8182	15.9683	16.7397	16.7397	16.4204	16.4204
Deg Centralization	0.3464	0.3044	0.2618	0.2384	0.2826	0.3163	0.3265	0.3475	0.3320	0.3905	0.3934	0.3934	0.3804	0.3804
Density	0.1249	0.0986	0.0826	0.0738	0.0811	0.1373	0.1332	0.1234	0.1152	0.1277	0.1154	0.1154	0.1053	0.1053
Components	9	9	10	9	8	6	7	7	7	7	7	7	6	6
Component Ratio	0.1739	0.1212	0.1169	0.0909	0.0737	0.0476	0.0556	0.0526	0.0500	0.0480	0.0414	0.0414	0.0321	0.0321
Avg Distance	2.1014	2.3322	2.5192	2.6402	2.5078	2.1943	2.1879	2.2070	2.2474	2.1732	2.1996	2.1996	2.2568	2.2568
SD Distance	0.7643	0.7713	0.8522	0.9238	0.8534	0.7348	0.7269	0.7129	0.7132	0.6947	0.6832	0.6832	0.6937	0.6937
Diameter	4	4	4	5	5	4	4	4	4	4	4	4	4	4
Connectedness	0.5291	0.6522	0.6344	0.6239	0.6647	0.8221	0.8101	0.8194	0.8278	0.8343	0.8559	0.8559	0.8775	0.8775
Fragmentation	0.4709	0.3478	0.3656	0.3761	0.3353	0.1779	0.1899	0.1806	0.1722	0.1657	0.1441	0.1441	0.1225	0.1225
Watts-Strogatz Clustering Coefficient	0.8969	0.8811	0.8846	0.8751	0.8582	0.8757	0.8717	0.8744	0.8775	0.8694	0.8529	0.8529	0.8541	0.8541
Network Clustering Coefficient (Transitivity)	0.7081	0.6272	0.6319	0.6235	0.5969	0.7010	0.6838	0.6608	0.6516	0.6330	0.5921	0.5921	0.5768	0.5768

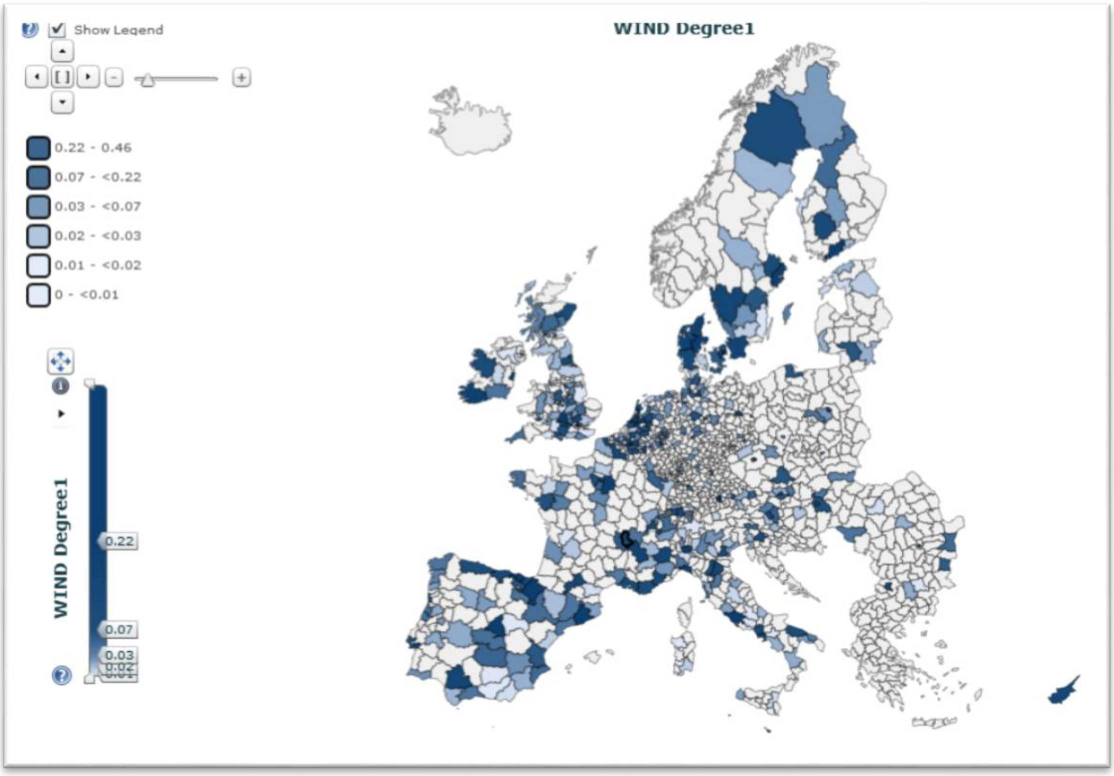
Organisations. Biomass Sector.

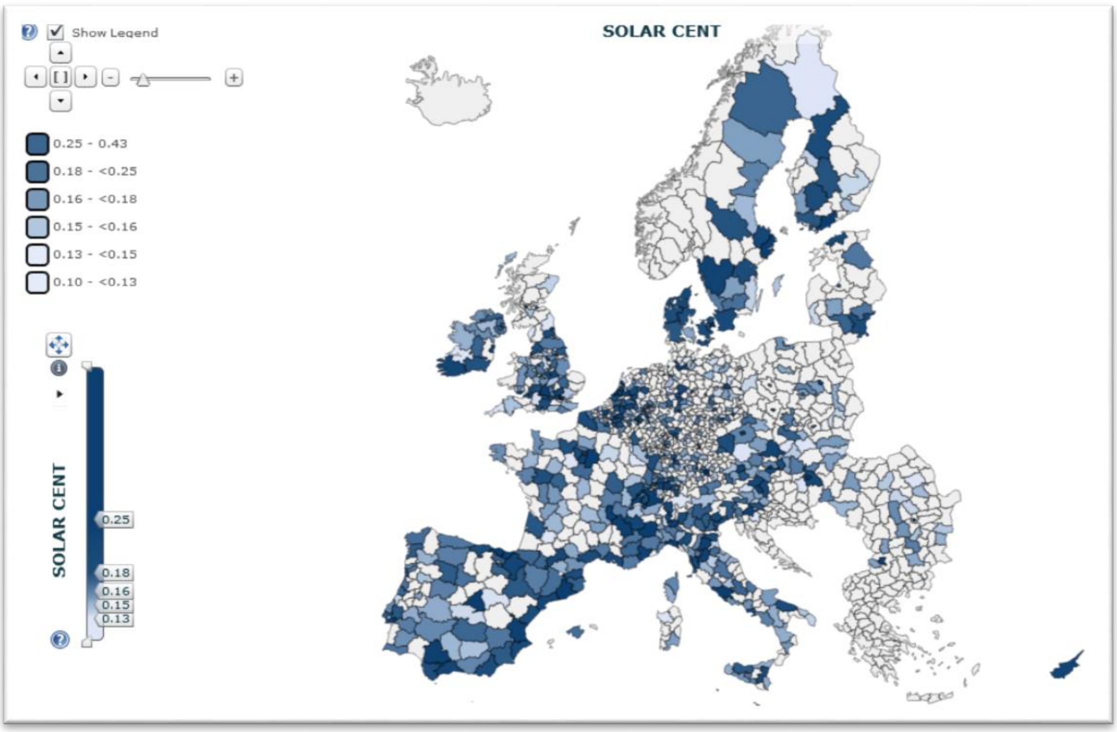
ID	**2000**	**2000-2001**	**2000-2002**	**2000-2003**	**2000-2004**	**2000-2005**	**2000-2006**	**2000-2007**	**2000-2008**	**2000-2009**	**2000-2010**	**2000-2011**	**2000-2012**	**2000-2013**
Avg Degree	8.6280	10.9142	14.8380	14.7080	17.7052	18.6433	19.1132	19.9392	20.1230	20.0349	20.3732	20.7560	21.4724	21.3750
Deg Centralization	0.0934	0.1400	0.1605	0.1491	0.1588	0.1410	0.1270	0.1201	0.1100	0.1038	0.0998	0.1018	0.0996	0.0973
Density	0.0209	0.0154	0.0155	0.0138	0.0137	0.0128	0.0119	0.0114	0.0106	0.0097	0.0092	0.0086	0.0082	0.0080
Components	28	34	40	47	47	47	52	55	52	50	54	54	51	53
Component Ratio	0.0654	0.0465	0.0408	0.0432	0.0355	0.0317	0.0317	0.0310	0.0268	0.0238	0.0238	0.0221	0.0192	0.0195
Avg Distance	3.3108	3.4125	3.3125	3.2625	3.1591	3.1107	3.0939	3.0695	3.0948	3.0908	3.0713	3.0768	3.0525	3.0547
SD Distance	0.9621	0.9470	0.9084	0.8804	0.8519	0.8018	0.7803	0.7588	0.7835	0.7477	0.7322	0.7427	0.7210	0.7190
Diameter	6	7	7	7	7	7	7	7	8	7	7	7	7	7
Connectedness	0.7080	0.8105	0.7718	0.7507	0.8019	0.8270	0.8362	0.8420	0.8634	0.8765	0.8775	0.8980	0.9132	0.9166
Fragmentation	0.2920	0.1895	0.2282	0.2493	0.1981	0.1730	0.1638	0.1580	0.1366	0.1235	0.1225	0.1020	0.0868	0.0834
Watts-Strogatz Clustering Coefficient	0.8761	0.8877	0.8992	0.8945	0.8964	0.8946	0.8938	0.8918	0.8862	0.8878	0.8849	0.8828	0.8855	0.8855
Network Clustering Coefficient (Transitivity)	0.5380	0.5408	0.6638	0.6140	0.5858	0.5599	0.5375	0.5265	0.4956	0.4750	0.4482	0.4167	0.3998	0.3933

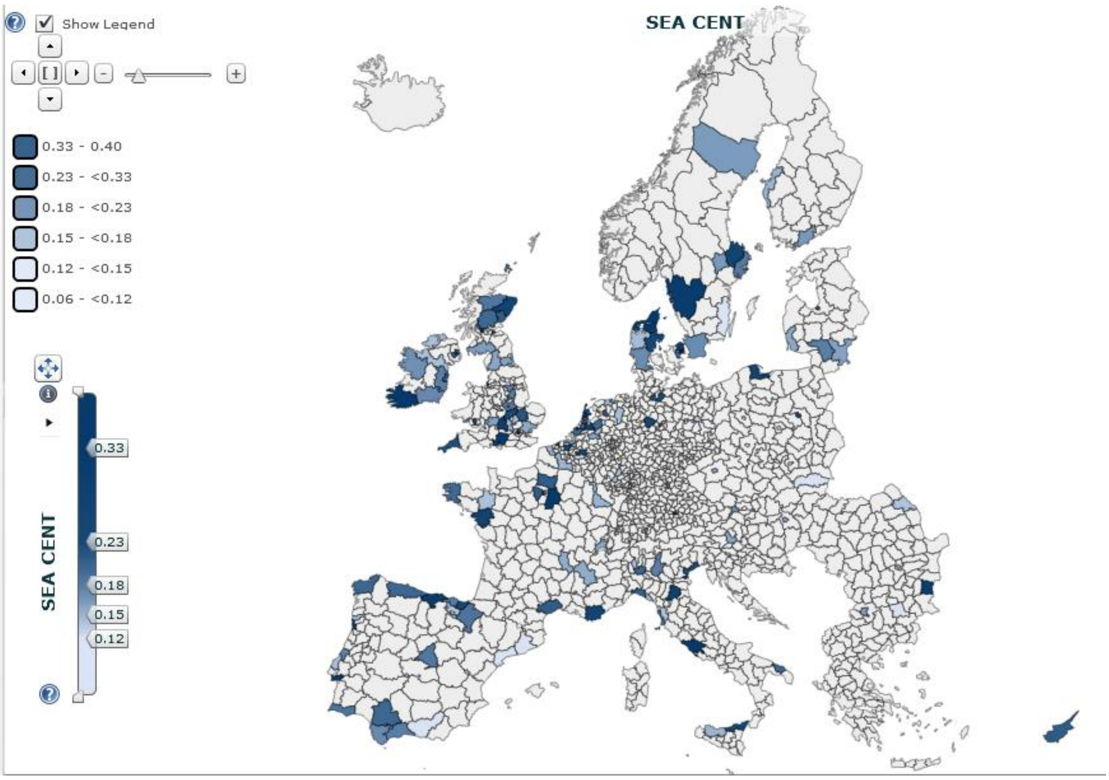
Local regions. Biomass Sector.

ID	2000	2000-2001	2000-2002	2000-2003	2000-2004	2000-2005	2000-2006	2000-2007	2000-2008	2000-2009	2000-2010	2000-2011	2000-2012	2000-2013
Avg Degree	11.8917	16.2353	20.8571	21.5240	26.2480	28.6717	30.2996	32.5000	34.0067	34.8315	36.8356	38.1110	39.9862	40.2076
Deg Centralization	0.1819	0.2159	0.2882	0.2914	0.3410	0.3289	0.3479	0.3752	0.3976	0.3809	0.3691	0.3855	0.3972	0.3961
Density	0.0498	0.0479	0.0515	0.0494	0.0535	0.0545	0.0548	0.0569	0.0569	0.0560	0.0567	0.0557	0.0554	0.0550
Components	7	9	7	7	8	8	7	7	7	7	6	6	3	3
Component Ratio	0.0251	0.0236	0.0148	0.0138	0.0143	0.0133	0.0108	0.0105	0.0100	0.0096	0.0077	0.0073	0.0028	0.0027
Avg Distance	2.5940	2.4262	2.3807	2.3701	2.2988	2.2712	2.2558	2.2258	2.2142	2.2139	2.1988	2.1932	2.1829	2.1790
SD Distance	0.7288	0.6199	0.6140	0.5992	0.5728	0.5626	0.5554	0.5431	0.5362	0.5342	0.5261	0.5199	0.5117	0.5085
Diameter	6	5	5	5	5	5	5	4	4	4	4	4	4	4
Connectedness	0.9424	0.9477	0.9706	0.9727	0.9717	0.9736	0.9784	0.9791	0.9801	0.9808	0.9847	0.9854	0.9945	0.9945
Fragmentation	0.0576	0.0523	0.0294	0.0273	0.0283	0.0264	0.0216	0.0209	0.0199	0.0192	0.0153	0.0146	0.0055	0.0055
Watts-Strogatz Clustering Coefficient	0.7648	0.7521	0.7591	0.7574	0.7645	0.7597	0.7569	0.7506	0.7448	0.7413	0.7341	0.7364	0.7410	0.7400
Network Clustering Coefficient (Transitivity)	0.3997	0.3499	0.3826	0.3639	0.3705	0.3610	0.3523	0.3513	0.3418	0.3377	0.3332	0.3287	0.3230	0.3200

Annex F: Geographic maps for centrality






SEA CENT
Show Legend
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0.15 - <0.18
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0.06 - <0.12
SEA CENT
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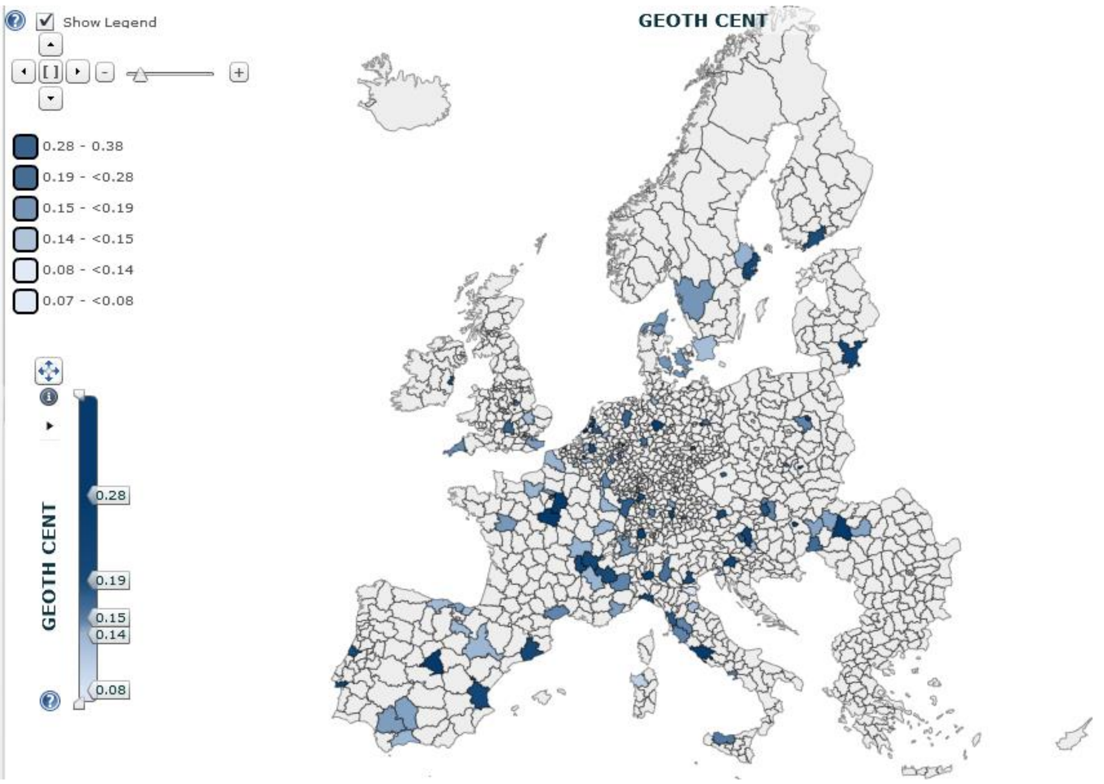
0.18
0.15
0.12


GEOTH CENT
Show Legend
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0.07 - <0.08
GEOTH CENT
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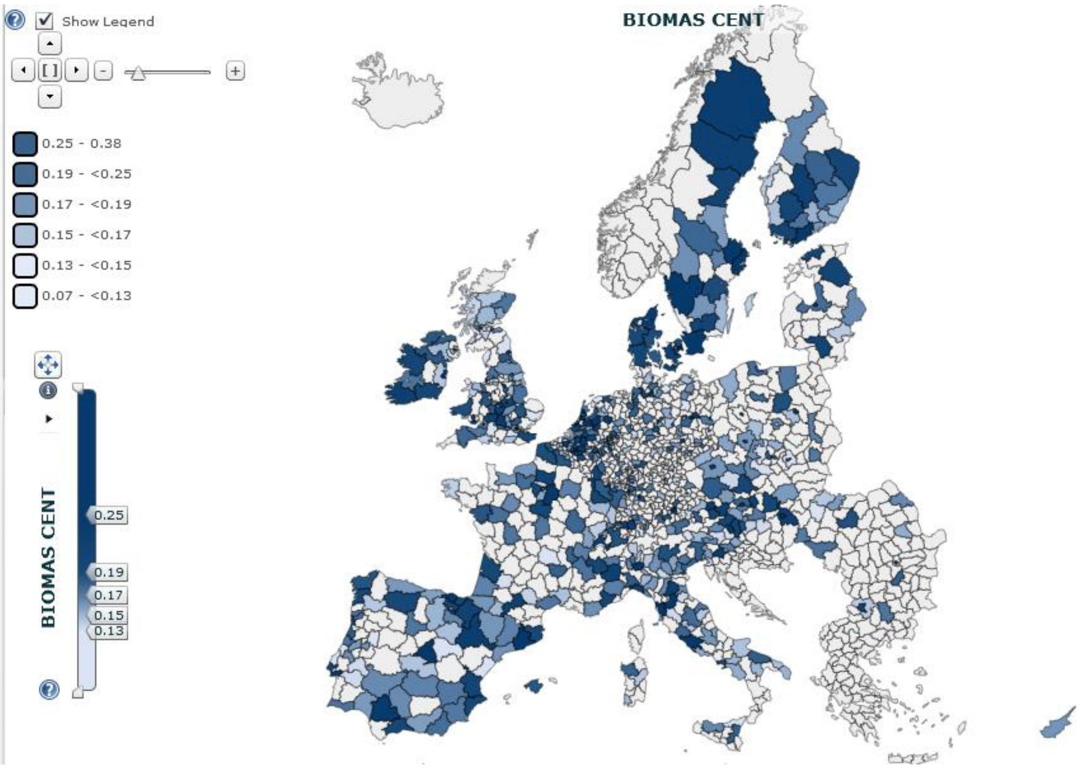
0.08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BIOMAS CENT
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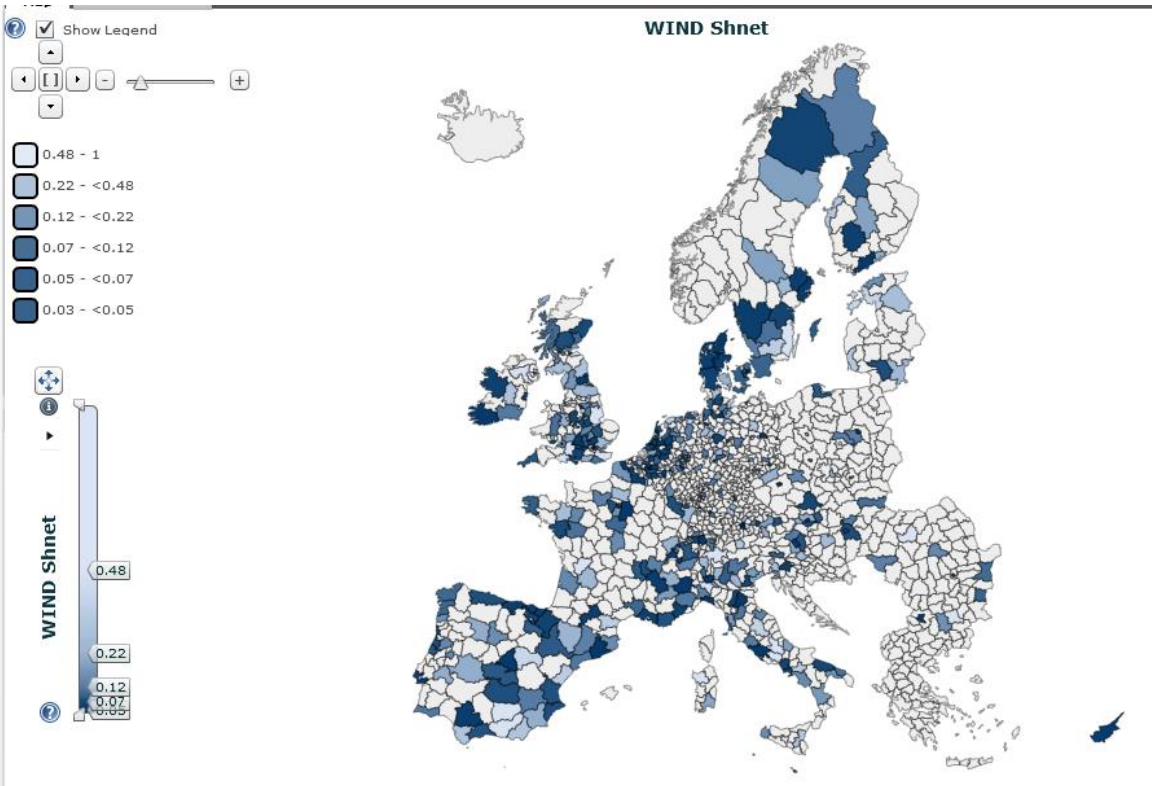
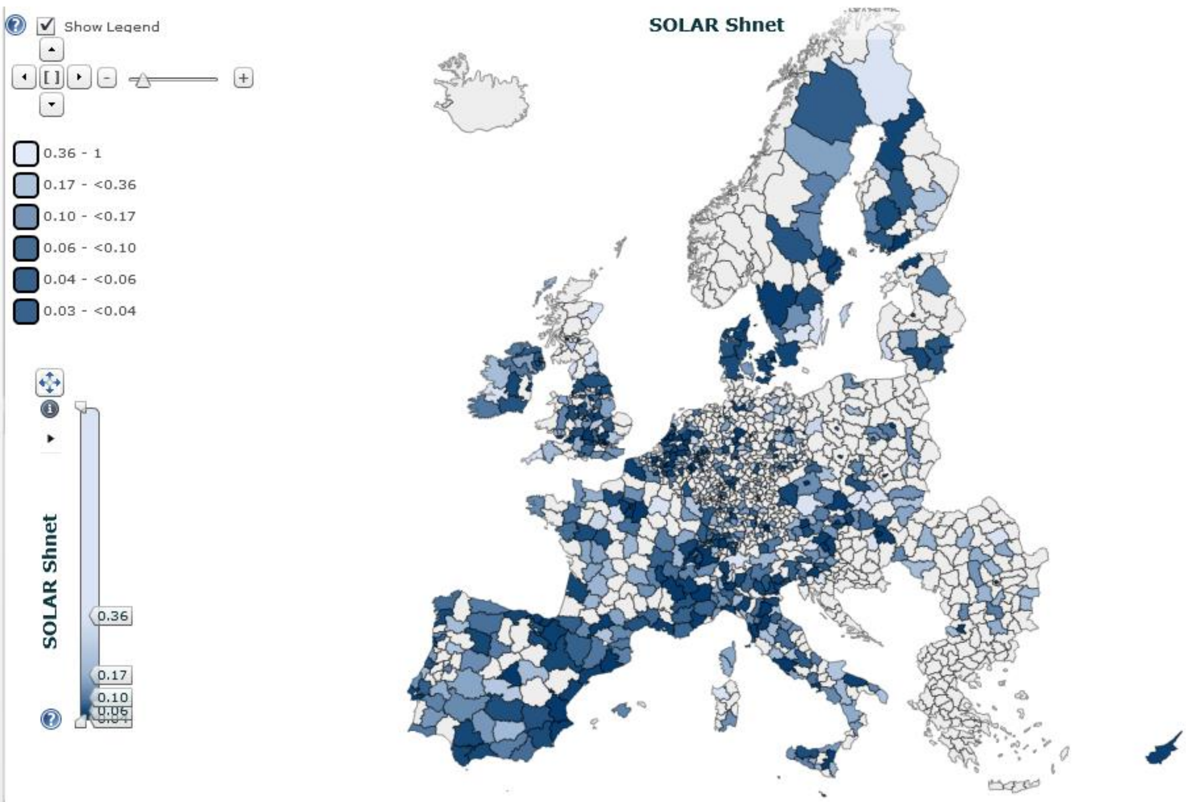
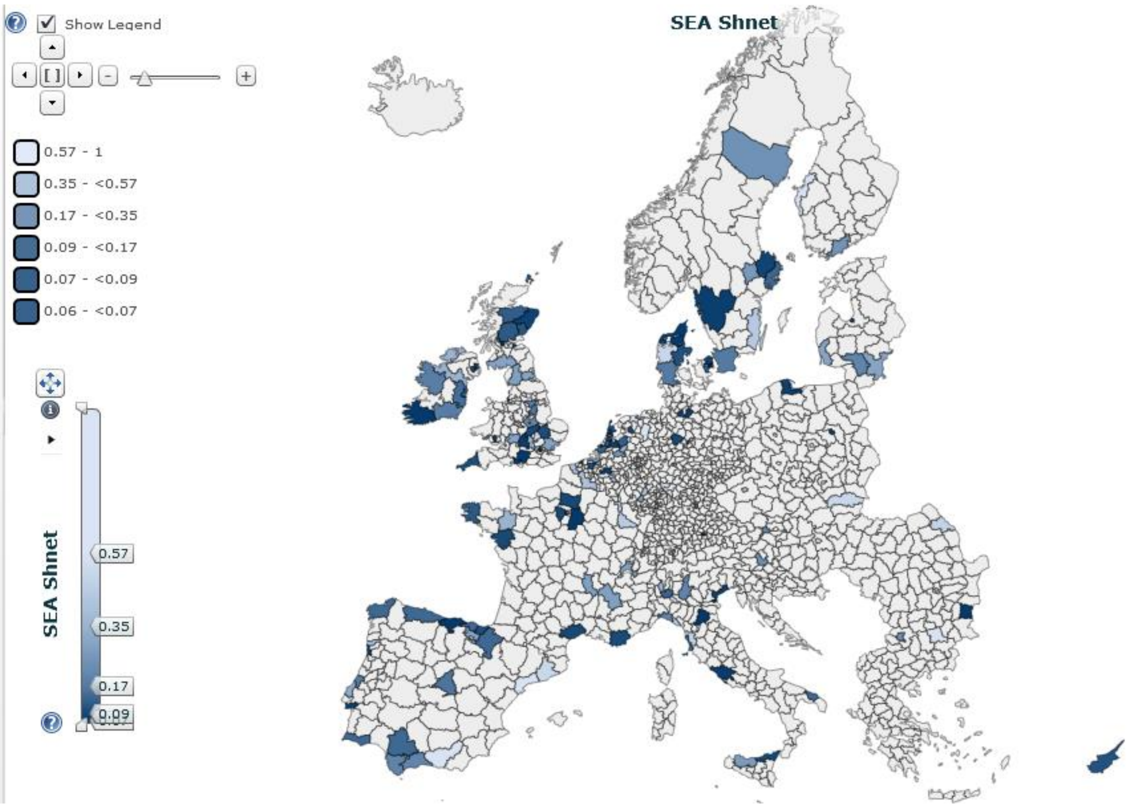
0.19
0.17
0.15
0.13
BIOMAS CENT

Annex G: Geographic maps for Structural Holes



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0.06 - <0.07
SEA Shnet
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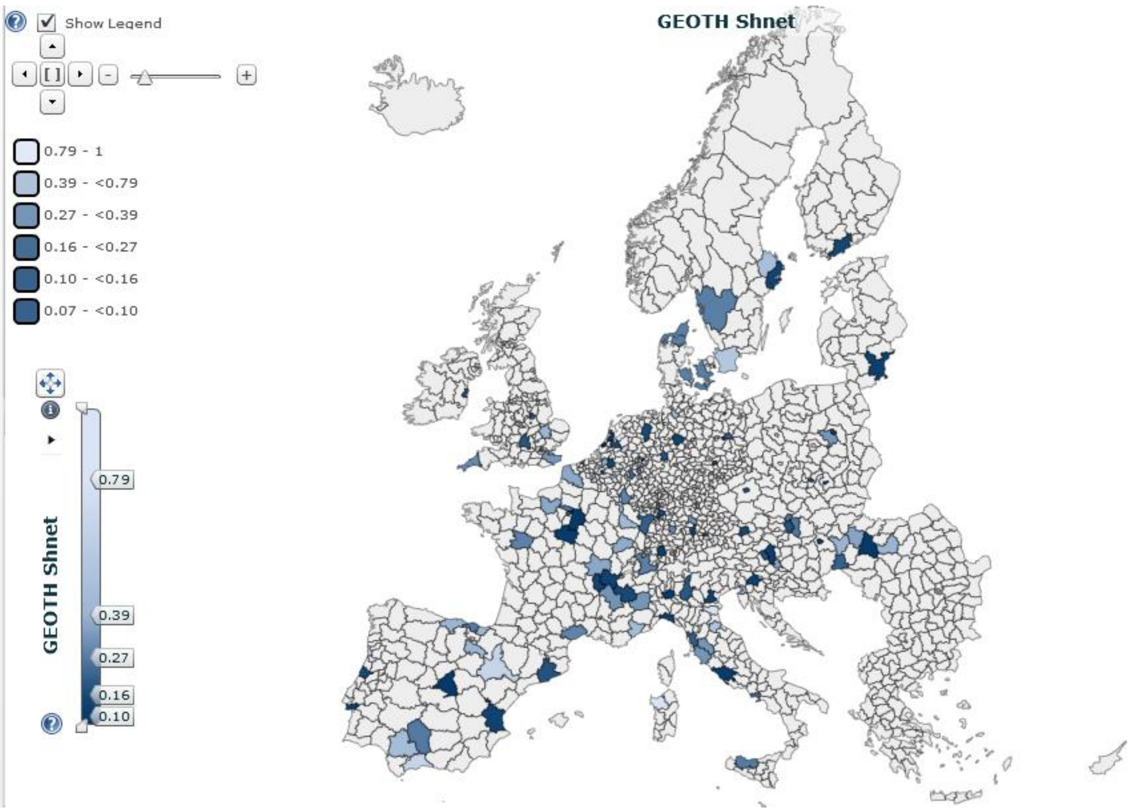
0.17
0.09
SEA Shnet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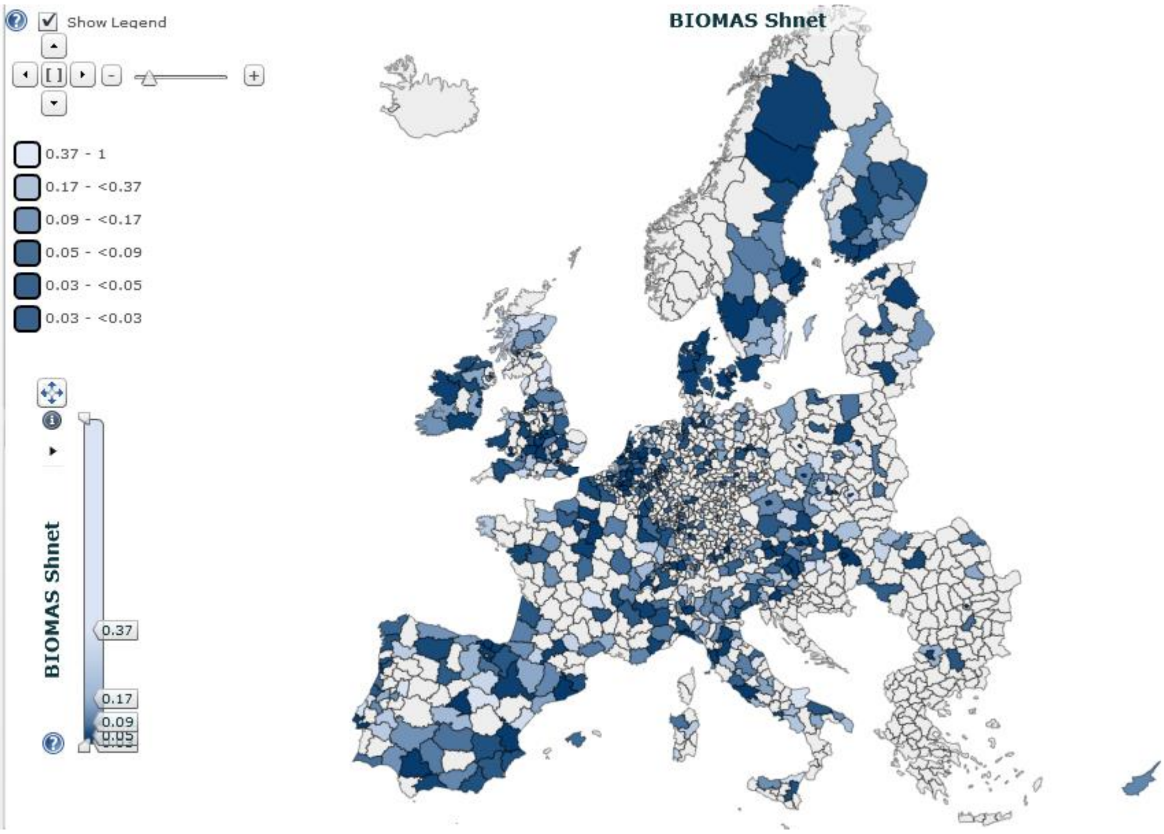
0.10
GEOTH Shnet



Show Legend
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BIOMAS Shnet
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0.05
BIOMAS Shnet

Annex H: Terms maps: “keywords” and “Subjects”

Terms map. WIND sector:

Keywords WIND 0013	CENT	Keywords WIND 0013	SHnet (constraint)
Wind energy	0.2748	ELECTRIC POWER GENERATION	0.1846
ELECTRIC POWER GENERATION	0.2105	Wind energy	0.2797
TURBOMACHINERY	0.1719	TURBOMACHINERY	0.2843
WINDFARMS	0.1719	WINDFARMS	0.2843
ENERGY (PHYSICS)	0.1719	ENERGY (PHYSICS)	0.2843
BIOGAS	0.1653	ATMOSPHERIC CIRCULATION	0.3077
Solar energy	0.1653	CONSTRUCTION TECHNOLOGY	0.3077
100% RES	0.1590	ENERGY SOURCES	0.3077
architect	0.1590	HILLS	0.3077
architecture	0.1590	POWER TECHNOLOGY	0.3077
biomass	0.1590	STRUCTURAL ELEMENTS	0.3077
competition	0.1590	100% RES	0.3287
passive house	0.1590	architect	0.3287
planners	0.1590	architecture	0.3287
sustainable housing	0.1590	biomass	0.3287
urban redevelopment	0.1590	competition	0.3287
revitalisation	0.1590	passive house	0.3287
ATMOSPHERIC CIRCULATION	0.1571	planners	0.3287
CONSTRUCTION TECHNOLOGY	0.1571	sustainable housing	0.3287
ENERGY SOURCES	0.1571	urban redevelopment	0.3287
HILLS	0.1571	revitalisation	0.3287
POWER TECHNOLOGY	0.1571	ENERGY CONSUMPTION	0.3430
STRUCTURAL ELEMENTS	0.1571	INDUSTRIAL PLANTS	0.3430
Evolution	0.1442	ROOFS	0.3430
Nucleosynthesis	0.1442	TECHNOLOGICAL INNOVATIONS	0.3430
Winds (including Solar Wind)	0.1442	ENERGY	0.3430
BUILDINGS	0.1421	BUILDINGS	0.3430
ENERGY CONSUMPTION	0.1421	ENVIRONMENT PROTECTION	0.3931
INDUSTRIAL PLANTS	0.1421	Winds (including Solar Wind)	0.3941
ROOFS	0.1421	Evolution	0.3941
TECHNOLOGICAL INNOVATIONS	0.1421	Nucleosynthesis	0.3941

ENERGY	0.1421	CONTROL EQUIPMENT	0.4319
ENVIRONMENT PROTECTION	0.1337	POWER PLANTS	0.4319
CONTROL EQUIPMENT	0.1311	Low-Temperature Plasmas	0.4938
POWER PLANTS	0.1311	Plasma Chemistry & Applications	0.4938
Renewable energy	0.1299	BIOGAS	0.6144
renewables	0.1290	Solar energy	0.6144
Sustainable	0.1290	indicators	0.6216
Low-Temperature Plasmas	0.1210	legal framework	0.6216
Consumers	0.1101	offshore wind	0.6216
Green Electricity	0.1101	policy	0.6216
indicators	0.1101	renewables	0.6233
legal framework	0.1101	Sustainable	0.6233
Liberalisation	0.1101	Renewable energy	0.6808
Markets	0.1101	Consumers	0.7560
offshore wind	0.1101	Green Electricity	0.7560
policy	0.1101	Liberalisation	0.7560
Barriers	0.1077	Markets	0.7560
Brownfield Sites	0.1077	Barriers	0.7656
Clean Agriculture	0.1077	Brownfield Sites	0.7656
Regional Development	0.1077	Clean Agriculture	0.7656
Renewable Energy Sources in Agriculture	0.1077	Regional Development	0.7656
Sustainable Building Design	0.1077	Renewable Energy Sources in Agriculture	0.7656
Training of engineers	0.1077	Sustainable Building Design	0.7656
Trust Fund	0.1077	Training of engineers	0.7656
Renewable Energy Sources in Communities	0.1077	Trust Fund	0.7656
Windpower	0.1077	Renewable Energy Sources in Communities	0.7656
100 communities 100% RES	0.1027	Windpower	0.7656
Central and Eastern Europe	0.1027	100 communities 100% RES	0.9259
promotion	0.1027	Central and Eastern Europe	0.9259
renewable energy technologies	0.1027	promotion	0.9259
RES best practise	0.1027	renewable energy technologies	0.9259
RES Partnership	0.1027	RES best practise	0.9259
Export	0.1027	RES Partnership	0.9259
Regional Energy Plan	0.1027	Export	0.9259
Environmental Technologies & Instrumentation	0.0976	Regional Energy Plan	0.9259
Ocean/Atmosphere Interactions	0.0976	Environmental Technologies & Instrumentation	1.1250

Earth Observation Technologies & Remote Sensing	0.0976	Ocean/Atmosphere Interactions	1.1250
end of pipe/air (industrial activities)	0.0876	end of pipe/air (industrial activities)	0.0000
JRC	0.0876	JRC	0.0000
Offshore sweden windmill seacable foundation	0.0876	Offshore sweden windmill seacable foundation	0.0000

Subject WIND 0013	CENT
Scientific Research	0.4502
Environmental Protection	0.4274
Economic Aspects	0.3648
Social Aspects	0.3383
Safety	0.3375
Renewable Sources of Energy	0.3259
Energy Saving	0.3136
Coordination, Cooperation	0.2785
Industrial Manufacture	0.2636
Transport	0.2599
Information Processing, Information Systems	0.2536
Innovation, Technology Transfer	0.2399
Meteorology	0.2376
Education, Training	0.2217
Standards	0.2207
Forecasting	0.2040
Aerospace Technology	0.2026
Other Energy Topics	0.2015
Earth Sciences	0.2005
Materials Technology	0.1910
Employment issues	0.1907
Measurement Methods	0.1882
Telecommunications	0.1876
Security	0.1853
Construction Technology	0.1765
Mathematics, Statistics	0.1747
Agriculture	0.1734
Life Sciences	0.1734
Policies	0.1725
Energy Storage, Energy Transport	0.1714
Biotechnology	0.1636
Information, Media	0.1636
Waste Management	0.1636
Sustainable development	0.1597
Other Technology	0.1516

Subject WIND 0013	Constraint
Economic Aspects	0.2575
Scientific Research	0.2616
Social Aspects	0.2902
Information Processing, Information Systems	0.3135
Innovation, Technology Transfer	0.3252
Meteorology	0.3517
Safety	0.3523
Renewable Sources of Energy	0.3661
Aerospace Technology	0.3853
Transport	0.4031
Energy Storage, Energy Transport	0.4195
Telecommunications	0.4223
Employment issues	0.4251
Coordination, Cooperation	0.4342
Education, Training	0.4495
Environmental Protection	0.4504
Electronics, Microelectronics	0.4537
Forecasting	0.4574
Standards	0.4632
Industrial Manufacture	0.4691
Agriculture	0.4711
Life Sciences	0.4711
Security	0.4906
Materials Technology	0.4944
Mathematics, Statistics	0.4946
Information and communication technology applications	0.5253
Information, Media	0.5429
Energy Saving	0.5810
Network technologies	0.6119
Policies	0.6140
Earth Sciences	0.6574
Biotechnology	0.7100
Waste Management	0.7100
Sustainable development	0.7649
Construction Technology	0.7704

Medicine, Health	0.1516
Electronics, Microelectronics	0.1444
Information and communication technology applications	0.1441
Network technologies	0.1294
Project management methodologies	0.1251
Reference Materials	0.1092
Hydrogen and fuel cells	0.0630

Other Technology	0.7818
Medicine, Health	0.7818
Measurement Methods	0.8680
Other Energy Topics	0.8881
Project management methodologies	1.0000
Reference Materials	1.0000
Hydrogen and fuel cells	0.0000

Terms maps. SOLAR sector:

Keyword SOLAR 0013	**CENT**
Solar Energy	0.3466
ENERGY (PHYSICS)	0.1998
buildings	0.1743
ENERGY SOURCES	0.1593
ELECTRICAL TECHNOLOGY	0.1593
ELECTRIC GENERATORS	0.1593
SOLAR GENERATORS	0.1593
PHOTOELECTRIC DEVICES	0.1593
ENERGY CONSUMPTION	0.1557
Renewable Energy	0.1510
Wind energy	0.1483
GRID CONNECTION	0.1432
ELECTRIC POWER GENERATION	0.1419
ENERGY	0.1418
ROOFS	0.1392
PUBLIC BUILDINGS	0.1364
ARCHITECTURAL DESIGN	0.1323
WALLS	0.1300
ENERGY CONSERVATION	0.1281
URBAN AREAS	0.1279
PASSIVE SOLAR SYSTEMS	0.1251

Keyword SOLAR 0013	**Constraint**
ENERGY (PHYSICS)	0.1345
ENERGY CONSUMPTION	0.1400
ELECTRIC POWER GENERATION	0.1547
ROOFS	0.1596
ENERGY	0.1597
ARCHITECTURAL DESIGN	0.1603
URBAN AREAS	0.1651
PUBLIC BUILDINGS	0.1781
GRID CONNECTION	0.1844
ENERGY CONSERVATION	0.1956
ENERGY SOURCES	0.2013
ELECTRICAL TECHNOLOGY	0.2013
ELECTRIC GENERATORS	0.2013
SOLAR GENERATORS	0.2013
PHOTOELECTRIC DEVICES	0.2013
Solar Energy	0.2017
SOLAR CELLS	0.2087
WALLS	0.2168
HEATING	0.2175
COOLING	0.2175
PASSIVE SOLAR SYSTEMS	0.2285

Renewables	0.1218	HOUSING	0.2301
HEATING	0.1213	URBAN AREA	0.2301
COOLING	0.1213	TECHNOLOGICAL INNOVATION	0.2301
HOUSING	0.1211	DEMONSTRATION	0.2368
URBAN AREA	0.1211	INDUSTRIAL PLANTS	0.2393
TECHNOLOGICAL INNOVATION	0.1211	TECHNOLOGICAL INNOVATIONS	0.2393
BIOGAS	0.1211	LOW COST HOUSING	0.2467
SOLAR CELLS	0.1190	PREFABRICATED CONSTRUCTION	0.2467
Photovoltaic	0.1177	CHP	0.2476
CHP	0.1167	ENERGY MANAGEMENT SYSTEM	0.2476
ENERGY MANAGEMENT SYSTEM	0.1167	NATURAL RESOURCES	0.2476
NATURAL RESOURCES	0.1167	WATER CONSUMPTION	0.2476
WATER CONSUMPTION	0.1167	SCHOOL BUILDINGS	0.2514
POWER PLANTS	0.1163	VENTILATION	0.2514
CONCENTRATING	0.1163	POWER PLANTS	0.2563
SCHOOL BUILDINGS	0.1163	CONCENTRATING	0.2563
LOW COST HOUSING	0.1163	OPTICAL EQUIPMENT	0.2563
OPTICAL EQUIPMENT	0.1163	REFLECTION	0.2563
REFLECTION	0.1163	HORIZONTAL AXIS	0.2563
VENTILATION	0.1163	RAILWAY TRANSPORT	0.2634
HORIZONTAL AXIS	0.1163	REMOTE CONTROL	0.2634
PREFABRICATED CONSTRUCTION	0.1163	PUBLIC TRANSPORT	0.2664
PUBLIC TRANSPORT	0.1141	TRAINS	0.2664
RAILWAY TRANSPORT	0.1141	CONTROL EQUIPMENT	0.2664
TRAINS	0.1141	ISLANDS	0.2788
CONTROL EQUIPMENT	0.1141	MEDITERRANEAN COUNTRIES	0.2788
REMOTE CONTROL	0.1141	ENERGY RESOURCES	0.2830
ISLANDS	0.1119	COST DECREASES	0.2830
MEDITERRANEAN COUNTRIES	0.1119	Wind energy	0.2999
INDUSTRIAL PLANTS	0.1102	URBAN PLANNING	0.3116

TECHNOLOGICAL INNOVATIONS	0.1102	AIR CONDITIONING	0.3116
URBAN PLANNING	0.1097	RESIDENTIAL BUILDINGS	0.3116
AIR CONDITIONING	0.1097	ENVIRONMENT MANAGEMENT	0.3116
RESIDENTIAL BUILDINGS	0.1097	THERMAL ENERGY	0.3189
DEMONSTRATION	0.1097	LARGE-SCALE OPERATION	0.3189
ENVIRONMENT MANAGEMENT	0.1097	POWER PLANT	0.3189
ENERGY RESOURCES	0.1080	TURBOMACHINERY	0.3189
COST DECREASES	0.1080	Optical Phenomena/Properties	0.3302
THERMAL ENERGY	0.1075	Renewable Energy	0.3418
LARGE-SCALE OPERATION	0.1075	Photovoltaic	0.3539
POWER PLANT	0.1075	revitalisation	0.3577
TURBOMACHINERY	0.1075	urban redevelopment	0.3577
energy substitution	0.1070	sustainable housing	0.3577
sustainable technology	0.1070	solar	0.3577
geothermal energy	0.1070	100% RES	0.3577
geothermal greenhouse	0.1070	competition	0.3577
solar greenhouse	0.1070	architecture	0.3577
solar thermal	0.1052	architect	0.3577
revitalisation	0.1038	planners	0.3577
urban redevelopment	0.1038	biomass	0.3577
sustainable housing	0.1038	Renewables	0.3902
solar	0.1038	energy substitution	0.4153
100% RES	0.1038	sustainable technology	0.4153
competition	0.1038	geothermal energy	0.4153
architecture	0.1038	geothermal greenhouse	0.4153
architect	0.1038	solar greenhouse	0.4153
planners	0.1038	Semiconductors	0.4269
biomass	0.1038	Films	0.4269
Quality	0.1036	Coating	0.4269
Standards	0.1036	Wires & Fibres	0.4269
Training	0.1036	Mechanical Properties	0.4589
Certification	0.1036	Crystalline Strucure	0.4589
Sustainable	0.1031	Structural Phase Transitionsn	0.4589

Schools	0.0913	Defects	0.4589
education	0.0913	BIOGAS	0.4604
photovoltaics (PV)	0.0913	Sustainable	0.4669
Markets	0.0909	solar thermal	0.4808
Green Electricity	0.0909	Quality	0.5327
Liberalisation	0.0909	Standards	0.5327
Consumers	0.0909	Training	0.5327
Monitoring	0.0902	Certification	0.5327
Targets	0.0902	renewable energy technologies	0.5350
Statistics	0.0902	Surfaces	0.5499
Legislation	0.0902	Interfaces & Microstructures	0.5499
Passive downdraught	0.0897	Winds (including Solar Wind)	0.5564
evaporative cooling	0.0897	Nucleosynthesis	0.5564
Europe	0.0897	Evolution	0.5564
RES Communities	0.0868	Plasma Instabilities & Non-Linear Phenomena	0.5740
District energy system	0.0868	Schools	0.6633
Low energy buildings	0.0868	education	0.6633
Optical Phenomena/Properties	0.0792	photovoltaics (PV)	0.6633
PV	0.0790	Markets	0.6701
qualification	0.0790	Green Electricity	0.6701
marketing	0.0790	Liberalisation	0.6701
Semiconductors	0.0786	Consumers	0.6701
Films	0.0786	buildings	0.6794
Coating	0.0786	Photonics	0.6919
Wires & Fibres	0.0786	Physical Optics	0.6919
Crystalline Strucure	0.0744	Nonlinear Optics	0.6919
Structural Phase Transitionsn	0.0744	Laser	0.6919
Defects	0.0744	Monitoring	0.7093
Mechanical Properties	0.0744	Targets	0.7093
Winds (including Solar Wind)	0.0725	Statistics	0.7093
Nucleosynthesis	0.0725	Legislation	0.7093
Evolution	0.0725	Low-Temperature Plasmas	0.7298
Surfaces	0.0702	Plasma Chemistry & Applications	0.7298

Interfaces & Microstructures	0.0702	PV	0.7444
renewable energy technologies	0.0693	qualification	0.7444
Physical Optics	0.0681	marketing	0.7444
Nonlinear Optics	0.0681	Nanostructures	0.7607
Laser	0.0681	Quantum Dots	0.7607
Photonics	0.0681	Photochemistry	0.7607
Low-Temperature Plasmas	0.0680	Renewable Energy Sources in Communities	0.7656
Plasma Chemistry & Applications	0.0680	Renewable Energy Sources in Agriculture	0.7656
Renewable Energy Sources in Communities	0.0669	Training of engineers	0.7656
Renewable Energy Sources in Agriculture	0.0669	Sustainable Building Design	0.7656
Training of engineers	0.0669	Clean Agriculture	0.7656
Sustainable Building Design	0.0669	RES Communities	0.7813
Clean Agriculture	0.0669	District energy system	0.7813
Nanostructures	0.0660	Low energy buildings	0.7813
Quantum Dots	0.0660	ENERGY IN HOTELS	0.7940
Photochemistry	0.0660	HOTEL SECTOR	0.7940
ENERGY IN HOTELS	0.0650	TOURISM INDUSTRY	0.7940
HOTEL SECTOR	0.0650	Low-Dimensional Systems	0.8611
TOURISM INDUSTRY	0.0650	Electronic Properties & Magnetism	0.8611
Key Issues in Solar Thermal	0.0645	Passive downdraught	0.8906
Sun in Action	0.0645	evaporative cooling	0.8906
Solar Keymark	0.0645	Europe	0.8906
Combisystems	0.0645	Key Issues in Solar Thermal	0.9259
Plasma Instabilities & Non-Linear Phenomena	0.0642	Sun in Action	0.9259
Electromagnetic Processes	0.0639	Solar Keymark	0.9259
Fluid Dynamics	0.0639	Combisystems	0.9259
Low-Dimensional Systems	0.0639	Export	0.9742
Electronic Properties & Magnetism	0.0639	Central and Eastern Europe	0.9742
Export	0.0629	Experiments & Payloads	1.0000
Central and Eastern Europe	0.0629	Atmospheric Dynamics & Thermodynamics	1.0000

Energy Technology & Conversion	0.0622	Biogas - for rural communities' electricity	1.0000
European Consortium	0.0622	Renewable Sources Energy	1.0000
Renewable Energy Sources	0.0622	Domestic Photovoltaic Systems	1.0000
Solar Grade Silicon Production	0.0622	Meteorology/Climatology	1.0000
Sustainable PV policies	0.0622	heat and fuel demands	1.0000
Thermodynamics	0.0622	Electromagnetic Processes	1.0225
Experiments & Payloads	0.0614	Fluid Dynamics	1.0225
Atmospheric Dynamics & Thermodynamics	0.0599	Energy Technology & Conversion	1.1250
Biogas - for rural communities' electricity	0.0599	European Consortium	1.1250
Renewable Sources Energy	0.0599	Renewable Energy Sources	1.1250
Domestic Photovoltaic Systems	0.0599	Solar Grade Silicon Production	1.1250
Meteorology/Climatology	0.0599	Sustainable PV policies	1.1250
heat and fuel demands	0.0599	Thermodynamics	1.1250
end of pipe/waste (industrial activities)	0.0576	end of pipe/waste (industrial activities)	0.0000
JRC	0.0576	JRC	0.0000
Nanotechnology	0.0576	Nanotechnology	0.0000

Subjects SOLAR 0013	**CENT**	**Subjects SOLAR 0013**	**Constraint**
Environmental Protection	0.4843	Scientific Research	0.2480
Scientific Research	0.4337	Industrial Manufacture	0.2514
Renewable Sources of Energy	0.3344	Innovation, Technology Transfer	0.2648
Social Aspects	0.3342	Life Sciences	0.2653
Economic Aspects	0.3324	Environmental Protection	0.2683
Energy Saving	0.3169	Medicine, Health	0.2766
Industrial Manufacture	0.3003	Transport	0.2958
Coordination, Cooperation	0.2823	Agriculture	0.3220
Safety	0.2733	Safety	0.3286
Information Processing, Information Systems	0.2563	Energy Storage, Energy Transport	0.3343
Innovation, Technology Transfer	0.2468	Resources of the Sea, Fisheries	0.3480
Transport	0.2443	Renewable Sources of Energy	0.3540
Energy Storage, Energy Transport	0.2390	Aerospace Technology	0.3608

Life Sciences	0.2389	Information and communication technology applications	0.3618
Biotechnology	0.2367	Energy Saving	0.3673
Medicine, Health	0.2235	Social Aspects	0.3705
Education, Training	0.2212	Nanotechnology and Nanosciences	0.3830
Materials Technology	0.2209	Economic Aspects	0.3986
Nuclear Fission	0.2184	Coordination, Cooperation	0.4102
Waste Management	0.2166	Education, Training	0.4107
Nanotechnology and Nanosciences	0.2019	Electronics, Microelectronics	0.4219
Resources of the Sea, Fisheries	0.2015	Information, Media	0.4388
Construction Technology	0.2003	Information Processing, Information Systems	0.4467
Telecommunications	0.1991	Nuclear Fission	0.4724
Information and communication technology applications	0.1980	Biotechnology	0.4747
Earth Sciences	0.1951	Meteorology	0.4872
Forecasting	0.1921	Medical biotechnology	0.5112
Aerospace Technology	0.1902	Agricultural biotechnology	0.5112
Electronics, Microelectronics	0.1880	Space & satellite research	0.5303
Network technologies	0.1859	Policies	0.5508
Other Energy Topics	0.1854	Materials Technology	0.5511
Agriculture	0.1819	Construction Technology	0.5520
Information, Media	0.1787	Other Energy Topics	0.5577
Water resources and management	0.1776	Security	0.5586
Policies	0.1775	Forecasting	0.5632
Employment issues	0.1762	Telecommunications	0.5632
Radiation Protection	0.1706	Business aspects	0.5657
Meteorology	0.1590	Earth Sciences	0.5983
Standards	0.1590	Network technologies	0.6037
Business aspects	0.1548	Standards	0.6191
Security	0.1544	Water resources and management	0.6534
Sustainable development	0.1433	Employment issues	0.6952
Medical biotechnology	0.1429	Radiation Protection	0.7308
Agricultural biotechnology	0.1429	Waste Management	0.7811
Hydrogen and fuel cells	0.1406	Sustainable development	0.7812
Biofuels	0.1328	Hydrogen and fuel cells	1.0000
Research ethics	0.1328	Biofuels	1.0000
Regional Development	0.1319	Research ethics	1.0000
Space & satellite research	0.1308	Regional Development	1.0000
Project management methodologies	0.1296	Project management methodologies	1.0000
Reference Materials	0.0803	Reference Materials	1.0000
Measurement Methods	0.0803	Measurement Methods	1.0000
Food	0.0730	Food	0.0000
Fossil Fuels	0.0730	Fossil Fuels	0.0000

Terms maps. SEA sector:

Subjects SEA 0013	**CENT**
Environmental Protection	0.5930
Renewable Sources of Energy	0.3816
Economic Aspects	0.3810
Social Aspects	0.3573
Scientific Research	0.3492
Industrial Manufacture	0.2426
Innovation, Technology Transfer	0.2426
Safety	0.2426
Energy Saving	0.2413
Resources of the Sea, Fisheries	0.2136
Forecasting	0.2136
Meteorology	0.2136
Education, Training	0.2115
Employment issues	0.2115
Coordination, Cooperation	0.2057
Other Energy Topics	0.2043
Energy Storage, Energy Transport	0.1756
Earth Sciences	0.1688
Network technologies	0.1465

Subjects SEA 0013	**Constraint**
Renewable Sources of Energy	0.3064
Scientific Research	0.4414
Industrial Manufacture	0.5143
Innovation, Technology Transfer	0.5143
Safety	0.5143
Environmental Protection	0.5375
Economic Aspects	0.5747
Earth Sciences	0.6450
Coordination, Cooperation	0.6919
Social Aspects	0.7060
Resources of the Sea, Fisheries	0.7296
Forecasting	0.7327
Meteorology	0.7327
Energy Saving	0.7705
Other Energy Topics	0.7955
Education, Training	1.0377
Employment issues	1.0377
Energy Storage, Energy Transport	1.0931
Network technologies	1.1250

Terms maps. GEOTHERM sector:

Keywords Geotherm 0013	CENT	Keywords Geotherm 0013	Constraint
GEOTHERMAL ENERGY	0.2392	ENERGY (PHYSICS)	0.1499
ENERGY (PHYSICS)	0.1216	HEATING	0.1984
HEATING	0.0347	DISTRICT HEATING	0.2159
DISTRICT HEATING	0.0281	ENERGY CONSUMPTION	0.2245
ENERGY CONSUMPTION	0.0214	PIPES	0.2593
PIPES	0.0195	SPACE HEATING	0.2728
SPACE HEATING	0.0142	MEDITERRANEAN COUNTRIES	0.2728
MEDITERRANEAN COUNTRIES	0.0142	ENVIRONMENTAL TECHNOLOGY	0.2728
ENVIRONMENTAL TECHNOLOGY	0.0142	POLLUTION CONTROL	0.2728
POLLUTION CONTROL	0.0142	SEISMIC DETECTION	0.2728
SEISMIC DETECTION	0.0142	HEAT EXCHANGERS	0.2728
HEAT EXCHANGERS	0.0142	HEAT TRANSFER	0.2728
HEAT TRANSFER	0.0142	DRILLING	0.3022
DRILLING	0.0130	COST DECREASE	0.3022
COST DECREASE	0.0130	COMPUTER SOFTWARE	0.3022
COMPUTER SOFTWARE	0.0130	PETROLEUM INDUSTRY	0.3022
PETROLEUM INDUSTRY	0.0130	ECONOMIC CRITERIA	0.3022
ECONOMIC CRITERIA	0.0130	GEOTHERMAL ENERGY	0.3432
INDUSTRIAL SECTOR	0.0123	INDUSTRIAL SECTOR	0.3512
ELECTRIC POWER	0.0123	ELECTRIC POWER	0.3512
FOSSIL FUELS	0.0123	FOSSIL FUELS	0.3512
POWER PLANTS	0.0123	POWER PLANTS	0.3512
WATER TRANSPORT	0.0123	WATER TRANSPORT	0.3512
ENVIRONMENT PROTECTION	0.0123	ENVIRONMENT PROTECTION	0.3512
ENERGY IN HOTELS	0.0113	ENERGY RESOURCES	0.3687
RES Communities	0.0113	AGRICULTURE	0.3687
HOTEL SECTOR	0.0113	LOW COST EQUIPMENT	0.3687
Photovoltaic	0.0113	ELECTRIC POWER GENERATION	0.4297
District energy system	0.0113	GASES	0.4297
RENEWABLE ENERGY TECHNOLOGIES	0.0113	TURBOMACHINERY	0.4297
Low energy buildings	0.0113	CARBON DIOXIDE	0.4297
TOURISM INDUSTRY	0.0113	THERMAL POWER PLANTS	0.4297
renewable energy	0.0111	TECHNOLOGICAL INNOVATION	0.4490
ENERGY RESOURCES	0.0111	ELECTRIC POWER DISTRIBUTION	0.4490
energy substitution	0.0111	renewable energy	0.5411
ELECTRIC POWER GENERATION	0.0111	energy substitution	0.5411
sustainable technology	0.0111	sustainable technology	0.5411
GASES	0.0111	solar energy	0.5411
solar energy	0.0111	geothermal greenhouse	0.5411
TURBOMACHINERY	0.0111	solar greenhouse	0.5411
AGRICULTURE	0.0111	ENERGY IN HOTELS	0.9259
CARBON DIOXIDE	0.0111	RES Communities	0.9259
geothermal greenhouse	0.0111	HOTEL SECTOR	0.9259

LOW COST EQUIPMENT	0.0111	Photovoltaic	0.9259
solar greenhouse	0.0111	District energy system	0.9259
THERMAL POWER PLANTS	0.0111	RENEWABLE ENERGY TECHNOLOGIES	0.9259
Electromagnetic Processes	0.0107	Low energy buildings	0.9259
Exploration	0.0107	TOURISM INDUSTRY	0.9259
Renewable Energy Sources	0.0107	Electromagnetic Processes	1.1250
TECHNOLOGICAL INNOVATION	0.0098	Exploration	1.1250
ELECTRIC POWER DISTRIBUTION	0.0098	Renewable Energy Sources	1.1250

Subjects GEOTH 0013	**CENT**	**Subjects GEOTH 0013**	**Constraint**
Environmental Protection	0.4782	Renewable Sources of Energy	0.3137
Scientific Research	0.3717	Energy Saving	0.3612
Renewable Sources of Energy	0.3621	Economic Aspects	0.4170
Innovation, Technology Transfer	0.3618	Environmental Protection	0.4411
Earth Sciences	0.2974	Information, Media	0.4980
Social Aspects	0.2898	Innovation, Technology Transfer	0.5022
Energy Saving	0.2886	Education, Training	0.5120
Economic Aspects	0.2690	Earth Sciences	0.5185
Biotechnology	0.2611	Scientific Research	0.5336
Life Sciences	0.2611	Biotechnology	0.5417
Medicine, Health	0.2611	Life Sciences	0.5417
Waste Management	0.2611	Medicine, Health	0.5417
Information, Media	0.2074	Waste Management	0.5417
Education, Training	0.1889	Social Aspects	0.6953
Coordination, Cooperation	0.1832	Coordination, Cooperation	0.8616
Biofuels	0.1547	Biofuels	1.0000
Other Energy Topics	0.1547	Other Energy Topics	1.0000
Industrial Manufacture	0.1481	Industrial Manufacture	1.0000
Information and communication technology applications	0.0852	Information and communication technology applications	0.0000

Terms maps. BIOMASS sector:

Keywords Biomass 0013	**CENT**	**Keywords Biomass 0013**	**Constraint**
Biomass	0.3368	ENERGY (PHYSICS)	0.1187
CHP	0.2012	FLUIDIZED BEDS	0.1266
ENERGY (PHYSICS)	0.1766	POLLUTION CONTROL	0.1339
POLLUTION CONTROL	0.1636	ENERGY RESOURCES	0.1348
FLUIDIZED BEDS	0.1576	HEATING	0.1348
ENERGY RESOURCES	0.1514	POWER PLANTS	0.1357
HEATING	0.1514	COMBUSTION	0.1561
POWER PLANTS	0.1481	ENVIRONMENTAL TECHNOLOGY	0.1561
Wood	0.1444	ENERGY CONSUMPTION	0.1764
COMBUSTION	0.1433	RESOURCES SUBSTITUTION	0.1764

ENVIRONMENTAL TECHNOLOGY	0.1433	SOLID FUELS	0.1764
ENERGY CONSUMPTION	0.1384	COAL	0.1764
RESOURCES SUBSTITUTION	0.1384	BURNING	0.1764
SOLID FUELS	0.1384	FUELS	0.1799
COAL	0.1384	CARBON DIOXIDE	0.1918
BURNING	0.1384	CORROSION PROTECTION	0.1918
FUELS	0.1329	HEAT EXCHANGERS	0.1918
CARBON DIOXIDE	0.1262	HEAT TRANSFER	0.1918
CORROSION PROTECTION	0.1262	BIOTECHNOLOGY	0.2081
HEAT EXCHANGERS	0.1262	DOMESTIC WASTES	0.2081
HEAT TRANSFER	0.1262	TURBOMACHINERY	0.2081
BIOTECHNOLOGY	0.1240	COMBUSTION GASES	0.2081
DOMESTIC WASTES	0.1240	HEAT RECOVERY	0.2081
TURBOMACHINERY	0.1240	NATURAL GAS	0.2081
COMBUSTION GASES	0.1240	ELECTRIC POWER GENERATION	0.2081
HEAT RECOVERY	0.1240	GRID CONNECTION	0.2081
NATURAL GAS	0.1240	DRYING	0.2165
ELECTRIC POWER GENERATION	0.1240	POWER GENERATION	0.2165
GRID CONNECTION	0.1240	TECHNOLOGICAL INNOVATIONS	0.2165
ENERGY	0.1215	ENVIRONMENTAL EFFECTS	0.2165
COST DECREASE	0.1215	ENERGY	0.2165
DRYING	0.1215	COST DECREASE	0.2165
POWER GENERATION	0.1215	GASIFICATION	0.2213
TECHNOLOGICAL INNOVATIONS	0.1215	STRESS (MECHANICS)	0.2213
ENVIRONMENTAL EFFECTS	0.1215	BOILERS	0.2213
GASIFICATION	0.1193	Biomass	0.2393
STRESS (MECHANICS)	0.1193	Wood	0.3272
BOILERS	0.1193	revitalisation	0.3541
Energy crops	0.1143	urban redevelopment	0.3541
revitalisation	0.1141	sustainable housing	0.3541
urban redevelopment	0.1141	solar	0.3541
sustainable housing	0.1141	100% RES	0.3541
solar	0.1141	competition	0.3541
100% RES	0.1141	architecture	0.3541
competition	0.1141	architect	0.3541
architecture	0.1141	planners	0.3541
architect	0.1141	wind energy	0.3541
planners	0.1141	Wood Energy Business Toolbox	0.3923
wind energy	0.1141	Regional Anaerobic Digestion Groups	0.3923
district heating	0.1048	Advisory Service	0.3923
Wood Energy Business Toolbox	0.1018	Codes of Practice	0.3923
Regional Anaerobic Digestion Groups	0.1018	Centralised anaerobic digestion plant	0.3923
Advisory Service	0.1018	On-farm anaerobic digestion plant	0.3923
Codes of Practice	0.1018	National anaerobic digestion network	0.3923
Centralised anaerobic digestion plant	0.1018	National heating network	0.3923
On-farm anaerobic digestion plant	0.1018	Biogas	0.3923

National anaerobic digestion network	0.1018	ENERGY SOURCES	0.4168
National heating network	0.1018	GAS PLANTS	0.4168
Biogas	0.1018	WASTE TREATMENT	0.4168
Local planning	0.1014	district heating	0.4581
Education	0.1014	Local planning	0.4897
Information	0.1014	Education	0.4897
pyrolysis	0.1000	Information	0.4897
Revue	0.1000	Biomass supply	0.5473
wood-energy	0.1000	Forest and agro-industrial wastes	0.5473
magazine	0.1000	Engineering project	0.5473
standards	0.1000	Financial mechanisms	0.5473
wood fuel investment	0.1000	Power plant	0.5473
markets	0.1000	renewable energy	0.5602
network design	0.1000	energy substitution	0.5602
cost benefit analyses	0.1000	sustainable technology	0.5602
ITEBE	0.1000	geothermal energy	0.5602
liquid fuels	0.1000	solar energy	0.5602
Codigestion	0.0977	geothermal greenhouse	0.5602
small-scale plants	0.0977	solar greenhouse	0.5602
waste biogas	0.0977	Energy crops	0.5925
co-generation	0.0977	wood fuel investment	0.5935
hydropower	0.0977	network design	0.5935
ENERGY SOURCES	0.0969	cost benefit analyses	0.5935
GAS PLANTS	0.0969	Revue	0.6148
WASTE TREATMENT	0.0969	wood-energy	0.6148
Biomass supply	0.0965	magazine	0.6148
Forest and agro-industrial wastes	0.0965	ITEBE	0.6148
Engineering project	0.0965	CHP	0.6156
Financial mechanisms	0.0965	pyrolysis	0.6172
Power plant	0.0965	standards	0.6172
Mediterranean	0.0947	markets	0.6172
biofuels	0.0947	liquid fuels	0.6172
co-combustion	0.0947	liquid biofuels	0.6303
liquid biofuels	0.0845	integration	0.6303
integration	0.0845	multiplecriteria model	0.6303
multiplecriteria model	0.0845	spatial decision-making system	0.6303
spatial decision-making system	0.0845	small-scale plants	0.6363
renewable energy	0.0728	co-generation	0.6363
energy substitution	0.0728	Codigestion	0.7205
sustainable technology	0.0728	waste biogas	0.7205
geothermal energy	0.0728	hydropower	0.7205
solar energy	0.0728	Mediterranean	0.7309
geothermal greenhouse	0.0728	biofuels	0.7309
solar greenhouse	0.0728	co-combustion	0.7309
Renewable Energy Sources in Communities	0.0678	Renewable Energy Sources in Communities	0.7656
Renewables	0.0678	Renewables	0.7656

Solid biofuels	0.0678	Solid biofuels	0.7656
Wood fuels	0.0678	Wood fuels	0.7656
Woodpellets	0.0678	Woodpellets	0.7656
Biomass CHP technologies	0.0678	Biomass CHP technologies	0.7656
energy wood procurement	0.0678	energy wood procurement	0.7656
market deployment	0.0678	market deployment	0.7656
Monitoring	0.0678	Monitoring	0.7656
Renewable Energy Sources in Agriculture	0.0678	Renewable Energy Sources in Agriculture	0.7656
biomass combustion	0.0678	biomass combustion	0.7656
Biomass logistics	0.0678	Biomass logistics	0.7656
logistics	0.0678	logistics	0.7656
Targets	0.0678	Targets	0.7656
Training of engineers	0.0678	Training of engineers	0.7656
quality	0.0678	quality	0.7656
Statistics	0.0678	Statistics	0.7656
Sustainable Building Design	0.0678	Sustainable Building Design	0.7656
Training course material	0.0678	Training course material	0.7656
wood pellets	0.0678	wood pellets	0.7656
Clean Agriculture	0.0678	Clean Agriculture	0.7656
heat market	0.0678	heat market	0.7656
Legislation	0.0678	Legislation	0.7656
training	0.0678	training	0.7656
Wood fuel information	0.0678	Wood fuel information	0.7656
bio-energy economics	0.0653	bio-energy economics	0.9259
diesel fuel from waste oils and fats	0.0653	diesel fuel from waste oils and fats	0.9259
ENERGY IN HOTELS	0.0653	ENERGY IN HOTELS	0.9259
Regional Energy Plan	0.0653	Regional Energy Plan	0.9259
biodiesel/biogas	0.0653	biodiesel/biogas	0.9259
HOTEL SECTOR	0.0653	HOTEL SECTOR	0.9259
mathematical programming	0.0653	mathematical programming	0.9259
RES Partnership	0.0653	RES Partnership	0.9259
Dimethyl ether/methanol	0.0653	Dimethyl ether/methanol	0.9259
public policy in agriculture	0.0653	public policy in agriculture	0.9259
RENEWABLE ENERGY TECHNOLOGIES	0.0653	RENEWABLE ENERGY TECHNOLOGIES	0.9259
RES best practise	0.0653	RES best practise	0.9259
100 communities 100% RES	0.0653	100 communities 100% RES	0.9259
heating from used frying oil	0.0653	heating from used frying oil	0.9259
multi-criteria analysis	0.0653	multi-criteria analysis	0.9259
TOURISM INDUSTRY	0.0653	TOURISM INDUSTRY	0.9259
Biochemistry	0.0628	Biochemistry	1.1250
Export	0.0628	Export	1.1250
Oceanography	0.0628	Oceanography	1.1250
Aquatic Ecology	0.0628	Aquatic Ecology	1.1250
Bacteriology	0.0628	Bacteriology	1.1250
renewable energy technologies, promotion	0.0628	renewable energy technologies, promotion	1.1250

Bio-Energetics	0.0628	Bio-Energetics	1.1250
Biophysics	0.0628	Biophysics	1.1250
Central and Eastern Europe	0.0628	Central and Eastern Europe	1.1250
Biogas - for rural communities' electricity, heat and fuel demands	0.0577	Biogas - for rural communities' electricity, heat and fuel demands	0.0000
JRC	0.0577	JRC	0.0000
Sites	0.0577	Sites	0.0000

Subjects Biomass 0013	**CENT**	**Subjects Biomass 0013**	**Constraint**
Environmental Protection	0.4780	Environmental Protection	0.2494
Scientific Research	0.3318	Agriculture	0.2803
Coordination, Cooperation	0.3206	Biofuels	0.2934
Innovation, Technology Transfer	0.3115	Economic Aspects	0.2981
Biotechnology	0.2954	Scientific Research	0.3013
Economic Aspects	0.2929	Waste Management	0.3041
Renewable Sources of Energy	0.2722	Earth Sciences	0.3050
Waste Management	0.2701	Biotechnology	0.3258
Agriculture	0.2573	Innovation, Technology Transfer	0.3353
Biofuels	0.2517	Social Aspects	0.3384
Industrial Manufacture	0.2481	Medical biotechnology	0.3492
Social Aspects	0.2381	Life Sciences	0.3593
Agricultural biotechnology	0.2337	Security	0.3976
Life Sciences	0.2308	Agricultural biotechnology	0.3992
Earth Sciences	0.2297	Coordination, Cooperation	0.4029
Medicine, Health	0.2240	Industrial Manufacture	0.4128
Energy Saving	0.2194	Other Energy Topics	0.4186
Meteorology	0.2158	Telecommunications	0.4203
Food	0.2035	Standards	0.4253
Education, Training	0.1941	Meteorology	0.4627
Security	0.1924	Food	0.4730
Other Energy Topics	0.1919	Medicine, Health	0.4885
Materials Technology	0.1769	Renewable Sources of Energy	0.5210
Telecommunications	0.1741	Materials Technology	0.5542
Standards	0.1717	Sustainable development	0.5546
Water resources and management	0.1685	Education, Training	0.5745
Sustainable development	0.1671	Water resources and management	0.5748
Safety	0.1647	Forecasting	0.6307
Employment issues	0.1639	Energy Saving	0.6389
Forecasting	0.1600	Safety	0.6790
Energy Storage, Energy Transport	0.1518	Employment issues	0.7347
Regional Development	0.1484	Policies	0.7445
Medical biotechnology	0.1462	Electronics, Microelectronics	0.8227
Climate change & Carbon cycle research	0.1426	Other Technology	0.8227
Electronics, Microelectronics	0.1418	Business aspects	0.8764
Other Technology	0.1418	Energy Storage, Energy Transport	0.8932
Business aspects	0.1324	Network technologies	0.9636

Transport	0.1302	Regional Development	0.9919
Nanotechnology and Nanosciences	0.1269	Climate change & Carbon cycle research	1.0000
Policies	0.1257	Transport	1.0000
Project management methodologies	0.1208	Nanotechnology and Nanosciences	1.0000
Network technologies	0.1192	Project management methodologies	1.0000
Legislation, Regulations	0.1003	Legislation, Regulations	1.0000
Information Processing, Information Systems	0.0626	Information Processing, Information Systems	0.0000

Annex I: NUTS3 clusters of RE sectors. K-means algorithm according to Structural holes and centrality, with Activity, Subject and Keywords terms.

WIND f(SHNet Cent) Cluster k-means 45																
NUTS3	**Degree**		**Betweenness**		**Closeness**		**SHnet**		**Shego**		**Activity**		**Subject**		**Keywords**	
ES511	UNIVERSIDAD POLITECNICA DE CATALUNYA	1	UNIVERSITY OF BARCELONA	1	CENTRE INTERNACIONAL DE METODES NUMERICS EN ENGINYERIA	2	CENTRE INTERNACIONAL DE METODES NUMERICS EN ENGINYERIA	2	UNIVERSIDAD POLITECNICA DE CATALUNYA	1	Multi-use offshore platforms	2 (32)	Scientific Research	3 (25)	Clean Agriculture	1 (10)
	CENTRE INTERNACIONAL DE METODES NUMERICS EN ENGINYERIA	2	CENTRE DE RECERCA I INVESTIGACIO DE CATALUNYA, S.A	2	METEOSIM TRUEWIND S.L.	3	UNIVERSIDAD POLITECNICA DE CATALUNYA	1	CENTRE INTERNACIONAL DE METODES NUMERICS EN ENGINYERIA	2	Collective Research (all areas of science and technology)	2	Environmental Protection	2	Renewable Energy Sources in Agriculture	1
	CENTRE DE RECERCA I INVESTIGACIO DE CATALUNYA, S.A	2	UNIVERSIDAD POLITECNICA DE CATALUNYA	1	SUSTAINABLE TECHNOLOGIES SL	3	CENTRE DE RECERCA I INVESTIGACIO DE CATALUNYA, S.A	2	CENTRE DE RECERCA I INVESTIGACIO DE CATALUNYA, S.A	2	Research for SMEs	2	Information and communication technology applications	2	Renewable Energy Sources in Communities	1
	UNIVERSITY OF BARCELONA	1	CENTRE INTERNACIONAL DE METODES NUMERICS EN ENGINYERIA	2	UNIVERSIDAD POLITECNICA DE CATALUNYA	1	UNIVERSITY OF BARCELONA	1	UNIVERSITY OF BARCELONA	1	ICT for energy-positive neighbourhoods	2	Energy Saving	1	Sustainable Building Design	1
	INSTITUT CATALA D ENERGIA	2	ECOTECNIA SOCIEDAD COOPERATIVA CATALANA LTD	3	CENTRE DE RECERCA I INVESTIGACIO DE CATALUNYA, S.A	2	ECOTECNIA SOCIEDAD COOPERATIVA CATALANA LTD	3	ACONDICIONAMIENTO TARRASENSE ASSOCIACION	5	Design studies: feasibility studies	2	Life Sciences	1	Training of engineers	1
ES300	Centro de Investigaciones Energeticas Medioambientales y Tecnologicas - CIEMAT	2	Centro de Investigaciones Energeticas Medioambientales y Tecnologicas - CIEMAT	2	UNIVERSIDAD POLITECNICA DE MADRID	1	Centro de Investigaciones Energeticas Medioambientales y Tecnologicas - CIEMAT	2	CSIC CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS	2	Key action Cleaner Energy Systems, including Renewable Energies	12 (81)	Energy Saving; Environmental Protection; Renewable Sources of Energy	12 (61)	Wind energy	2 (18)
	RED ELECTRICA DE ESPANA S.A.	3	CSIC CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS	2	RED ELECTRICA DE ESPANA S.A.	3	CSIC CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS	2	Centro de Investigaciones Energeticas Medioambientales y Tecnologicas - CIEMAT	2	Sustainable energy systems	9	Scientific Research	9	BIOGAS	2
	CSIC CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS	2	UNIVERSIDAD POLITECNICA DE MADRID	1	Centro de Investigaciones Energeticas Medioambientales y Tecnologicas - CIEMAT	2	UNIVERSIDAD POLITECNICA DE MADRID	1	RED ELECTRICA DE ESPANA S.A.	3	Competitive transport operations	4	Transport	6	Solar energy	2
	UNIVERSIDAD POLITECNICA DE MADRID	1	RED ELECTRICA DE ESPANA S.A.	3	UNIVERSIDAD CARLOS III DE MADRID	1	RED ELECTRICA DE ESPANA S.A.	3	UNIVERSIDAD POLITECNICA DE MADRID	1	Use Case scenarios and early trials	3	Environmental Protection	4	renewables	2

	UNIVERSIDAD CARLOS III DE MADRID	1	INSTITUTO PARA LA DIVERSIFICACION Y AHORRO DE ENERGIA (IDAE)	2	CSIC CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS	2	UNIVERSIDAD COMPLUTENSE DE MADRID	1	INSTITUTO ESPANOL DE OCEANOGRAFIA	2	Wind-Grid Integration: overall optimisation of the electricity grid with wind and storage	3	Other Energy Topics; Renewable Sources of Energy	3	Sustainable	2
DE111	UNIVERSITY OF STUTTGART	1	DEUTSCHES ZENTRUM FUER LUFT UND RAUMFAHRT E.V.	2	UNIVERSITY OF STUTTGART	1	UNIVERSITY OF STUTTGART	1	UNIVERSITY OF STUTTGART	1	Key action Cleaner Energy Systems, including Renewable Energies	3 (27)	Scientific Research	5 (25)	Wind energy	1 (5)
	DEUTSCHES ZENTRUM FUER LUFT UND RAUMFAHRT E.V.	2	UNIVERSITY OF STUTTGART	1	DEUTSCHES ZENTRUM FUER LUFT UND RAUMFAHRT E.V.	2	DEUTSCHES ZENTRUM FUER LUFT UND RAUMFAHRT E.V.	2	DEUTSCHES ZENTRUM FUER LUFT UND RAUMFAHRT E.V.	2	Multi-functional technical textiles for construction, medical applications and protective clothing	2	Energy Saving	3	BIOGAS	1
	GERMAN AEROSPACE CENTRE	2	MAX PLANCK GESELLSCHAFT ZUR FOERDERUNG DER WISSENSCHAFTEN E.V.	2	GERMAN AEROSPACE CENTRE	2	GERMAN AEROSPACE CENTRE	2	LABOR BLUM	3	Innovative tools for the future coordinated and stable operation of the pan-European electricity transmission system	2	Energy Saving; Environmental Protection; Renewable Sources of Energy	3	Solar energy	1
	LABOR BLUM	3	GERMAN AEROSPACE CENTRE	2	ROBERT BOSCH GMBH	3	ROBERT BOSCH GMBH	3	WAGNER ROSEMARIE (WAGNER TRAGWERKE)	3	Towards zero-defect manufacturing	2	Industrial Manufacture	3	renewables	1
	WAGNER ROSEMARIE (WAGNER TRAGWERKE)	3	Daimler-Benz AG	3	Daimler-Benz AG	3	Daimler-Benz AG	3	GERMAN AEROSPACE CENTRE	2	Modelling and testing for improved safety of alternatively-powered vehicles	2	Renewable Sources of Energy	2	Sustainable	1
BE100	EUROPEAN WIND ENERGY ASSOCIATION	5	3E N.V.	3	EUROPEAN WIND ENERGY ASSOCIATION	5	3E N.V.	3	3E N.V.	3	Wind-Grid Integration: overall optimisation of the electricity grid with wind and storage	4 (47)	Energy Saving	5 (38)	Central and Eastern Europe	6 (65)
	3E N.V.	3	EUROPEAN WIND ENERGY ASSOCIATION	5	3E N.V.	3	EUROPEAN WIND ENERGY ASSOCIATION	5	EUROPEAN WIND ENERGY ASSOCIATION	5	Key action Economic and Efficient Energy for a Competitive Europe	3	Other Energy Topics; Renewable Sources of Energy	5	Export	6
	UNIVERSITY OF VUB BRUSSEL	1	JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION	2	UNIVERSITY OF VUB BRUSSEL	1	ELIA SYSTEM OPERATOR SA	3	UNIVERSITY OF VUB BRUSSEL	1	Demonstration of large scale systems for on- and off-shore wind farms	3	Scientific Research	4	promotion	6
	ELIA SYSTEM OPERATOR SA	3	ELIA SYSTEM OPERATOR SA	3	ELIA SYSTEM OPERATOR SA	3	UNIVERSITY OF VUB BRUSSEL	1	ELIA SYSTEM OPERATOR SA	3	Multi-functional technical textiles for construction, medical applications and protective clothing	3	Renewable Sources of Energy	4	renewable energy technologies	6
	CENTRE SCIENTIFIQUE AND TECHNIQUE DE L	2	EUROPEAN PHOTOVOLTAIC INDUSTRY ASSOCIATION	5	UNIVERSITE LIBRE DE BRUXELLES	1	CENTRE SCIENTIFIQUE AND TECHNIQUE DE L	2	CENTRE SCIENTIFIQUE AND TECHNIQUE DE L	2	Sustainable energy systems	2	Economic Aspects; Energy Saving	3	Wind energy	2

	INDUSTRIE TEXTILE BELGE						INDUSTRIE TEXTILE BELGE		INDUSTRIE TEXTILE BELGE							
ITC33	RINA SERVICES SPA	3	D APPOLONIA SPA	3	RINA SERVICES SPA	3	RINA SERVICES SPA	3	RINA SERVICES SPA	3	Sustainable energy systems	4 (18)	Scientific Research	2 (12)	N/A	
	D APPOLONIA SPA	3	UNIVERSITY OF GENEVE	1	D APPOLONIA SPA	3	UNIVERSITY OF GENOVA	1	D APPOLONIA SPA	3	Marie Curie Research Training Networks (RTN)	2	Construction Technology; Medicine, Health; Other Technology; Safety	1	N/A	
	UNIVERSITY OF GENOVA	1	UNIVERSITY OF GENOVA	1	UNIVERSITY OF GENOVA	1	D APPOLONIA SPA	3	UNIVERSITY OF GENOVA	1	Research for SMEs	1	Aerospace Technology; Transport	1	N/A	
	COLUMBUS SUPERCONDUCTORS SPA	3	COLUMBUS SUPERCONDUCTORS SPA	3	REGIONE LIGURIA	4	COLUMBUS SUPERCONDUCTORS SPA	3	COLUMBUS SUPERCONDUCTORS SPA	3	Key action Cleaner Energy Systems, including Renewable Energies	1	Environmental Protection	1	N/A	
	CONSORZIO ANSALDO ENERGIE RENNOVABILI	4	CONSORZIO ANSALDO ENERGIE RENNOVABILI	4	COLUMBUS SUPERCONDUCTORS SPA	3	ANSALDO SUPERCONDUTTORI SPA	3	CONSORZIO ANSALDO ENERGIE RENNOVABILI	4	Multi-use offshore platforms	1	Information and communication technology applications	1	N/A	
FI181	TEKNOLOGIAN TUTKIMUSKESKUS VTT	2	TEKNOLOGIAN TUTKIMUSKESKUS VTT	2	TEKNOLOGIAN TUTKIMUSKESKUS VTT	2	TEKNOLOGIAN TUTKIMUSKESKUS VTT	2	TEKNOLOGIAN TUTKIMUSKESKUS VTT	2	Cost-effective supply of renewable energies	4 (36)	Scientific Research	4 (29)	N/A	
	TECHNICAL RESEARCH CENTRE OF FINLAND	2	Finnish Meteorological Institute	2	TECHNICAL RESEARCH CENTRE OF FINLAND	2	TECHNICAL RESEARCH CENTRE OF FINLAND	2	TECHNICAL RESEARCH CENTRE OF FINLAND	2	Wind energy optimisation	3	Renewable Sources of Energy	4	N/A	
	ABB OY	3	ILMATIETEEN LAITOS - FINNISH METEOROLOGICAL INSTITUTE	2	ABB OY	3	ABB OY	3	ABB OY	3	Research for SMEs	2	Security; Space & satellite research	2	N/A	
	Finnish Meteorological Institute	2	TECHNICAL RESEARCH CENTRE OF FINLAND	2	ILMATIETEEN LAITOS - FINNISH METEOROLOGICAL INSTITUTE	2	Finnish Meteorological Institute	2	Finnish Meteorological Institute	2	Embedded technology for sustainable urban life; Smart environments and scalable digital services	2	Education, Training; Innovation, Technology Transfer; Scientific Research	2	N/A	
	ILMATIETEEN LAITOS - FINNISH METEOROLOGICAL INSTITUTE	2	UNIVERSITY OF HELSINKI	1	Finnish Meteorological Institute	2	ILMATIETEEN LAITOS - FINNISH METEOROLOGICAL INSTITUTE	2	ILMATIETEEN LAITOS - FINNISH METEOROLOGICAL INSTITUTE	2	Marie Curie IAPP transfer of knowledge programme	2	Industrial Manufacture; Safety; Sustainable development	2	N/A	
ITE43	CONSIGLIO NAZIONALE DELLE RICHERCHE	2	CONSIGLIO NAZIONALE DELLE RICHERCHE	2	Ente Nazionale per l Energia Elettrica SpA (ENEL)	4	Ente Nazionale per l Energia Elettrica SpA (ENEL)	4	Ente Nazionale per l Energia Elettrica SpA (ENEL)	4	Multi-use offshore platforms	3 (37)	Scientific Research	5 (32)	Renewable energy	1 (5)
	Ente Nazionale per l Energia Elettrica SpA (ENEL)	4	Ente Nazionale per l Energia Elettrica SpA (ENEL)	4	CONSIGLIO NAZIONALE DELLE RICHERCHE	2	CONSIGLIO NAZIONALE DELLE RICHERCHE	2	CONSIGLIO NAZIONALE DELLE RICHERCHE	2	Research domain 4.13 (only for rail transport and powered two-wheelers) and research domains 4.15 and 4.16	2	Environmental Protection	5	Consumers	1
	CONSORZIO NAZIONALE INTERUNIVERSITARIO PER LE SCIENZE DEL MARE	1	VTT	2	CIAOTECH SRL	3	UNIVERSITY OF ROMA TRE	1	CONSORZIO NAZIONALE INTERUNIVERSITARIO PER LE SCIENZE DEL MARE	1	Use Case scenarios and early trials	2	Scientific Research; Transport	2	Green Electricity	1

	UNIVERSITY OF ROMA TRE	1	ERICSSON	3	RELEX ITALIA SRL	3	CONSORZIO NAZIONALE INTERUNIVERSITARIO PER LE SCIENZE DEL MARE	1	UNIVERSITY OF ROMA TRE	1	Knowledge-base and tools for regional networks of MPAs, integrated management of activities together with assessment of wind energy potential in the Mediterranean and the Black Sea	2	Aerospace Technology; Transport	2	Liberalisation	1
	ERICSSON	3	UNIVERSITY OF ROMA TRE	1	CONSORZIO NAZIONALE INTERUNIVERSITARIO PER LE SCIENZE DEL MARE	1	ERICSSON	3	ERICSSON	3	Coordination action on off-shore renewable energy conversion platforms	2	Coordination, Cooperation; Renewable Sources of Energy	2	Markets	1
NL333	UNIVERSITY OF TECHNOLOGY OF DELFT	1	UNIVERSITY OF TECHNOLOGY OF DELFT	1	UNIVERSITY OF TECHNOLOGY OF DELFT	1	UNIVERSITY OF TECHNOLOGY OF DELFT	1	UNIVERSITY OF TECHNOLOGY OF DELFT	1	Cost-effective materials for larger blades for off-shore wind energy applications	2 (22)	Scientific Research	3 (19)	N/A	
	T.N.O	2	T.N.O	2	SHELL	3	T.N.O	2	T.N.O	2	R&D on crucial technical aspects (e.g. unsteady and 3D aerodynamics, noise reduction and propagation, component loads, fatigue, condition monitoring, corrosion, interference with radio waves, lightning strike effects, etc)	2	Environmental Protection	3	N/A	
	SHELL	3	SHELL	3	T.N.O	2	SHELL	3	SHELL	3	Developing Earth Observation for the monitoring and prediction of environmental impacts from energy resource extraction, transportation and/or exploitation	2	Renewable Sources of Energy; Scientific Research	2	N/A	
	STICHTING DELTARES	4	STICHTING DELTARES	4	STICHTING DELTARES	4	STICHTING DELTARES	4	STICHTING DELTARES	4	Research for SMEs	1	Renewable Sources of Energy	1	N/A	
	UNESCO-IHE INSTITUTE FOR WATER EDUCATION	2	UNESCO-IHE INSTITUTE FOR WATER EDUCATION	2	STICHTING NEDERLANDS NORMALISATIE - INSTITUUT	2	UNESCO-IHE INSTITUTE FOR WATER EDUCATION	2	UNESCO-IHE INSTITUTE FOR WATER EDUCATION	2	Wind energy	1	Economic Aspects; Scientific Research	1	N/A	

ITC11	UNIVERSITY OF TECHNOLOGY OF MILAN	1	UNIVERSITY OF TECHNOLOGY OF MILAN	1	UNIVERSITY OF TECHNOLOGY OF MILAN	1	UNIVERSITY OF TECHNOLOGY OF MILAN	1	UNIVERSITY OF TECHNOLOGY OF MILAN	1	Embedded technology for sustainable urban life; Smart environments and scalable digital services	2 (14)	Scientific Research	4 (10)	N/A	
	CENTRO RICERCHE FIAT S.C.P.A.	2	CENTRO RICERCHE FIAT S.C.P.A.	2	CENTRO RICERCHE FIAT S.C.P.A.	2	CENTRO RICERCHE FIAT S.C.P.A.	2	CENTRO RICERCHE FIAT S.C.P.A.	2	Sustainable energy systems	2	Industrial Manufacture; Safety; Sustainable development	2	N/A	
	SOLARWALL ITALIA SRL	3	SOLARWALL ITALIA SRL	3	SOLARWALL ITALIA SRL	3	SOLARWALL ITALIA SRL	3	SOLARWALL ITALIA SRL	3	Modelling and testing for improved safety of alternatively-powered vehicles	2	Industrial Manufacture	2	N/A	
	WAVE FOR ENERGY SRL	3	WAVE FOR ENERGY SRL	3	FAIVELEY TRANSPORT SA	3	WAVE FOR ENERGY SRL	3	WAVE FOR ENERGY SRL	3	Integration of variable distributed resources in distribution networks	2	Energy Saving; Transport	1	N/A	
	FAIVELEY TRANSPORT SA	3	FAIVELEY TRANSPORT SA	3	I.SO.TEST ENGINEERING S.R.L.	3	I.SO.TEST ENGINEERING S.R.L.	3	FAIVELEY TRANSPORT SA	3	Gurney flap actuator and mechanism for a full scale helicopter rotor blade	2	Energy Storage, Energy Transport; Other Energy Topics; Scientific Research	1	N/A	
ITC45	Siemens	3	Siemens	3	Siemens	3	Siemens	3	Siemens	3	Embedded technology for sustainable urban life; Smart environments and scalable digital services	2 (24)	Scientific Research	5 (22)	Wind energy	2 (25)
	STMICROELECTRONICS SRL	3	CESI - CENTRO ELETTROTECNICO SPERIMENTALE ITALIANO GIACINTO MOTTA SPA	2	ENEA - RICERCA SUL SISTEMA ELETTRICO S.P.A.	3	STMICROELECTRONICS SRL	3	STMICROELECTRONICS SRL	3	Key action Cleaner Energy Systems, including Renewable Energies	2	Industrial Manufacture; Safety; Sustainable development	2	100% RES	2
	INTEGRA RENEWABLE ENERGIES SRL	3	STMICROELECTRONICS SRL	3	RICERCA SUL SISTEMA ENERGETICO - RSE SPA	3	INTEGRA RENEWABLE ENERGIES SRL	3	INTEGRA RENEWABLE ENERGIES SRL	3	Coordination action on off-shore renewable energy conversion platforms	2	Industrial Manufacture	2	architect	2
	LARFON ISOLANTI SRL	3	INTEGRA RENEWABLE ENERGIES SRL	3	FONDAZIONE POLITECNICO DI MILANO	1	ENEA - RICERCA SUL SISTEMA ELETTRICO S.P.A.	3	LARFON ISOLANTI SRL	3	Towards zero-defect manufacturing	2	Coordination, Cooperation; Renewable Sources of Energy	2	architecture	2
	ALCATEL	3	LARFON ISOLANTI SRL	3	CESI - CENTRO ELETTROTECNICO SPERIMENTALE ITALIANO GIACINTO MOTTA SPA	2	RICERCA SUL SISTEMA ENERGETICO - RSE SPA	3	ALCATEL	3	RTD activities of a generic nature	2	Energy Saving; Transport	1	biomass	2

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NUTS3	**Degree**		**Betweenness**		**Closeness**		**SHnet**		**Shego**		**Activity**		**Subject**		**Keywords**	
ITC11	UNIVERSITY OF TECHNOLOGY OF MILAN	1	UNIVERSITY OF TECHNOLOGY OF MILAN	1	UNIVERSITY OF TECHNOLOGY OF MILAN	1	UNIVERSITY OF TECHNOLOGY OF MILAN	1	UNIVERSITY OF TECHNOLOGY OF MILAN	1	Development of nanostructured materials	5 (61)	Scientific Research	13 (98)	N/A	
	CENTRO RICERCHE FIAT S.C.P.A.	2	CENTRO RICERCHE FIAT S.C.P.A.	2	CENTRO RICERCHE FIAT S.C.P.A.	2	CENTRO RICERCHE FIAT S.C.P.A.	2	CENTRO RICERCHE FIAT S.C.P.A.	2	Sustainable energy systems	4	Industrial Manufacture	12	N/A	
	WOLFRAM CARB SPA	3	WOLFRAM CARB SPA	3	ISTITUTO ELETTROTECNICO NAZIONALE GALILEO FERRARIS	2	WOLFRAM CARB SPA	3	WOLFRAM CARB SPA	3	Nanostructured coatings and thin films	4	Environmental Protection	8	N/A	
	ISTITUTO ELETTROTECNICO NAZIONALE GALILEO FERRARIS	2	TRATTAMENTI TERMICI FERIOLI E GIANOTTI SPA	3	WEBASTO SPA	3	ISTITUTO ELETTROTECNICO NAZIONALE GALILEO FERRARIS	2	ISTITUTO ELETTROTECNICO NAZIONALE GALILEO FERRARIS	2	Complete vehicle energy management	3	Economic Aspects	7	N/A	
	SOLARWALL ITALIA SRL	3	AVIO S.P.A.	3	WOLFRAM CARB SPA	3	TRATTAMENTI TERMICI FERIOLI E GIANOTTI SPA	3	SOLARWALL ITALIA SRL	3	Research for SMEs	2	Nanotechnology and Nanosciences	7	N/A	
DK012	UNIVERSITY OF TECHNOLOGY OF DENMARK	1	UNIVERSITY OF TECHNOLOGY OF DENMARK	1	UNIVERSITY OF TECHNOLOGY OF DENMARK	1	UNIVERSITY OF TECHNOLOGY OF DENMARK	1	CENERGIA ENERGY CONSULTANTS	3	Sustainable energy systems	5 (51)	Energy Saving	14 (79)	Renewables	1 (20)
	CENERGIA ENERGY CONSULTANTS	3	CENERGIA ENERGY CONSULTANTS	3	CENERGIA ENERGY CONSULTANTS	3	CENERGIA ENERGY CONSULTANTS	3	UNIVERSITY OF TECHNOLOGY OF DENMARK	1	CONCERTO communities: the way to the future	5	Renewable Sources of Energy	13	Legislation	1
	Solar Energy Center Denmark	2	INSTITUTTET FOR PRODUKTUDVIKLING (INSTITUTE FOR PRODUCT DEVELOPMENT)	2	FORCE TECHNOLOGY	3	Solar Energy Center Denmark	2	Solar Energy Center Denmark	2	Efficient space heating, cooling, ventilation, lighting systems and domestic appliances, and integration of renewables into buildings	3	Economic Aspects	12	Monitoring	1

	FORCE TECHNOLOGY	3	Solar Energy Center Denmark	2	Solar Energy Center Denmark	2	FORCE TECHNOLOGY	3	FORCE TECHNOLOGY	3	Research for SMEs	2	Scientific Research	10	Statistics	1
	HOEJE-TAASTRUP KOMMUNE	4	INSTITUTTET FOR PRODUKTUDVIKLING	2	STOBBE TECH CERAMICS A/S	3	HOEJE-TAASTRUP KOMMUNE	4	HOEJE-TAASTRUP KOMMUNE	4	Building sustainability	2	Construction Technology	7	Targets	1
UKD53	UNIVERSITY OF CAMBRIDGE	1	TWI LIMITED	3	UNIVERSITY OF CAMBRIDGE	1	UNIVERSITY OF CAMBRIDGE	1	UNIVERSITY OF CAMBRIDGE	1	Research for SMEs	3 (31)	Scientific Research	16 (47)	Electromagnetic Processes	1 (1)
	TWI LIMITED	3	UNIVERSITY OF CAMBRIDGE	1	AIXTRON AG	3	AIXTRON AG	3	TWI LIMITED	3	Research for SME associations	3	Industrial Manufacture	6	-	-
	AIXTRON AG	3	AIXTRON AG	3	TWI LIMITED	3	TWI LIMITED	3	AIXTRON AG	3	Novel materials for smart windows conceived as affordable multifunctional systems offering enhanced energy control	2	Economic Aspects	4	-	-
	EIGHT19 LIMITED	3	BRITISH ANTARCTIC SURVEY	2	EIGHT19 LIMITED	3	EIGHT19 LIMITED	3	EIGHT19 LIMITED	3	Marie Curie Action: "Intra-European Fellowships for Career Development"	2	Education, Training	4	-	-
	KERONITE LTD	3	OPEN SOURCE MANAGEMENT LIMITED	3	DZP TECHNOLOGIES LIMITED	3	KERONITE LTD	3	KERONITE LTD	3	Horizontal research activities involving SMEs	1	Materials Technology	3	-	-
ES523	UNIVERSIDAD POLITECNICA DE VALENCIA	1	ASOCIACION DE INVESTIGACION DE MATERIALES PLASTICOS Y CONEXAS - AIMPLAS	5	APLICACIONES TECNICAS DE LA ENERGIA (ATERSA)	3	UNIVERSIDAD POLITECNICA DE VALENCIA	1	UNIVERSIDAD POLITECNICA DE VALENCIA	1	Research for SMEs	5 (33)	Scientific Research	11 (51)	N/A	
	UNIVERSITY OF VALENCIA	1	UNIVERSIDAD POLITECNICA DE VALENCIA	1	UNIVERSITY OF VALENCIA	1	UNIVERSITY OF VALENCIA	1	UNIVERSITY OF VALENCIA	1	CPA12: Application services provision	4	Economic Aspects	8	N/A	
	APLICACIONES TECNICAS DE LA ENERGIA (ATERSA)	3	APLICACIONES TECNICAS DE LA ENERGIA (ATERSA)	3	INSTITUTO TECNOLOGICO DEL EMBALAJE, TRANSPORTE Y LOGISTICA	2	APLICACIONES TECNICAS DE LA ENERGIA (ATERSA)	3	INSTITUTO TECNOLOGICO DEL EMBALAJE, TRANSPORTE Y LOGISTICA	2	Key action Economic and Efficient Energy for a Competitive Europe	3	Energy Saving	6	N/A	
	INSTITUTO TECNOLOGICO DEL EMBALAJE, TRANSPORTE Y LOGISTICA	2	INSTITUTO TECNOLOGICO DEL EMBALAJE, TRANSPORTE Y LOGISTICA	2	UNIVERSIDAD POLITECNICA DE VALENCIA	1	INSTITUTO TECNOLOGICO DEL EMBALAJE, TRANSPORTE Y LOGISTICA	2	APLICACIONES TECNICAS DE LA ENERGIA (ATERSA)	3	ICT for energy efficiency	2	Innovation, Technology Transfer	4	N/A	

	ASOCIACION DE INVESTIGACION DE LA INDUSTRIA AGROALIMENTARIA.	5	UNIVERSITY OF VALENCIA	1	ASOCIACION DE INVESTIGACION DE LA INDUSTRIA AGROALIMENTARIA.	5	ASOCIACION DE INVESTIGACION DE LA INDUSTRIA AGROALIMENTARIA.	5	ASOCIACION DE INVESTIGACION DE LA INDUSTRIA AGROALIMENTARIA.	5	Research for SME associations	1	Information Processing, Information Systems	4	N/A	
DE212	WIRTSCHAFT UND INFRASTRUKTUR GMBH AND CO PLANUNGS KG	3	WIRTSCHAFT UND INFRASTRUKTUR GMBH AND CO PLANUNGS KG	3	WIRTSCHAFT UND INFRASTRUKTUR GMBH AND CO PLANUNGS KG	3	WIRTSCHAFT UND INFRASTRUKTUR GMBH AND CO PLANUNGS KG	3	WIRTSCHAFT UND INFRASTRUKTUR GMBH AND CO PLANUNGS KG	3	New and advanced concepts in renewable energy technologies - PV	15 (169)	Scientific Research	46 (251)	Renewable Energy	1 (20)
	INFINEON TECHNOLOGIES AG	3	UNIVERSITY OF TECHNOLOGY OF MUNICH	1	AVANCIS GMBH AND CO. KG	3	AVANCIS GMBH AND CO. KG	3	INFINEON TECHNOLOGIES AG	3	Research for SMEs	9	Renewable Sources of Energy	32	solar thermal	1
	AVANCIS GMBH AND CO. KG	3	INFINEON TECHNOLOGIES AG	3	DOCOMO COMMUNICATIONS LABORATORIES EUROPE GMBH	3	INFINEON TECHNOLOGIES AG	3	AVANCIS GMBH AND CO. KG	3	Cost-effective supply of renewable energies	8	Energy Saving	27	education	1
	UNIVERSITY OF TECHNOLOGY OF MUNICH	1	MARKETING- UND TECHNOLOGIE-CONSULT GMBH	3	DEUTSCHE GESELLSCHAFT FUER SONNENENERGIE E.V.	5	UNIVERSITY OF TECHNOLOGY OF MUNICH	1	UNIVERSITY OF TECHNOLOGY OF MUNICH	1	Co-operative Research (all areas of science and technology)	5	Environmental Protection	21	photovoltaics (PV)	1
	DOCOMO COMMUNICATIONS LABORATORIES EUROPE GMBH	3	AVANCIS GMBH AND CO. KG	3	SOLARWORLD INDUSTRIES DEUTSCHLAND GMBH	3	UNIVERSITY OF MUNICH	1	UNIVERSITY OF MUNICH	1	Future Emerging Technologies	4	Economic Aspects	20	Schools	1
ES511	UNIVERSITY OF BARCELONA	1	UNIVERSIDAD POLITECNICA DE CATALUNYA	1	UNIVERSITY OF BARCELONA	1	INSTITUT CATALA D ENERGIA	2	UNIVERSITY OF BARCELONA	1	Key action Economic and Efficient Energy for a Competitive Europe	9 (123)	Renewable Sources of Energy	36 (224)	Solar Energy	4 (69)
	INSTITUT CATALA D ENERGIA	2	INSTITUT CATALA D ENERGIA	2	INSTITUT CATALA D ENERGIA	2	UNIVERSITY OF BARCELONA	1	INSTITUT CATALA D ENERGIA	2	Co-operative Research (all areas of science and technology)	6	Scientific Research	34	Photovoltaic	4
	TRAMA TECNOAMBIENTAL S.L.	3	UNIVERSITY OF BARCELONA	1	UNIVERSIDAD POLITECNICA DE CATALUNYA	1	UNIVERSIDAD POLITECNICA DE CATALUNYA	1	UNIVERSIDAD POLITECNICA DE CATALUNYA	1	Research for SMEs	5	Energy Saving	31	District energy system	4
	UNIVERSIDAD POLITECNICA DE CATALUNYA	1	TRAMA TECNOAMBIENTAL S.L.	3	TRAMA TECNOAMBIENTAL S.L.	3	TRAMA TECNOAMBIENTAL S.L.	3	TRAMA TECNOAMBIENTAL S.L.	3	Renewable energies in buildings	5	Economic Aspects	26	Low energy buildings	4
	UNIVERSIDAD AUTONOMA DE BARCELONA	1	CENTRE DE RECERCA I INVESTIGACIO DE CATALUNYA, S.A	2	BARCELONA REGIONAL - AGENCIA METROPOLITANA SA	3	UNIVERSIDAD AUTONOMA DE BARCELONA	1	UNIVERSIDAD AUTONOMA DE BARCELONA	1	Cost-effective supply of renewable energies	4	Environmental Protection	21	RES Communities	4

UKJ14	OXFORD BROOKES UNIVERSITY	1	OXFORD BROOKES UNIVERSITY	1	UNIVERSITY OF OXFORD	1	UNIVERSITY OF OXFORD	1	OXFORD BROOKES UNIVERSITY	1	Key action Economic and Efficient Energy for a Competitive Europe	3 (36)	Scientific Research	13 (63)	Renewables	1 (6)
	UNIVERSITY OF OXFORD	1	UNIVERSITY OF OXFORD	1	OXFORD BROOKES UNIVERSITY	1	OXFORD BROOKES UNIVERSITY	1	UNIVERSITY OF OXFORD	1	Research for SMEs	3	Economic Aspects	9	JRC	1
	UK INTELLIGENT SYSTEMS RESEARCH INSTITUTE LIMITED	2	UK INTELLIGENT SYSTEMS RESEARCH INSTITUTE LIMITED	2	OXFORD LASERS LTD	3	AEA Technology plc	3	UNIVERSITY OF OXFORD BROOKES	1	Research for SME associations	3	Renewable Sources of Energy	5	Legislation	1
	UNIVERSITY OF OXFORD BROOKES	1	AEA Technology plc	3	UK INTELLIGENT SYSTEMS RESEARCH INSTITUTE LIMITED	2	UK INTELLIGENT SYSTEMS RESEARCH INSTITUTE LIMITED	2	UK INTELLIGENT SYSTEMS RESEARCH INSTITUTE LIMITED	2	Pilot lines for precision synthesis of nanomaterials	2	Energy Saving	5	Monitoring	1
	AEA Technology plc	3	CRYSTALOX LTD.	3	EXITECH LTD	3	UNIVERSITY OF OXFORD BROOKES	1	AEA Technology plc	3	Multifunctional ceramic thin films with radically new properties	2	Environmental Protection	5	Statistics	1
HU101	BUDAPESTI MUSZAKI ES GAZDASAGTUDOMANYI EGYETEM	4	RESEARCH INSTITUTE FOR TECHNICAL PHYSICS AND MATERIALS SCIENCE	2	BUDAPESTI MUSZAKI ES GAZDASAGTUDOMANYI EGYETEM	4	BUDAPESTI MUSZAKI ES GAZDASAGTUDOMANYI EGYETEM	4	BUDAPESTI MUSZAKI ES GAZDASAGTUDOMANYI EGYETEM	4	Sustainable energy systems	6 (46)	Scientific Research	9 (69)	JCR	5 (1)
	RESEARCH CENTRE FOR NATURAL SCIENCES, HUNGARIAN ACADEMY OF SCIENCES	2	MUSZAKI FIZIKAI ES ANYAGTUDOMANYI KUTATOINTEZET - MAGYAR TUDOMANYOS AKADEMIA	2	BAY ZOLTAN ALKALMAZOTT KUTATASI KOZHASZNU NONPROFIT KFT.	6	RESEARCH CENTRE FOR NATURAL SCIENCES, HUNGARIAN ACADEMY OF SCIENCES	2	HUNGARIAN FEDERATION OF ROOFING CONTRACTORS	5	RTD Activities of a Generic Nature : materials and their technologies for production and transformation and new and improved materials and production technologies in the steel field	3	Environmental Protection	6	-	-
	HUNGARIAN FEDERATION OF ROOFING CONTRACTORS	5	KFKI - ATOMIC ENERGY RESEARCH INSTITUTE - HUNGARIAN ACADEMY OF SCIENCES	2	MAGYAR TUDOMANYOS AKADEMIA KFKI ATOMENERGIA KUTATOINTEZET	2	MUSZAKI FIZIKAI ES ANYAGTUDOMANYI KUTATOINTEZET - MAGYAR TUDOMANYOS AKADEMIA	2	NON PROFIT COMPANY FOR QUALITY CONTROL AND INNOVATION IN BUILDING	6	Collective Research (all areas of science and technology)	3	Nuclear Fission	6	-	-
	NON PROFIT COMPANY FOR QUALITY CONTROL AND INNOVATION IN BUILDING	6	BUDAPESTI MUSZAKI ES GAZDASAGTUDOMANYI EGYETEM	4	INNOVATEXT TEXTILIPARI MUSZAKI FEJLESZTO ES VIZSGALO INTEZET RT	3	RESEARCH LNSTITUTE FOR TECHNICAL PHYSICS AND MATERIALS SCIENCE, HUNGARIAN ACADEMY OF SCIENCES	2	PUSKASMUVEK B.DOGOSIPARI KFT	3	Key action Sustainable Marine Ecosystems	3	Industrial Manufacture	5	-	-
	PUSKASMUVEK B.DOGOSIPARI KFT	3	UNIVERSITY OF TECHNOLOGY AND ECONOMICS OF BUDAPEST	1	ORSZAGOS METEOROLOGIAI SZOLGALAT	2	HUNGARIAN FEDERATION OF ROOFING CONTRACTORS	5	RESEARCH CENTRE FOR NATURAL SCIENCES, HUNGARIAN ACADEMY OF SCIENCES	2	Key action Economic and Efficient Energy for a Competitive Europe	2	Materials Technology	4	-	-

ITE43	CONSIGLIO NAZIONALE DELLE RICHERCHE	2	CONSIGLIO NAZIONALE DELLE RICHERCHE	2	CONSIGLIO NAZIONALE DELLE RICHERCHE	2	CONSIGLIO NAZIONALE DELLE RICHERCHE	2	CONSIGLIO NAZIONALE DELLE RICHERCHE	2	Future Emerging Technologies	6 (132)	Scientific Research	45 (207)	Combisystems	2 (35)
	AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE	4	AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE	4	AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE	4	AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE	4	AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE	4	Cost-effective supply of renewable energies	6	Renewable Sources of Energy	25	Key Issues in Solar Thermal	2
	Ente Nazionale per l Energia Elettrica SpA (ENEL)	4	SHAP SRL	3	ITALIAN AGENCY FOR NEW TECHNOLOGY, ENERGY AND THE ENVIRONMENT	4	Ente Nazionale per l Energia Elettrica SpA (ENEL)	4	Ente Nazionale per l Energia Elettrica SpA (ENEL)	4	Key action Economic and Efficient Energy for a Competitive Europe	5	Energy Saving	22	Solar Keymark	2
	ITALIAN AGENCY FOR NEW TECHNOLOGY, ENERGY AND THE ENVIRONMENT	4	LABOR S.R.L.	3	Ente Nazionale per l Energia Elettrica SpA (ENEL)	4	ITALIAN AGENCY FOR NEW TECHNOLOGY, ENERGY AND THE ENVIRONMENT	4	ITALIAN AGENCY FOR NEW TECHNOLOGY, ENERGY AND THE ENVIRONMENT	4	Research for SMEs	4	Economic Aspects	16	Sun in Action	2
	ERICSSON	3	ERICSSON	3	UNIVERSITY OF ROMA LA SAPIENZA	1	UNIVERSITY OF ROMA LA SAPIENZA	1	ERICSSON	3	Co-operative Research (all areas of science and technology)	4	Environmental Protection	12	Renewable Energy	2
CH021	UNIVERSITY OF BERN	1	UNIVERSITY OF BERN	1	UNIVERSITY OF BERN	1	UNIVERSITY OF BERN	1	UNIVERSITY OF BERN	1	Cost-effective supply of renewable energies	2 (31)	Scientific Research	10 (49)	JRC	2 (6)
	HSR HOCHSCHULE FUR TECHNIK RAPPERSWIL	1	SWISS SUSTAINABLE SYSTEMS AG	3	METEOTEST	4	SWISS SUSTAINABLE SYSTEMS AG	3	HSR HOCHSCHULE FUR TECHNIK RAPPERSWIL	1	Key action Economic and Efficient Energy for a Competitive Europe	2	Energy Saving	8	Combisystems	1
	SWISS SUSTAINABLE SYSTEMS AG	3	HSR HOCHSCHULE FUR TECHNIK RAPPERSWIL	1	HSR HOCHSCHULE FUR TECHNIK RAPPERSWIL	1	HSR HOCHSCHULE FUR TECHNIK RAPPERSWIL	1	SWISS SUSTAINABLE SYSTEMS AG	3	Research for SMEs	2	Renewable Sources of Energy	4	Key Issues in Solar Thermal	1
	HOCHSCHULE RAPPERSWIL, SOLARTECHNIK PRUFUNG FORSCHUNG	1	BERNER FACHHOCHSCHULE	1	3S SWISS SOLAR SYSTEMS AG	3	HOCHSCHULE FUR TECHNIK	1	HOCHSCHULE RAPPERSWIL, SOLARTECHNIK PRUFUNG FORSCHUNG	1	RTD Activities of a Generic Nature : materials and their technologies for production and transformation and new and improved materials and production technologies in the steel field	2	Economic Aspects	4	Solar Keymark	1
	BUNDESAMT FUR ENERGIE	3	METEOTEST	4	AMANUENSIS GMBH	3	HOCHSCHULE RAPPERSWIL, SOLARTECHNIK PRUFUNG FORSCHUNG	1	BUNDESAMT FUR ENERGIE	3	Revisiting solar-thermal systems for using breakthroughs in scientific and	2	Coordination, Cooperation	4	Sun in Action	1

											technological fields					

SEA 00-13

SEA f(SHNet Cent) Clutser k-means 31																
NUTS3	**Degree**		**Betweenness**		**Closeness**		**SHnet**		**Shego**		**Activity**		**Subject**		**Keywords**	
ES130	DESARROLLO Y GESTION INDUSTRIAL Y DEL MEDIO AMBIENTE SA	3	DESARROLLO Y GESTION INDUSTRIAL Y DEL MEDIO AMBIENTE SA	3	DESARROLLO Y GESTION INDUSTRIAL Y DEL MEDIO AMBIENTE SA	3	DESARROLLO Y GESTION INDUSTRIAL Y DEL MEDIO AMBIENTE SA	3	DESARROLLO Y GESTION INDUSTRIAL Y DEL MEDIO AMBIENTE SA	3	Research for SMEs	2 (6)	Scientific Research	2 (7)	N/A	
	ERZIA TECHNOLOGIES SL	3	ERZIA TECHNOLOGIES SL	3	ERZIA TECHNOLOGIES SL	3	ERZIA TECHNOLOGIES SL	3	ERZIA TECHNOLOGIES SL	3	Ocean: demonstration of innovative full size systems	2	Other Energy Topics	2	N/A	
	WEDGE GLOBAL S.L	3	WEDGE GLOBAL S.L	3	WEDGE GLOBAL S.L	3	WEDGE GLOBAL S.L	3	WEDGE GLOBAL S.L	3	Multi-use offshore platforms	1	Environmental Protection	1	N/A	
	-	-	-	-	-	-	-	-	-		Innovative coastal defence technologies	1	Economic Aspects	1	N/A	
	-	-	-	-	-	-	-	-	-		-	-	Resources of the Sea, Fisheries	1	N/A	
EL303	UNIVERSITY OF ATHENS RESEARCH CENTER ECONOMICS AND BUSINESS	2	NATIONAL TECHNICAL UNIVERSITY OF ATHENS	1	NATIONAL TECHNICAL UNIVERSITY OF ATHENS	1	NATIONAL TECHNICAL UNIVERSITY OF ATHENS	1	NATIONAL TECHNICAL UNIVERSITY OF ATHENS	1	Multi-use offshore platforms	2 (6)	Environmental Protection	2 (6)	N/A	
	NATIONAL TECHNICAL UNIVERSITY OF ATHENS	1	UNIVERSITY OF ATHENS	1	UNIVERSITY OF ATHENS	1	UNIVERSITY OF ATHENS RESEARCH CENTER ECONOMICS AND BUSINESS	2	UNIVERSITY OF ATHENS RESEARCH CENTER ECONOMICS AND BUSINESS	2	Research for SMEs	1	Scientific Research	1	N/A	

	UNIVERSITY OF ATHENS	1	UNIVERSITY OF ATHENS RESEARCH CENTER ECONOMICS AND BUSINESS	2	UNIVERSITY OF ATHENS RESEARCH CENTER ECONOMICS AND BUSINESS	2	UNIVERSITY OF ATHENS	1	UNIVERSITY OF ATHENS	1	Innovative coastal defence technologies	1	Economic Aspects	1	N/A	
	-	-	-	-	-	-	-	-	-		Deep off-shore multi-purpose renewable energy conversion platforms for wind/ocean energy conversion	1	Resources of the Sea, Fisheries	1	N/A	
	-	-	-	-	-	-	-	-	-		Research activities having an impact in the medium and longer term	1	Renewable Sources of Energy	1	N/A	
FR102	TECHNIP FRANCE SAS	3	TECHNIP FRANCE SAS	3	TECHNIP FRANCE SAS	3	TECHNIP FRANCE SAS	3	TECHNIP FRANCE SAS	3	Innovative coastal defence technologies	1 (5)	Renewable Sources of Energy	2 (5)	N/A	
	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	2	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	2	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	2	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	2	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	2	Deep off-shore multi-purpose renewable energy conversion platforms for wind/ocean energy conversion	1	Resources of the Sea, Fisheries	1	N/A	
	CATALYSE PRODUCTIONS	3	CATALYSE PRODUCTIONS	3	CATALYSE PRODUCTIONS	3	CATALYSE PRODUCTIONS	3	CATALYSE PRODUCTIONS	3	Research activities having an impact in the medium and longer term	1	Other Energy Topics	1	N/A	
	-	-	-	-	-	-	-	-	-		Pre-normative research for ocean energy	1	Social Aspects	1	N/A	
	-	-	-	-	-	-	-	-	-		Co-productions	1	-	-	N/A	
BG331	BULGARIAN SHIP HYDRODYNAMICS CENTRE	2	INSTITUTE OF OCEANOLOGY - BULGARIAN ACADEMY OF SCIENCES	2	BULGARIAN SHIP HYDRODYNAMICS CENTRE	2	BULGARIAN SHIP HYDRODYNAMICS CENTRE	2	BULGARIAN SHIP HYDRODYNAMICS CENTRE	2	Innovative coastal defence technologies	1 (3)	Resources of the Sea, Fisheries	2 (5)	N/A	
	INSTITUTE OF OCEANOLOGY - BULGARIAN ACADEMY OF SCIENCES	2	BULGARIAN SHIP HYDRODYNAMICS CENTRE	2	INSTITUTE OF OCEANOLOGY - BULGARIAN ACADEMY OF SCIENCES	2	INSTITUTE OF OCEANOLOGY - BULGARIAN ACADEMY OF SCIENCES	2	INSTITUTE OF OCEANOLOGY - BULGARIAN ACADEMY OF SCIENCES	2	Research activities having an impact in the medium and longer term	1	Environmental Protection	1	N/A	
	-	-	-	-	-	-	-	-	-		Key action Global Change, Climate and Biodiversity	1	Forecasting	1	N/A	

	-	-	-	-	-	-	-	-	-		-	-	Meteorology	1	N/A	
	-	-	-	-	-	-	-	-	-		-	-	-	-	N/A	
DK050	UNIVERSITY OF AALBORG	1	UNIVERSITY OF AALBORG	1	UNIVERSITY OF AALBORG	1	UNIVERSITY OF AALBORG	1	UNIVERSITY OF AALBORG	1	New and advanced concepts in renewable energy technologies - Other RES	2 (9)	Renewable Sources of Energy	3 (12)	N/A	
	HVALPSUND NET AS	3	HVALPSUND NET AS	3	HVALPSUND NET AS	3	HVALPSUND NET AS	3	HVALPSUND NET AS	3	Innovative coastal defence technologies	1	Environmental Protection	2	N/A	
	-	-	-	-	-	-	-	-	-		Research activities having an impact in the medium and longer term	1	Resources of the Sea, Fisheries	1	N/A	
	-	-	-	-	-	-	-	-	-		Pre-normative research for ocean energy	1	Other Energy Topics	1	N/A	
	-	-	-	-	-	-	-	-	-		Multi-use offshore platforms	1	Social Aspects	1	N/A	
IE025	UNIVERSITY COLLEGE CORK, NATIONAL UNIVERSITY OF IRELAND, CORK	1	UNIVERSITY COLLEGE CORK, NATIONAL UNIVERSITY OF IRELAND, CORK	1	UNIVERSITY COLLEGE CORK, NATIONAL UNIVERSITY OF IRELAND, CORK	1	UNIVERSITY COLLEGE CORK, NATIONAL UNIVERSITY OF IRELAND, CORK	1	UNIVERSITY COLLEGE CORK, NATIONAL UNIVERSITY OF IRELAND, CORK	1	Transnational cooperation between regional research-driven clusters	3 (19)	Renewable Sources of Energy	9 (34)	N/A	
	OCEAN ENERGY LIMITED	3	OCEAN ENERGY LIMITED	3	OCEAN ENERGY LIMITED	3	OCEAN ENERGY LIMITED	3	OCEAN ENERGY LIMITED	3	Research activities having an impact in the medium and longer term	2	Scientific Research	5	N/A	
	CORK INSTITUTE OF TECHNOLOGY	2	CORK INSTITUTE OF TECHNOLOGY	2	CORK INSTITUTE OF TECHNOLOGY	2	CORK INSTITUTE OF TECHNOLOGY	2	CORK INSTITUTE OF TECHNOLOGY	2	Key action Cleaner Energy Systems, including Renewable Energies	2	Environmental Protection	3	N/A	
	SOUTH-WEST REGIONAL AUTHORITY	4	SOUTH-WEST REGIONAL AUTHORITY	4	SOUTH-WEST REGIONAL AUTHORITY	4	SOUTH-WEST REGIONAL AUTHORITY	4	SOUTH-WEST REGIONAL AUTHORITY	4	New components and concepts for ocean energy converters	2	Other Energy Topics	3	N/A	

	THE CORK CHAMBER OF COMMERCE	5	THE CORK CHAMBER OF COMMERCE	5	THE CORK CHAMBER OF COMMERCE	5	THE CORK CHAMBER OF COMMERCE	5	THE CORK CHAMBER OF COMMERCE	5	Pre-normative research for ocean energy	1	Energy Saving	3	N/A	
EL522	UNIVERSITY OF ARISTOTELES OF THESSALONIKI	1	UNIVERSITY OF ARISTOTELES OF THESSALONIKI	1	UNIVERSITY OF ARISTOTELES OF THESSALONIKI	1	UNIVERSITY OF ARISTOTELES OF THESSALONIKI	1	UNIVERSITY OF ARISTOTELES OF THESSALONIKI	1	Innovative coastal defence technologies	1 (2)	Resources of the Sea, Fisheries	1 (1)	N/A	
	CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS	2	CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS	2	CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS	2	CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS	2	CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS	2	Demonstration action	1	-	-	N/A	
	-	-	-	-	-	-	-	-	-		-	-	-	-	N/A	
	-	-	-	-	-	-	-	-	-		-	-	-	-	N/A	
	-	-	-	-	-	-	-	-	-		-	-	-	-	N/A	
UKI11	DONG ENERGY	3	DONG ENERGY	3	DONG ENERGY	3	DONG ENERGY	3	DONG ENERGY	3	Innovative coastal defence technologies	1 (8)	Renewable Sources of Energy	2 (10)	N/A	
	UNIVERSITY OF MIDDLESEX	1	UNIVERSITY OF MIDDLESEX	1	FRED,OLSEN LTD	3	UNIVERSITY OF MIDDLESEX	1	UNIVERSITY OF MIDDLESEX	1	Multi-use offshore platforms	1	Environmental Protection	2	N/A	
	ARMSTRONG TECHNOLOGY ASSOCIATES LTD	3	ARMSTRONG TECHNOLOGY ASSOCIATES LTD	3	UNIVERSITY OF MIDDLESEX	1	ARMSTRONG TECHNOLOGY ASSOCIATES LTD	3	FRED,OLSEN LTD	3	Key action Cleaner Energy Systems, including Renewable Energies	1	Resources of the Sea, Fisheries	1	N/A	
	FRED,OLSEN LTD	3	FRED,OLSEN LTD	3	LLOYD S REGISTER EMEA	3	FRED,OLSEN LTD	3	ARMSTRONG TECHNOLOGY ASSOCIATES LTD	3	Marie Curie Action: "Networks for Initial Training"	1	Energy Saving	1	N/A	
	LLOYD S REGISTER EMEA	3	LLOYD S REGISTER EMEA	3	ARMSTRONG TECHNOLOGY ASSOCIATES LTD	3	LLOYD S REGISTER EMEA	3	LLOYD S REGISTER EMEA	3	Deep off-shore multi-purpose renewable energy conversion platforms for wind/ocean energy conversion	1	Social Aspects	1	N/A	

DK012	UNIVERSITY OF TECHNOLOGY OF DENMARK	1	UNIVERSITY OF TECHNOLOGY OF DENMARK	1	UNIVERSITY OF TECHNOLOGY OF DENMARK	1	UNIVERSITY OF TECHNOLOGY OF DENMARK	1	UNIVERSITY OF TECHNOLOGY OF DENMARK	1	c	2 (9)	Renewable Sources of Energy	4 (11)	N/A	
	WAVEPLANE PRODUCTION A/S	3	WAVEPLANE PRODUCTION A/S	3	WAVEPLANE PRODUCTION A/S	3	WAVEPLANE PRODUCTION A/S	3	WAVEPLANE PRODUCTION A/S	3	Research activities having an impact in the medium and longer term	2	Environmental Protection	3	N/A	
	BALSLEV CONSULTING ENGINEERS A/S	3	BALSLEV CONSULTING ENGINEERS A/S	3	BALSLEV CONSULTING ENGINEERS A/S	3	BALSLEV CONSULTING ENGINEERS A/S	3	BALSLEV CONSULTING ENGINEERS A/S	3	Multi-use offshore platforms	1	Energy Saving	2	N/A	
	WAVEPLANE INTERNATIONAL A/S	3	WAVEPLANE INTERNATIONAL A/S	3	WAVEPLANE INTERNATIONAL A/S	3	WAVEPLANE INTERNATIONAL A/S	3	WAVEPLANE INTERNATIONAL A/S	3	Deep off-shore multi-purpose renewable energy conversion platforms for wind/ocean energy conversion	1	Scientific Research	1	N/A	
	-	-	-	-	-	-	-	-	-	-	New and advanced concepts in renewable energy technologies - Other RES	1	Coordination, Cooperation	1	N/A	
DE212	UNIVERSITY OF TECHNOLOGY OF MUNICH	1	UNIVERSITY OF TECHNOLOGY OF MUNICH	1	UNIVERSITY OF TECHNOLOGY OF MUNICH	1	UNIVERSITY OF TECHNOLOGY OF MUNICH	1	UNIVERSITY OF TECHNOLOGY OF MUNICH	1	New and advanced concepts in renewable energy technologies - Other RES	2 (8)	Renewable Sources of Energy	3 (7)	N/A	
	-	-	-	-	-	-	-	-	-	-	Research activities having an impact in the medium and longer term	1	Scientific Research	1	N/A	
	-	-	-	-	-	-	-	-	-	-	Deep off-shore multi-purpose renewable energy conversion platforms for wind/ocean energy conversion	1	Coordination, Cooperation	1	N/A	
	-	-	-	-	-	-	-	-	-	-	Research for SMEs	1	Energy Storage, Energy Transport	1	N/A	
	-	-	-	-	-	-	-	-	-	-	Coordination action on off-shore renewable energy conversion platforms	1	Economic Aspects	1	N/A	

GEOTHERMIC 00-13

GEOTH f(SHNet Cent) Cluster k-means 27																
NUTS3	**Degree**		**Betweenness**		**Closeness**		**SHnet**		**Shego**		**Activity**		**Subject**		**Keywords**	
BE100	EUROPEAN HEAT PUMP ASSOCIATION GEIE	5	EUROPEAN GEOTHERMAL ENERGY COUNCIL	4	EUROPEAN HEAT PUMP ASSOCIATION GEIE	5	EUROPEAN HEAT PUMP ASSOCIATION GEIE	5	EUROPEAN HEAT PUMP ASSOCIATION GEIE	5	Improved ground source heat pumps	2 (8)	Renewable Sources of Energy	5 (18)	ENERGY IN HOTELS	4 (16)
	EUROPEAN HEALTH TELEMATICS ASSOCIATION	5	EUROPEAN HEAT PUMP ASSOCIATION GEIE	5	EUROPEAN HEALTH TELEMATICS ASSOCIATION	5	EUROPEAN HEALTH TELEMATICS ASSOCIATION	5	EUROPEAN HEALTH TELEMATICS ASSOCIATION	5	Other renewable energies	2	Energy Saving	5	HOTEL SECTOR	4
	ERTZBERG CVBA	3	EUROPEAN HEALTH TELEMATICS ASSOCIATION	5	GEOLOGICAL SURVEY OF BELGIUM	4	ERTZBERG CVBA	3	ERTZBERG CVBA	3	New technologies for energy efficiency at district level	2	Environmental Protection	2	RENEWABLE ENERGY TECHNOLOGIES	4
	INTESASANPAOLO EURODESK S.P.R.L	3	ERTZBERG CVBA	3	EUROPEAN GEOTHERMAL ENERGY COUNCIL	4	INTESASANPAOLO EURODESK S.P.R.L	3	INTESASANPAOLO EURODESK S.P.R.L	3	Key action Economic and Efficient Energy for a Competitive Europe	1	Other Energy Topics	2	TOURISM INDUSTRY	4
	EUROPEAN GEOTHERMAL ENERGY COUNCIL	4	INTESASANPAOLO EURODESK S.P.R.L	3	EUROPEAN PHOTOVOLTAIC INDUSTRY ASSOCIATION	5	EUROPEAN GEOTHERMAL ENERGY COUNCIL	4	EUROPEAN GEOTHERMAL ENERGY COUNCIL	4	Hybrid systems based on solar thermal heating/ cooling, backed up by biomass or geothermal to compensate heat load intermittence	1	Industrial Manufacture	2	i-	i-
RO111	UNIVERSITY OF ORADEA	1	UNIVERSITY OF ORADEA	1	UNIVERSITY OF ORADEA	1	UNIVERSITY OF ORADEA	1	UNIVERSITY OF ORADEA	1	Cost-effective supply of renewable energies	2 (7)	Other Energy Topics	2 (7)	N/A	
	PRIMARIA SACUIENI	4	PRIMARIA SACUIENI	4	TRANSGEX	3	PRIMARIA SACUIENI	4	PRIMARIA SACUIENI	4	Research and rural economies	2	Economic Aspects	2	N/A	
	TRANSGEX	3	TRANSGEX	3	PRIMARIA SACUIENI	4	TRANSGEX	3	TRANSGEX	3	Improved ground source heat pumps	1	Scientific Research	2	N/A	
	-	-	-	-	-	-	-	-	-		New and advanced concepts in renewable energy technologies - Other RES	1	Renewable Sources of Energy	1	N/A	

	-	-	-	-	-	-	-	-	-		CONCERTO communities: the way to the future	1	-	-	N/A	
ES300	INSTITUTO GEOLOGICO Y MINERO DE ESPANA	2	INSTITUTO GEOLOGICO Y MINERO DE ESPANA	2	INSTITUTO GEOLOGICO Y MINERO DE ESPANA	2	INSTITUTO GEOLOGICO Y MINERO DE ESPANA	2	INSTITUTO GEOLOGICO Y MINERO DE ESPANA	2	ICT for energy-positive neighbourhoods	3 (8)	Energy Saving	3 (11)	District energy system	2 (15)
	BESEL S.A.	3	BESEL S.A.	3	BESEL S.A.	3	BESEL S.A.	3	BESEL S.A.	3	New technologies for energy efficiency at district level	2	Information and communication technology applications	3	Low energy buildings	2
	Centro de Investigaciones Energeticas Medioambientales y Tecnologicas - CIEMAT	2	Centro de Investigaciones Energeticas Medioambientales y Tecnologicas - CIEMAT	2	Centro de Investigaciones Energeticas Medioambientales y Tecnologicas - CIEMAT	2	Centro de Investigaciones Energeticas Medioambientales y Tecnologicas - CIEMAT	2	Centro de Investigaciones Energeticas Medioambientales y Tecnologicas - CIEMAT	2	Improved ground source heat pumps	1	Renewable Sources of Energy	2	Photovoltaic	2
	BP SOLAR	3	BP SOLAR	3	BP SOLAR	3	BP SOLAR	3	BP SOLAR	3	New and advanced concepts in renewable energy technologies - Other RES	1	Industrial Manufacture	2	RES Communities	2
	UNIVERSIDAD PONTIFICIA COMILLAS	1	UNIVERSIDAD PONTIFICIA COMILLAS	1	ASOCIACION PARA LA INVESTIGACION Y DIAGNOSIS DE LA ENERGIA	5	UNIVERSIDAD PONTIFICIA COMILLAS	1	UNIVERSIDAD PONTIFICIA COMILLAS	1	INDUSTRY	1	Other Energy Topics	1	GEOTHERMAL ENERGY	1
FR102	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	2	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	2	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	2	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	2	CATALYSE PRODUCTIONS	3	New and advanced concepts in renewable energy technologies - Other RES	6 (16)	Renewable Sources of Energy	4 13)	N/A	
	Association pour la Recherche et le Developpement de Methodes et Processus Industriels (ARMINES)	2	Association pour la Recherche et le Developpement de Methodes et Processus Industriels (ARMINES)	2	Association pour la Recherche et le Developpement de Methodes et Processus Industriels (ARMINES)	2	Association pour la Recherche et le Developpement de Methodes et Processus Industriels (ARMINES)	2	Association pour la Recherche et le Developpement de Methodes et Processus Industriels (ARMINES)	2	Cost-effective supply of renewable energies	2	Scientific Research	2	N/A	
	CATALYSE PRODUCTIONS	3	CATALYSE PRODUCTIONS	3	CATALYSE PRODUCTIONS	3	CATALYSE PRODUCTIONS	3	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	2	Understanding and mitigation of induced seismicity associated with geothermal field development	2	Energy Saving	1	N/A	
	-	-	-	-	-	-	-	-	-		New technologies for energy efficiency at district level	1	Industrial Manufacture	1	N/A	
	-	-	-	-	-	-	-	-	-		Improved ground source heat pumps	1	Other Energy Topics	1	N/A	

EL305	CENTER FOR RENEWABLE ENERGY SOURCES - CRES	2	CENTER FOR RENEWABLE ENERGY SOURCES - CRES	2	CENTER FOR RENEWABLE ENERGY SOURCES - CRES	2	CENTER FOR RENEWABLE ENERGY SOURCES - CRES	2	CENTER FOR RENEWABLE ENERGY SOURCES - CRES	2	New and advanced concepts in renewable energy technologies - Other RES	3 (7)	Renewable Sources of Energy	2 (5)	ENERGY IN HOTELS	1 (4
	-	-	-	-	-	-	-	-	-		Cost-effective supply of renewable energies	2	Energy Saving	1	HOTEL SECTOR	1
	-	-	-	-	-	-	-	-	-		Improved ground source heat pumps	1	Other Energy Topics	1	RENEWABLE ENERGY TECHNOLOGIES	1
	-	-	-	-	-	-	-	-	-		Other renewable energies	1	Environmental Protection	1	TOURISM INDUSTRY	1
	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-
NL326	VERENIGING VOOR CHRISTELIJK HOGER ONDERWIJS WETENSCHAPPELIJK ONDERZOEK EN PATIENTENZORG	2	VERENIGING VOOR CHRISTELIJK HOGER ONDERWIJS WETENSCHAPPELIJK ONDERZOEK EN PATIENTENZORG	2	VERENIGING VOOR CHRISTELIJK HOGER ONDERWIJS WETENSCHAPPELIJK ONDERZOEK EN PATIENTENZORG	2	VERENIGING VOOR CHRISTELIJK HOGER ONDERWIJS WETENSCHAPPELIJK ONDERZOEK EN PATIENTENZORG	2	VERENIGING VOOR CHRISTELIJK HOGER ONDERWIJS WETENSCHAPPELIJK ONDERZOEK EN PATIENTENZORG	2	New and advanced concepts in renewable energy technologies - Other RES	1 (3)	Renewable Sources of Energy	2 (5)	N/A	
	GROENHOLLAND GEO-ENERGIESYSTEMEN BV	3	GROENHOLLAND GEO-ENERGIESYSTEMEN BV	3	GROENHOLLAND GEO-ENERGIESYSTEMEN BV	3	GROENHOLLAND GEO-ENERGIESYSTEMEN BV	3	GROENHOLLAND GEO-ENERGIESYSTEMEN BV	3	Improved ground source heat pumps	1	Energy Saving	1	N/A	
	GROENHOLLAND BV	3	GROENHOLLAND BV	3	GROENHOLLAND BV	3	GROENHOLLAND BV	3	GROENHOLLAND BV	3	Key action Cleaner Energy Systems, including Renewable Energies	1	Other Energy Topics	1	N/A	
	-	-	-	-	-	-	-	-	-		-	-	Environmental Protection	1	N/A	
	-	-	-	-	-	-	-	-	-		-	-	-	-	N/A	
EL303	EDRASIS CH PSALLIDAS S.A	3	MENTOR INVESTMENT CONSULTANTS S.A.	3	MENTOR INVESTMENT CONSULTANTS S.A.	3	EDRASIS CH PSALLIDAS S.A	3	EDRASIS CH PSALLIDAS S.A	3	Other renewable energies	2 (8)	Renewable Sources of Energy	4 (17)	District energy system	1 (4)

	MENTOR INVESTMENT CONSULTANTS S.A.	3	EDRASIS CH PSALLIDAS S.A	3	EDRASIS CH PSALLIDAS S.A	3	MENTOR INVESTMENT CONSULTANTS S.A.	3	MENTOR INVESTMENT CONSULTANTS S.A.	3	Improved ground source heat pumps	1	Energy Saving	3	Low energy buildings	1
	INSTITUTE OF GEOLOGY AND MINERAL EXPLORATION	2	INSTITUTE OF GEOLOGY AND MINERAL EXPLORATION	2	INSTITUTE OF GEOLOGY AND MINERAL EXPLORATION	2	INSTITUTE OF GEOLOGY AND MINERAL EXPLORATION	2	INSTITUTE OF GEOLOGY AND MINERAL EXPLORATION	2	Cost-effective supply of renewable energies	1	Environmental Protection	3	Photovoltaic	1
	UNIVERSITY OF ATHENS	1	UNIVERSITY OF ATHENS	1	NATIONAL CENTRE FOR SOCIAL RESEARCH	2	UNIVERSITY OF ATHENS	1	UNIVERSITY OF ATHENS	1	Key action Economic and Efficient Energy for a Competitive Europe	1	Economic Aspects	2	RES Communities	1
	NATIONAL CENTRE FOR SOCIAL RESEARCH	2	NATIONAL CENTRE FOR SOCIAL RESEARCH	2	UNIVERSITY OF ATHENS	1	NATIONAL CENTRE FOR SOCIAL RESEARCH	2	NATIONAL CENTRE FOR SOCIAL RESEARCH	2	Earth Sciences, Environment, Energy; INTAS	1	-	-	-	-
NL333	T.N.O	2	T.N.O	2	T.N.O	2	T.N.O	2	T.N.O	2	Other renewable energies	1 (5)	Energy Saving	3 (7)	N/A	
	SHELL	3	SHELL	3	SHELL	3	SHELL	3	SHELL	3	New and advanced concepts in renewable energy technologies - Other RES	1	Renewable Sources of Energy	2	N/A	
	MINISTERIE VAN ECONOMISCHE ZAKEN, LANDBOUW EN INNOVATIE	4	MINISTERIE VAN ECONOMISCHE ZAKEN, LANDBOUW EN INNOVATIE	4	MINISTERIE VAN ECONOMISCHE ZAKEN, LANDBOUW EN INNOVATIE	4	MINISTERIE VAN ECONOMISCHE ZAKEN, LANDBOUW EN INNOVATIE	4	MINISTERIE VAN ECONOMISCHE ZAKEN, LANDBOUW EN INNOVATIE	4	Understanding and mitigation of induced seismicity associated with geothermal field development	1	Environmental Protection	1	N/A	
	-	-	-	-	-	-	-	-	-		New technologies for energy efficiency at district level	1	Industrial Manufacture	1	N/A	
	-	-	-	-	-	-	-	-	-		Supporting the coordination of national research activities of Member States and Associated States in the field of GEOTHERMAL energy (ERA-NET)	1	-	-	N/A	
ITC45	CESTEC- CENTRO PER LO SVILUPPO TECNOLOGICO, L ENERGIA E LA COMPETITIVITA DELLE PICCOLE E MEDIE IMPRESE LOMBARDE	2	CESTEC- CENTRO PER LO SVILUPPO TECNOLOGICO, L ENERGIA E LA COMPETITIVITA DELLE PICCOLE E MEDIE IMPRESE LOMBARDE	2	DIPARTIMENTO DI ENERGETICA - POLITECNICO DI MILANO	1	CESTEC- CENTRO PER LO SVILUPPO TECNOLOGICO, L ENERGIA E LA COMPETITIVITA DELLE PICCOLE E MEDIE IMPRESE LOMBARDE	2	CESTEC- CENTRO PER LO SVILUPPO TECNOLOGICO, L ENERGIA E LA COMPETITIVITA DELLE PICCOLE E MEDIE IMPRESE LOMBARDE	2	Other renewable energies	1 (5)	Energy Saving	2 (10)	N/A	

	AMBIENTE ITALIA SRL	3	AMBIENTE ITALIA SRL	3	CESTEC- CENTRO PER LO SVILUPPO TECNOLOGICO, L ENERGIA E LA COMPETITIVITA DELLE PICCOLE E MEDIE IMPRESE LOMBARDE	2	DIPARTIMENTO DI ENERGETICA - POLITECNICO DI MILANO	1	AMBIENTE ITALIA SRL	3	New technologies for energy efficiency at district level	1	Renewable Sources of Energy	2	N/A	
	MAPRO INTERNATIONAL SRL	3	MAPRO INTERNATIONAL SRL	3	Unione Geotermica Italiana - AIRU	5	AMBIENTE ITALIA SRL	3	MAPRO INTERNATIONAL SRL	3	Cost-effective supply of renewable energies	1	Environmental Protection	2	N/A	
	DIPARTIMENTO DI ENERGETICA - POLITECNICO DI MILANO	1	DIPARTIMENTO DI ENERGETICA - POLITECNICO DI MILANO	1	MAPRO INTERNATIONAL SRL	3	MAPRO INTERNATIONAL SRL	3	DIPARTIMENTO DI ENERGETICA - POLITECNICO DI MILANO	1	Key action Sustainable Management and Quality of Water	1	Industrial Manufacture	1	N/A	
	Unione Geotermica Italiana - AIRU	5	Unione Geotermica Italiana - AIRU	5	AMBIENTE ITALIA SRL	3	Unione Geotermica Italiana - AIRU	5	Unione Geotermica Italiana - AIRU	5	Hybrid systems based on solar thermal heating/ cooling, backed up by biomass or geothermal to compensate heat load intermittence	1	Economic Aspects	1	N/A	
EL522	CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS	2	CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS	2	CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS	2	CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS	2	CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS	2	Other renewable energies	1 (3)	Energy Saving	1 (3)	N/A	
	UNIVERSITY OF ARISTOTELES OF THESSALONIKI	1	UNIVERSITY OF ARISTOTELES OF THESSALONIKI	1	UNIVERSITY OF ARISTOTELES OF THESSALONIKI	1	UNIVERSITY OF ARISTOTELES OF THESSALONIKI	1	UNIVERSITY OF ARISTOTELES OF THESSALONIKI	1	Cost-effective supply of renewable energies	1	Renewable Sources of Energy	1	N/A	
	-	-	-	-	-	-	-	-	-		New and advanced concepts in renewable energy technologies - Other RES	1	Environmental Protection	1	N/A	
	-	-	-	-	-	-	-	-	-		-	-	-	-	N/A	
	-	-	-	-	-	-	-	-	-		-	-	-	-	N/A	

BIOMASS 00-13

BIOMASS f(SHNet Cent) Cluster k-means 43																
NUTS3	**Degree**		**Betweenness**		**Closeness**		**SHnet**		**Shego**		**Activity**		**Subject**		**Keywords**	
FI181	TEKNOLOGIAN TUTKIMUSKESKUS VTT	2	TEKNOLOGIAN TUTKIMUSKESKUS VTT	2	TEKNOLOGIAN TUTKIMUSKESKUS VTT	2	TEKNOLOGIAN TUTKIMUSKESKUS VTT	2	TEKNOLOGIAN TUTKIMUSKESKUS VTT	2	New and advanced concepts in renewable energy technologies - Biomass	13 (87)	Environmental Protection	14 (124)	JRC	3 (21)
	VALTION TEKNILLINEN TUTKIMUSKESKUS (TECHNICAL RESEARCH CENTRE OF FINLAND)	2	VALTION TEKNILLINEN TUTKIMUSKESKUS (TECHNICAL RESEARCH CENTRE OF FINLAND)	2	VALTION TEKNILLINEN TUTKIMUSKESKUS (TECHNICAL RESEARCH CENTRE OF FINLAND)	2	VALTION TEKNILLINEN TUTKIMUSKESKUS (TECHNICAL RESEARCH CENTRE OF FINLAND)	2	VALTION TEKNILLINEN TUTKIMUSKESKUS (TECHNICAL RESEARCH CENTRE OF FINLAND)	2	Bioethanol production from lignocellulosics	6	Biotechnology	11	Biomass	2
	TECHNICAL RESEARCH CENTRE OF FINLAND	2	TECHNICAL RESEARCH CENTRE OF FINLAND	2	TECHNICAL RESEARCH CENTRE OF FINLAND	2	TECHNICAL RESEARCH CENTRE OF FINLAND	2	TECHNICAL RESEARCH CENTRE OF FINLAND	2	High-efficiency medium-to-large scale electricity generation from biomass and waste	4	Other Energy Topics	11	CHP	1
	METSANTUTKIMUSLAITOS	2	AALTO-KORKEAKOULUSAATIO	4	ROAL OY	3	METSANTUTKIMUSLAITOS	2	METSANTUTKIMUSLAITOS	2	Key action Cleaner Energy Systems, including Renewable Energies	3	Scientific Research	9	liquid fuels	1
	RAUTARUUKKI OYJ	3	ROAL OY	3	UNIVERSITY OF HELSINKI	1	AALTO-KORKEAKOULUSAATIO	4	RAUTARUUKKI OYJ	3	Efficiency increases in existing and new build pulverised coal power plants with a view to CCS	3	Biofuels	9	markets	1
DE212	WIRTSCHAFT UND INFRASTRUKTUR GMBH AND CO PLANUNGS KG	3	WIRTSCHAFT UND INFRASTRUKTUR GMBH AND CO PLANUNGS KG	3	WIRTSCHAFT UND INFRASTRUKTUR GMBH AND CO PLANUNGS KG	3	WIRTSCHAFT UND INFRASTRUKTUR GMBH AND CO PLANUNGS KG	3	WIRTSCHAFT UND INFRASTRUKTUR GMBH AND CO PLANUNGS KG	3	Research for SMEs	4 (61)	Scientific Research	13 (85)	Clean Agriculture	1 (5)
	UNIVERSITY OF TECHNOLOGY OF MUNICH	1	UNIVERSITY OF TECHNOLOGY OF MUNICH	1	UNIVERSITY OF TECHNOLOGY OF MUNICH	1	UNIVERSITY OF TECHNOLOGY OF MUNICH	1	UNIVERSITY OF TECHNOLOGY OF MUNICH	1	New and advanced concepts in renewable energy technologies - Biomass	3	Environmental Protection	11	Renewable Energy Sources in Agriculture	1
	B.A.U.M. CONSULT GMBH	3	B.A.U.M. CONSULT GMBH	3	DEUTSCHE GESELLSCHAFT FUER SONNENENERGIE E.V.	5	B.A.U.M. CONSULT GMBH	3	B.A.U.M. CONSULT GMBH	3	Towards a sustainable bio-industry - Biotechnology for renewable chemicals and innovative downstream processes	2	Biotechnology	9	Renewable Energy Sources in Communities	1

	SUD CHEMIE AG	3	SUD CHEMIE AG	3	B.A.U.M. CONSULT GMBH	3	BAYERISCHES STAATSMINISTERIUM FUR ERNAHRUNG, LANDWIRTSCHAFT UND FORSTEN	2	SUD CHEMIE AG	3	Biomass (including waste) conversion systems	2	Renewable Sources of Energy	6	Sustainable Building Design	1
	BAYERISCHES STAATSMINISTERIUM FUR ERNAHRUNG, LANDWIRTSCHAFT UND FORSTEN	2	BAYERISCHES STAATSMINISTERIUM FUR ERNAHRUNG, LANDWIRTSCHAFT UND FORSTEN	2	ISODETECT GMBH	3	DEUTSCHE GESELLSCHAFT FUER SONNENENERGIE E.V.	5	BAYERISCHES STAATSMINISTERIUM FUR ERNAHRUNG, LANDWIRTSCHAFT UND FORSTEN	2	Large scale integration of RES into energy supplies	2	Energy Saving	5	Training of engineers	1
FR102	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	2	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	2	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	2	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	2	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	2	New and advanced concepts in renewable energy technologies - Biomass	7 (94)	Environmental Protection	22 (152)	biodiesel/biogas	1 (4)
	Association pour la Recherche et le Developpement de Methodes et Processus Industriels (ARMINES)	2	Association pour la Recherche et le Developpement de Methodes et Processus Industriels (ARMINES)	2	Association pour la Recherche et le Developpement de Methodes et Processus Industriels (ARMINES)	2	Association pour la Recherche et le Developpement de Methodes et Processus Industriels (ARMINES)	2	Association pour la Recherche et le Developpement de Methodes et Processus Industriels (ARMINES)	2	Co-ordination of activities in the fileds of NMP in an enlarged Europe	6	Scientific Research	14	diesel fuel from waste oils and fats	1
	INRA TRANSFERT S.A.	3	INRA TRANSFERT S.A.	3	INRA TRANSFERT S.A.	3	INRA TRANSFERT S.A.	3	INRA TRANSFERT S.A.	3	Large scale integration of RES into energy supplies	4	Energy Saving	13	Dimethyl ether/methanol	1
	INSTITUT TECHNOLOGIQUE FCBA (FORETCELLULOSE BOIS-CONSTRUCTION AMEUBLEMENT)	2	ORGANISATION NATIONALE INTERPROFESSIONELLE DES OLEAGINEUX	5	INSTITUT TECHNOLOGIQUE FCBA (FORETCELLULOSE BOIS-CONSTRUCTION AMEUBLEMENT)	2	INSTITUT TECHNOLOGIQUE FCBA (FORETCELLULOSE BOIS-CONSTRUCTION AMEUBLEMENT)	2	INSTITUT TECHNOLOGIQUE FCBA (FORETCELLULOSE BOIS-CONSTRUCTION AMEUBLEMENT)	2	Research infrastructures for forestry research	4	Agricultural biotechnology	11	heating from used frying oil	1
	AUBERT ET DUVAL	3	INSTITUT TECHNOLOGIQUE FCBA (FORETCELLULOSE BOIS-CONSTRUCTION AMEUBLEMENT)	2	L AIR LIQUIDE SA	3	BIOGEMMA	3	L AIR LIQUIDE SA	3	Propulsion	4	Renewable Sources of Energy	10	-	-
NL221	STICHTING DIENST LANDBOUWKUNDIG ONDERZOEK	4	STICHTING DIENST LANDBOUWKUNDIG ONDERZOEK	4	STICHTING DIENST LANDBOUWKUNDIG ONDERZOEK	4	STICHTING DIENST LANDBOUWKUNDIG ONDERZOEK	4	STICHTING DIENST LANDBOUWKUNDIG ONDERZOEK	4	Key action Sustainable Agriculture, Fisheries and Forestry	5 (58)	Environmental Protection	18 (127)	biomass combustion	1 (5)
	UNIVERSITY OF WAGENINGEN	1	UNIVERSITY OF WAGENINGEN	1	UNIVERSITY OF WAGENINGEN	1	UNIVERSITY OF WAGENINGEN	1	UNIVERSITY OF WAGENINGEN	1	New and advanced concepts in renewable energy technologies - Biomass	4	Agriculture	10	heat market	1
	DYADIC NEDERLAND BV	3	ATO B.V.	3	SPARKLING PROJECTS B.V.	3	DYADIC NEDERLAND BV	3	DYADIC NEDERLAND BV	3	Key action Cleaner Energy Systems, including Renewable Energies	2	Biotechnology	10	market deployment	1
	AGROTECHNOLOGY AND FOOD INNOVATIONS BV	3	UNIVERSITY OF UPPSALA	1	DYADIC NEDERLAND BV	3	SPARKLING PROJECTS B.V.	3	AGROTECHNOLOGY AND FOOD INNOVATIONS BV	3	Jatropha curcas - breeding strategy - towards a sustainable crop for biomaterials	2	Economic Aspects	9	Wood fuels	1

											and biofuels - SICA (India and/or African ACP and/or Latin America)					
	SPARKLING PROJECTS B.V.	3	DYADIC NEDERLAND BV	3	ATO B.V.	3	UNIVERSITY OF UPPSALA	1	SPARKLING PROJECTS B.V.	3	Biofuels from microalgae or macroalgae	2	Scientific Research	7	wood pellets	1
ITE43	CONSIGLIO NAZIONALE DELLE RICHERCHE	2	CONSIGLIO NAZIONALE DELLE RICHERCHE	2	CONSIGLIO NAZIONALE DELLE RICHERCHE	2	CONSIGLIO NAZIONALE DELLE RICHERCHE	2	CONSIGLIO NAZIONALE DELLE RICHERCHE	2	Coal combustion, clean and efficient coal technologies, CO2 capture	6 (78)	Environmental Protection	23 (122)	CHP	2 (27)
	CENTRO SVILUPPO MATERIALI SPA	2	VTT	2	CENTRO SVILUPPO MATERIALI SPA	2	CONSIGLIO PER LA RICERCA E SPERIMENTAZIONE IN AGRICOLTURA	2	CONSIGLIO PER LA RICERCA E SPERIMENTAZIONE IN AGRICOLTURA	2	Key action Cleaner Energy Systems, including Renewable Energies	5	Scientific Research	13	Energy crops	2
	CONSIGLIO PER LA RICERCA E SPERIMENTAZIONE IN AGRICOLTURA	2	CONSIGLIO PER LA RICERCA E SPERIMENTAZIONE IN AGRICOLTURA	2	AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE	4	Ente Nazionale per l Energia Elettrica SpA (ENEL)	4	CENTRO SVILUPPO MATERIALI SPA	2	Research for SMEs	5	Energy Saving	12	biofuels	2
	Ente Nazionale per l Energia Elettrica SpA (ENEL)	4	Ente Nazionale per l Energia Elettrica SpA (ENEL)	4	Ente Nazionale per l Energia Elettrica SpA (ENEL)	4	CENTRO SVILUPPO MATERIALI SPA	2	Ente Nazionale per l Energia Elettrica SpA (ENEL)	4	New and advanced concepts in renewable energy technologies - Biomass	4	Materials Technology	10	co-combustion	2
	AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE	4	CENTRO SVILUPPO MATERIALI SPA	2	CONSIGLIO PER LA RICERCA E SPERIMENTAZIONE IN AGRICOLTURA	2	AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE	4	AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE	4	Demonstration of innovative multi-purpose solar power plant	4	Industrial Manufacture	7	Mediterranean	2
AT221	UNIVERSITY OF TECHNOLOGY OF GRAZ	1	JOANNEUM RESEARCH FORSCHUNGSGESELLSCHAFT MBH	2	UNIVERSITY OF TECHNOLOGY OF GRAZ	1	UNIVERSITY OF TECHNOLOGY OF GRAZ	1	UNIVERSITY OF TECHNOLOGY OF GRAZ	1	Key action Cleaner Energy Systems, including Renewable Energies	4 (50)	Energy Saving	16 (94)	Biomass	2 (34)
	JOANNEUM RESEARCH FORSCHUNGSGESELLSCHAFT MBH	2	UNIVERSITY OF TECHNOLOGY OF GRAZ	1	JOANNEUM RESEARCH FORSCHUNGSGESELLSCHAFT MBH	2	JOANNEUM RESEARCH FORSCHUNGSGESELLSCHAFT MBH	2	JOANNEUM RESEARCH FORSCHUNGSGESELLSCHAFT MBH	2	New and advanced concepts in renewable energy technologies - Biomass	4	Renewable Sources of Energy	16	Energy crops	1
	BIOENERGY 2020+ GMBH	3	BIOS BIOENERGIESYSTEME GMBH	3	BIOENERGY 2020+ GMBH	3	BIOENERGY 2020+ GMBH	3	BIOENERGY 2020+ GMBH	3	Demonstration of a new generation of boilers and stoves	4	Environmental Protection	13	liquid fuels	1
	BIOS BIOENERGIESYSTEME GMBH	3	BIOENERGY 2020+ GMBH	3	BIOS BIOENERGIESYSTEME GMBH	3	BIOS BIOENERGIESYSTEME GMBH	3	BIOS BIOENERGIESYSTEME GMBH	3	Energy from biomass and waste	4	Waste Management	8	markets	1

	LANDESKAMMER FUR LAND- UND FORSTWIRTSCHAFT STEIERMARK	5	AVL LIST GMBH	3	LANDESKAMMER FUR LAND- UND FORSTWIRTSCHAFT STEIERMARK	5	LANDESKAMMER FUR LAND- UND FORSTWIRTSCHAFT STEIERMARK	5	LANDESKAMMER FUR LAND- UND FORSTWIRTSCHAFT STEIERMARK	5	Key action Economic and Efficient Energy for a Competitive Europe	3	Scientific Research	7	pyrolysis	1
NL213	B.T.G. BIOMASS TECHNOLOGY GROUP BV	3	B.T.G. BIOMASS TECHNOLOGY GROUP BV	3	B.T.G. BIOMASS TECHNOLOGY GROUP BV	3	B.T.G. BIOMASS TECHNOLOGY GROUP BV	3	B.T.G. BIOMASS TECHNOLOGY GROUP BV	3	Key action Cleaner Energy Systems, including Renewable Energies	7 (53)	Renewable Sources of Energy	20 (98)	Biomass CHP technologies	1 (8)
	UNIVERSITY OF TWENTE	1	BIOMASS TECHNOLOGY GROUP BV	3	BIOMASS TECHNOLOGY GROUP BV	3	BIOMASS TECHNOLOGY GROUP BV	3	BIOMASS TECHNOLOGY GROUP BV	3	Energy from biomass and waste	6	Energy Saving	17	Biomass logistics	1
	BIOMASS TECHNOLOGY GROUP BV	3	UNIVERSITY OF TWENTE	1	UNIVERSITY OF TWENTE	1	UNIVERSITY OF TWENTE	1	UNIVERSITY OF TWENTE	1	Key action Economic and Efficient Energy for a Competitive Europe	6	Economic Aspects	10	Solid biofuels	1
	PROCEDE BIOMASS BV	3	SPARQLE INTERNATIONAL B.V.	3	PROCEDE BIOMASS BV	3	PROCEDE BIOMASS BV	3	PROCEDE BIOMASS BV	3	New and advanced concepts in renewable energy technologies - Biomass	4	Environmental Protection	8	Training course material	1
	DUTCH4 AARDGAS B.V.	3	PROCEDE BIOMASS BV	3	BRUINS EN KWAST EXPLOITATIE B.V.	3	BRUINS EN KWAST EXPLOITATIE B.V.	3	DUTCH4 AARDGAS B.V.	3	High efficiency poly-generation - renewable energies for applications in industry	4	Other Energy Topics	8	Wood fuel information	1
BE100	EUROPEAN BIOMASS INDUSTRY ASSOCIATION	5	EUROPEAN BIOMASS INDUSTRY ASSOCIATION	5	EUROPEAN BIOMASS INDUSTRY ASSOCIATION	5	EUROPEAN BIOMASS INDUSTRY ASSOCIATION	5	EUROPEAN BIOMASS INDUSTRY ASSOCIATION	5	Key action Cleaner Energy Systems, including Renewable Energies	4 (48)	Environmental Protection	16 (79)	Central and Eastern Europe	6 (56)
	JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION	2	JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION	2	JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION	2	JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION	2	JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION	2	New and advanced concepts in renewable energy technologies - Biomass	4	Renewable Sources of Energy	11	Export	6
	EUROPEAN RENEWABLE ENERGY COUNCIL	4	3E N.V.	3	EUREC AGENCY E.E.I.G.	4	EUROPEAN RENEWABLE ENERGY COUNCIL	4	EUROPEAN RENEWABLE ENERGY COUNCIL	4	Research infrastructures for forestry research	3	Energy Saving	7	renewable energy technologies, promotion	6
	EUROHEAT AND POWER AISBL - EHP	3	UNIVERSITY OF VUB BRUSSEL	1	JOINT RESEARCH CENTRE	2	VLAAMS GEWEST	4	EUROHEAT AND POWER AISBL - EHP	3	Stimulating the development of downstream GMES services	3	Scientific Research	6	ENERGY IN HOTELS	4
	BERWIN LEIGHTON PAISNER	3	EUROHEAT AND POWER AISBL - EHP	3	EUREC-AGENCY	4	EUROHEAT AND POWER AISBL - EHP	3	BERWIN LEIGHTON PAISNER	3	Large-scale co-firing	2	Waste Management	5	HOTEL SECTOR	4

DK012	UNIVERSITY OF TECHNOLOGY OF DENMARK	1	UNIVERSITY OF TECHNOLOGY OF DENMARK	1	UNIVERSITY OF TECHNOLOGY OF DENMARK	1	UNIVERSITY OF TECHNOLOGY OF DENMARK	1	UNIVERSITY OF TECHNOLOGY OF DENMARK	1	Sustainable energy systems	5 (56)	Energy Saving	12 (85)	Biomass	1 (16)
	CENERGIA ENERGY CONSULTANTS	3	CENERGIA ENERGY CONSULTANTS	3	HALDOR TOPSOE A/S	3	CENERGIA ENERGY CONSULTANTS	3	CENERGIA ENERGY CONSULTANTS	3	Key action Cleaner Energy Systems, including Renewable Energies	5	Renewable Sources of Energy	11	100% RES	1
	NOVOZYMES A/S	3	HALDOR TOPSOE A/S	3	FORCE TECHNOLOGY	3	NOVOZYMES A/S	3	NOVOZYMES A/S	3	Sustainable Biorefineries	3	Environmental Protection	10	architect	1
	HALDOR TOPSOE A/S	3	NOVOZYMES A/S	3	NOVOZYMES A/S	3	HALDOR TOPSOE A/S	3	HALDOR TOPSOE A/S	3	New and advanced concepts in renewable energy technologies - Biomass	3	Scientific Research	9	architecture	1
	FORCE TECHNOLOGY	3	FORCE TECHNOLOGY	3	HOLM CHRISTENSEN BIOSYSTEMER APS	3	FORCE TECHNOLOGY	3	FORCE TECHNOLOGY	3	Key action Economic and Efficient Energy for a Competitive Europe	3	Biofuels	8	competition	1
ES300	CSIC CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS	2	CSIC CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS	2	Centro de Investigaciones Energeticas Medioambientales y Tecnologicas - CIEMAT	2	CSIC CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS	2	CSIC CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS	2	Key action Cleaner Energy Systems, including Renewable Energies	7 (85)	Scientific Research	22 (150)	Legislation	2 (35)
	Centro de Investigaciones Energeticas Medioambientales y Tecnologicas - CIEMAT	2	Centro de Investigaciones Energeticas Medioambientales y Tecnologicas - CIEMAT	2	CSIC CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS	2	Centro de Investigaciones Energeticas Medioambientales y Tecnologicas - CIEMAT	2	Centro de Investigaciones Energeticas Medioambientales y Tecnologicas - CIEMAT	2	New and advanced concepts in renewable energy technologies - Biomass	7	Renewable Sources of Energy	20	Monitoring	2
	TECNATOM S.A.	3	UNIVERSIDAD COMPLUTENSE DE MADRID	1	TECNATOM S.A.	3	TECNATOM S.A.	3	TECNATOM S.A.	3	Hybridisation of CSP with other energy sources	5	Environmental Protection	20	Renewables	2
	UNIVERSIDAD POLITECNICA DE MADRID	1	UNIVERSIDAD POLITECNICA DE MADRID	1	UNIVERSIDAD POLITECNICA DE MADRID	1	UNIVERSIDAD POLITECNICA DE MADRID	1	UNIVERSIDAD POLITECNICA DE MADRID	1	Key action Economic and Efficient Energy for a Competitive Europe	4	Energy Saving	15	Statistics	2
	INSTITUTO NACIONAL DE INVESTIGACION Y TECNOLOGIA AGRARIA Y ALIMENTARIA	2	TECNATOM S.A.	3	INSTITUTO NACIONAL DE INVESTIGACION Y TECNOLOGIA AGRARIA Y ALIMENTARIA	2	INSTITUTO NACIONAL DE INVESTIGACION Y TECNOLOGIA AGRARIA Y ALIMENTARIA	2	INSTITUTO ESPANOL DE OCEANOGRAFIA	2	Energy from biomass and waste	4	Waste Management	13	Targets	2