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O Cluster das Energias na Região Norte: uma abordagem em Geografia Económica

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DECLARAÇÕES

Declaro que esta tese é o resultado da minha investigação pessoal e independente. O seu conteúdo é original e todas as fontes consultadas estão devidamente mencionadas no texto, nas notas e na bibliografia.

O Candidato,

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Lisboa, 26 de novembro de 2018

Declaro que esta tese se encontra em condições de ser apreciada pelo júri a designar.

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A Co- Orientadora,

Professora Doutora Ana Monteiro
Lisboa, 26 de novembro de 2018

Ao José e ao Gonçalo

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Ao apoio incondicional do meu companheiro de uma vida, ao meu filho Gonçalo que muitas vezes soube esperar para lhe explicar algumas matérias do ensino secundário, aos meus pais por aquilo que sou, à Professora Doutora Regina Salvador que me acompanhou neste percurso e que me abriu a possibilidade de estudar as questões do mar, à Professora Doutora Ana Monteiro, à Professora Doutora Rosário Matos da Universidade Aberta, que me incentivou a estudar além da licenciatura.

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“Energy is a fundamental ingredient of a modern society and its supply impacts directly on social and economic development of nations”

Gómez - Expósito et al. (2008: 2)

O Cluster das Energias na Região Norte: uma abordagem em Geografia Económica

ANA CRISTINA HORTA CORVO DIAS PEGO

RESUMO

O conceito de cluster está directamente relacionado com o impacte na economia porque promove importantes ligações entre os sectores, nomeadamente na cooperação e colaboração, e indica a contribuição para o investimento e o emprego para um sector específico. Este estudo apresenta o cluster de energia offshore (eólica) em Portugal e suas implicações para a economia nacional. Considera-se que as implicações da energia offshore em Portugal (2017) estão directamente relacionadas com o emprego e o investimento nacional. Para tingir o objetivo de investigação (existe um cluster de energia offshore em Portugal?) foi utilizada a metodologia mista ou seja, a metodologia qualitativa baseada no Modelo de Diamante de Porter e a metodologia quantitativa baseada na matriz de produção Input Output (2013). O confronto entre os resultados permitiu concluir que existe um cluster emergente, e um impacte positivo no emprego e, no investimento direto. Os resultados provaram igualmente que num futuro próximo, o cluster de energia offshore em Portugal será um importante fornecedor de energia e contribuirá para a diminuição da dependência energética, economia verde e uma economia mais sustentável. Além disso, espera-se que projetos de I&D Offshore promovam uma dinâmica empresarial, trabalhadores qualificados, especialização inteligente, em virtude de uma crescente cooperação entre empresas e ao apoio financeiro nacional e europeu. A investigação feita contribuirá para compreender o funcionamento da estratégia de mercado do cluster em termos de colaboração e cooperação entre os players, mas também para definir estratégias no setor em termos de atuação no mercado nacional e europeu.

PALAVRAS - CHAVE: energia offshore, energia do vento, cluster, impacte económico, localização geográfica

The Energy Cluster in the North Region: an approach in Economic Geography

ANA CRISTINA HORTA CORVO DIAS PEGO

ABSTRACT

The concept of the cluster is directly related with an important impact on the economy because it promotes important linkages between sectors, namely cooperation and collaboration and it indicates the contribution towards investment and employment for a specific sector of the economy. This study presents the offshore energy cluster (wind) in Portugal and its implications for the economy. It is considered that the implications from offshore energy farms in Portugal (2017) are consistent with positive features in national employment and investment. A mixed methodology was used to discuss the results, a qualitative methodology based on Porter's Diamond Model and a quantitative methodology based on the IO matrix (2013). The confrontation between the results endowed an emergent cluster with weak linkages between sectors but a positive impact on employment and direct investment. The results will also prove that in the near future, the offshore energy cluster in Portugal will be an important renewable energy supply and will contribute activity with less dependence on fuel energy. Additionally, it is expected that R&D projects related to offshore value chains, technology and innovation, business dynamics, skilled workers and smart specialization will have national and European financial support because of their positive impact on the economy. The research will contribute to understanding the offshore renewable energy sector at the national and European level, and will provide support for other cluster studies.

KEYWORDS: offshore energy, wind energy, cluster, economic impact, geographic location

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CHAPTER 1- INTRODUCTION

"One of the first public experiments in which electrical power was used in a public space in country took place in Coimbra on Wednesday, 8 May 1867. (…) That night there was electric light! The flocks of peregrine birds spread their lazy wings from their mysterious nests and flew into the light, lured and fascinated like night butterflies…they trembled as they burned in the electric light"

Figueira (2018:16)

The energy used in human activities provided increasingly better resources and labour over time. Energy accompanied the activity of man and was a necessary tool for the performance of his activities.

The evolution of society and the emergence of electric power in the twentieth century led man to look at energy resources as essential to their activities. Electricity is associated with essential goods of human activity and prevails as an economic resource.

This work is framed in the field of economic geography. Several studies underline the importance of economic analysis in geography (Marshall, 1920; Krugman,1992; Garafoli, 1994; Bacattini, 2002).

Economic geography studies the occupation space of activities. Marshall (1920) identified the occupation of territory as "industrial districts" with agglomeration of activities.

The benefits derived from collaboration among organizations and individuals is a fundamental instrument for cluster planning (Cooke, 2002), and cannot be seen in isolation, but has multiple functions (Benneworth and Henry, 2004).

Geographical concentration (Marshall, 1920; Peroux, 1950) is the basis for the cluster concept. The evolution of industrial districts performed a new concept of industrial location based on regional innovation and learning regions. More recently, the economic cluster presented by Porter (2000) involves a network of organizations that are connected to each other through supplier-buyer relations, knowledge and cooperation between stakeholders.

The cluster as an engine of economic development (Porter, 1998; Porter, 2000; Turner, 2001; Ketels and Memedovic, 2008) includes enterprises and other organizations, such as, universities, public institutions (Maskell and Kebir, 2006).The importance of cooperation reveals a dynamic character and associated activities, cooperation in an evaluation of natural, human and technical resources.

The cluster is related to the location sector in a territory (McDonald et al., 2007;Ianca and Batrinca, 2010;), form of innovation and the development of industrial economic organizations. The creation of specialized products tends to form a cluster due to resources and skilled labour needs, not available elsewhere (Audretsch and Feldman, 1996).

However, the cluster location depends on *objective* factors (geographical location, transport network connections, supply of skilled labour, availability of land, energy costs, financial and municipal charges), and *subjective* (economic environment, image of the city/region, universities, research institutions and technology, innovative profile and performance of commercial and industrial associations) (Meyer-Stamer, 2001).

Simões (2013) identifies four typologies types of cluster: mini-cluster, industrial cluster, regional cluster and mega-cluster.

Some authors have considered electric energy cluster development; Frisillo (2007) describes electric energy clusters as groups of industries and other institutions, which favours innovation, entrepreneurship, knowledge transfer, better relations between partners and more efficient government intervention. The offshore energy cluster is an economic, social and environmental development model, associated with better use of synergies. These synergies reflect regional and local development (Simas, 2012) in energy independence, job creation and technological and industrial development.

Due the lack of studies about offshore wind energy applied to a specific geographical area, my motivation was to contribute to an enhanced understanding of the potential offshore energy cluster in Portugal, taking into account my personal interest in environmental issues.

Additionally, researchers have presented few studies in the renewable energy sector; therefore, this project will lead to awareness about the use of natural resources in Portugal and other European countries.

The researcher has a tool to develop his research, the methodology. The research process is related to epistemology (researcher perspective and the method how the researcher achieves that perspective), ontology (research phenomenon) and methodology (researcher knowledge process) (Matos, 2006: 91).

As Matos (2006:91) put it: “The methodology is the process of constructing knowledge from the researcher, as well as the set of procedures and research methods used to acquire the knowledge”.

The research question of the thesis is the following:

Is there an offshore energy (wave and wind) cluster in Portugal?

In order to answer this research question, the work will follow a mixed methodology (Crewswell and Clark, 2017: 208). The triangular design defined by Crewswell and Clark (2017: 210) exposes a set of procedures where the researcher compares results from qualitative and quantitative data; therefore, the researcher identifies the variables with which he is confronted and at the same time works towards solutions for the research questions. The importance of a mixed methodology is discussed when a researcher tries to link various social sciences. Consequently, its importance reflects the capacity of analysing social phenomena both quantitatively or qualitatively.

The regional problems of spatial distribution and equilibrium are related to location decisions (Bathelt and Glückeen, 2003:117). The location problem is not a fixed model, but a dynamic model characterized by the relationships within regions; where it can be studied, taking into account qualitative methodology (economic agents' behavior) and also a quantitative methodology (the impact of economic agents in the region).The importance of mixed methodology relays to a conceptual model where a dynamic analysis can be presented with rationality.

In addition to economic theory, social theories and their conceptualization are also applied to this approach to explain localized economic phenomena (Bathelt and Glückeer, 2003:123). This means a relationship between organisations, technologies and territories (Bathelt and Glückeer, 2003:130).

The proposed methodology presents a relationship between organizations, innovation and interaction (Bathelt and Glückeer (2003:131).Therefore, the research is a map of objectives and goals which are confirmed in a positive (quantitative) and interpretative (qualitative) way. Mixing methodologies should be connected with data analysis (first analysis) and data collection (second phase) (Crewswell and Clark, 2017:208). The interesting issue about mixing methodology is integrating and embedding data for a better phenomenon, moving understanding towards a better interpretation of the entire analysis.

Furthermore, mixed methodology allows the researcher to compare two types of data (quantitative or qualitative) and determine if there are any convergences, differences or combinations. Moreover, mixed methods are advantageous because they are familiar to most researchers and can result in well-validated and substantiated findings. For this purpose, the research will follow two methods (Porter's Diamond Model analysis and the Input-Ouput (IO) model). The objective is to compare data and findings for a better understanding of the research.

To sum up, qualitative and quantitative methodologies were used to describe the effects resulting from the renewable energy cluster. As the IO model has considerable merits of its own, the qualitative method based on the Diamond Model confirms the results from the IO analysis.

The research design_also demonstrates the research purposes and its linkages to the problem that you want to answer (Sekaran, 2003) with information leading towards a categorized problem (D'Oliveira, 2007).

The research design resides in the benefits from its use as economic, social, and technical or conversion systems (Kühn, 2001; Henderson et al., 2003; Sclavounos et al., 2008; Elkinton et al., 2006).

The research design will determine the possibility of an offshore wind energy cluster in Portugal through a quantitative method (production IO matrix 2013), and a qualitative method (Porter's Diamond model).

The sample will be based on stakeholders that influence offshore energy (suppliers, public institutions, companies, organizations, universities, NGOs) and which can contribute to the offshore cluster in Portugal.

The research question led to the following premises:

1*. Which factors can contribute most to the offshore energy cluster in Portugal?*

2. What are the direct, indirect and induced impacts of the offshore renewable energy sector on investment and employment?

3. What lessons can be used in Portugal from offshore energy clusters in other European countries?

In order to answer to these questions the research is divided into nine main chapters:

The first chapter is introductory and describes the necessity of this research; the second chapter, named Geographical Space and Clusters focuses on the geographical space and the clusters; the third chapter, named Maritime Economy and Clusters, discusses the maritime economy and maritime clusters; the fourth chapter, named Maritime Energy focuses on maritime energy, comprising the definition of energy, renewable energy and offshore energy; the chapter five, named Maritime Energy in the EU and Portugal focus on the maritime energy in EU and Portugal. The European energy policy as well as the renewable energy evolution in Europe and Portugal offshore energy investments is discussed; the chapter six, named A Geographical Analysis of the Portuguese Offshore Coast analyses why offshore energy production is influenced by the continental shelf, wind and wave features; the chapter seven, named The Input Output matrix focuses on a theoretical model where the input-output matrix is presented along with its importance on this research based on an analytical analysis and the usefulness of the IO matrix, as well as advantages and limitations; the chapter eight, named The Offshore Energy Cluster in Portugal. An Economic and Geographical analysis presents the methodology and the results from the electronic questionnaire to the potential stakeholders and the IO matrix; the chapter nine presents the conclusions of the research. The conclusions about the cluster are presented, and recommendations are given for further research.

CHAPTER 2– GEOGRAPHICAL SPACE AND CLUSTERS

"The concept of clustering has become a central concept for analyzing the performance of nations, industries and firms"

Langen (2002:209)

The second chapter focuses on the relation between geographical space and clusters. Concepts such as competitive advantages, geographical location are important because they explain the success of a cluster in the territory. On the other hand, organisation, space, territory and Knowlodge are discussed in order to analyse factors which comprise the cluster concept. The importance of geographical concentration in clusters and in the Porter Diamond Model (qualitative analysis in this research) is discussed.

2.1. THE CLUSTER ORGANISATION AND COMPETITIVE ADVANTAGE

"A economia redescobre a importância do Espaço e da Geografia que poderão trazer à economia o realismo e a capacidade de intervenção necessária à resolução dos problemas do mundo contemporâneo"

Pontes and Salvador (2002:283)

2.1.1. Competitive and Comparative Advantage

Since the 18th century, economists have been studying the relationship between organisations and production factors (work and land) as a means to survive in the market. Awareness about commercial trade is the beginning of comparative advantages, where goods and services are produced at a lower opportunity cost.

Competitive advantage is the conditions that allow a company or a country to produce a good or a service at a lower price. These conditions allow productive capacity to generate more sales or at a higher margin than its competition. The classical theory of comparative advantage is based on the premise that there is only one productive factor (work) (Adam Smith, Robert Torrens, David Ricardo and Stuart Mill) (Salvador, 1993:15).

The main distinguishing feature of international trade singled out by Ricardo (1817: 134) was the international immobility of factors of production. Factors were regarded as perfectly mobile within countries and completely immobile between countries, whereas goods were perfectly mobile within and between countries (at zero transport costs). Ricardo rather glossed over the question of the interdependence of industries, treating them as integrated, producing one output and using one primary input (labour). The latter being internally mobile, the unit cost of each good was constant, depending only on the amount of labour required to produce it (Chipman, J. S., 1965:479).

However, it is important to note that this theory does not apply to individuals' welfare or how benefits are distributed by countries.

According to Salvador (1993:42), the classic theory of comparative advantages presents some limitations but offers a good explication about commercial earnings and specialized international mechanisms. It was the first theory to demonstrate the disadvantages of protectionism.

The authors Heckscher (1919) and Ohlin (1933) were the founders of the Neoclassical Theory. The model set up by the authors considers the production function equal between countries. The different levels of productivity are because of different endowments of factors. The *Heckscher-Ohlin-Samuelson* (HOS) theorem says that a country will export goods where the production factors are used intensively and import goods where scarce production factors are used (Salvador, 1993:43).

2.1.2 Geographical Location and Competitive Advantage

"To my mind, however, the most important reason to look again at economic geography is the intellectual and empirical laboratory that is provided"

Krugman, P. (1990: 8)

Geographical location determines the distribution of economic activity (Fernandes et al., 2016) as in the theories of distribution of agriculture location (JHVonThünen), industry (A. Weber) and services (W. Christaller and A. Lösch).

Favourable geographical location can promote innovation and economic development through product specialization (Audretsch and Feldman, 1996; OCDE, 2005).

There are attractive factors for business implementation, such as employment, capital, technology and human resources in a geographic place. Moreover, Van Thünen. J. (1826), Weber, A. (1909), Perroux, A. (1950), Lösch, A. (1954) and Christaller, W. (1966) studied industrial location based on transportation and production costs.

Later, industrial concentration, transport and production factors were associated with information, collaboration between companies, human resources specialization and business cooperation.

Krugman (1992) related industrial agglomerations to demand interaction, increasing marginal incomes and lower transport costs, moving towards a divergent regional cumulative process, where organizations find externalities. Malmberg and Markell (2007) consider geographic location as a crucial factor for innovation and knowledge.

Companies desire to locate near a larger market, and, workers' desire to have access to goods and services. For this reason, companies settle where they can achieve competitiveness and cooperation. For this reason, companies will settle in a particular geographical location if there is an economic and social environment that favours cooperation, social benefits and competitiveness.

Therefore, geographical location is a key factor for defining companies strategies. Geographical location is sustainable if related to the availability of human capital, regarding the most favourable "place" for their installations.

Santos and Delazari (2011) argue that it is possible to establish a relationship between the resources available in a particular geographical location and competitive advantage.

Table 1– Competitive Implications in Geographical Location

The resources are Possessed by the organization	Valuable	Rare	Hard to imitate	Hard to substitute	Competitive implications
No	---	---	---	---	Competitive disadvantages (CD)
Yes	No	---	---	---	Competitive disadvantages (CD)
Yes	Yes	No	---	---	Temporary competitive parity (TCP)
Yes	Yes	Yes	No	---	Temporary competitive advantage (TCA)
Yes	Yes	Yes	Yes	No	Competitive parity (CP)
Yes	Yes	Yes	Yes	Yes	Sustainable competitive advantage (SCA)

Source: Santos and Delazari (2011:106)

Geographical location is a determinant factor for a competitive process where organizations take into account the resources available. Factors such as resources, skills, market and dynamic capabilities determine competitive advantages for a particular location.

An organization is more competitive if there are resources available for its activity, but it is also more competitive if there is availability of innovation, knowledge, and synergy exchanges. Therefore, a competitive advantage is a relationship between external and internal factors, industry structures and market processes towards a market strategy, which operates within a region.

Table 2– Explanatory Theories in Competitive Advantage

Competitive advantage can be explained by external factors (markets, industry structure)	***Structural Industry Analysis*** *(Industrial organization: SCP[1] model, positioning analysis)*	***Market Process*** *(Hayek– Austrian School, Schumpeter)*
Competitive advantage is explained by specific factors internal to the firm	***Resource Skills*** *(Resources Theory)*	***Capabilities and Dynamics*** *(Dynamic Capabilities Theory)*
	Static Industry Structure: Balance and Structure	Market Process

Source: Vasconcelos and Cyrino (2000:23)

From the organisations perspective, it is of interest to be in the market with product differentiation with cost advantages, complemented with size and positive financial resources in order to move towards industrial attractiveness and competitive advantage.

Moreover, the market is also related to an organization's capacity to deal with external agents, like clients and suppliers. The dynamic theory (Harrod, 1939) addressed competitive advantage based on the relationship between consumers and others related with internal analysis and market processes within organizations. For this reason, it is important to cooperate with other organisations in the same market share. This cooperation results in new products, new production processes, new markets, high profits, intellectual property and employment.

[1]SCP model (structure-conduct-performance). Mason, E.(1939) and Bain, J. (1972)argue that organizations' economic performance is the direct result of their competitive behaviour in terms of pricing and costs and this behaviour depends on the economic structure in which firms are embedded (Vasconcelos and Cyrino, 2000).

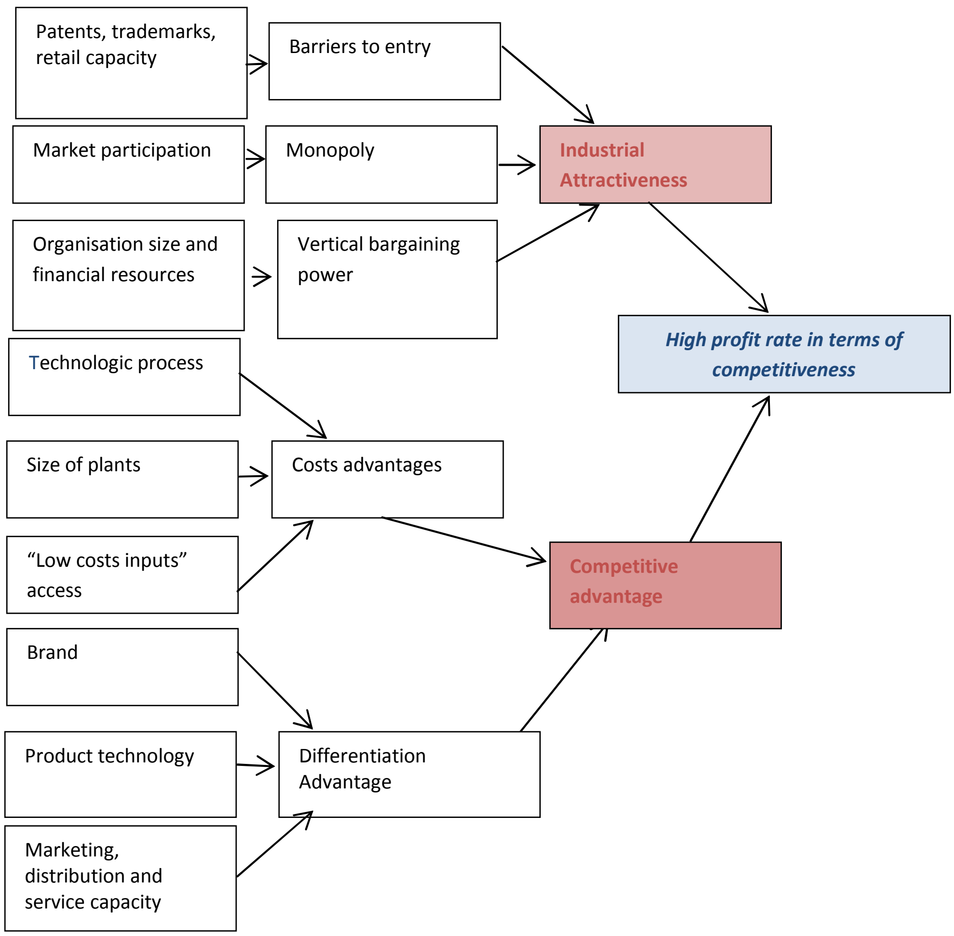


Figure 1– Basic Resources for Competitive Advantage Success
Source: Grant, R.M. (1991:7)

In recent years, researchers (e.g. Krugman) have been working on the "variable space", which influences the relationships between geography and the economy through international trade. Competitive advantages based on specialized agglomerations create relations between innovation, location and concentration of production.

2.1.3 The Organization Concept

Organization and scientific knowledge are linked to practical tasks due to a specific goal via technology (Galbraith, 1985).Porter (1985) argues that an organization is a set of activities performed to design, produce, deliver and support its products through collaboration and cooperation with other organizations in order to keep competitive. In a more traditional meaning, an organization uses primary factors, scarce goods and services in order to transform them into other goods and services: this information is the production.

The organization is an economic operator, which uses production factors (inputs) to produce an output (Sousa, 1987: 93).An organization produces goods and services geared to the value added creation which maximizes its usefulness.

Chiavenato (1987) argues that an organisation can use resources efficiently, yielding the best results. Organizational models can be rational or natural.

A rational model implies that the organization aims to achieve targets and predefined objectives (theories: Taylor's scientific management, Taylor's classical theory, Weber's bureaucracy theory).

The model describes the organization as a set of interdependent variable parts that together form a whole: each part contributes something and gets something from the whole, which in turn is interdependent on a wider environment. It is an open system, and presents expected uncertainty and unpredictability (Modern Management Theory grounded in system theory).

Table 3– Organisation Typology

Authors	**Organization typology**
Stanley Udy (1959)	Economic production organizations – organizations whose main function is economic andthat can develop other objectives according to the environment in which they operate (production and distribution companies, products and services); political organisations– organisations that aim to allocate forces in society(NGOs); integrative organizations – related to the adjustment of conflicts and thedirection motivation to fulfil certain social expectations (hospitals with the integration of services related to the social need for certain medical care); standard maintenance organisations – organisations whose main function is cultural oreducational(churches and schools).
Blau and Scott (1962)	Mutual benefit associations – the main beneficiaries are the organization's members themselves (cooperatives, associations, unions, etc.); Commercial interest organizations – the owners or shareholders are the main beneficiaries(private companies and public limited companies); service organizations –where the customer group is the main beneficiary (hospitals, universities, schools, religious organizations and social agencies); state organizations – where the beneficiary is the public ingeneral (legal institutions);
Etzioni (1967)	Coercive organizations –power is imposed by force or by checks based on premiums or punishments; utility organizations– organizations where power is concentrated in central economic incentives; normative organizations–where power is concentrated in the consensus on goals andorganization methods;
Pugh, d. S., Hickson, d. J., Hinings, c. R., & Turner, c. (1968)	Total bureaucracy –authority concentration, strong structuring of activities alongside a high degree of dependence, low integration of technology in the workflow, standard procedures for the selection and promotion of staff and formal functions; the “source” of total bureaucracy is the same as above, but to a less marked degree; workflow bureaucracy – highly structured activities, combined with little emphasis on other structural factors; bureaucracy work – flows spring with the same characteristics as the previous one, but to a less marked degree; bureaucracy pre-flow job – little activity structuring; implicitly structured organisation – low-structured activities; bureaucracy staff – little activity structuring and high line control, high concentration of authority.

2.1.4 Space, Territory and Knowledge

"A geografia, assim como a economia espacial e a ciência regional, tem na localização das atividades económicas e na articulação entre os diferentes lugares dois dos seus temas principais"

Castillo and Frederico (2010: 461)

The space precedes the territory (Saquet and Sposito, 2009) and the territory is the object of study of many disciplines and the subject of many policies (Dentinho, 2012).

Knowledge is the binding factor in relationships between individuals and organisations.

Knowledge and its integration are the basis for local development in a region. Therefore, knowledge is the basis on which individuals and organizations interact with economic development and sustainability. It is the key to maximizing the relationship between performance, people and procedures for decision analysis within organizations; i.e. the dynamic leads to a research connection between knowledge, information, and technology in a geographic space.

Haesbaert (2004: 87) defines territory as one of the main concepts that seeks to answer the problem of society and its relationship with space. An organization occupies territory in order to maximize its use. In this perspective, space and territory are involved in individual's utility functions in a particular place. Therefore, indexing the problem of business location, maximized utility is obtained when there is a low cost of implementation, through a relationship of three factors: location, territory and transmission of knowledge.

Utility is also determined when variables like investment, specialized work or natural resources can relate space and location (Raffestin, 1984; Saquet, 2005; Sack 1983; Saquet and Sposito, 2009: 82).

The relationship that individuals establish in the territory is completed when territorial governance establishes cooperation between agents (Saquet and Sposito, 2009).

In the territory there are physical, political, economic and symbolic dimensions (Lages *et al*., 2004:27), and these are related with territory dimension (size) and three main areas of activity (Lages *et. al.,* 2004: 45):

a) The innovative environments "milieux innovateurs" –a concept developed in the 1980s, which relates the environment as a set of material (organizations and infrastructures), immaterial (knowledge) and institutional elements (legislation) that make up a network of relationships directed towards innovation (Proulx, 1994; Camagni and Capello, 2002; Moulaert and Sekia, 2003; Amara et al., 2005).

b) *The production and innovative system*–a concept developed in the 1990s by Freeman (1982), Lundvall (1990), and Nelson (1993). From this perspective, innovation is a systemic and an interactive phenomenon involving various factors such as businesses, which establish links between the production, dissemination and use of knowledge.

c) *The new industrial space* – Storper (1997b: 20) assumes that: "an activity is totally" territorialized "when their economic viability is rooted in assets (including practices and relationships) that are not available in many other places and that cannot be easily or quickly created or imitated in places that do not have the same". These assets range from work and technologies to the capacity for interaction and relationships. Scott (1988:74) envisions the new industrial space as the "outcome of a twofold process involving a tendency for modern, flexible production systems to avoid older centres of accumulation, combined with a location dynamic implosion resulting from increasing levels of externalization".

Territorial dynamics are also based on spatial planning, regarding goals, means, processes, methods, setting and monitoring and strategic evaluation (Ferrão, 2014:41, 42) and the positive impact on regions is measured by the linkages between territory and organization (Lages et al., 2004:65).

However, activities have greater performance when they are in the same geographic area, with innovative activities, or technological districts (Cowan el al., 2001:181).

2.2 REGIONAL DEVELOPMENT

"We have become acutely aware in recent years of the existence of a 'regional' problem– the problem, that is, of different regions growing at uneven rates; with some regions developing relatively fast and others tending to be left behind"

Kaldor (1970:337)

Local and regional development has become an increasingly important activity for national as well as local and regional governments across the world since the 1960s and 1970s (Pikeet al., 2006: 3). Clearly, regional development has also become a problem for many economies, and one which organizations, people and policy makers are confronted with.

The economic, social, environmental and political factors relationships within a region are the main factors for the study of regional development and its positive or negative effects.

The phenomena which arise from the regional development can be conceptual or operational. The conceptual applies for the *variable space* (homogeneity of variances), *regional interdependence* (interactions between the socioeconomic system and the environment) and *multidisciplinary approaches* (interdependence between system elements), whereas operational regional development considers a scale of values adopted by society (Lopes, 1987).

Stimson et al. (2006:241) discussed regional development which influences the development of industrial clusters. Regional development is a list of new values (Gaspar, 1996) which identify a region based on the development of sustainable spaces.

Regionalism deals with economic growth within regions towards creation, improvement and value capture (Coe et al., 2004: 469,470).

Regional development and the regional innovation system (RIS) are connected. RIS allows a set of key factors to be identified, which contribute to understanding the innovation and economic growth considering the innovation system or the cluster process (Ramos, 2005:49). RIS allows the dynamics between SME and local environment to be quantified to settle objectively the local determinants of innovation in these firms (Fernandes, 2004:13).

The problems which arise from regional development have to be analysed through business opportunities, goods and services exportation, labour specialization, entrepreneurship and small business growth (Lopes, 1987: 22).

Regional planning leads to an economic development area, through regional development strategies (Pike et al., 2006). Its importance valorizes objectives for each economic activity and competitiveness advantage through employment and sustainable growth via business environments and strategies. Strategies in regions can end up in new development areas with more performance and competitiveness (Stimson et al., 2006: 256).

The importance of studying regional indicators arises from the fact that they are a measure that allows us to confirm economic, social or political phenomena. Cobb and Risford (1998) and Quivy and Campenhoudbt (1997) define the indicator as a study of a variable related to social, economic, environmental and political issues, which can be measured or not. From measurability, we can find qualitative and quantitative indicators, which allow the political objective quantification of technological process performance, or check if goals are achieved or pursued (Mourão, 2006: 80) (e.g. European Energy Policy 2020).

Mourão (2006:80) and Fernandes et al (2016:253) explain that indicators analyse relevant information. Mourão (2006: 80) defines the indicator as"*um indicador persegue os propósitos de clarificar e definir objectivos, guiar tendências presentes e futuras respeitantes a objectivos e valores, avaliar programas específicos, revelar progressos, medir mudanças em condições específicas ou ao longo do tempo, determinar o impacto de programas e formular propostas alternativas relacionadas com o processo de prossecução de objectivos*". The indicators explain relevant information qualitatively or quantitatively with eight criteria: policy applicability, specificity, validity, relevance, sensitivity, measurability, comprehensiveness and cost efficiency. The importance of these criteria allows policies to be set up according to the region. Also, these characteristics (axiom of anonymity, axiom of progressive transfers, bounds, decomposability), will also help us to understand why empirical results could differ depending on the index applied (Palan, N., 2010: 8).

The use of indicators allows us to present reliable conclusions about the evolution of certain variables (e.g. employment and investments), solutions regarding the region and regional policy implementation.

On the other hand, regional indicators can identify historical context problems, understand the situation in the region, and support decision-making for social and investment policies.

The qualitative and qualitative variables can be measured according to a small number of methods.

In this particular work, we point out the benefits of using specialization index *(SI) (A)* and location quotients *(LQ) (B)*.

For Salvador (1993), one of the most frequently used indicators to measure the degree of specialization in the economy is the SI. For Cabral and Sousa (2001:5) the outcome from SI enables "characterizing the region's economy in terms of greater or lesser specialization in its production structure compared to the standard".

There are two types of SI:

- *Absolute specialization (A.1)*(this describes a country's absolute specialization. A country would be considered specialized if a small number of industries exhibit high shares of the overall employment of the country);

- H*eterogeneity indices (A.2)* (this focuses on the deviation of a country's industry structure from the average industry structure of the reference group of countries) (Palan, N., 2010: 6).

According to the same author,

The absolute specialization indices (A.1) are:

1. The Hirschman- Herfindahl Index (HHI) – much used in industrial economics to measure market concentration and to investigate the existence of an oligopoly or cartel. It is also used as a measure of economic diversity and for macroeconomic specialization analyses; 2. The Shannon Entropy Index (SEI) – used in the research of income distribution; 3. The Ogive Index (OI) – used to study specialization when there

isequal distribution of employment across all sectors as an explicit benchmark for maximum dispersion; 4. the Diversification Index (DI) – used to study the employment shares of each industry of country n and then sort them in ascending order according to their size; itdoes not, however, compare the shares of each industry by pairs, but only compares the degree of specialization; 5. the Absolute Gini Index (AGI)(a measure of income equality and heterogeneity of economic structures. It has not yet been applied as an absolute measure in the field of specialization).

The heterogeneity indices (A.2) *are:*

1. The Krugman Specialization Index (KSI) –it is the standard index among the specialization measures. Basically, it is the standard error of industry shares, i.e. it calculates the share of employment which would have to be relocated to achieve an industry structure equivalent to the average structure of the reference group; 2. the Index of Inequality in Productive Structure (IP) –this is the variance of employment shares; it is similar's to Krugman's Specialization Index, but by adding up the squared deviations of employment shares, it gives more weight to large deviations; 3. The Relative Gini Index (RGI) –this is a common index in many fields of economics, with many applications also in the context of industry structure and specialization; 4. The Theil Index (TI) –this has been implemented for analyses of specialization and concentration.

The benefits of using these methods for estimating specialization are related to the capacity of product innovations, new forms of organization or new skills which are arrived at in interactive processes within industrial systems. This means studying new forms of agglomeration, where there is related economic activity recreated as a result of an increasing demand for rapid knowledge transfer between firms (Malmberg and Maskell, 1997:25). From another point of view, the industry measurement from SI, whether frominter-industry specialization or trade, reflects the conventional forces of comparative advantage accompanied by intra-industry specialization, which reflects economies of scale and consumers' taste for a diversity of products (Krugman, 1981:959).

B– The location quotient (LQ). The LQ can be defined as a measure of the relative importance of a certain industry sector or commodity in a region, or more significantly, the use of location quotients in estimating regional economic impacts (Isserman, 1977: 33).The measurements which occur in the regions related to economic impacts are the results of heterogeneity in the regions. Therefore, the location quotient is the measurement of a variable (e. g. employment, investment) when compared with the sector in the same region and the total of regions in a territory (QL= (eij/ei)/ej/E) (Salvador, 1993:106).The benefit of using the LQ for measuring regional economic impacts is the possibility of comparison variables from different regions. Therefore, it is possible to draw conclusions about the concentration, disparities, equilibrium or imbalance in the region when compared with other regions.

2.3. CLUSTER: CONCEPT AND THEORY

"Although the phenomenon of clusters in one form or another has been recognized and explored in a range of literatures, clusters cannot be understood independent of a broader theory of competition and competitive strategy in a global economy"

Porter (2000:16)

2.3.1 The Role of Geographical Concentration

There is no clear definition of a cluster; authors have similar definitions, connected to a situation of geographic concentration. Brown (2000:4) points out that, there is no cluster theory per se but rather a broad range of theories and ideas that constitute the logic of clusters.

The cluster is a major concept in present-day society, and reflects relationships between organizations in the market outlook.

Barsoumian et al. (2011:90) presented a theoretical foundation about local industrial concentrations which are linked with the agglomeration economies (Marshall, 1920), external location economies (Hoover, 1948) and cluster theory (Porter, 1990).

Alfred Marshall (1890) and Perroux (1950) point out that geographic concentration is associated with an industrial development sector (Simões, 2013), where specialization and knowledge are very important transfer (Alfred Marshall, 1890).

The evolution of these geographical concentrations can be presented taking in account territorial models:

- During the 19th the *first territorial model* came out – industrial districts with homogeneity of local institutions. The features are: a) territory of mainly small and medium enterprises, spatially concentrated and specialized by sector; b) a strong, relatively homogenous, cultural and social background, linking the economic agents and creating a common and widely accepted behavioural code, sometimes explicit but often implicit; c) an intense set of backward, forward, horizontal and labour linkages, based on market and non-market exchanges of goods, services, information and people; d) a network of public and private local institutions supporting the economic agents in the clusters (Armstrong and Taylor, 2000:293).

- The *second territorial model* presented by Porter during the 80's indicates s the factors which comprises the industry rivalry, such as, bargaining power from the suppliers, threats of new Entrants, threats of Substitutes and bargaining power of Buyers (Porter, 1980);
- The *third territorial model* arose during the 90s (regional innovation and learning regions). The features are: a) close networking between different firms and the many other private and public sector organizations promoting technology; b) free movement within the local labour market of persons with specialized scientific and management expertise; c) the spinoff of new SMEs from existing firms, higher education institutions and governmental research institutions (Armstrong and Taylor, 2000:298);
- The New Industrial Spaces Theory, considered as the *fourth territorial models*; clusters are considered as a "residual" from this third type because they do not have any affinity with the regional economy (Ferro, 2014:13). This means that there are linkages with other regions in order to develop business, innovation and knowledge. The regional cluster is residual because their relationships with others are strongly related to the agglomeration economies.

Few assumptions are made of industrial districts. Industrial districts are industrial concentrations where a specialization in tasks and competitive advantages are identified.

Brown (2000:15) expounds industrial districts as: a highly geographically concentrated group of companies that 'either work directly or indirectly, for the same end market, share values and knowledge so it is important that they define a cultural environment, and are specifically linked to one another, in a complex mix of competition and cooperation between firms, a result of a close intertwining of economic, social and community relations'.

Ferreira (2012:61) argues that "industrial districts" are the perfect osmosis between the local community and organizations. Garafoli (1994) cited by Ferreira (2012:59) analyses industrial districts according to small organizations' importance within an endogenous development.

Industrial districts can pass through a possible development process from "areas of productive specialization" via "local productive systems" to "systems areas" as the most advanced forms (Asheim, 1996:383).

The importance of industrial districts as a mature cluster (Keller, 2008:40) enacts cooperation (vertical or horizontal) between organizations and local economic agents, which contributes to local production, innovation capacity and sectorial business association.

The study of industrial districts and their goals toward better performance in a geographic place is a strategy for alternative models where existing activities are sustained or transformed.

Table 4– Productive Systems: Relationships between Organization and Exterior

Industrial Districts (Marshall and Becatinni); *Local production systems* (Garafoli)	Interpersonal networks, informal circulation of information; direct knowledge as a confidence factor; through the socio-cultural as accumulated culture; importance of mechanisms for collective learning; transfer of human resources; productive specialization a division of optical sectorial work; productive fabric functionally atomized; significant horizontal competition; importance of adaptation strategy market developments (demand response); open in graw material and/or final product to exterior market;	**Localization economy**
System-areas *Territorial Complexes* (Leborgne and Lipietz); *Innovative Means* (Aydalot)	Strong circulation information;geographical proximity as a favourable personal factor of contact direct for strategic decisions; intensity of relations around production (institutions, education, training, investigation, public administration); intra-sectorial jobs; integration, functional flexibility (horizontal/vertical): relative stability of customers and suppliers, subcontracting specialty, use of qualified services and diverse support; importance of innovative strategies.	**Agglomeration economy**

Source: Fernandes (2004: 56)

2.3.2 The Porter "Diamond Model"

The basic cluster model was presented by Porter (1990). Maxoulis et al. (2007), Zhao et al. (2011), Dögl et al. (2012), and Monteiro et al. (2013) are some of the many authors that use this model.

Porter’s Diamond Model is used to estimate the relationships within the internal variables (factor conditions, demand conditions, related support industries, firms' strategies, structure and rivalry) and external variables (chance, government) towards industry competitiveness.

Porter (1990: 77) argues that internal factors of competitive advantage are:

1- ***Factor conditions***: the region position in the factors of production, such as skilled labour or infrastructures, is necessary to compete in a given industry; the competitiveness in the market is also related to information that generates more data as a company performs its activities, as organizations collect and capture information that was lost and necessary (Porter, 1980:152). Therefore, information can be the key factor for stimulating the relationship within market factors, as described by Porter's Diamond Model (1990), since the information is the connection between activities in the market.

2- ***Demand conditions***: demand for industry’s product or service; home-market or international;

3- ***Related and supporting industries***: the presence in the region of supply industries and other related activities;

4- ***Firms strategy, structure and rivalry***: the conditions of cooperation and competition between companies. External factors, such as government policies (positively or negatively by their intervention in politics, economy, and chance (events or occurrences that are outside of the control of the firms, industries or even governments) (Aghdaie et al., 2012:133).

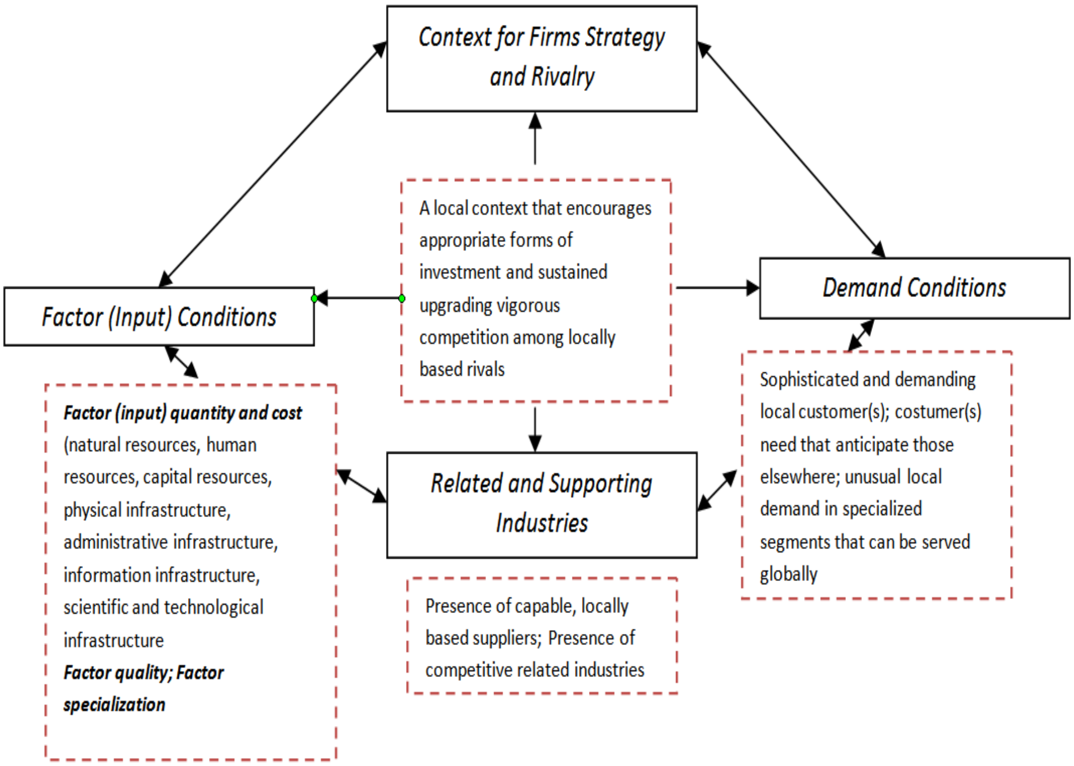


Figure 2– Porter Diamond Model
Source: Porter (2000:20)

The interest of studying Porter’s model relates to companies. Success is a game where companies play within the market, and as such "compete" in a dynamic process, where there are strategies towards competitive advantages.

Therefore, this dynamic process can be analysed using Porter’s Diamond Model. According to Porter (2000:18), clusters represent a new way of thinking about local economies and enhance competitiveness. Porter's Diamond Model can show the linkages between those and present solutions for cooperation and competitiveness in the long run.

This means more coordination and mutual improvement in areas of common concern with less risk of distorting competition or limiting the intensity of rivalry (Porter, 2000:20). Therefore, the Diamond Model demonstrates cooperation and competitiveness' linkages within market conditions, and promotes the organisation’s position among others in the market.

The objective is to obtain success in the market with a relative gaining position. Competitive advantage is related to lower cost than rivals, or the ability to differentiate and command a premium price that exceeds the extra costs of doing so (Porter, 1991:101).

The organisation performance in the market is divided into opportunities and values and barriers.

Table 5– Market Barriers

		Exit Barriers	
		Low	High
Entry Barriers	Low	Low returns	Worst case
	High	Best case	High returns, but risky

Source: Porter (1980:37)

The organization challenge is to be part of the market as long as the market needs. Since 1980, Porter has presented a number of models where the organization's position in the market is analysed, taking into account external or internal factors. As such, its importance reveals the capacity of organizations in the market towards a better performance and utility.

The study presented by Porter (1998) indicates the typology of Portuguese Regional clusters. According to the author, Portuguese exporting clusters tend to be more natural resource and labour intensive; this means that the industries' typologies are directly linked with the regional products (e.g. wine, horticulture) where intensive labour constitutes an important factor.

A number of points have to be discussed about Portuguese Regional clusters:

Firstly, the clusters location in the region, which is directly related to natural conditions and resources;

Secondly, local engagement, which is related to the capacity of the companies, suppliers, institutions to create the potential for economic value; about this matter the investments made in industries in recent years have given the local companies and stakeholders the capacity to create economic value;

Thirdly, upgrading the clusters, which means upgrading new industrial processes to be more competitive; most Portuguese companies from the cluster have benefited from new industrial manufacturing processes from the use of European funds;

Fourthly, working collectively, the Portuguese clusters are not yet fully organised by associations, although, governmental institutions, such as IEFP,[2] have an important role in training and research programs in the companies.

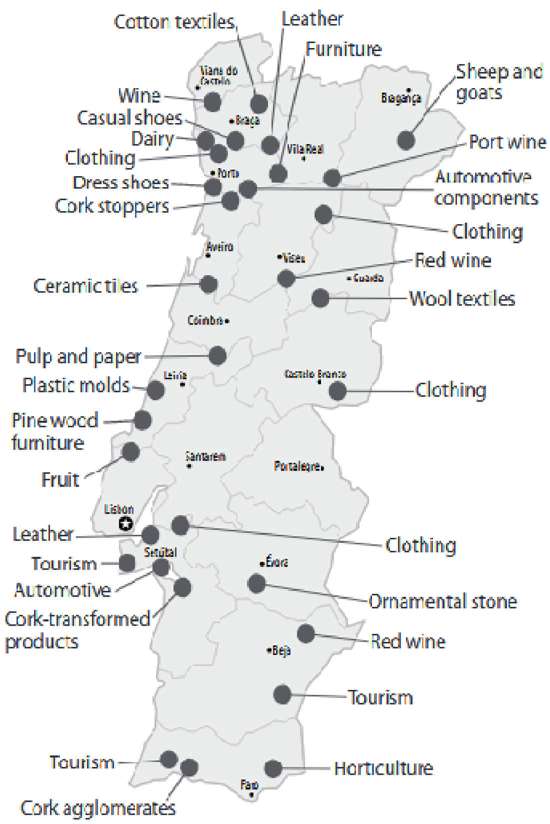


Figure 3– Mapping Portugal's Clusters
Source: Porter (1998:87)

[2] The Institute of Employment and Professional Training

The Diamond Model by Porter (1990) applies more technology, human expertise and the use of natural resources with less direct and indirect costs, moving towards competitiveness. Porter's Diamond Model is considered by several authors as a good model to study competitiveness in the energy sector (Maxoulis, C. N. et al., 2007; Zhao et al.,2011; Dögl et al., 2012:193).

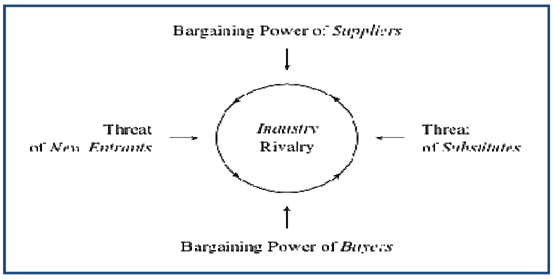
Table 6–Operationalization of Porter's Diamond Model for the Renewable Energy Industry

Determinants	Contents	Causal Variables	Proxy Variable
Factor conditions	Solar resource potential, generation costs and on-grid power price, programs and projects, and technology	Natural resources; Scientists, Infrastructure &innovation	Available potential of renewable energy resources; Quality of math and science Education; Renewable energy infrastructure; Patent applications field under the PCT for renewable technologies;
Demand Condictions	Overall market, installed capacity, and on-grid PV systems	Market size &growth; R&D investments &sophistication	Currently installed capacity in MW Market growth (% p.a.);New investment by region; Education index;
Related and supporting industries	Industry rules, and industry competitions	Related &supporting firms; R&D investments	Share of medium & high-tech value added in total manufacturing; Gross domestic expenditure on R&D;
Firm strategy, structure and rivalry	PV cell manufacturing, and grid construction industry	Competition in home product market; M&A innovative drive	Competition intensity; - Corporate M&A by country of Target Capacity of innovation;
Government and culture	Legislation, policies, financial incentives, and taxation	Government support; Impact of national culture	Financial support systems and environmental regulations; Hofstede: Values for "Masculinity"and "Uncertainty Avoidance"
Change	Industry advantages, and industry challenges		

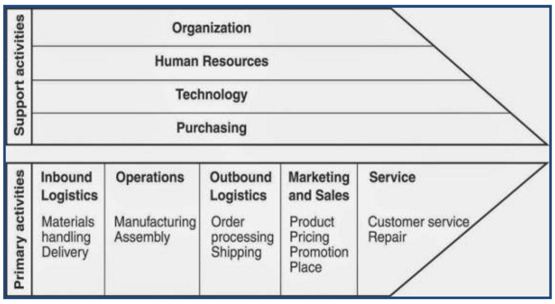
Source: Dögl et al. (2012:197); Zhao et al (2011:4970)

Porter's model comprises a number of stages in accordance with the regional development and cluster performance. This means that clusters and their position in the geographic space and the relationships with others organisations, government policies and the consumers are the basis for this evaluation. Therefore, the four stages presented comprise these relationships. The Diamond Model is one of them and comprises the stages where there are factors which influence the cluster implementation and development in the region.

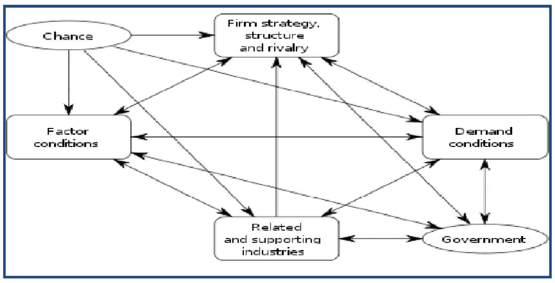
Phase 1- **Competitive advantage by positioning**
(*PORTER, M. Competitive Strategy: Techniques for analyzing industries and competitors. New York: The Free Press, 1980*)



Phase 2- **Value Chain**
(*PORTER, M. Competitive advantage: Creating and sustaining superior performance. New York: The Free Press, 1985.*)



Phase 3- **Diamond Model**
(*PORTER, M. The Competitive Advantage of Nations. New York: The Free Press, 1990.*)



*Phase 4 -***Value-based competition**
(*PORTER, M.; TEISBERG, E. Redefining health care: Creating value-based competition on results. Boston: Harvard Business School Press, 2006*).

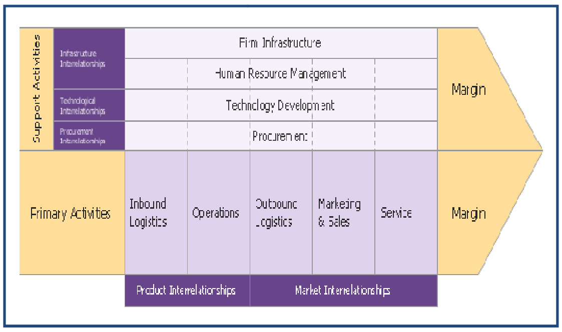


Figure 4– Porter's Competitiveness Models

2.3.3 The Evolution of the Cluster

The development of cities, information and regions gave industrial districts a new concept based on a hub-and-spoke industrial district, revolving around one or more dominant, externally oriented firms; a satellite platform, an assemblage of unconnected branch plants embedded in external organization links; and the state-anchored district, focused on one or more public-sector institutions (Markusen, 2017:177).

Audretsch and Feldaman (1996:257) found that the propensity of innovative activity to cluster geographically tends to be greater in industries where new economic knowledge plays a more important role.

However, we should point out that: “Industries which are undergoing rapid change and innovation and which produce specialty products tend to cluster together because of the need for specialized resources, particularly skilled labour, not available elsewhere” (Browne,1980:6, quoted in Audretsch and Feldaman,1996:265). For this reason, industrial districts tend to evolve towards innovation clusters, where there is knowledge in product and services.

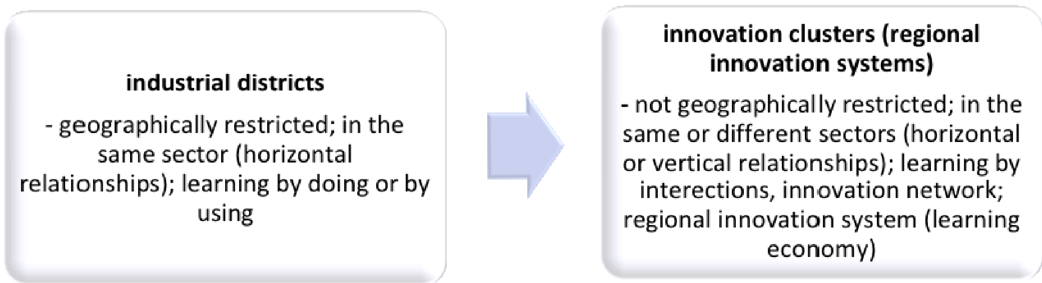


Figure 5– Industrial Districts vs. Innovation Clusters
Source: Fernandes (2004:59)

The cluster concept is the sum of several authors and concepts (Arancegui, 2003:16):

“economic innovation: innovation system; national, sector and technological systems", "economic organization – transaction costs, organization and resources theory", "economic geography– industrial districts" and "leading economy – new trade theory, new growth theory, location theory and regional growth and convergence".

The cluster is an important element in economic development (Menzel and Fornahl, 2009; Broekel, 2015; Porter, 2000).

In regional industrial clusters there are relationships, leaderships and infrastructures, networking, marketing intelligence and capacity building, and the use of endowed resources is maximized.

Therefore, regional economic performance is a sum of identifying industry clusters, examining changing markets, assessing supplier adequacy and identifying the foundations for each industry (Stimson et al., 2006:247). The clusters depend on geographic location, either horizontally or vertically (Ianca and Batrinca, 2010).

Nowadays, the cluster concept is adopted by several organizations (OECD, 2005). Clusters reveal the interaction between sectors; therefore their importance reflects a territory with the same economic characteristics and complementary services (technologies, skills, information, marketing, customer needs in organizations and industries) (Porter, 2000:18).

Porter (1990) argues that the advantages of the cluster approach is based on location and interaction factors. These factors promote economic advantages and linkages between companies, associated services in organizations (universities, organizations or trade associations) towards competitiveness and cooperation (Porter, 2000; OECD, 2005). Porter (1996: 85) stressed the definition of the cluster as a group of industries connected by specialization buyer-supplier relationships as related by technology or skills.

The cluster establishes development strategies in a particular activity sector, associated with increasingly specialized services. Clusters can be recognized by their geographic concentration, both horizontal and vertical (Ianka and Batrinca, 2010); clusters can be urban, regional or local (Iammarino and McCann, 2006), considering geographical location, synergies and collaboration of institutions (Porter, 2000).

Clusters are identified with industries' location in a region (Ianca and Batrinca, 2010; McDonald et al., 2007), dependency factors on natural resources (e.g. wind, water), tacit knowledge (codified knowledge towards spatial proximity on innovation, inter-firm collaboration and firm performance (Titze et al, 2011:91)), research and development.

The attractiveness from various domains constitutes an industry or a group of business areas (Ketels et al., 2013). These authors identify three pillars for cluster organization: attractiveness; innovation and R&D; and business development, which determine its success in terms of technological innovation.

The study of clusters and their location reveals a capacity to connect with other sectors, essential for creating competitive advantages for development strategies, and for specialization of quality sectors/services.

Asheim (1996:7) emphasizes that Porter's cluster is basically an economic concept, indicating that "industries are usually linked through vertical (buyer/supplier) or horizontal (common customers, technology, channels, etc.) relationships".

Clusters also are related to smart specialization, [3]knowledge and innovation (European Commission, 2016:13). From the European perspective, the *European Cluster Observatory, European Enterprise Network and Key Technology Infrastructures (European Commission, 2016:41)*, tried to bring together European Member States and regions in designing smart specialization and cluster strategies to assist companies in developing new, globally competitive advantages in emerging industries (European Commission, 2015:1). Clusters play an important role as catalysts for structural change, new industrial value chains and emerging industries, through a favourable environment facilitating entrepreneurship and cross-sectorial collaboration (market intelligence, matchmaking, project development, technology transfer and innovation vouchers) (European Commission, 2014:4,11).

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[3]*Smart specialization* is based on a set of strategies, such as: supporting investment on key vertical/regional priorities/challenges and needs for knowledge-based development; building up strengths, competitive advantages and potential for excellence; supporting innovation and stimulating private sector investments; the set of stakeholders involved and encouraging all forms of innovation and experimentation; monitoring and evaluation systems (European Commission, 2016:13).

Benito et al. (2003:203) stress: "Research has time and again shown that dynamic industrial and local clusters are important for the creation of economic value and, ultimately, for the prosperity of nations and the well-being of their citizens"

"Clustering" means a process where companies *collaborate* with each other to identify market failures. The clustering initiatives serve to streamline existing clusters of horizontal or vertical products.

The concept which arises from the word clustering is associated with marketing intelligence. This means using several tools to identify future collaboration spaces (European Commission, 2014: 13). Market intelligence is key to the successful anticipation of a new business opportunity– both in regard to developing new markets for already existing products and services and to developing products and services to be sold in markets that are just emerging due to the new needs of society and industry (European Commission, 2014: 12).

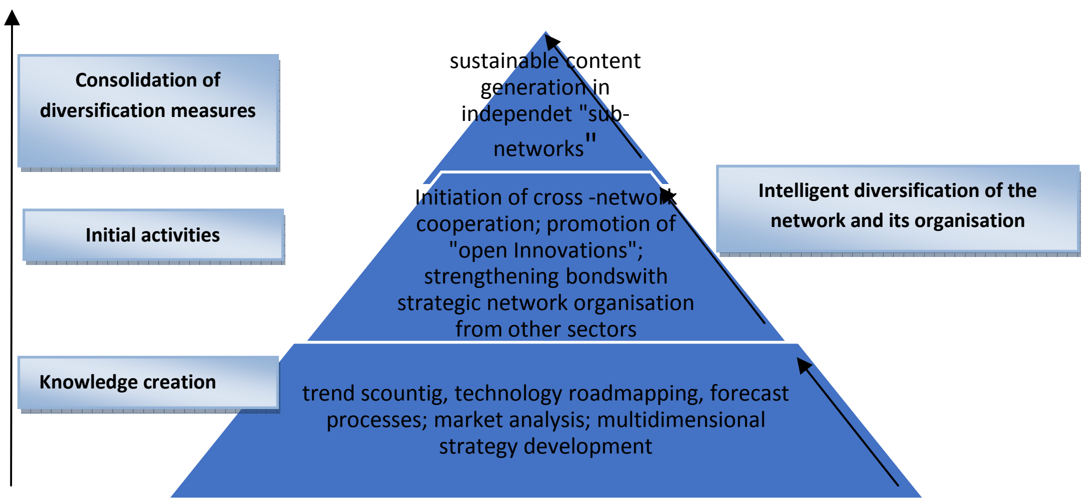


Figure 6– From Roadmapping to Cluster-to-Cluster Collaboration

Source: European Commission (2014, 13)

According to Fowcs-Williams, I.F.O.R. (2000:9) the clustering process should present various aspects: people and contact between them; consensus among participants; cluster actors at various levels; the connection between private and public sector; government acts as the main promoter through neutral participants; and cluster needs and benefits through “wish-lists”.

The clustering process is dynamic and involves internal and external actors. However, it depends on particular features present in a region, namely, specialized human resources, tacit knowledge or transmission of partial knowledge among multiple cluster members, infrastructures, communication and support services for information and communication technologies, business activity, and intervention at the regional level through national or supranational organizations (Cowan et al., 2001).

Menzel and Fornahl (2009) present cluster dynamics according to several stages, based on the growth strategy in various sectors and competitiveness, job creation, wealth, economic and social cohesion and efficiency across borders, with the aim of more equality between regions and industrial reorganization (Faustino, 2013).

The cluster cycle reflects an evolution (Broekel et al., 2015); its development promotes activities in the region (Ianca and Batrinca, 2010) and R&D organizations not available elsewhere (Audretsch and Feldman, 1996).

The environment where the cluster is embedded is the key factor for studying its dynamics and impacts on consumer demand for goods and services and on market regulations.

It is essential to strengthen the ability to create innovative ideas and creative capital gains, transforming ideas into concrete and sustainable realities through ideas exchange networking, providing delivery platforms through an efficient industrial sector, and finally, creating market needs in a particular geographical location.

The dynamics between the cluster and its environment promotes the development of various stages of growth and satisfies targeted regional needs related to local economic growth (OECD, 2005).

According to Ketels (2005:2) clusters and competitiveness are conceptual frameworks used to analyse the differences in economic performance across locations.

Cluster typology is identified with a number of aspects:

- *Geographic location*: connected organizations and institutions working in the same industry and with the same branch location. Organizations establish a causal relationship among themselves on the basis of natural resources, equipment, demand, or other factors that incite a particular sector's development (Santos and Varvakis, 1999);

- *Horizontal form*:when organisations produce the same products/services with cooperation (Keller, 2008);
- *Vertical or lateral form:* heterogenic and complementary specialised organisations which produce in time through a value chain (Piekarske and Torkomian, 2005);
- *By sectors*: arrangements (or systems) production (as sets of economic activities that enable competitiveness) as agglomorates (clusters) of certain sectors, which present a labour divisionbetween actors and coordination (horizontally or vertically) (Crocco et al., 2006).

OECD (2005) argues that the methodology used to define cluster typology is not always considered rational because the industrial concentration of a particular industry is not always a cluster.

It is considered a failure of geographical identification if the cluster benefits do not identify the regional actors' involvement.

For Piekarski and Torkomian (2005), it is possible to relate clusters with their performance analysis at the macro, medium industrial and micro business level. Therefore, it is possible to determine the level and actors' influence in geographical space.

The key characteristics of clusters that influence the design evaluation include (European Commission (b), 2016:43):

1. The type of cluster: e.g. industrial cluster, research-driven cluster, launched through a government policy or without public intervention, mature or emerging cluster;

2. Geographic scope: e.g. regional, cross-regional (within one country), transnational (in macro regions), international;

3. Thematic/industrial scope: e.g. narrowly defined cluster, sectoral focus, cross-sectorial or thematic focus; contribution to societal challenges;

4. Type of public intervention: e.g. supporting networking, channelling research and innovation funding through clusters, conducting training activities, supporting the internationalisation of SMEs, providing support to infrastructure.

As Rocha and Sternberg (2005: 267) argue: “Both clusters and entrepreneurship are highly visible among academics and policy makers given that similar historical conditions explain their resurgence and supposed impact on employment would justify their economic importance”.

Entrepreneurship is a complex process which stimulates business creation, while the cluster still involves industry agglomeration factors. The cluster is directly related with interaction between organizations (public sector, companies, universities, citizens and NGOs). The relationships that are established inside a cluster can be: bottom-up planning – the cluster is formed from companies and their networks towards efficiency in arrangements and organization (Porter, 2000).

Rocha and Sternberg (2005) argue that the relationship between clusters and entrepreneurship is based on the connection between new organizations and product or service supply towards economy of scale and an open market.

The planning process is the way by which clusters can be voluntarily established. Intrinsically, clusters allow complementary relationships between organizations, beginning with regional entrepreneurship planning. The planning process is consistent with decision-making from the organisation. This means that in the short run the organisation takes decisions for the near future, such as: (a) how to approach the planning problem; (b) what knowledge bears on the problem; (c) what kinds of actions to try to plan; (d) what specific actions to plan; and (e) how to allocate cognitive resources during planning (Trochim, 1989:1).

Cluster planning is based on four steps, related to performance in the market, capacity to deal with other organizations, and planning to go forward for the next step. This means that the cluster is dynamic with capacity for growth both in specialized products and the market itself.

Nevertheless, the planning process in the cluster is dynamic and goes through all stages to improve its capacity to be in the market and cooperate for better management decisions.

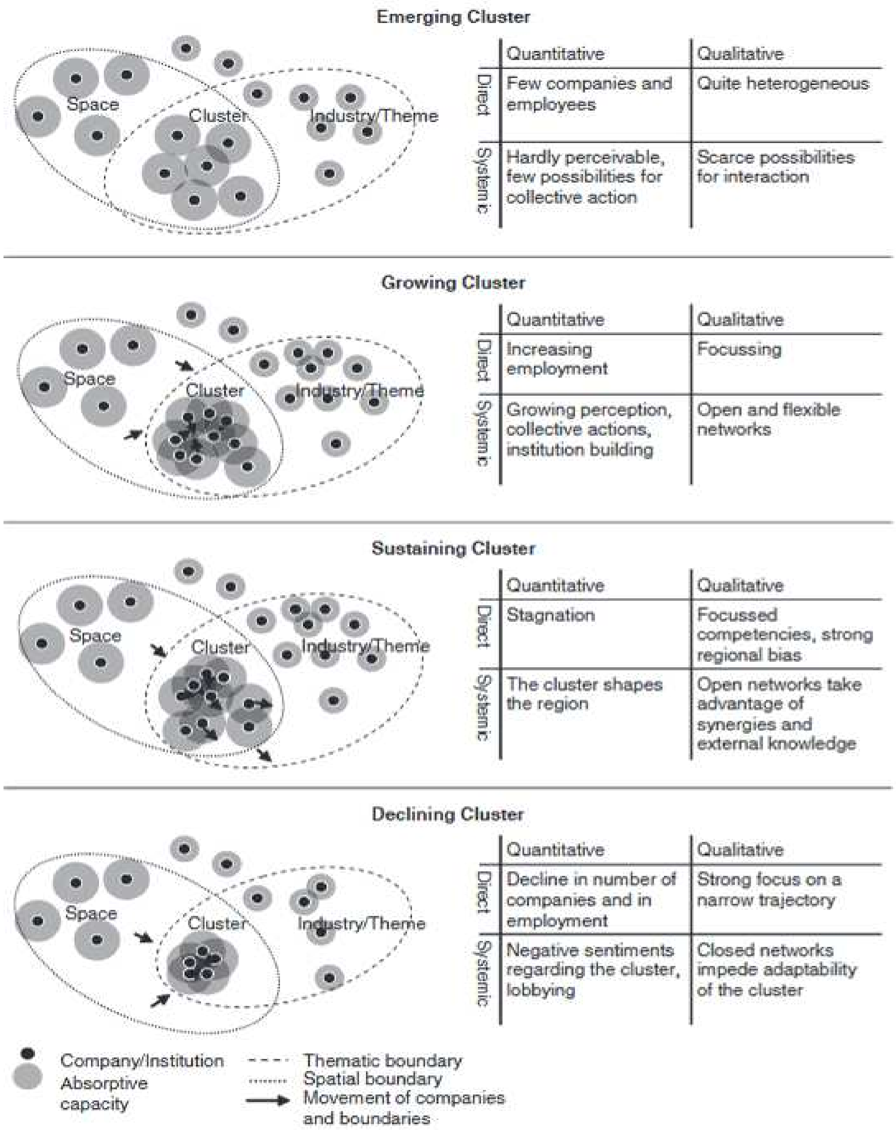


Figure 7– The Cluster Life Style
Source: Menzel and Fornahl (2009:229).

Clusters make market mechanisms more efficient for entrepreneurship than an industrial agglomeration because they establish complementary relationships with other sectors and create externalities from competitive advantages. These benefits are related to collective efficiency (Schmitz, 1992; Canie and Romijn, 2003): efficiency is related to production factors within an economy, independently of the development stage and cultural pattern (Rossetti, 1997:191).

Cluster potentiality and its impact on the economy relays on modern cluster policies that interact with smart specialization strategies across regions within an international value chain and emerging industries (European Commission (b), 2016:53).

The cluster’s value is smart specialization. There are direct linkages between smart specialization, cluster development, entrepreneurship ecosystems, new workspaces and business related facilities, and attraction of investment and knowledge (Rivas, M., 2016:18). The challenge is to face a new concept of clusters when there is innovation and knowledge.

This means studying the relationships between organisations based on value chains, externalities, innovation, collaboration and knowledge, when there is a cluster policy orientated towards impulsion and local stakeholder coordination and animation.

The interesting thing about the cluster is to observe how it is implemented and how it will survive based on the cluster's policy. The argument to study cluster policy is related to the decision-making process taken by companies as to their location and differences in success across locations (European Commission (b), 2016: 17).

Cluster policy arises from the fact that the cluster will survive if there are no market failures; this means that the market has offered benefits in terms of effectiveness. The fact is that the cluster policy can play an important role in changing a linear economy to a circular economy. Changing attitudes and valuing natural resources is the biggest step for economies. A circular economy provides a framework to face challenges and a guide for rethinking and redesigning the future.

Therefore, in the global economy, the challenge is to prove the benefits of belonging to a circular economy and natural innovation system.

Cluster policy also helps change business models and value chains when there are positive externalities from industries which constitute the cluster. Therefore, the European policy programme works towards new design, strategies and instruments for competitiveness and supporting mature clusters and developing emerging industries.

From the business perspective, cluster policy focuses on economic development based on specialization, innovation and internationalization. The cluster policy is based on three topics: analysis, strategy and action (European Commission (b), 2016: 25).

Cluster policy analysis consists of developing new strategies for more competitiveness, i.e., the choices to be made as to the ambition and value proposition that the location aspires to pursue. The local economy plays an important role for cluster policy analysis, when considering the dynamics and that is is subject to different sets of business environments (European Commission (b), 2016: 27).

Cluster policy supports a cross-sectorial collaboration on marketing intelligence (identifying opportunities in other industries), matchmaking (finding partners in other industrial sectors), project development (translating market intelligence and match marketing into cross-sectorial innovation), technology transfer (spreading capacity and knowledge), innovation vouchers (channelling funding through a cluster organisation) (European Commission, 2014:11; European Commission (b), 2016: 35), e.g., the international cleantech network (ICN) (www.internationalcleantechnetwork. com); regional meta clusters (www.multicluster.pl); European strategic cluster partnership (www.clustercollaboration.eu/escps).

Table 7– Dos and Don’ts of Modern Cluster Policy

Don’ts	Dos
Support individual specialised firms	Support new activities, in particular those being undertaken by groups or networks of related industries
Create clusters from scratch (i.e. implementing 'wishful thinking' of policy makers)	Facilitate the growth of clusters by building upon existing strengths (i.e implementing evidence-based policy by building upon a comparative analysis of regional strengths and 'entrepreneurial discovery')
Fund large numbers of widely varied clusters	Fund strategic cluster initiatives that focus on promoting the strengths, linkages and emerging competences and which are in line with the aims of national/regional smart specialization strategies
Follow growth trends without reflection	Capitalize upon regional competences to diversity into new activity areas and to develop emerging industries
Follow a narrow sectorial approach	Follow a systematic cluster approach focusing on related industries by capturing cross-sectoral linkages
Develop and implement cluster policy in isolation from other policy areas	Adopt an inclusive and participatory cluster approach (i.e. involving business, investors, academics and policy makers, and making links related to policy themes such as R&D, innovation, entrepreneurship, access to finance, SME internationalization, etc.)
Support cluster initiatives that are only inward looking	Support cluster initiatives that have an international perspective on the position of the cluster in international value chains
Focus exclusively on strengthening regional partnerships	Build regional partnerships as a basic for joining European Strategic Cluster Partnership

Source: European Commission (b) (2016: 23)

CHAPTER 3 – MARITIME ECONOMY AND CLUSTERS

"O Mar - Portugal é um desígnio nacional cujo potencial será concretizado pela valorização económica, social e ambiental do oceano e das zonas costeiras, para benefício de todos os Portugueses"

Governo de Portugal (2013:7)

The third chapter, Maritime Economy and Clusters, discusses the maritime economy and maritime clusters. The importance of this chapter consists of providing concepts related to the development of the ocean economy, namely emerging industries, in which offshore wind and wave are included. The concept of maritime strategy, including maritime projects and clusters, clusters typology and European ocean projects are presented. Additionally, the recent analyses of the Portuguese maritime economy are discussed.

3.1 MARITIME ECONOMY

"Ó mar salgado, quanto do teu sal
São lágrimas de Portugal!
Por te cruzarmos, quantas mães choraram,
Quantos filhos em vão rezaram!
Quantas noivas ficaram por casar
Para que fosses nosso, ó mar!
Valeu a pena? Tudo vale a pena
Se a alma não é pequena.
Quem quer passar além do Bojador
Tem que passar além da dor.
Deus ao mar o perigo e o abismo deu,
Mas nele é que espelhou o céu. "

Mar Portuguez, Fernando Pessoa (1888-1935)

OECD (2016:21-23) defines maritime economy as: "*all the sectorial and cross-sectorial economic activities related to the ocean, sea and coast. This includes the closest direct and indirect supporting activities necessary for the functioning of these economic sectors, which can be located anywhere, including in landlocked countries*".

The concept of ocean economy presented by Park et al. (2014) cited in OECD (2016:21) refers to "economic activities that take place in the ocean, receive outputs from the ocean, and provide goods and services to the ocean".

The marine economy is related both to emerging ocean industries and established ocean-based industries.

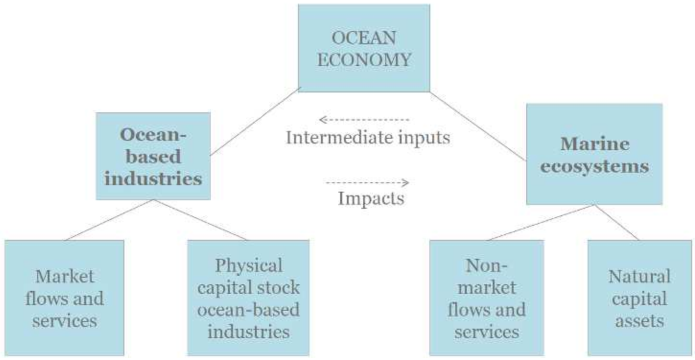
Table 8– Ocean-Based Industries

ESTABLISHED OCEAN-BASED INDUSTRIES	EMERGING OCEAN-BASED INDUSTRIES
Industrial capture fisheries	Industrial marine aquaculture
Industrial seafood processing	Deep and ultra-deep water oil and gas
Shipping	Offshore wind energy
Port activities	Ocean renewable energy
Shipbuilding	Marine and seabed mining
Offshore oil and gas (shallow water)	Marine safety and surveillance
Marine manufacturing and construction	Marine biotechnology
Maritime and coastal tourism	High-tech marine products and services
Marine business and services	Others
Marine R&D and education	
Dredging	

Source: Jolly, C. (2016: 8)

The concept of maritime economy is also related to investments made in each maritime sector. The relationship between them is the capacity to be involved in the market creating flows of services and products. Ocean-based industries need to invest capital and generate financial flow, while the marine ecosystem has natural capital assets, and does not operate directly in the market.

Table 9– The Concept of Ocean Economy



Source: Jolly (2016: 7)

As Jolly (2016) describes the ocean economy deals with ocean-based industries and marine ecosystems.

Stopford (2009:49) considers that the maritime economy includes vessel operations, shipbuilding, marine resources, marine fisheries and other maritime-related activities.

European maritime sectors have strong positions in the world (Peeters, 2008: 9).

Table 10– European Union Maritime Activities

European Union Maritime Activities	Jobs		Value (million €)	
Coastal and Maritime Tourism	1,614,968	48,0%	51,234	28,8%
Aquaculture	90,464	2,7%	1,633	0,9%
Renewable Energy	20,465	0,6%	2,640	1,5%
Mineral Resources	2,034	0,1%	228	0,1%
Biotechnology	185	0,0%	9	0,0%
Fisheries	732,239	21,8%	22,978	12,9%
Transport	520,281	15,5%	66,943	37,6%
Shipbuilding and Ship Repair	362,126	10,8%	17,891	10,1%
Offshore Oil and Gas	19,748	0,6%	14,344	8,1%
TOTAL	**3362510**	**100%**	**177,900**	**100%**

Source: Salvador et al. (2015: 4)

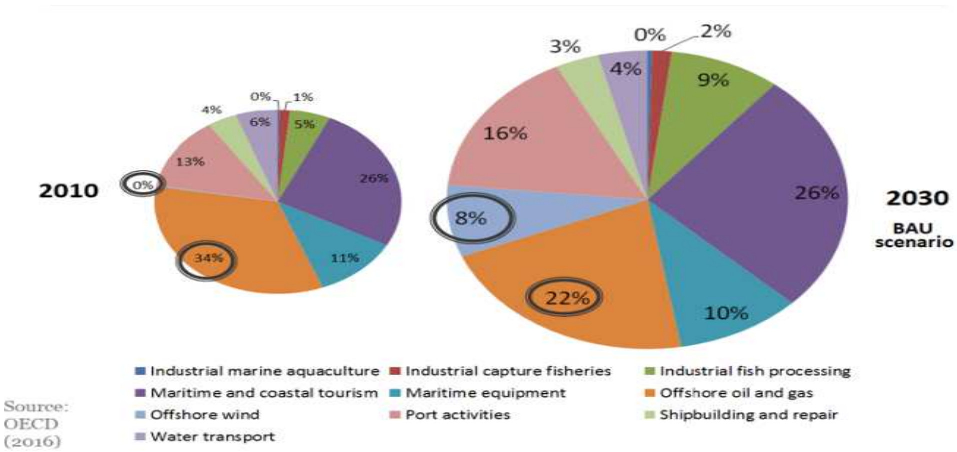


Figure 8– Ocean Industry value added

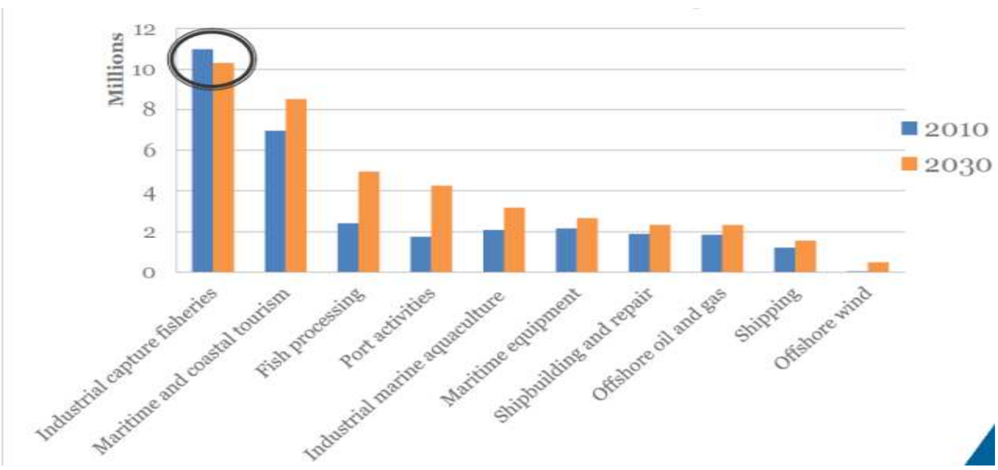


Figure 9– Ocean Industry employment
Source: Source: Jolly (2016: 15-16)

According to Jolly (2016) and Salvador et al. (2016), it is possible to conclude that the maritime sector with the greatest impacts on the economy are coastal and maritime tourism, fisheries, transport and shipbuilding. The tendency for 2030 is to maintain the same maritime sectors. Additionally, offshore wind energy will have the most substantial impact on value added in comparison with other maritime sectors. Employment will follow the same behaviour in maritime sectors.

Jolly (2016) points out the growth of ocean industries, where modest growth is related to capture fisheries, offshore oil and gas extraction in deep water; high long-term growth is related to shipping, shipbuilding, offshore wind, marine aquaculture, tourism, surveillance and safety; long-term potential but not yet on a commercial scale is associated with ocean renewable energy, marine biotechnology, deep-sea mining, carbon capture and storage.

At the European level, policy focuses on ensuring a strong competitive position in the world. In this respect, the European Commission develops measures to improve competitiveness and innovation under its policies for industry, transport innovation, shipbuilding and regional development research. National maritime policies are in line with European trends and policies. National maritime policies in general focus on stimulation of R&D increasing the intake of personnel and improvement of education, the promotion of the maritime cluster and the implementation of the State Aid Guidelines on Maritime Transport (Peeters, 2008: 14).

Maritime sectors comprise activities linked to the sea: the link between activities and the sea may be explained by the use of marine resources, marine areas or by the vicinity of these areas. The relationship between the activities and the sea can be more or less direct and maritime sectors cannot be seen as a single sector activity within the NACE classification but rather as a set of activities (Salvador et al., 2015: 3)

Simões (2013:96) identifies the maritime economy with these main sectors: fisheries and aquaculture, preparation and storage of fish, crustaceans and molluscs, shipbuilding, ship repair, transport by water, auxiliary transport activities by water (maritime ports) and activities of recreational boating and marinas. The sea economy tries to study consumption and production of goods and services related to economic activities, both directly and indirectly from the sea (INE,[4] 2014:1). According to the Portuguese Satellite Account for the Sea (SAS, 2016) the Portuguese maritime economy includes the following sectors:

1- Fisheries, aquaculture, processing, wholesale and retail of its products;

2- Non-living marine resources;

3- Ports, transports and logistics;

4- Recreation, sports, culture and tourism;

5- Shipbuilding, maintenance and repair;

6- Maritime equipment;

7- Infrastructure and maritime works;

8- Maritime services; and

9- New uses and resources of the ocean (unconventional energy resources– gas hydrates; marine renewable; gas storage).

Concern in grew uses and resources, Statistics Portugal (2015) measured a classification of these activities (fig. 10).

[4]Statistics of Portugal

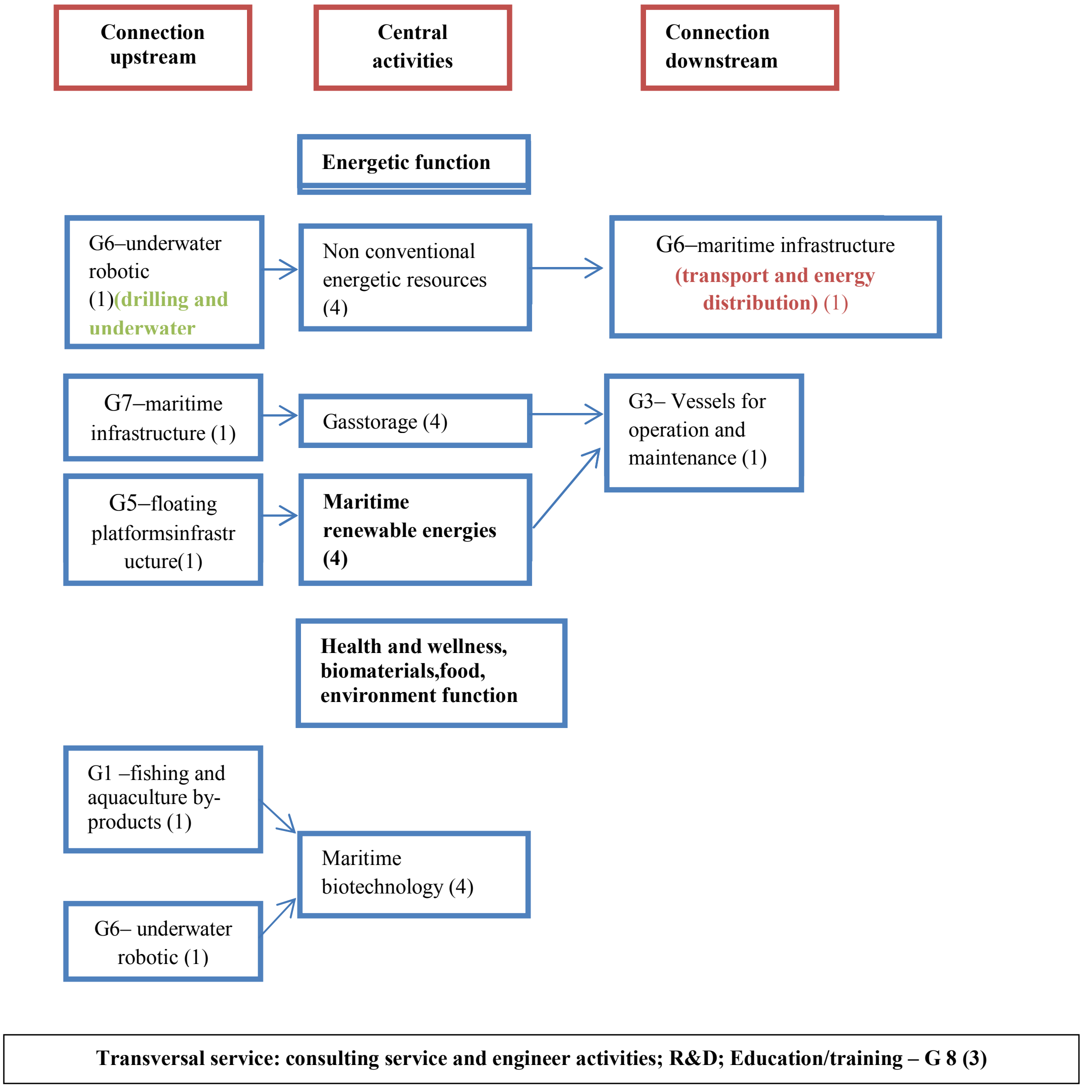


Figure 10– New uses and resources of the ocean value chain[5]
Source: Statistics Portugal (2015:16)

Marine renewable (**e.g. *energy)*** are considered a resource where there are linkages with the ocean value chain. Therefore, ocean energy is considered an important industry because it supports a connection between upstream and

[5] 1–Satellite account for the sea activity (or not); 2– connection activity upstream, activity centered on value chain; 3– transversal services;4– central activity based on value chain

downstream services and improves business opportunities. Marine energy can also be considered an important resource in the Atlantic area.

As Lima (2016:63) puts it "Nunca como hoje a bacia atlântica foi capaz de cruzar uma variedade tão interessante e tão rica em recursos, tecnologia, transporte, inovação e economia, catapultando a região para a primeira linha geopolítica da energia global".

3.2 MARITIME CLUSTERS

"Maritime clusters can derive benefit from knowledge sharing and knowledge transfer from research, encouraging joint innovation exercises (e.g. product development), ensuring availability of know-how (e.g.joint training programs) or innovative organisation methods covering a group of enterprises (e.g.common procurement or distribution)"

Wijnolst (2006: 16)

The Green Book about Maritime Europe published in 2006 is the first step to a global maritime strategy for the sea (Salvador, 2010).

The maritime activities development and coordination are based on Regulation (EC) No 1255/2011 from 30th November 2011. The European Integrated Maritime Policy (IMP) has enabled European economies to rethink maritime clusters as the best form of organization and promotion of its maritime business activities. Therefore, the cluster concept can be associated with sea business (Salvador, 2014) and its benefits, (cooperation and collaboration within the cluster) may be related to the concept of maritime cluster (Shinohara, 2010).

According to Cluster (2012:382), the maritime industry is a large and globally interconnected entity, in which it often makes little sense, to analyse national markets individually, as they are most often interrelated, due to commerce, transport and exchange of goods, as well as trade in general being a bilateral agreement.

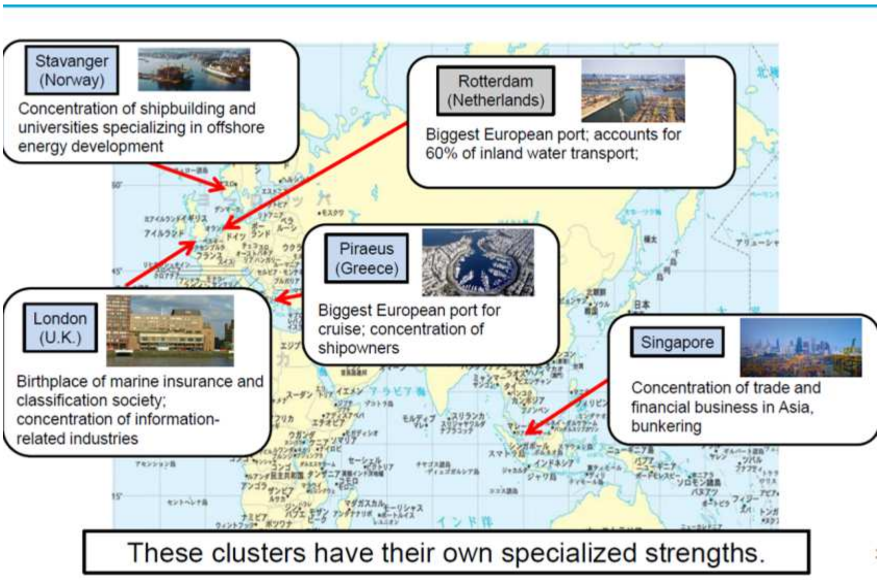


Figure 11– Maritime clusters of the world
Source: Otsub, S. (2016:3)

The marine cluster project was launched by the Marche Region in October 2004 with the goal of establishing a new, technically specialised yacht and shipbuilding system in Ancona.

According with OCDE (2010:7) the Marche region is one of the most industrialized regions in Italy and is considered a region of excellence, not only for its economic performance, but also for its cultural, natural and social richness. Marche belongs to what has come to be called the “Third Italy”: a model of development based on small and medium - sized enterprises (SMEs) located in industrial districts. Its economy is driven by the performance of a myriad of SMEs, which have been characterized by a high level of creativity and innovation in the past. Despite sound economic framework conditions, the Marche's industrial policy makers and stakeholders recognize the need for an important planning exercise, with the aim of implementing policies to strengthen the Marche region's entrepreneurship and small business performance and move towards an economic structure which, on one hand, recognizes and builds on the strong manufacturing tradition of the region but, on the other, is able to compete in the modern globalised arena with a renovated, dynamic, technology - based and green - oriented industrial system.

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The initiative promoted a system of goods and services related to navigation, namely shipbuilding, pleasure craft, accessories and infrastructures for tourism and commerce and horizontally connected to the other main regional sectors with the aim of further integrating the different clusters (Cooke, 2011:31).

By definition, all maritime cluster organizations capture more than one maritime sector. Maritime cluster organizations represent almost every traditional maritime sector– although in practice this does not (yet) always seems the case– except the sectors that only answer a broader definition of maritime sectors, such as the Navy and coastguard, inland navigation and maritime works. The fisheries and coastal (and marine) tourism and recreation sectors are sometimes represented by the national cluster organization, although less frequently than the traditional maritime sectors (Peeters, 2008: 14).

Benito et al. (2003) argue that studies on maritime cluster or others are mainly related to the relationships between ports, the shipping industry or services from the shipbuilding industry.

Salvador et al. (2016:26) argue that Michel Porter´s model can be applied to the marine sector, as the Norwegian maritime cluster presents the majority of characteristics that one can find in large industrial groups, including strong inter-sectorial linkages, economic diversity and competitive rivalry.

Cooke (2011:31) presents maritime clusters as relationships between competences, entrepreneurship and experiences, both inter- and intra-industries. This means that the marine cluster is related with organizations and services which comprise the relationships between the intra- and inter- sectors. In particular, Cooke (2011) identifies those sectors which have more impact (direct or indirect) on the marine economy. From Cook’s (2011) point of view, the engines and propulsion systems, tourism, services and manufacture constitute indirect impacts on the marine cluster; the other services are the direct impact.

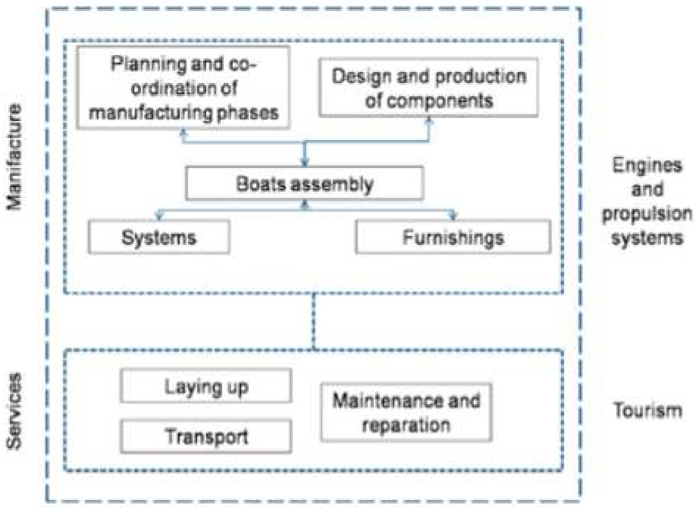


Figure 12– Schematic Maritime Cluster in Marche region
Source: Cooke (2011:31)

Salvador (2015) argues that European maritime clusters can be national or regional and top-down (Germany), bottom-up (Norway) or mixed (Netherlands).

There are different approaches to developing maritime cluster organisation. This initiative can be taken top-down– resulting in government induced organisations – or induced by leader firms and/or sector associations (bottom-up) (Peeters, C., 2008: 14).

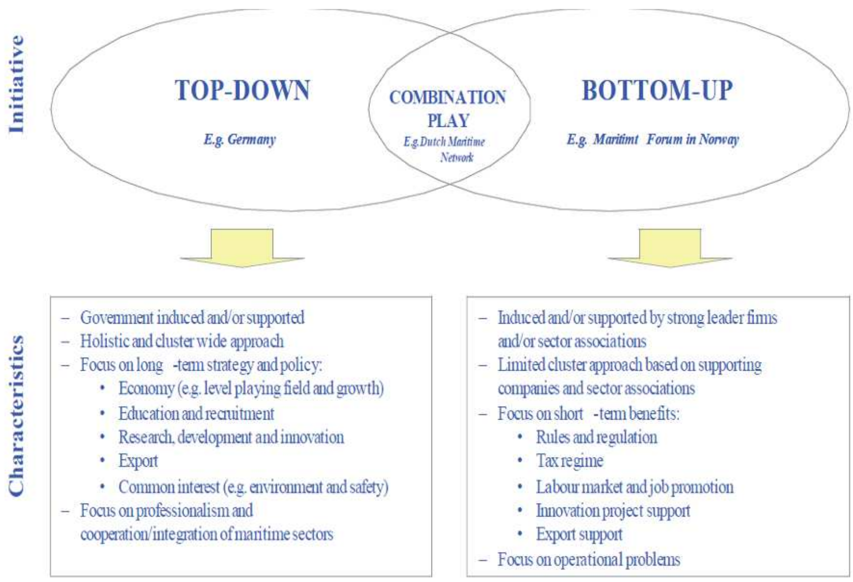


Figure 13– Classification of Maritime Cluster Organisation (top-down vs bottom -up)
Source: Peeters, C. (2008: 15)

However, according to Viederyte (2013: 624), Europe has an important maritime industry with a strong position in many sectors, which depends on needs, stakeholders' cooperation and coordination.

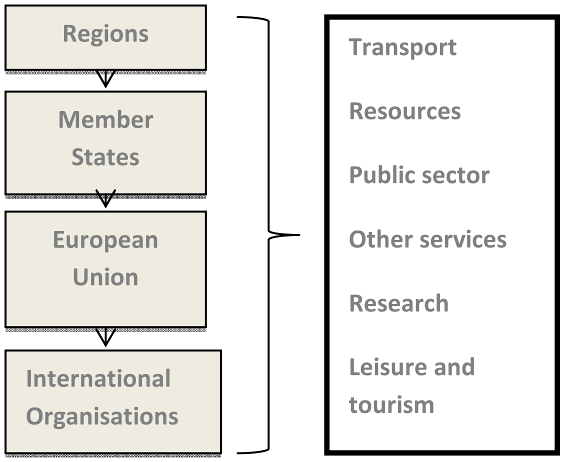


Figure 14– Dynamic European Maritime Clusters
Source: Wijnolst (2006:8)

Wijnolst (2006) identifies the relationship between different levels of clusters (regions, Member State, European Union, international organisation); these relationships are based on similar sectors and activities, such as transport, resources, public sector, other services, research, and leisure and tourism. The dynamic between them came from the interaction between their activities from different clusters. The positive aspect is the complementary activity and cooperation of goods and services between all levels of clusters.

Maritime cluster organisations exist at different geographical levels, focusing on an international and/or European, national, regional (incl. cross-border) or local level. Policy (initiatives) and actions are consequently translated to European national and regional levels, although not in a uniform manner (Peeters, 2008: 15).

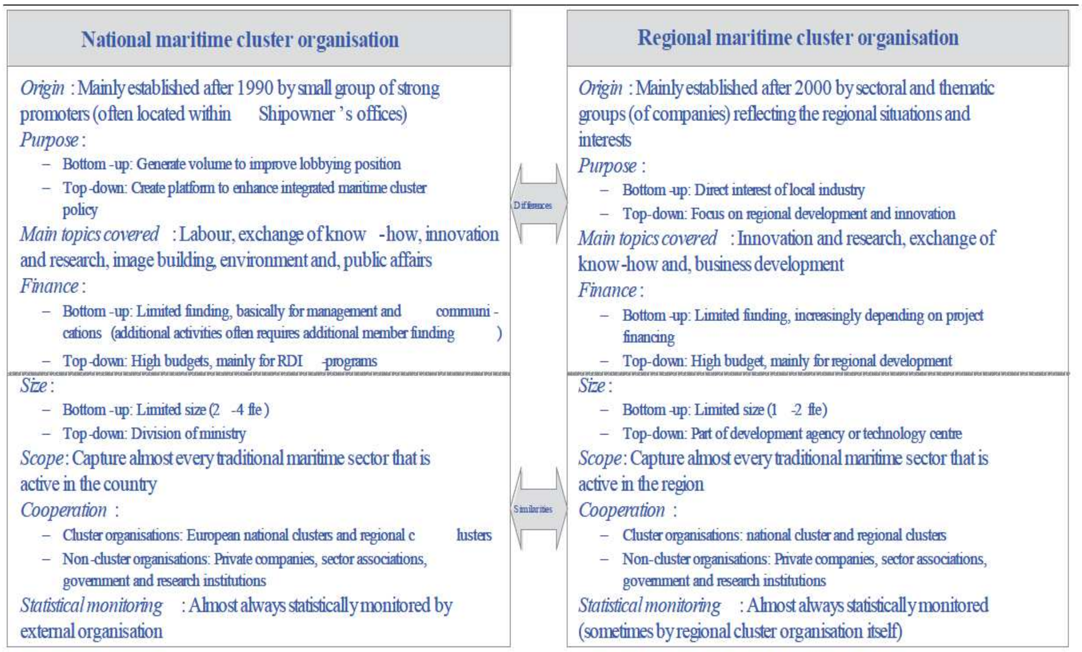
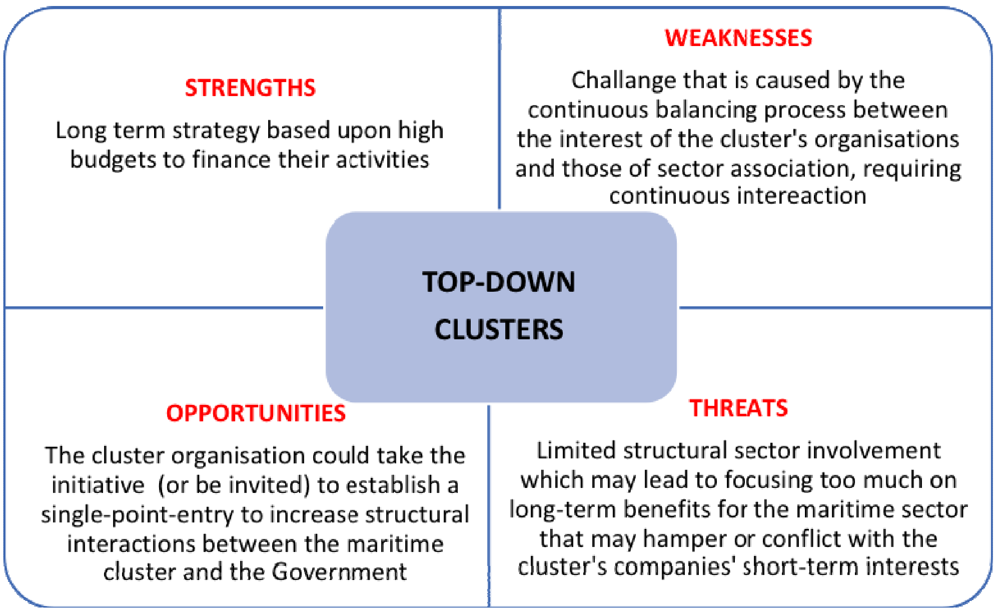


Figure 15– Differences between similarities of national and regional maritime clusters organisation

Source: Peeters (2008: 16)

Few authors have analysed the maritime cluster through SWOT analysis (Peeters, 2008; Viederyte, 2013). A SWOT analysis of maritime cluster organisations distinguishes the strengths, weaknesses, opportunities and threats of top-down and bottom-up clusters (Peeters, 2008: 17).



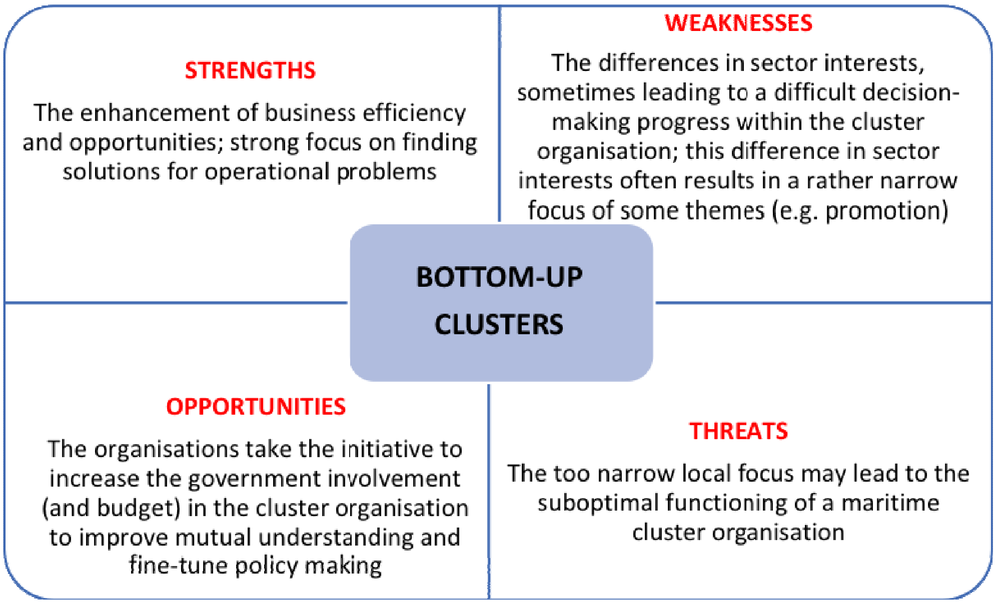


Figure 16– SWOT Analysis and Maritime Clusters
Source: Peeters (2008: 17-18)

Maritime cluster SWOT analysis puts in evidence the strategy for cooperation, collaboration and innovation between organisations and its benefits (Viederyte, 2013:327). The main benefits of (maritime) clusters are the increase efficiency, the increased level of business formations and the higher level of research, development and innovation; therefore, it will be important to build a permanent database on economic facts and figures, to have a clear-cut approach from the European Commission with respect to maritime clusters, and to formulate a strategy towards the future role of maritime cluster organisations (Peeters, 2008: 19).

Zhang and Lam (2013) identify four types of maritime clusters:

1st. The maritime cluster is related to activities in the port (loading and unloading) and boat activities. The relationships between the various sectors that comprise it are unimportant, and decisions are not taken together. Others are related to individual activities in certain sectors or port services (Dublin in Ireland and Selangor in Malaysia, Salvador (2015: 57));

2nd. The maritime cluster is based mainly on port loading and unloading and value added from port activity. The port is a transport, industry and commercial cluster. The direct and indirect cluster activities are related to trade partners and municipalities (Osaka in Japan and Kaohsiung in Taiwan, Salvador (2015: 57));

3rd. The maritime cluster is related to goods and capital but also to technology and intangible information. The activity is related to the regional and global scale, and plays an important role in information distribution, i.e., acting as economic and market "hub" transactions (Rotterdam in Netherlands, Hong Kong in China, Salvador (2015: 57));

4th. The fourth cluster generation operates on vertical and horizontal terms, and has a direct relationship to port activities, but also offers services (finance, insurance, loans) to users who may be geographically distant (London in UK, Salvador (2015: 57)).

According to Salvador et al. (2015: 8), the most dynamic clusters identified in the Atlantic area (France, Ireland, Spain, Portugal, UK) are the following:

Table 11– Atlantic Ocean Basin Most Dynamic Clusters

Atlantic Ocean Basin		
Cluster Area	**Activities involved in the cluster area**	**Status (mature, growing, early development)**
Galway/Western Ireland (IRL)	Cruise and nautical tourism; renewable; Windfloat areas; aquaculture; deep sea technologies (synergies)	Growing
Scottish West Coast (UK)	Offshore wind, marine aquatic resources, fisheries, ocean renewable energy, shipbuilding, blue biotech	Growing
Portuguese Coast (P)	**Deep and short-sea shipping; coastal, nautical and cruise tourism; offshore gas (south) and oil (north) (oil noted with question mark), marine minerals mining**	**Growing**
Bretagne, Brest (F)	Defence, blue biotechnology, shipbuilding fisheries, ocean renewable energy	Mature
Galician Coast (E)	Coastal tourism, short-sea shipping, fisheries, offshore renewable energy	Growing
South West England (UK)	Marine equipment, yachting, coastal tourism, ocean renewable energy (wave and tidal), fisheries	Growing

Source: Salvador et al. (2015:8)

Figure 17– European Maritime Cluster

source:http://www.cluster-maritime.fr/en/maritime-economy/10/network-european-maritime-clusters - consulted on 11/01/2018

Ketels and Protsiv (2014) argue that there are relationships between existing clusters and emerging industries, like information flux, human resources and technology, such as Blue Growth Industries.

Ketels (2015) argues that the EU Member States initiatives for increasing maritime clusters are: shared models between private and public sectors, internal procedures and cluster external environment performance.

Maritime clusters are related to the connection between external activity network and internal sustainability conditions through the economy, namely: tourism, value added services, maritime economy environment and development and cities. These sectors contribute positively to potential employment, cooperation, networking companies towards competitiveness and collaboration inside maritime cluster (Lópes, 2009:89).

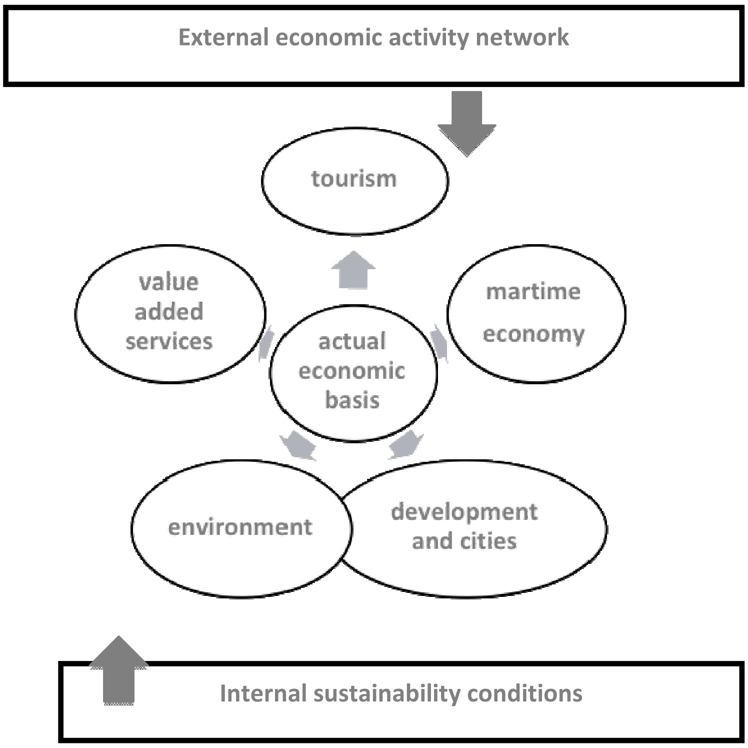


Figure 18– Strategy Sectors
Source: Lópes (2009: 72)

Some examples of maritime clusters (Japan, Norway and France) presented are consistent with the same sectors and the same methodology of production.

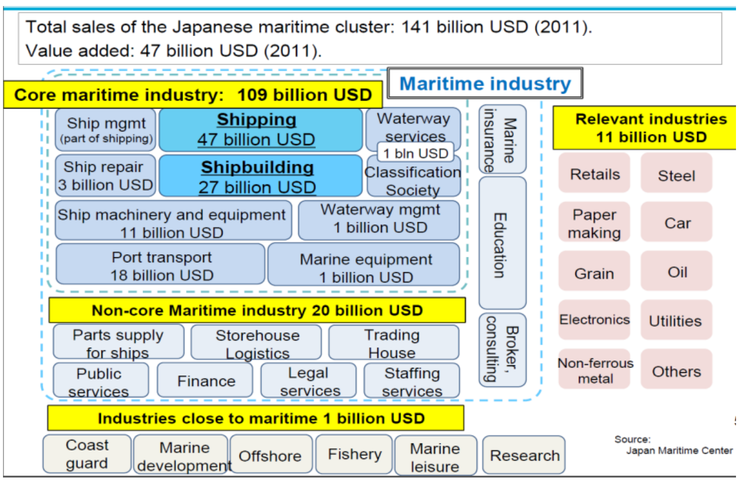


Figure 19– Maritime cluster in Japan
Source: Otsub (2016:5)

Figure 20– Norwegian maritime cluster
Source: Skogstad, B.A. (2016: 22)

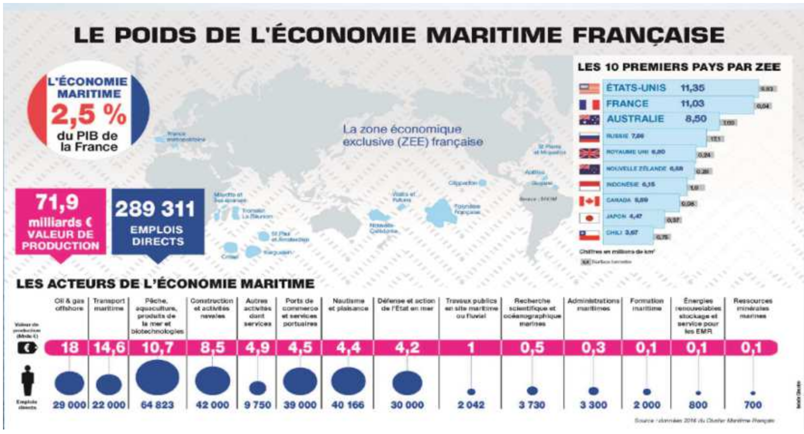


Figure 21– French maritime cluster
Source: http://www.cluster-maritime.fr/en - consulted on 14/01/2018

In Portugal, the modernization process in maritime sectors is long and complex. The strong dependency on European funds and governmental policy led maritime sectors to a weak level of competitiveness in comparison to other European countries. The Portuguese government strategy was to find a *key sector*, which could compete with their European partners.

According to Matias (2009:9) the majority of the Portuguese maritime economic sectors presented negative growing rates in the last three decades. A similar situation occurred in several European countries which however have succeeded in recovering, mainly through the strengthening of the maritime clusters, as a whole.

The "**Cluster do Mar Português/Portuguese Maritime Cluster**",[6] is promoted by Fórum Oceano – Associação da Economia do Mar, and was recognised by the Competitiveness Cluster Strategy by the Ministers of Economy, Maritime, Planning and Infrastructures, and National Defence. Fórum Oceano is the merger, by incorporation, of two Portuguese associations Oceano XXI – Association for the Knowledge and Economy of the Sea (established in 2009) with AFEM – Association Business Forum of the Sea Economy (established in 2010), which occurred in July 2015.

Its vision is that maritime activities are dynamic and competitive segments of the economy, enhancing the sea and its resources, generating value, promoting high-value jobs, and contributing to strengthening Portugal's position in the global economy.

Its mission is to strengthen dynamics of strategic cooperation between players; promote the competitiveness of the main value chains that utilise the sea and marine resources as the central elements of their activity; contribute, in a sustainable way, to economic growth and the growth of exports and employment; increase the maritime economy's importance to the national economy.

The association has more than 100 members connected to many sectors of the sea economy, including *traditional* ones, such as:

- Seafood Conservation, Processing and Commercialization;
- Shipbuilding, repair and maintenance;
- Nautical activities and Marine Tourism;
- Maritime construction;
- Fisheries and Aquaculture;
- Ports, Transport and Logistics**;**

or *complementary* areas, such as*:*

- Maritime Culture; Maritime Defence and Security; Services**;**

or *emerging* ones, such as:

[6]http://www.forumoceano.pt

 - Marine Bio resources and Biotechnology; Marine Renewable Energy; and Offshore Oil & Gas.

The Portuguese sea cluster has three main objectives: to increase the value added and the consolidated business from the sectors which comprise the cluster; to promote emergent activities and increase international market networks and investments. These objectives are based on entrepreneurship, innovation and modernization, sea technologies and knowledge, internationalization and strategic information.

Salvador (2015) addressed the maritime Portuguese cluster study through interviews with cluster stakeholders, followed by an input-output analysis applied to the maritime industries. The purpose was to establish potential links and connections between the sectors.

Additionally, Salvador (2016:58) pointed out that the Portuguese maritime cluster belongs to the first type (according to Zhang and Lam (2013) typology), with a focus on the port and shipbuilding. The connections between the sectors are quite loose.

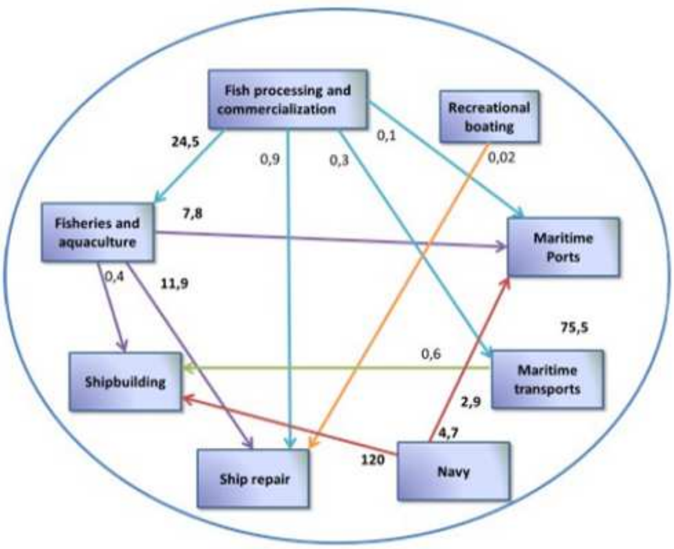


Figure 22– The Portuguese Maritime Cluster Commercial Relations (in millions of euros)
Source: Salvador (2016: 59)

Simões (2013:261) concluded that sectors with strong relationships are: *renewable energy*, maritime transport, shipbuilding and repair, maritime tourism, manufacturing, fishing and aquaculture, ports, maritime teaching and research, fluvial navigation, marine and maritime research.

The strategy for the Portuguese maritime cluster means developing the connections between ports, maritime transports and logistics centres.

These are the sectors with more intersectoral connections. Major firms can be found in them. Logistic infrastructures were already planned or developed during the last five or six years (Bobadela, Poceirão, Leixões, Sines Pole B, for instance).

Ports, in particular, have a sound financial situation and a good outlook (due to the growing exports by sea, namely to extra-EU markets). They can also have access to the Spanish market.

On the other hand, public strategy should also prioritize universities and R&D centres, as these are also sectors which are largely interconnected with the other sectors of the cluster, with broad international connections (Salvador, 2016: 58).

CHAPTER 4 – MARITIME ENERGY

"Nunca como hoje a bacia atlântica foi capaz de cruzar uma variedade tão interessante e tão rica em recursos, tecnologia, transporte, inovação e economia, catapultando a região em primeira linha da geopolítica da energia global"

Lima (2016: 63)

The fourth chapter focuses on maritime energy, comprising the definition of energy, renewable energy and offshore energy. The offshore energy cluster and its features are also discussed, according to some authors. Environmental economic impacts are analysed and the European energy policy is presented. The cleantech cluster concept is discussed because of the relationships between renewable energy, maritime clusters and clean cities. In order to prove the dynamic in clusters, the Helix Model, Convas Model and Pentagonal problem is presented. The circular economy is also presented because of its linkages with renewable energy and clusters. As is pointed out, renewable energy is considered in the system as a factor for the minimization of waste and external costs. Furthermore, an offshore energy SWOT analysis is explored.

4.1 RENEWABLE AND OFFSHORE ENERGIES

“Of all the forces of nature, I should think the wind contains the greatest amount of power”

Abraham Lincoln

From the Greek “enérgiea”and the Latin“energia” (Grande Dicionário de Língua Portuguesa, 2004:568) énergie“elleapparraît d’abord en mécanique,où ele signifie capacité de travail” (Encyclopaedia Universalis, 2002:227) ou, “capacidade de fornecer trabalho, força física demonstrada” (Dicionário de Língua Portuguesa Contemporânea, 2001:1408).

Castro (2012: 4) identifies “energy” as a set of activities, namely: fuel burning, charging batteries or running machines. Energy is the technology conversion currency (Dincer, 2000: 158).

Electric energyis "uma forma de energia facilmente convertível em outras modalidades de energia (mecânica, luminosa, química) ou, o que resulta da conversão destas” (Grande Dicionário de Língua Portuguesa, 2004:542), with the purpose of minimizing costs through primary energy consumption.

To Beels e tal. (2007:1) oceans are an enormous source of energy.

Renewable energy means energy from natural resources: “a energia explorada a partir de fontes naturais como o vento, as marés, o sal e a água e que provém de fontes inesgotáveis podendo renovar-se” (Grande Dicionário de Língua Portuguesa, 2004:568) e “a força energética obtida de uma fonte cuja matéria-prima não é eliminada pelo facto de ser transformada” (Dicionário de Língua Portuguesa Contemporânea, 2001:1408).

Renewable energy comes from non-fossil resources: renewable energy includes the primary equivalent to hydro (excluding pumped storage) geothermal, solar, wind, tide and wave. It also includes energy derived from solid biofuels, bio gasoline, biodiesel, other liquid fuels, biogases and the renewable fraction of municipal waste (OECD, 2016:106).

Renewable energy is a new capacity for energy supply be provided through technology and specialised human resources.

Renewable energy is fundamental for society and the economy (Kajikawa et al., 2008:771). Its use became popular from the 70s with the petroleum crises (Castro, 2012 and Pinto, 2013).

Renewable energy usually refers to that energy that does not pollute the environment and could be recycled in nature (Zhang et al., 2009:440).

The use of renewable energy has several advantages: reduction of fossil fuel consumption and environmental impacts; greater security of supply and reducing oil dependence, and disadvantages: production standard control; production and consumption are not in equal proportion, that is, efficiency losses in the electrical system, since energy cannot be stored on a large scale (Castro, 2013).

There are a number of types of renewable energy: 1. Eolic (kinetic energy from moving air masses (wind); 2. Solar (energy from light or sun heating); 3. Aerothermal (energy stored in the form of heat in the air); 4. Geothermal (energy stored in the form of heat beneath the solid surface of the Earth); 5) Hydraulic, biomass, landfill gas, treatment of waste and biogases; 6. Hydrothermal (energy stored in the form of heat in surface water) and oceanic (Pinto, 2013).

Ocean energy has the potential to play a significant role in the future energy system, whilst contributing to the reduction of carbon emissions and stimulating economic growth in coastal and remote areas. Ocean energy has attracted increasing interest, particularly in the EU, which is currently at the forefront of ocean energy development (Magagna and Uihlein, 2015:84).

According to *Blanco and Rodrigues (2009:2847)* the wind energy sector has grown exponentially since the end of the 1990s, especially within the European Union (EU), and this has affected the employment levels of the regions involved.

Wind and wave offshore energy are the future of energy supply in Portugal. The environment policy and the economic impact on Portuguese economy are the main factors.

The point is to change for a sustainable economy based on renewable energy in order to decrease the energy dependency towards a green economy. Therefore, the key challenge of offshore suppliers is to compete with other energy fossil productions.

Offshore energy is directly related to expertise employment, technology and direct investment in electric equipment, dry docks, maritime transport support, engineering and consultancy studies and expert knowledge.

There are few aspects with which this sector deals in a negative way; the spatial needs for energy sectors means that the energy and economic infrastructures do not meet regional needs.

According to the European Commission (2015: 8) exploration, fixed installation, and decommissioning are the fragile points which countries need to deal with in environment and use impacts. In order to achieve the targets proposed by the European Union 2020 programme, every country has to design different strategies to accomplish the general goal. The development of renewable energy has an outstanding effect on sustainable economic growth, for the harmonious coexistence of humans and the environment as well as sustainable development.

Offshore renewable energy faces similar changes in most countries, such as: location of offshore wind farms, port facilities, underwater cables, operation and maintenance and decommissioning projects.

On the other hand, environmental impact and spatial competition between energy and other maritime activities should be analysed. Environmental impacts are normally related with noise, infrastructure and decommissioning projects, which mean that the impact on sea species and birds, as well as soil spills should be taken into account by stakeholders.

Moreover, benefits from the energy sector on the economy (spatial synergies from wave-tidal-wind; certainty and consistency (certain planning from stakeholders towards investments in this sector); grid development and grid interconnection within other sectors; cross-border cooperation in knowledge, skills, development and experience towards market corridors for regional energy market integration; and data collection from energy sector) should be analysed.

The objective is to reduce the cost of installation for each type of energy and guarantee a better performance; in technology, innovation and learning by doing must be translated into a comprehensive cost-reduction pathway if wave and tidal energy technologies are to achieve cost competitiveness in commercial markets (Badcock-Broe, A.,2014:31).

According to the European Wind Energy Association (EWEA) (2009:13) wind energy continues to expand rapidly and follows a similar development path to other power sources that are now mainstream.

Castro (2012) points out wind energy as a mature technology and its use has increased (Blanco and Rodrigues, 2009; Castro, 2012) more than other energy sources (Teixeira, 2010).

Wieczorek et al. (2013:305) argue that offshore wind technology holds the potential for tackling major energy issues, climate change problems and creating jobs and economic growth. Therefore, wind energy is a part of an economic system where activities are related, as a cluster.

Figure 23- Offshore energy farm in Scotland (August 2016)

Table 12– Offshore Wind Energy Cluster

Authors	*Sectors*
Wieczorek et al. (2013:300)	Wind motors, ships or other waterborne vessels; equipment for shipping; separation; dynamo electric machines; machine or engines for liquids; earth or rock drilling, hydraulic engineering; pipes; joint or fittings for pipes; shaping or joining of plastics
Sarja (2013: 148)	Mining and quarrying, manufacturing, construction, transportation and storage, information and communication, real estate activities, professional, scientific and technical activities, and administrative and support services activities.
Bolon et al (2007:20)	Collaborative design/R&D facilities; universities, legislators (national, EU, regional), subcomponent manufacturers, turbine manufactures; supporting industries (engine, bearing manufactures), wind consultancies; NGOs, financiers, project developers, wind farm construction& operations

Additionally, positive and negative impacts on environment are considered:

Table 13– Environmental Impacts of Wind Energy Conversion Technologies

Arguments against offshore wind	***Arguments for offshore wind***
Ruins special/historic seascape (Yes)	Mitigates climate change (Yes)
Kills birds (Yes)	Decreases water use (Yes)
Harms fisheries (No)	Improves air quality (Yes)
Harms marine mammals (No)	Reduces foreign fuel dependence (Yes)
Requires subsidies (Yes)	Creates jobs (Yes)
Endangers shipping/navigation (No)	Creates electrical price stability (Yes)
Hurts tourism (No)	Close to population centres (No)
	Higher winds offshore (No)
	Reduced user conflicts (No)

Source: Snyder and Kaiser (2009: 1569)

To Cruz (2007: 3) Wave energy is reaching a crucial stage, following over three decades of intensive research and development.

Wave energy belongs to the offshore renewable energy group. Wave energy is derived from the winds as they blow across the oceans, and this energy transfer provides a convenient and natural concentration of wind energy in the water near the free surface. Once created, waves can travel thousands of kilometres with little energy loss (Clément et al., 2002:407).

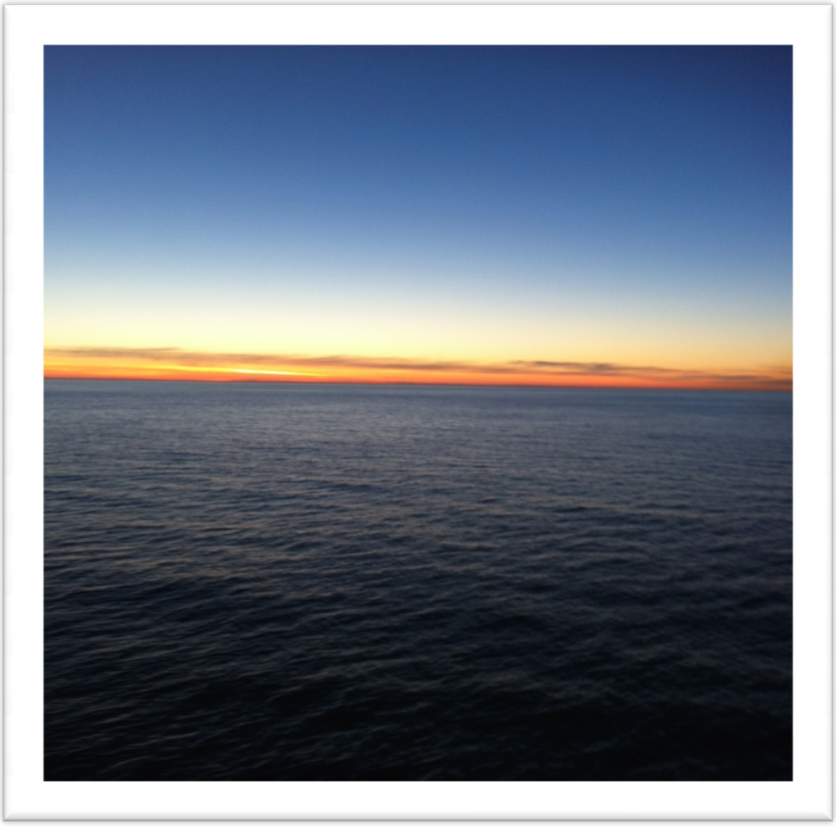


Figure 24- North Sea (August 2017)

As well as, the offshore wind cluster (previous point), wave energy comprises several sectors and belongs to an economic system, which forms a cluster.

Table 14– Wave Energy Cluster

Inputs to the productivity and costs assessment	Sea characteristics Vessel characteristics Device characteristics
Economic assessment	Maintenance activity, onshore substations; submarine connectors; onshore cable; submarine cable; assembly; mooring lines; onboard electric equipment; instrumentation and control; hull-structure; bearing line, generic components, motors; dynamic risers;

Source: Teillant et al. (2012:224-225).

There are advantages for using wave energy: it is renewable, it does not produce any pollution and is less dependent on the coastal conditions.

The disadvantages are: reduced power plants; it requires special geometry of the coast and with great amplitude waves; it prevents navigation (in most cases); and the deterioration of materials by exposure to salty sea water.

Additionally, the impacts on the environment are:

Table 15– Environmental Impacts of Wave Energy Conversion Technologies

ENVIRONMENTAL EFFECTS	*SHORELINE*	*NEARSHORE*	*OFFSHORE*
Land use/sterilization	w		
Construction/maintenance sites	w		
Recreation	w	w	
Coastal erosion	w	w-m	w-m
Sedimentary flow patterns		w	w
Navigation hazard		w	w
Fish & marine biota	w	w	w
Acoustic noise	w		
Working fluid losses		w	w
Endangered species	w	w	
Device/mooring damage		w-m	w-m

source: Clément et al.(2002:409)

w=weak effect; m=medium effect

The environment impacts from wave energy can be divided into three main areas: shoreline, nearshore, offshore. The shoreline has weak effects overall, while nearshore and offshore present a similar impact on the environment.

As Yegorov (2014:3) puts it, it is possible to conclude that while renewable energies represent a remedy, full transition will not be easy. (…) Hence, while transition to a modest fraction of renewable energies is not a problem, full transition might be problematic (even technically at present) and practically non-implemented under a short term horizon when the discussed crises would give clear market signal for the necessity of such transition.

Considering the importance of renewable energies and its impact, maritime planning and its implication for the economy are considered an important feature for the future of the maritime sector.

Therefore, maritime spatial planning (MSP) is a transparent and comprehensive process based on stakeholders' involvement, the aim of which is to analyse and plan when human activities take place at sea to support sustainable development and growth in the maritime sector, applying an ecosystem-based approach (European Commission, 2015:7).

The importance of MSP is to give an opportunity to all relevant stakeholders to be involved, whereas marine ecosystems and human activities evolve constantly in these sectors: environment, fisheries, maritime transport and energy.

Additionally, Member States need to have these requirements: involve stakeholders, develop cross-border cooperation, apply an ecosystem-based approach, use the best available data and share information, take into account land-sea interaction, promote the co-existence of activities and review plans at least every 10 years (European Commission, 2015:7).

MSP allows the benefits derived from Europe's sea to be maximized without comprising their ability to continue to provide benefits for generations to come (Badock-Broe, A. et al., 2014:36).

The EU 2030 Framework for Climate and Energy has confirmed its decision to support marine renewable energy. Clearly, this decision affected the marine renewable energy plan towards a better use of natural resources, technologies and human resources. Each renewable energy source requires specific devices, which will have different spatial features.

Offshore renewable energies comprise spatial needs depending on their production and location. Therefore, offshore wind energy depends on the location of offshore wind farms, namely, wind conditions, seabed suitability, the presence of available infrastructure (e.g. cables) and the instalment of new cables; other factors affecting the location may be the presence of wrecks or other archaeological remains on the seabed. On the other hand, port facilities are an important part of logistics.

Spatial and infrastructural needs will depend on the vocation of the port. Moreover, underwater cables are necessary to transfer the energy produced. After the offshore wind farm is built it is necessary to plan operational and maintenance activities. The decommissioning phase is critical; the planning process can choose between two things: re-use the area or replace the turbine (European Commission, 2015:11).

4.2 THE CLEANTECH MODELS

"Further extensive and diachronic analysis of cleantech clusters is however needed to explore the underlying triggers and drivers for their evolution […] hybridized cleantech clusters are best seen as heterogeneous assemblies …However, as hybridised cleantech clustering indicates, more progressive voices and actions that pay attention to non-market forces, community empowerment, environmental resilience and quality of life, have not yet been entirely suppressed"

Davies (2013:1293)

According to Pego (2018:321), the word "cleantech" (green) is a new concept of clean energy, and it is related to transport, recycling &waste, materials, building & energy efficiency, renewable energy, air, water environment and agriculture & food sectors. Cleantech is defined as (clean technology) products and services that use technology to compete for favourable price and performance, while reducing pollution, waste, and use of natural resources. The main areas involving cleantech are: ***renewable energy (Onshore, Offshore Wind, Solar, Geothermal and Bio energy);*** *clean cities* (Green Buildings, Clean Water, Smart Grid, Solid Waste, Clean Road Transport) and *perspectives* (Maritime Cleantech, Carbon Storage, Energy Storage).

Additionally, the cleantech capacity involves regions, markets, consumers and renewable energy as niche activities, which are directly related to regional development, socio-technical transitions in organizations, coordinated activities, and institutional involvement. Some institutions have developed cleantech studies (e.g.

Cleantech Finland (2014) and Henriksen et. al 2012)) in order to classify methodologies about renewable energy.

Pego (2018:322) argues that cleantech clusters comprise benefits, such as: the specialization of regions in activities, higher employment and greater expansion rates, reducing the cost of production and the cost of exchanging by strengthening trading relationships, local knowledge spill over, local R&D institutions, business collaboration and research activities, and strong clusters in the same geographical region.

At the European level, smart grid clusters can be presented which are involved in the European electricity network towards a sustainable green economy. The cleantech model based on this premise allows them to: "support the three European energy policy pillars (security of supply, sustainability and market efficiency) and the related short term ("20-20-20") energy policy targets by 2020. These targets translate into both massive integration of renewable energy sources (RES) into the electricity system (mainly variable sources such as wind and solar power), and energy efficiency measures" (EGGI, 2013:3) two types of impacts are expected: "i) optimizing further capital investment and operational expenditure intensity needed to increase the network capacity for grid-users; ii) paving the way for a fully decarbonised pan European electricity system by 2050 (through an extremely large share of renewable electricity production)" (EEGI, 2013:7).

Table 16- Cleantech Industries

Industry	*Examples*
Advanced Materials and Nanotechnology	- Non-platinum catalysts for catalytic converters; - Nano-materials for more efficient and fungible solar photovoltaic panels;
Agriculture and Nutrition	- Innovative plant technologies and modified crops designed to reduce reliance on pesticides or fungicides;
Air Quality	- Stationary and mobile emission scrubbers; - Testing and compliance services;
Consumer Products	- Biodegradable plastic ware; - Nontoxic household cleaners;
Enabling Technologies and Services	- Advanced materials research services; - High throughput screening research equipment;
Energy Generation, Storage, and Infrastructure	***- Solar photovoltaic technology; - Wind power; - Hydrogen generation; - Batteries and power management technology;***
Environmental Information Technology	- Regulatory and policy compliance software; - Geographic Information Services (GIS);
Manufacturing/Industrial Technologies	- Hardware and software to increase manufacturing productivity and efficiency;
Materials Recovering and Recycling	- Chemical recovery and reprocessing in industrial Manufacturing; - Remanufacturing;
Transportation and Logistics	- Fuel cells for cars; - Diesel retrofits equipment; - Hybrid electric systems for cars, buses, and trucks;
Waste and Water Purification and Management	- Biological and chemical processes for water and waste purification; - Fluid flow metering technology

Source: Burtis et al (2004: 11)

The report presented by Cluster (2012) shows the main sectors which comprise cleantech and it can be seen that renewable energy either offshore or onshore is one of these. Renewable energy belongs to the cleantech sector and at same time to the maritime economy (Chapter 3). The renewable energy cluster is concomitant with economic and social resource optimization criteria, physical aspects, climate change and soil features.

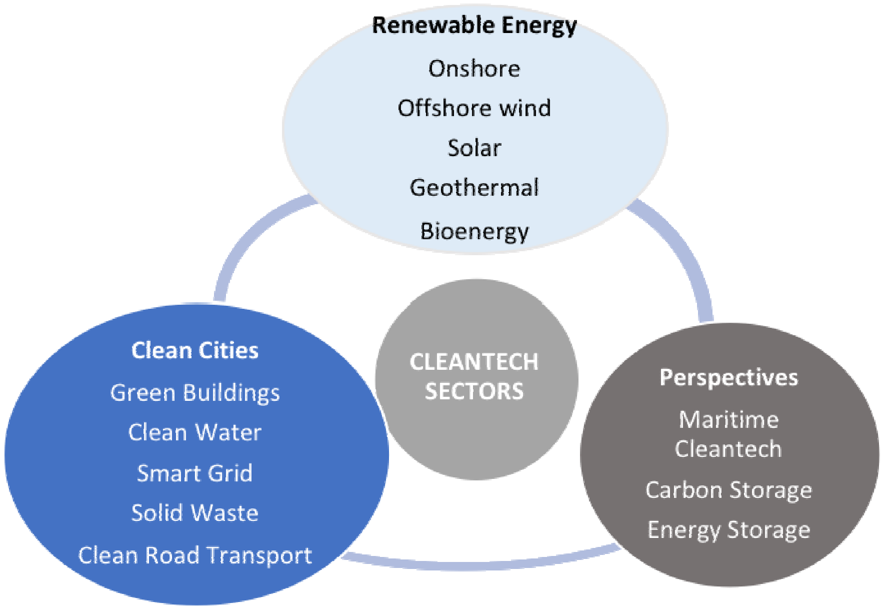


Figure 25– Cleantech Sectors
Source: Cluster (2012:10)

Cleantech capacity involves regions, markets, consumers and renewable energy as niche activities, which are directly related to regional development, socio-technical transitions in organizations, coordinated activities, and institutional involvement (McCauley and Stephens, 2012).

According to Cleantech Finland (2014) cleantech is defined as any product, service, processes or technology that prevents or decreases the negative impacts on the environment that the business might cause.

Some institutions have developed cleantech studies (e.g. Cleantech Finland, 2014) and Henriksen et. al 2012)) in order to classify methodologies about renewable energy. Cleantech clusters comprise benefits, such as: the specialization of regions in activities, higher employment and greater expansion rates, reducing the cost of production and the cost of exchanging by strengthening trading relationships, local knowledge spill over, local R&D institutions, business collaboration and research activities, as well as strong clusters in the same geographical region (Davies, 2013:1289).

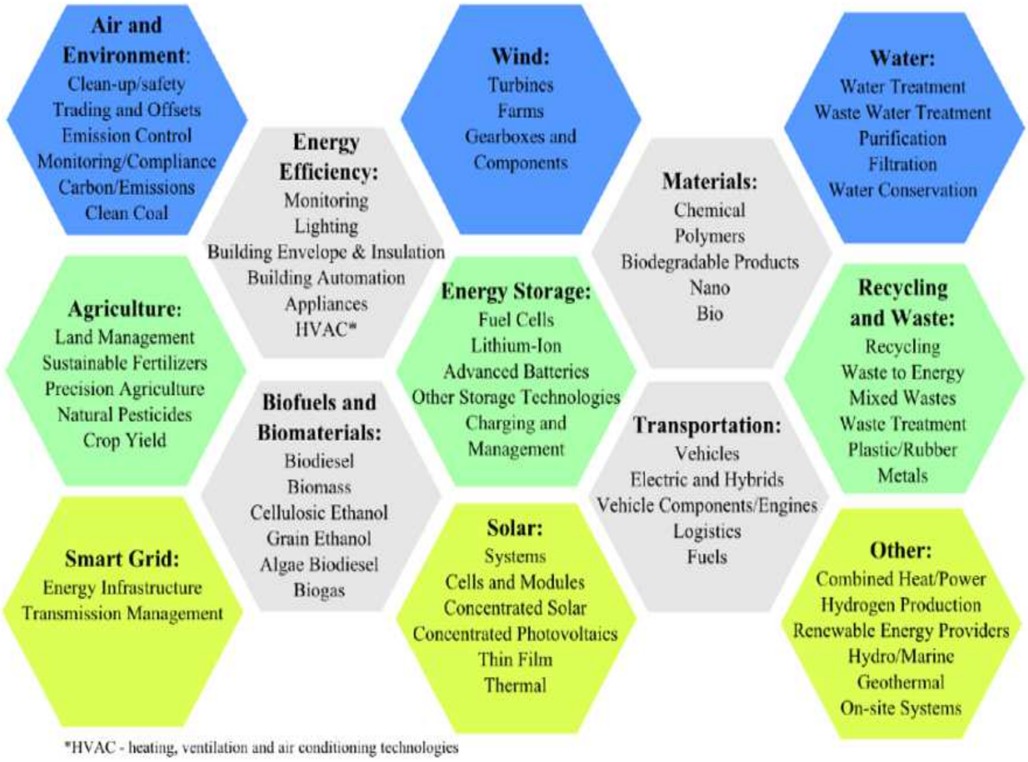


Figure 26–Cleantech industry segments
Source: Ragozin (2012:14)

The cleantech industry can be organized through this classification with thirteen segments where cleantech is used at the moment (Ragozin, 2012:13).

The biggest step towards a world cleantech cluster started in 2009 with the International Cleantech Network (http://internationalcleantechnetwork.com).

The objective was to perform *an exclusive network of cleantech clusters* from the world's leading cleantech regions with new business opportunities enhancing competitive advantages and creating value for companies.

The purpose of creating this international collaborative platform between cleantech clusters is to enhance knowledge between businesses, institutions and local authorities, and to improve collaboration between the regions in which the cluster is located to give a competitive edge in the battle for new technologies, talent and market share (Lämmer et al., 2014:27).

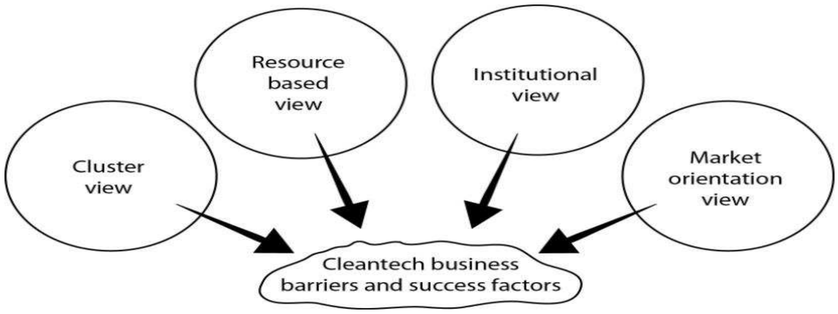


Figure 27– Cleantech Barriers
Source: Frankelius et al. (2011:7)

Few institutions developed Cleantech studies (e.g. Cleantech Finland (2014) and Bisgaard et. al 2012)) in order to classify methodologies about renewable energies. Cleantech clusters comprise benefits such as: specialization of regions in high value added activities, higher employment and growth rates, strengthened trading relationships, local knowledge spill over, local R&D institutions, business collaboration and research activities, and strong clusters in the same geographical region (Davis, 2013:1289).

The globalization of cleantech industries around the world brings about a new concept of organizing business methodologies based on cooperation and collaboration between those intervening (countries). Expertise areas and investment are sectors with a high impact on the economy; therefore, it is important to set up cleantech policies to obtain economic and social benefits from their performance.

To summarize, the use of any model in *green clusters* (**green electricity**) where Circular Economy (CE) acts constitute an important issue in the green market, since it will promote organization competitiveness, maximized consumers utility, and innovation and collaboration.

4.2.1 THE Helix model

The *Helix Model* (Cleantech Finland, 2014:6) combines five points: customers needs, enterprise/private sector, coordination of cooperation, education and research and the public sector.

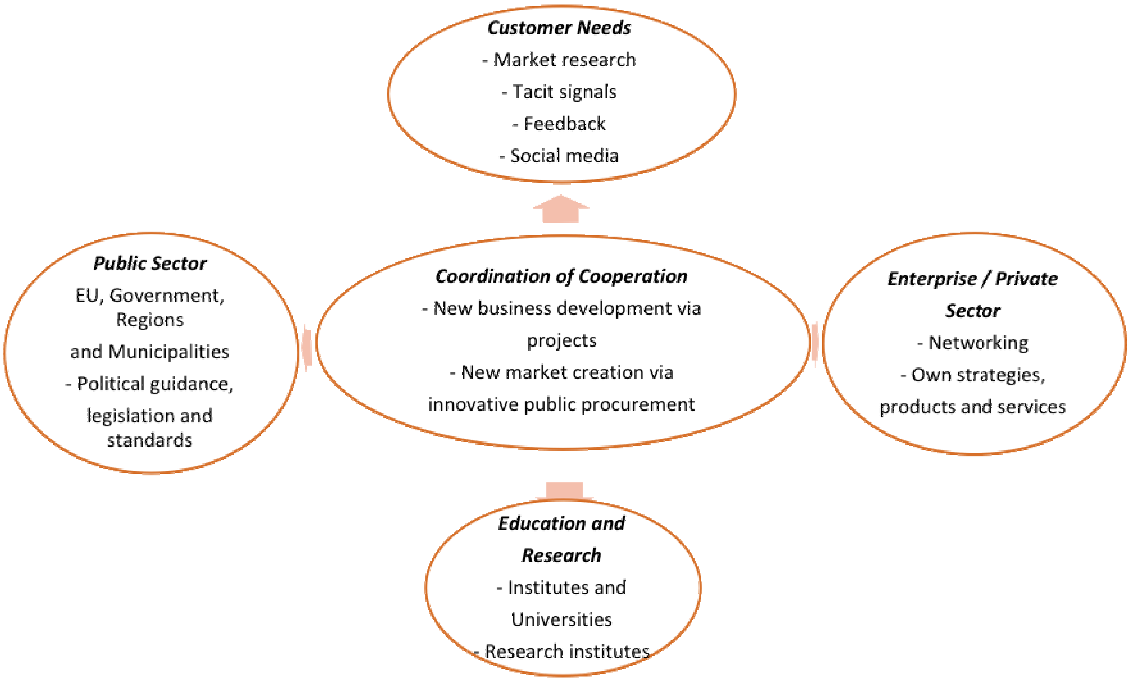


Figure 28– Business development framework (Helix Model)
Source: Cleantech Finland (2014:6)

The model comprises a new methodology to approach five vectors. This means a new way of implemented a business model where the cooperation and collaboration between the main actors in the economy act. In the long run, it is possible to establish a linkage within the sectors towards the intervention of the all economy. The goal is to develop strategies in order to maximize cooperation between all sectors in the economy with an innovative business model where market needs, government, research, and networking are combined. There is a possibility of vertical interaction between the value chain, a combined of products and services for more sustainability.

4.2.2 The Convas Model

The Convas model is discussed in the chapter about renewable energy clusters towards business competitiveness.

The *Convas Model* tries to understand green business models and innovation. It is based on eleven factors: growth strategy, key partners, key activities, key resources, value proposition, customer's relationships, customer segments, cost structures, revenue streams and comparative strategies (Henriksen et al., 2012, 33).

4.3. THE CIRCULAR ECONOMY AND THE OFFSHORE RENEWABLE ENERGY BUSINESS MODEL

Innovation constitutes a problem in a modern economy, if related to new products, such as eco innovation, eco technologies, and new processes for production. The innovation problem derives from the concept of more sustainability and new challenges for production (Pego, 2018). The circular economy (CE) refers to the industrial character of the economy, which becomes self-sustainable through the use of renewable energy, and there diction of toxic substances and waste (Costea-Dunarintu, 2016: 150).

The concept of CE (Su et al., 2013; Lieder and Rashid, 2016) is well known for the transition which allows materials to safely re-enter the biosphere or continue to circulate as high-quality production resources; the opposite of a linear model where 'take, make and dispose' is applied. There are linkages between CE and the business model. The concept of the business model is based on industrial innovation of future productivity and competitiveness between organizations. Di Fonzo and Hime (2017:15) point out some features of business models based on CE, such as decision-making support for business, measure and value decision-making,regulators, and research funders.

The CE business model solution can be improved if companies transfer knowledge from their previous experience based on the relationship with customers, monetizing idle capacity, having better control of the product life cycle, and creating stable revenue streams and premiums (MacArthur et al., 2014:47).

CE performs four types of resource benefits: improving resource security and decreasing import dependency; environmental benefits: less environmental impact; economic benefits: opportunities for economic growth and innovation; and social benefits: sustainable consumer behaviour and job opportunities (European Environment Energy (EEA), 2016:13).

The potential gaps to address include: the development of more accurate metrics i.e. regional rather than global and country level data; improved biodiversity and soil metrics (through consideration of relevant definitions and ways to report changes in context); strengthening the linkages between any suggested metrics and core business processes (Di Fonzo andHime, 2017:23).

On the other hand, the network system and the potential for collaborative markets constitute the goal for the CE system (MacArthur*et al.*, 2014:39). Further studies in this field can be based on top-down (legislation and policy, support infrastructure, social awareness) or bottom-up approaches (collaborative business models, product design, supply chain and information and communication technology) (Lieder and Rashid, 2016: 47).

Therefore, the business model based on this methodology is consistent with sustainable solutions at the product level, and it can be aggregated across businesses in order to improve their sustainability as well as economic systems.

Moreover, a business strategy based on CE needs to optimize materials and energy flows inside regions or industrial ecosystems.

This raises a new challenge for resource recovery and tax exemption policy for companies involved in reverse supply chain activities.

Additionally, the expectation from stakeholders about CE business based on production, value chain and competitiveness constitute an important vector for social, environment and resource efficiency in the society.

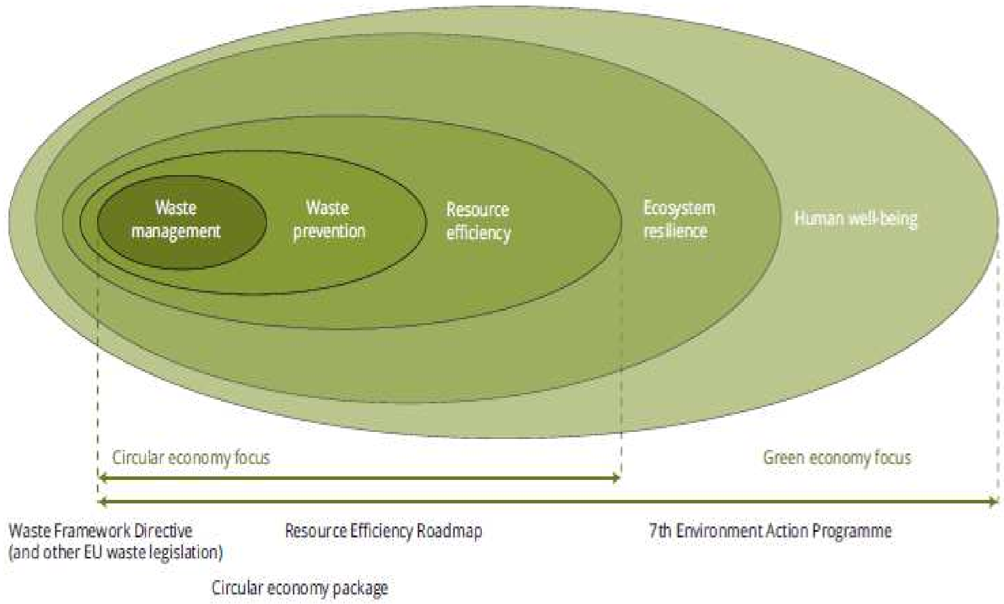


Figure 29– Circular Economy and Green Economy
Source: EEA (2016:31)

Action plans and strategic directions are the vectors for the future of CE in Europe. However, some technical, social, political and economic barriers can be pointed out: companies are often not aware or do not have the ability or the knowledge to choose CE solutions; systems, infrastructures, business models and technology of today can lock the economy into a linear model; investments in efficiency measures or innovative business models remain insufficient and are considered risky and complicated; the demand for sustainable products and services can remain low, especially if they involve changes in behaviour; often, prices reflect actual costs incurred by the company for the consumption of resources and energy; the signals of political transition to a circular economy are not strong enough or consistent (Costea-Dunarintu, 2016:158).

The European Academic Science Advisory Board (EASAB) (2010: 4) points out some benefits of CE: fostering competitiveness by creating savings and reducing raw materials and energy dependency; security of supply and control of rising costs; contributing to EU climate change policy by reducing greenhouse gas emissions;

employment opportunities; reducing environmental impact of resource extraction and waste disposal; opportunities for new businesses by selling goods or offering services.

Consequently, studying offshore energy and its linkages to the CE value chain and direct or indirect impacts is one of the advantages of studying the relationship between production and value added on the economy.

A better comparison can be achieved if the values for CE and linear economy or efficiency, competitiveness, value added and environment impacts are compared. Energy savings represent an essential component of meeting climate goals, and energy management is an unparalleled opportunity to enable organizations across all sectors to achieve ongoing energy consumption reductions.

Accomplishing this goal would enhance economic development at the organizational, national, and global levels, and would contribute greatly to addressing urgent global concerns regarding emissions from the use of non-renewable energy sources and associated climate change impact (Energy Management and Energy Systems - EMES, 2017:7).

In other words, CE is a concept which involves a set of competencies which are useful for welfare. This means a network with a number of competencies: system thinking, goals, strategic and adoption, with external and internal effects, and which promotes positive externalities in the economy.

Renewable energy is considered in this system as a factor which allows for the minimization of wastes and external costs. To sum up, the importance of CE in the business model is related to the capacity of the organization to provide externalities to the economy. The value-added generated by the symbioses of different sectors in CE promotes different levels of waste.

In Portugal some organisations are promoting CE in the energy sector. The goal is to define market strategies to implement the following concepts: refuse, rethink, reduce, re-use, repair, remanufacture, recycle, recover, repurpose and refurbish. The goal is to implement a market strategy based on innovation technologies, product design, revenue models, and institutional change. The strategy implemented by the

Portuguese government considered the following ambition for Portugal2050, mentioned in the Action Plan for the Circular Economy (APCE), and which consists ofthe following elements: a carbon-neutral economy; knowledge as impulse; inclusive and resilient economic prosperity; and a flourishing, responsible, dynamic and inclusive society (Resolução do Conselho de Ministros n.º 190-A/2017). These are some of the organisations which use CE in Portugal related with energy sector: COOPERNICO, LIPOR, EDP, BLC3, EDP, VEOLIA, VPS (www.eco.nomia.pt - consulted on 28/07/2018).

4.4 THE IMPACT OF RENEWABLE ENERGY ON ECONOMY

“A “smart grid” is a strategic part of most cleantech activities, and includes construction and real estate developers as well as ICT companies and software providers**”**

Andersson et. al (2012:30, 31)

Ferreira (2007:V) points out the sustainability and positive impact of renewable energy through externalities: “Energy decisions play a major role in the achievement of sustainable development and consequences on the economic, environmental and social welfare of future generations. Combining energy efficiency with renewable energy resources constitutes a key strategy for a sustainable future, emphasised in the European and Portuguese policy guidelines”.

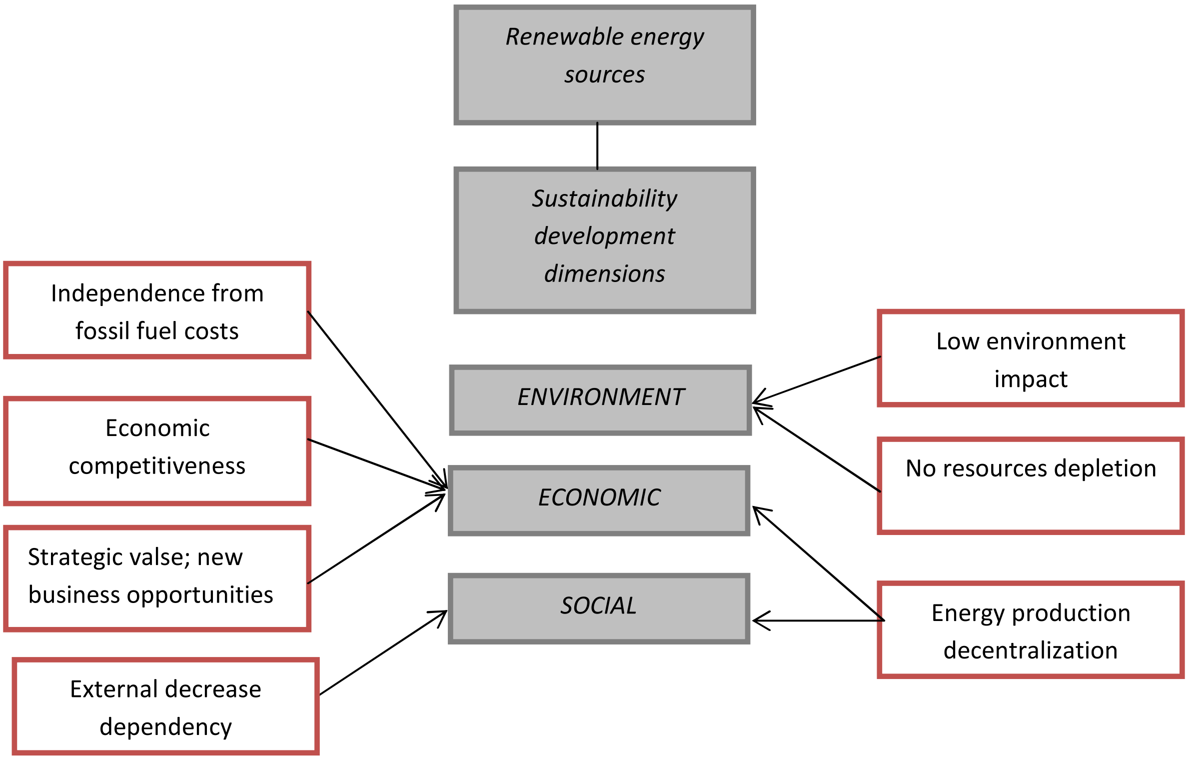


Figure 30– The Renewable Sustainability

Source: Ferreira (2007:44)

According to Chien and Hu (2008) the renewable energy impact can be estimated through an econometric model through GDP (Gross Domestic Product) increase (GDP= $a_1I+a_2TB+a_3C+a_4E$) + a_5RN+E_1 where, $I=b_1RN+b_2C+E_2$; $TB=c_1EI+c_2RN+E_3$; $EI=d_1RN+E_4$; $C=f_1EI+f_2TB+E_5$ and C= consumption; I= investment; RN= renewable energy; EI= energy import; TB= trade balance); government expenditure was not included due to the multicolinearity problem.

The model presented by Chien and Hu (2008) identified which macroeconomic variables has major impact in the economy from the renewable energy sector. According to the authors, there is a direct impact on three main groups, environment, economic and social towards a GDP increase; the coefficients are the impact which influences directly the macroeconomic variables. The goal is to estimate and to control the coefficients towards a positive impact on economy from renewable energy.

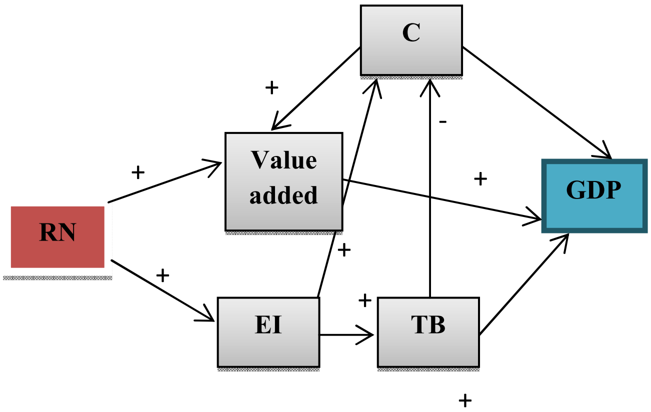


Figure 31– The Renewable Energy Influence on GDP[7]

Source: Chien and Hu (2008:3050)

The model presented by Chien and Hu (2008) studied 116 countries, e.g. Austria, Belgium, Denmark, Estonia, Finland, France, Greece, Iceland, Ireland, Italy, the Netherlands, Norway, Portugal, and the United Kingdom. It presents the relationships between renewables and macroeconomic variables towards GDP sustainability.

Johansson, T. B. (1993) and Diccer (2000) point out some effects of renewable energy use: economic and social development, air pollution reduction, decrease in carbon and gas, energy supply diversification, and reduced nuclear weapons. Renewable energy has essentially three functions in the economy: electricity supply, transport, heating and refrigeration (Castro (2012:8).

From the Portuguese point of view, the economic impact on employment from offshore renewable energy was presented by Direção Geral de Recursos Naturais, Segurança e Serviços Marítimos (DGRM) (2016: 105). The data shows an important participation in employment in different offshore renewable energy sectors. According to the same source, the capital yield will be near 30% (€1 will promotes €1.3 of capital) and the value added will be near €400M in 2020.

[7] C- household consumption; TB- trade balance; EI - Energy imports; RN- renewable;

Table 17–Activity Provision and Its Impact on Employment (2015-2022)

Project	Year	Total investment (M€)	National Public Investment (M€)	Portuguese Spending	Employment created (nº of persons)
R&D National projects	2015-2022	4.4	3.5	4.4	87.5
R&D European projects	2015-2022	50	0	7.5	150
Provision of services	2003-2014	2.8	0	2.2	27
Demogravi3	2015-2018	20	0	9.3	55
Windfloat Atlantic	2017-2022	105	48.9	70	350
Cabo Offshore V. do Castelo	2017-2018	30	30	10	50
CorPower (Prototype)	2017-2018	9	4	7	35
CorPower (1st farm)	2020-2022	13	7	10	50
Waveroller (prototype)	2016	3	0	1.5	7.5
WaveRoller (demo farm)	2017-2018	8	3	5	25
Waveroller (NER300 farm)	2019-2022	9	2	6	30
Total	**2015-2020**	**254**	**98**	**133**	**150**

Source: DGRM (2016: 105)

Table 18– Activity Prevision (2022-2030)

Year	Wind (MW)	Wave (MW)	Total Investment Wind	Total Investment Wave	Portuguese spending (M€) wind	Portuguese spending (M€) wave	Employment Wind (nº of persons)	Employment Wave (nº of persons)
2024	50	10	150	40	105	32	1080	12
2026	60	20	168	74	118	59	1440	40
2028	70	45	182	149	127	119	2070	103
2030	80	65	192	195	137	156	2610	235
total	*260*	*140*	*692*	*458*	*484*	*366*	*7200*	*390*

Source: DGRM (2016: 105)

4.5. OFFSHORE ENERGY CLUSTERS SWOT ANALYSIS

"SWOT analysis has been praised for its simplicity and practicality. As a framework, it has been widely adopted but, generally, its use has been accepted uncritically. It is timely to reappraise its value as a strategic management tool"

Pickton and Wright (1998: 101).

SWOT analysis is the beginning of a business strategy in any market; therefore, in order to survive, any organisation needs to assess and evaluat products, to be competitive. In this perspective it is important to analyse the market position in comparison with other organisations with the same market segmentation.

Moreover, the SWOT analysis completes how clusters deal with their strengths, weaknesses, opportunities and threats.

According to Kartakoullis et al. (2002:8) the SWOT analysis allows the researcher to summarize the relationship between key environmental influences, the strategic capability of the organization, and the agenda for developing new strategies.

Terrados et al. (2007: 1276) define strategic planning as an extended tool for regional development and territorial structure. Consequently, SWOT analysis is an instrument which comprises internal and external factors associated with favourable and unfavourable factors (Valentin, 2001:54).

In this point of view, there are four main fields in SWOT analysis:

- "**Strengths":** internal positive characteristics that the organization can exploit to achieve its goals;
- **"Weaknesses"**: internal characteristics that may inhibit the organization from achieving its goals;
- **"Threats":** external environment characteristics that may prevent the organization from achieving its strategic goals;
- "**Opportunities"** are described as the characteristics of the external environment that have the potential to help the organization to achieve or exceed its strategic goals (Kartakoulliset al., 2002:8).

SWOT analysis is a methodology to set up a business plan based on hierarchical objectives, quantitative objectives, real goals and consistent objectives (Kotler and Keller, 2007:53). SWOT analysis presents some limitations, such as:inadequate definition or lack of prioritization of factors; over-subjectivity in the generation of factors: compiler bias (Pickton and Wright, 1998: 105).

Terrados et al (2005), Markovska et al. (2009), Aydin (2014) and Chen et al.(2014) point out the importance of using SWOT analysis to face problems in a renewable energy industry, namely suitable strategies that could overcome such problems, and also summarize key issues of the business environment, including the organization capability strategy (Kartakoulliset al., 2002:8).

Not surprisingly, clusters can be related to SWOT analysis. The regional planning and regional strategy are both concepts which comprise better cluster performance.

SWOT analysis confirms plans for better utility of resources. The general balance either internal or external is shortly exposed in the organisation through a business plan towards problems which emerge in relationship with the environment.

According to Karppi et al. (2001: 17) any process of choice will become a process of planning (or strategic choice) if the selection of the current actions is made only after a formulation and comparison of possible solutions over a wider field of decisions relating to certain anticipated as well as current situations.

Aydin (2014:6) presents the most important points off a SWOT analysis for the renewable wind energy sector:

1- **Strengths**– domestic source; new business opportunity; resources are environmentally friendly; wind energy is renewed on a daily basis; it provides a central control for each government; the supply of sources depends on the needs; well-planned transport system can reduce costs on the supply chain; contribution to long-term energy demand; contribution to energy diversification and energy competitiveness.

2- **Weaknesses** – Energy share still small in the world market, although this share will increase but it will only surpass the fossil fuel by 2030. Governments are required to promote this type of energy otherwise they will fall behind fossil fuel. The initial investment is high and production does not occur on a stable level;

3- **Opportunities** - Development of new technologies; market size will increase effectiveness; more effective SME technologies due to the use of super conductors;

4- **Threats** – few grants; tax exemptions needed to be provided by governments (otherwise prices will be higher than fuel energy); as some initial setup costs are high, there are negative effects on market entry.

The SWOT analysis presented by the European Commission (2013:15) for central Europe (Austria, Czech Republic, Hungary, Slovakia, Italy, Poland) on energy and environment presents the following (it was not mentioned the Opportunities and weaknesses):

Strengths

- better energy promotion and environment industry; transfer of knowledge and know-how; cluster internationalization, sharing research and testing facilities, and developing new and better services for clustered firms; ability to innovate common projects with real business value; generates market for others products; sharing best practices; regional development policy influence; boosting interests of potential members due to access to European Union funding.

Threats

- economic crises and lack of financing sources; decrease in clusters members' activity; cultural differences; lack of trust among clusters; differences among the mega clusters members (national/regional, priority differences); without a members string commitment, the mega clusters can became a platform without any real content.

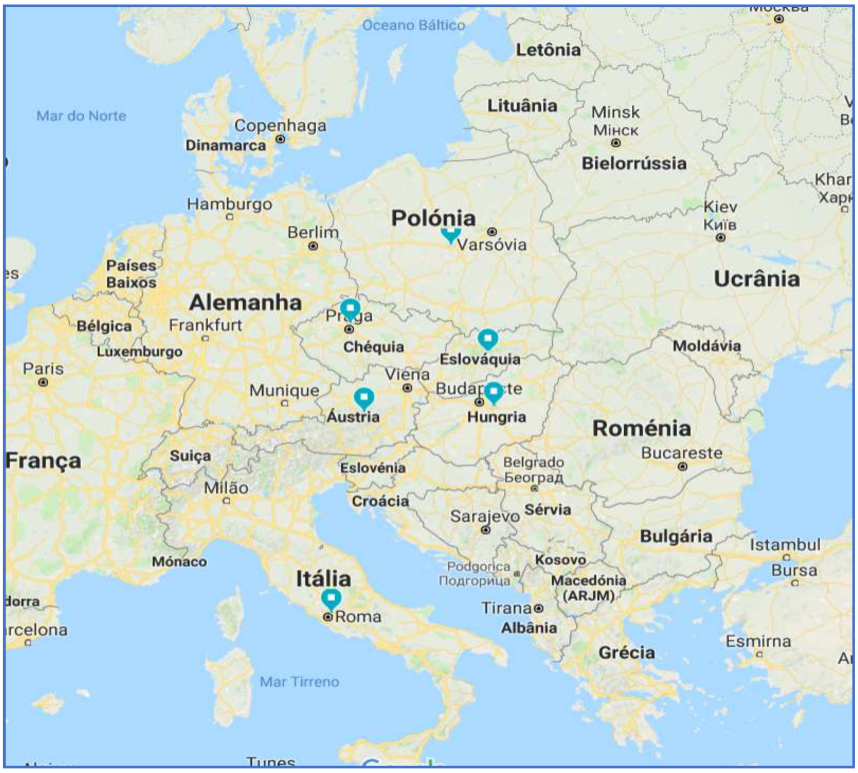


Figure 32- SWOT Analysis location Map for Central Europe

Ferreira and Vieira (2010:3) developed a SWOT energy sector analysis in Portugal, referring to the characteristics of the Portuguese energy system and the internal features of companies presently operating in the market and project investments. The SWOT analysis of the offshore wind cluster is presented below.

Table 19– SWOT Analysis of the Offshore Wind Energy in Portugal

Internal	***Strengths***	***Weaknesses***
	Offshore wind speed higher than onshore wind speed; no population density; experience of national companies in the sector; motivation of private companies; national cluster for the wind industry; Independence from fossil fuel markets.	High installation costs; unpredictability of the wind speed; technology still under development; reduced experience with the technology; economic viability dependent on regulated tariffs
External	***Opportunities***	***Threats***
	Still no offshore wind farms in Portugal; market growth perspectives; revenues protected by feed-in tariffs and by ensured access to the grid; energy and climate change are a priority on policy agenda	Competition from other renewable energy sources; high concentration of the electricity market; tariff liberalization trend in the market; increasing demand for turbines across the world

Source: Ferreira and Vieira (2010:3)

Moreira and Almeida (2013:27) also analysed Portuguese offshore wind energy through SWOT analysis. The strategy was to study the organisations and its relations with external and internal features towards a major valuation of wind energy highlight sector expansiveness, low environmental impact, market growth perspectives, access to electric network, and the possibility of an energetic national cluster.

However, some negative aspects are also pointed, namely high costs, low experience and supply of other renewable energy sources.

The study presented by Reid et al (2007) highlights the economic features of a renewable energy cluster and SWOT analysis. The study refers to the economic challenges of a cluster-based strategy.

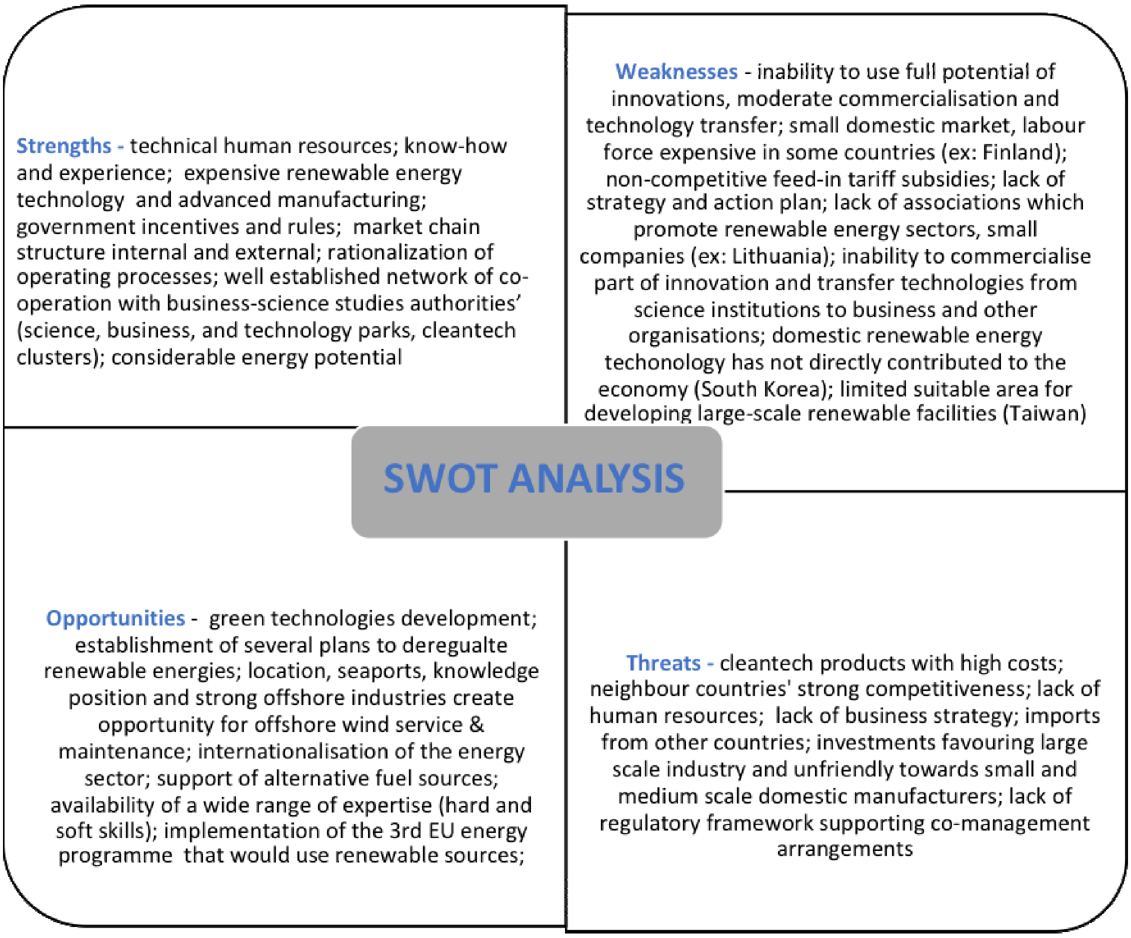


Figure 33– Offshore Wind Clusters SWOT Analysis in Several Countries[8]
Source: Michler-Cieluch (2009); Regozin (2012:63, 64); Stewart (2013); Chen et al. (2014: 324,326, 327)

To sum up, the swot analysis methodology and its applicability to energy sector is a good instrument to analyse the market and the players. This means, a new way to improve market strategies and perform a business networking. In long run, it is important to set up a plan to be competitive with the energy sector in terms of costs, human resources and prices.

[8]Japan, South Korea, Finland, Lithuania, Taiwan, Germany, USA

CHAPTER 5– MARITIME ENERGY IN THE EU AND IN PORTUGAL

"It takes more than machines and lines for electricity supply to any country to be perfect; it takes organisation"

Figueira (2018:66*)*

The chapter five focus on maritime energy in EU and in Portugal. The European Energy Policy it is discussed, as well as, the renewable energy evolution in Europe and in Portugal, offshore energy investments included. To complete the analysis, the economic impact concept is also discussed. This chapter ends with the presentation of the planned offshore energy projects in Portugal.

5.1 THE RENEWABLE ENERGY IN EUROPE AND PORTUGAL

"el consumo de energía, de materias primas, resultado del desarrrollo económico e industrial a escala mundial (…) Se dessarrolan por tanto nuevas técnicas de propección (por ejemplo de teledetección) y de extracción además de verificar como referimos un esfuerzo creciente de criacón de soluciones alternativas: utilización de los recursos renovables como la energía hidroeléctrica, la energía geotérmica, do los océanos e eólica"

R. Salvador (2005: 632).

Renewable energy has become an important issue in the EU due to the fact it can make a significant contribution to total electricity production. It is viewed as a potential industry to stimulate economic development and improve energy dependence, as well as national competitiveness and re-regulating the economy.

Renewable energy comprises benefits such as reducing the use of fossil fuels, delivering higher security and reducing energy imports.

The following tables show the importance of renewable energy in energy production. The data shows an important participation of renewable energy in gross electrical production, share of energy from renewable sources in consumption (%), and the contribution of renewable energy to the total primary supply.

Table 20– Member States (and Norway) Renewable Energy Production Growth rate (TWH) in %

Countries	Growth rate 2014/2005	Countries	Growth rate 2014/2005
Austria	25	Finland	13
Sweden	5	Germany	158
Portugal	***106***	Ireland	239
Denmark	89	Greece	103
Spain	122	**UK**	**329**
Italy	167	France	58
Belgium	**486**	Holand	55
Norway	1		

Source: DGEG (2015:18/19)

Table 21– EU Renewable Gross Electricity Production (wind and tidal, wave and ocean), 2018, 1990-2013 (GWH)

	1990	1995	2000	2005	2011	2012	2013	Growth rate (1990/2013)
Wind	778	4068	22254	70455	179669	205980	235012	301.1%
Tide, wave and ocean	503	507	507	481	478	462	420	-16.5%

Source: Eurostat (2015:91)

Table 22– Share of Renewable Sources in Gross Final Consumption of Energy (%)

	2011	2012	2013	TARGET 2020
EU-28	12.9	14.3	15.0	20
Portugal	24.7	25.0	25.7	31

Source: Eurostat (2015:91)

Table 23– Renewable Sources as a Percentage of Total Primary Energy Supply

	1970	1990	2010	2014
Portugal	21.6%	19.5%	23.2%	24.6%
UE 28	----	4.3%	9.8%	-----
OECD	-----	5.9%	7.8%	9.2%

Source: OECD (2016: 107)

The European Commission (2016:12) argues that "the energy sector plays a fundamental role in society and in the Portuguese economy";all agents in the electrical sector have unanimously recognised that there is a very significant potential for developing renewable energy in Portugal.

The Directive 2009/28/EC of 23 April established a target of 31% for Portugal as the share of renewable energy in the nation's gross final energy consumption, to be achieved by 2020, which implies an increase of 11.3% as compared to the figure recorded in the base year of 2005, which was 19.8% (European Commission, 2016:23). Therefore, the potential that exists for developing new projects with regard to RES will increase the Portuguese capacity for the share of renewable energy consumption for 2020 (31% of the total).

This recognition reflected the importance of renewable energy in various sectors of activity, such as transport industry and the domestic sector.

From the point of view of security of supply, as Portugal does not have known fossil fuel resources or reserves, renewable energy sources play an essential role in promoting the energy diversification and contributes towards sustainability production, transmission and energy consumption.

Portuguese RES is considered the big change for energy production and competitive energy sector supply. The expectation is to support sectors strategically with strong electricity dependency, such as transport.

Table 24– Expected Installed Capacity & Yearly Growth (2020-2030)

	Portugal	Rest of EU	U.S.A	Japan	Rest of the World
MW	314	96,529	38,000	9,800	62,882
Yearly Growth 2020-30	28.8%	14.2%	33.8%	42.3%	19.2%

Source: PwC (2016:5)

Table 25– Estimation of Total Contribution (installed capacity, gross electricity generation) in Portugal to meet the Binding 2020 Targets and the Indicative Interim Trajectory Offshore from Renewable Recourses in Electricity Sector 2017-2020

	2017 (MW/GWH)	2018(MW/GWH)	2019(MW/GWH)	2020(MW/GWH)
Tide, wave and ocean	100/159	125/206	175/297	250/437
Wind offshore	25/60	25/60	25/60	75/180

Source: European Commission (2016: 119)

Portuguese offshore renewable projects were developed in two main typologies: wind offshore and wave. However, the offshore wind energy will have an important role in increasing renewable energy consumption.

According to the European Commission (2016:121), the exploration of the offshore potential for wind energy will play a negligible role by 2020, in terms of contributing towards the production of electricity, since the use of this resource depends on technological developments and its economic viability.

Among the existing technologies, the support structure for the towers that are the best suited to the conditions of the Portuguese coast are still at a nascent stage and entail very high costs.

Thus, it is expected that by 2020 the installed capacity for offshore wind energy will not have exceeded 75MW, which will essentially serve the purposes of research and technological development.

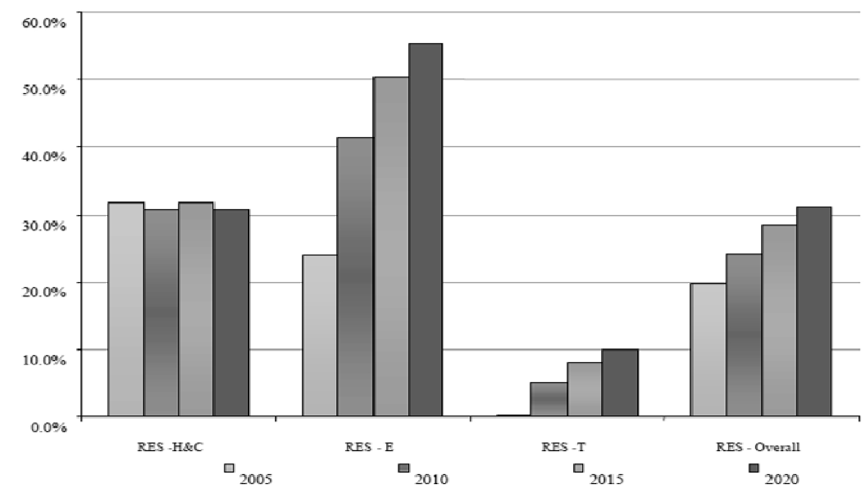


Figure 34– Evolution of the Estimated Trajectory of Energy Consumption from Renewable Sources in the Heating and Cooling, Electricity and Transport Sectors

Source: European Commission (2016:26)

5.2 THE EUROPEAN ENERGY POLICY

"ENVE[9] will contribute to increase the role of local and regional authorities in the EU Energy Policy: especially as regards to the micro-production of renewable energy, energy efficiency, exchange of energy data, energy infrastructure and smart grids, as well as innovative low carbon technology and the position of consumers in the internal market"

Work programme of the ENVE Commission, Committee of the Regions EU, February 2016

[9]The **Commission for the Environment, Climate Change and Energy (ENVE)** coordinates the Committee of the Regions' work in the following areas:

- Climate change: adaptation and mitigation
- Renewable energy
- Environment Policy
- Trans-European networks in the energy sector
- New energy policie
- Space policy for territorial development (Galileo, GMES/Kopernikus and related issues)

The European Energy Policy (2014-2020) is synonymous with consistency with the environment. On renewable energy, the EU's Framework Strategy Goals for a resilient Energy Union 2020,[10] introduced in 2015, complements the existing climate change (Eurostat, 2016) and energy governance up to 2020 and guides development until 2030.

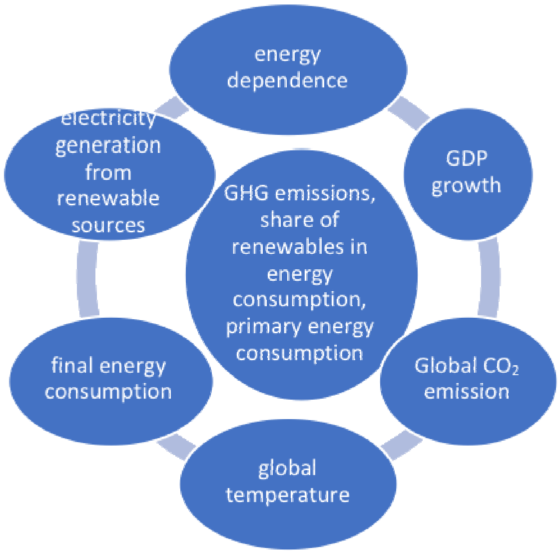


Figure 35– Climate Change Dimensions
Source: Eurostat (2016:89)

In order to meet the climate change dimensions, every Member State presents a National Renewable Action Plan.[11] The plan presented by Member States defines national targets with regard to the share of energy from renewable sources used in the transport, electricity and heating and cooling sectors in 2020, as well as the respective

[10] Reducing GHG emissions by at least 20% compared with 1990 levels; increasing the share of renewable energy in final energy consumption to 20%; moving towards a 20% increase in energy efficiency. (Eurostat, 2016:88)

[11]Directive 2009/28/EC of the European Parliament and of the Council, of 23 April 2009 establishes, in Article 4, that Member States must approve and present a National Renewable Energy Action Plan (NREAP) to the European Commission by 30 June 2010. On renewable energy, the National Renewable Energy Action Plan for Portugal was based on the Commission Decision of 30 June 2009, which provides a template for national renewable energy action plans in the second paragraph of Article 4(1) of the same European directive.

trajectories in accordance with the pace of implementing the measures and actions that have been envisaged for each of these sectors.

The plan must identify and describe these sectorial measures. In addition to suitable measures to achieve overall national targets, the plan must take into consideration the effects of other policies pertaining to energy efficiency in the context of energy use as well as measures to be implemented in order to comply with the requirements established in articles 12 to 17 of Directive 2009/28/EC.

The plan considered all contributions and synergies, such as cooperation between local, regional and national authorities, the possibility of using mechanisms to physically or statistically transfer energy, joint projects with other Member States and national policies to develop existing endogenous resources and to mobilize new endogenous resources.

The legal basis of the European energy policy legislation is laid down in Article 194 of the European Union Treaty

- 1. In the context of the establishment and functioning of the internal market and with regard for the need to preserve and improve the environment, Union policy on energy shall aim, in a spirit of solidarity between Member States, to:
- (a) ensure the functioning of the energy market;
- (b) ensure security of energy supply in the Union;
- (c) promote energy efficiency and energy saving and the development of new and renewable forms of energy; and
- (d) promote the interconnection of energy networks.
- 2. Without prejudice to the application of other provisions of the Treaties, the European Parliament and the Council, acting in accordance with the ordinary legislative procedure, shall establish the measures necessary to achieve the objectives in paragraph 1. Such measures shall be adopted after consultation of the Economic and Social Committee and the Committee of the Regions.
- Such measures shall not affect a Member State's right to determine the conditions for exploiting its energy resources, its choice between different energy sources and the general structure of its energy supply, without prejudice to Article 192(2)(c).
- 3. By way of derogation from paragraph 2, the Council, acting in accordance with a special legislative procedure, shall unanimously and after consulting the European Parliament, establish the measures referred to therein when they are primarily of a fiscal nature.
- Source:http://www.lisbon-treaty.org/wcm/the-lisbon-treaty/treaty-on-the-functioning-of-the-european-union-and-comments/part-3-union-policies-and-internal-actions/title-xxi-energy/485-article-194.html, consulted in 15/10/2018

According to the European Commission (2015b:4), energy production sustainability should be based on competitiveness, security and sustainability, and enhance new energy technologies, with regard to renewable energy sources and sustainable fossil fuel technologies and public and private funding. Some actions have been implemented in order to achieve those goals: the White Book (1997): "Integrate climate and energy policies by 2020" (adopted by the European Council in March 2007); the Green book publication: "A framework for climate and energy policy in 2030" (27^{th} March 2013); the Roadmap for energy 2050: the "Internal energy market accomplishment"; "External relations in energy field establishment"; the "Energy supply improvement security and promotion"; and the "European Strategic Plan for Energy Technologies" (SET plan).

Nevertheless, the European Plan for renewable energy is based on the

e-Highway 2050 program. The program examines the framework conditions and, using various scenarios, develops approaches for planning the expansion of the European electricity grid by 2020, 2030, 2040 and 2050 respectively. Stakeholders from all over Europe are invited to discuss assumptions and intermediate results and to assess the final results of the different work packages in different consultations and workshops. The overall objective is to support the planning of the Pan-European Transmission Network, focusing on 2020 to 2050, to ensure the reliable delivery of renewable electricity and pan-European market integration.

The project will result in a modular development plan for possible electricity highways, based on various future power system options such as high Renewable Energy Sources (RES) penetration, technology breakthroughs in transmission technologies, innovative active demand-side management, and others.

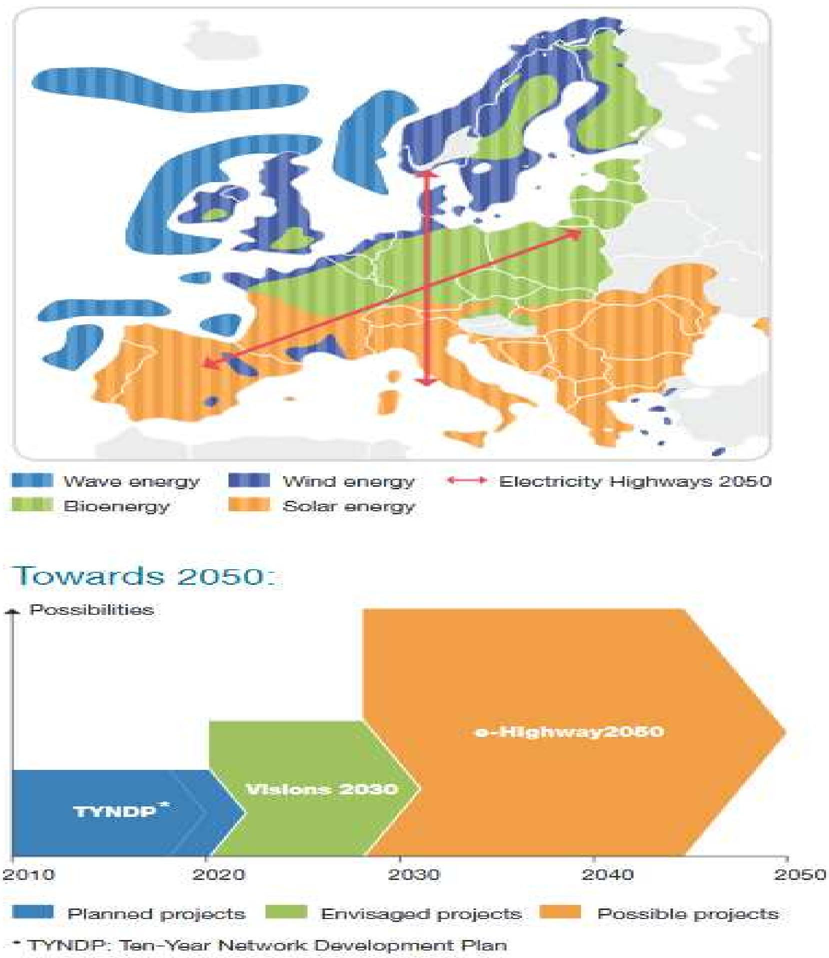


Figure 36– Renewable Energy Sources (RES) development by 2050

Source: https://shop.dena.de/fileadmin/denashop/media/Downloads_Dateien/verkehr/9013_MOB_Brochure_ehighway2050_englisch.pdf (20/07/2018)

Portugal today has a scheme to access the electricity network which prioritizes RES. Moreover, over the course of recent years Portugal has created a series of financial and fiscal measures to support investment in renewable energy. These measures have been boosted with the creation of differentiated tariffs for electricity produced in renewable plants and feed-in tariffs (FIT), according to the degree of maturity of the various technologies that are available in the national market.

These measures have helped to successfully achieve the overall objectives of the national energy policy. Renewable energy has become increasingly important and visible in national strategies.

The latest National Energy Strategy (NES 2020)[12] continues to attributing a pivotal role to renewable energy and its targets that have been delineated for this sector, with a very significant impact on the Portuguese economy.

NES 2020 incorporates the objectives of the energy policy, and seeks to maintain Portugal at the forefront of the energy revolution, with regard to the use of renewable energy. It will be based on unarticulated increase in the installed hydro and wind energy capacity.

Wave energy will be very important in the future. Specific instruments have been envisaged to promote it and to develop the necessary technologies. Amongst these measures, it is especially important to note the implementation of the pilot zone created by Decree Law No. 5/2008, to test technologies that serve to harness wave energy.

The main objectives of the National Energy Policy 2020 include:

- Guaranteeing compliance with Portugal's commitments in the context of European energy policies and measures to fight climate change, ensuring that 31% of the gross final energy consumption, 60% of the electricity produced and 10% of the energy consumptionin the road transport sector will be derived from renewable sources in 2020;
- Reducing Portugal's energy dependence on the importation of fossil fuels, to around 74% in 2020, by means of increasingthe use of endogenous energy resources (estimated reduction using a Brent reference of 80USD/bbl);
- Reducing the balance of energy imports by 25% (around €2 billion) with the energy produced from endogenous sources, making it possible to reduce imports by an estimated60 million barrels of oil;
- Consolidating the industrial cluster associated with wind energy and to create new clusters associated with new technologies in the renewable energy sector, ensuring a Gross Added Value of 3.8 billion euros and creating 100,000 new jobs in addition to the existing 35,000 jobs associated with the production of electricity from RES by 2020;

[12]Approved by Government Resolution No. 29/2010, of 15 April

- Promoting sustainable development, creating the necessary conditions to meet the commitments that Portugal has made with regard to reducing green house gases, by means of a greater use of RES and energy efficiency.In addition, the energy policy for RES, by means of the NES 2020, also established a series of specific measures in order to comply with these targets;
- Updating the micro-production programme, establishing more ambitious targets and introducing a mini-production programme aimed at projects with capacities of up to 150kW or 250 kW, according to the technologies used;
- Promoting the production of forest biomass, so as to ensure theconsumption needs that have already been installed and will be installed, by means of access to public support schemes, the promotion of certification for sustainable forest management, assessing and promoting energy crops, as well as, the residual biomass resulting from agricultural and agro-industrial activities.
- Creating, by the end of 2010, a permanent planning and monitoring system for demand and potential supplies of energy, so as to optimise the integrated management of available resources, improving the security of energy supplies and promoting more efficient use, along with the integration of different types of renewable energy.
- Implementing the National Plan for High-Capacity Hydroelectric Dams (PNBEPH), the new hydropower initiatives that are underway and reinforce the expected capacities, making it possible to make better use of potential hydropower and facilitating the growth of wind energy, by introducing a stabilising element in the form of reversible capacity in the planned investments.
- Creating the necessary conditions to introduce and popularise the use of electric vehicles, as a means of promoting the consumption of the renewable energy produced, with a view to positioning Portugal as a benchmark reference in terms oftesting, developing and producing solutions for electric mobility.

5.3 THE OFFSHORE ENERGY INVESTMENTS (WAVE AND WIND) IN PORTUGAL

5.3.1 Introduction

According to Figueira (2018:188) besides traditional forms of electricity production - coal fired, fuel or diesel thermal and hydroelectric power stations- which were used in Portugal from the nineteenth century, new forms of power, particularly renewable energy sources, such as wind, solar biomass, geothermal and tidal (wave) power are gaining ground in words and plans alike. Plans for renewable have become ever-more present since the last decade of the twentieth century and have been the focus of the energy debate in the country, together with the construction of large dams.

The same author point out that wind power was the first new power source to appear due to the technological advancement it achieved up to the 1980s-1990s, which meant it had reached a greater technical maturity and was able to guarantee operational and economic results. Although the first plans for the use of wind power to produce electricity in Portugal date from the early 1980s, only by the end of the century did it become reality (Figueira, 2018:192).

The latest European agenda for renewable energy 2020 argues for a more beneficial usage of natural maritime resources.

According to the Blue Growth program, the European Structural Funds provide good experiences for Members State as they can gain knowledge in research methodologies and applied science transfer.

Ocean energy is related to integrate maritime surveillance, maritime spatial planning and maritime knowledge towards sustainability in the economy, environment and social affairs.

However, negative impacts from Ocean Renewable Energy (ORE) can be pointed out: construction, operation and maintenance may impact on the environment; completed projects may result in a loss of access for fishers and navigation; aesthetic impacts may have a negative non-market impact on local communities in addition to market impacts on tourism and property values;

technologies involve substantial onshore coastal development in the form of cable landfall, transformer stations, ports and harbours and even power take-off in the case of devices which pump water ashore (Dalton et al., 2015:863).

The investments made in ORE (Dalton et al., 2015:854) can be divided into two main groups:

a) *Capital expenditure*, i.e. total project costs or initial project costs (*CAPEX*), which include: devices; cables/pipelines; foundations; installation (e.g. of device, moorings, cables, or electrical connections);

b) *Operating expenditure* for ocean energy technologies (OPEX), which includes: maintenance, insurance, site rent, other rents and annual impact statements.

Portugal has benefited from EU support both in R&D and infrastructures.

Offshore energy projects have benefited mainly from *the 7th Framework Program for Research and Technological Development– FP7*[13] *(2009-2013).*

Between 2007 and 2012 Portugal received about 12% (€7.6M) of total funding from FP7 funding (Intelligent Energy Europe). The main R&D offshore energy projects with EU support (2009-2018) are:

Table 26– R&D Offshore Energy Projects in Portugal

Projects	Funding	Period	Value (€M)	Partners (Beneficiaries)
SURGE	FP7 - ENERGY	2009-2013	3.0	AW- Energy
WAVEPORT	FP7 - ENERGY	2010-2014	4.6	UK Intelligent Systems Research Institute (ISRI); ISRI (United Kingdom), Wave Energy Centre (Portugal), University of Exeter (United Kingdom), Degima (Spain), Fugro-Oceanor AS (Norway), Ocean Power Technologies Inc., (USA)
DEMOFLOAT	FP7 - ENERGY	2011-2015	4.0	EDP Inovação; Principle Power (Europe);Limited, Vestas Wind Systems A/S, Sea Energy Renewables, Damen Shipyards Gorinchem, Laboratório Nacional de Engenharia e Geologia, Instituto de Soldadura e Qualidade, Caixa – Banco de Investimento, Sgurrenergy, National Renewable Energy Laboratory, A. Silva Matos Energia and

[13] *The FP7program* aims to respond to Europe's needs for jobs and competitiveness, and maintain knowledge leadership in the global economy. National institutions and companies participated in 1,788 FP7 projects, 364 (20.4%) with Portuguese coordination. These projects resulted from a total of 9,449 proposals submitted, which represents a success rate of 18.9%, similar to the EU average, which leads to a weak investmentin the sector.

				WavEC.
POLYWEC	FP7 - ENERGY	2012-2016	2.1	Scuola Superiore Sant'Anna, PetruPoni Institute, Selmar S.r.l.,University of Edinburgh; WavEC
DTOCEAN	FP7 - ENERGY	2013-2016	4.2	University of Edinburgh,IWES, University of Exeter, Marintek, France Energy Marines, Vattenfall, Prysmian, ITP, Join Research Centre, Tecnalia, HMR UCC, Aarborg University, Wavec, Iberdrola, Deme Blue Energy, Tension Technologies International, Sandia National Laboratoires, Oceans Energy Europe
MARINE TT	FP7-INFRASTRUCTURES	2011-2015	9.0	AquaTT; EurOcean Partner
TROPOS	FP7-TRANSPORT	2012-2015	4.9	Advance Intelligence Development S. L., University of Edinburgh, University of Strathclyde, Norsk Institutt for Vannforskning, Danmarks Tekniske Universitet, Phytolutions GMGH, Universitaet Bremen, Fraunhofer Gesellschaft, Hellenic Center for Marine Research, PMP - TVT, École Centrale de Nantes, Bureau Veritas, DCNS, EnerOcean S.L., Abengoa Seapower SA, Acciona Infrastructure, Universidad Politécnica de Madrid, Wave Energy Centre- Centro da Energia das Ondas
OCEANET	FP7-PEOPLE	2013-2017	3.4	WavEC Offshore Renewables(WAVEC), Instituto Superior Técnico (IST), Uppsala Universitet (UU), Fraunhofer – IWES (Fraunhofer-IWES), Maritime Research Institute Netherlands (Marin), Universidad de Cantabria (UC), École Centrale de Nantes (ECN), The University of Exeter (UNEXE), Tecnalia (TECNALIA), University College Cork (UCC-HMRC)
KIC- OTS	KIC-INNOENERGY	2011-2014	(not available from the source)	*Shareholders*(ABB Ab, AGH- University of Science and Technology, AREVA SA, Commissariate à l'Énergie atomique et aux énergies alternatives (CEA), Eindhoven University of Technology, Électricité de France S.A.S, ESADE, Fundació Institut de Recerca de l'energia de Catalunya
HIWAVE	KIC-INNOENERGY	2013-2016	2.3	CorPower Ocean, Wavec, Iberdrola
SOWFIA	IEE	201-2013	1.4	University of Plymouth, European Ocean energy Association, University College Cork, Wave Energy Centre- Centro de Energia das Ondas, Ente Vasco de la Energia, The University of Exeter, Instalaciones Inabensa Sa, École Centrale de Nates, Usapala University
SIOCEAN	IEE	2012-2014	0.8	European Ocean Energy, Wave Energy Centre, The University of Edinburgh, RenewableUK Association Limited, JRC Join Research Centre, DHI, The Carbon Trust
FAME	ATLANTIC AREA - INTERREG IV	2010-2013	2.2	Royal Society for the Protection of Birds (RSPB), BirdWatch Ireland (BWI), Ligue pour la Protection des Oiseaux (LPO), Sociedade Portuguesa para o Estudo das Aves (SPEA), Universidade do Minho (UMinho), Wave Energy Centre (WavEC), Sociedade Portuguesa de Vida Selvagem, Agência Francesa de Áreas Marinhas Protegidas, Martifer SGPS, SA
ATLANTICPC	ATLANTIC AREA	2012-2014	2.0	
ROADMAP	FCT (national project)	2010-2013	(not available from the	

			source)	
OTEO	QREN –COMPETE (national project)	2011-2013	0.2	
SDWED	DANISH COUNCIL	2010-2014	(n.a.)	Det Norske Veritas (England) - DNV, University of Bologna, Federal University of Rio de JanEI-ERO/COPPE, Ocean Structures & Underwater Technology - UFRJ, Rambøll Oil & Gas A/S (Denmark) - RAM, Wave Energy Centre - WavEC, Aalborg University Esbjerg (Denmark) - AAU-E, Edinburgh University, Fraunhofer (Germany) - FRAU
RICORE	H2020	2015-2016	1.4	Robert Gordon University from Scotland; Marine Scotland;University College Cork; WavEC; AZTI-Tecnalia;E-Cube Strategy Consultants
WETFEE	H2020	2015-2018	3.4	WavEC Offshore Renewables, Johannes Kepler University Linz, Plymouth University, INNOSEA, EDP, Selmar S.r.l., the Faculty of Engineering of Lisbon Technical University, Teamwork Technology, Aurora Ventures Ltd, Trelleborg, Scuola Superiore Sant'Anna (SSSA), University of Edinburgh
WAVEROLLER	H2020	2016-2020	10.0	Fortum, Wartsila, Eneólica, Metso, Wavec, Hempel Garrad Hassan, DCNS, Lloyd's Register energy

Source: Wavec (2013-2014)

The first pre-commercial phase was related to R&D. The infrastructures were partially supported by EU funds, and this will be continued for new projects (CapitalNER300 fund: wind €30M; wave €9.5M), as well as by the Portuguese government and private companies.

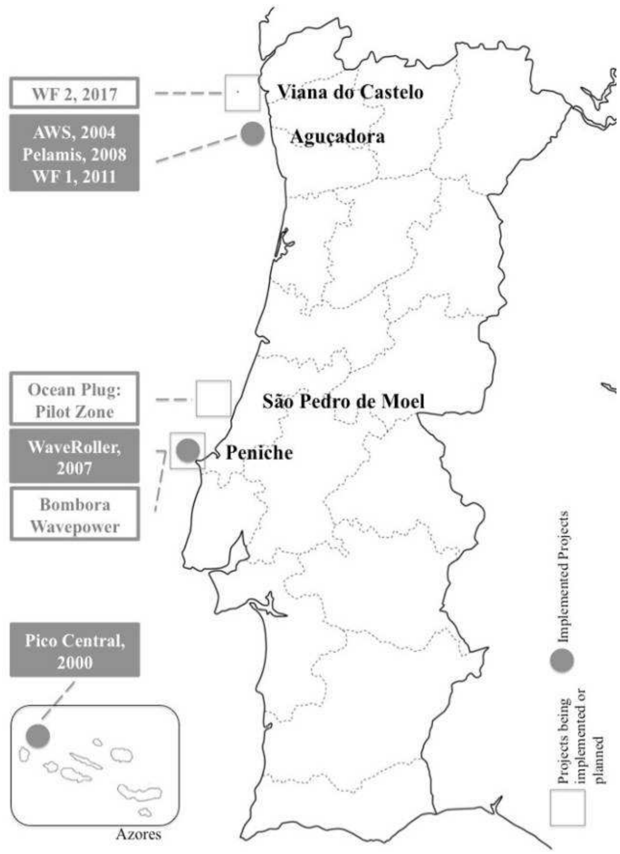


Figure 37– Offshore Infrastructures
Source: PwC (2016:6)

The map shows the infrastructures that have been built since the beginning of the offshore energy projects. The projects were mainly built in the Centre and North regions, due to the climate features and economic infrastructures (e.g. ports and related activities). It is expected that the latest offshore energy project located in Aguçadoura will create a new challenge for the national maritime economy, associated with jobs, value added and development of local activities.

Portuguese Offshore Energy Projects are divided in two types: wave and wind. The first investment in offshore energy in Portugal was the wave Pico Island Central (Falcão, 2000). It was followed by three wave energy investments: two at Aguçadoura (AWS, 2004 and Pelamis, 2008) and the WaveRoller at Peniche (2007). While Pico Central is still operational, the two wave farms at Aguçadoura have been shut down, providing evidence that a technology adjusted to the natural conditions in the north of the Portuguese offshore is not yet available, which is in fact a general problem as wave energy has still not been widely explored commercially (Falcão, 2010, Guedes Soares et al., 2012).

On the contrary, Windfloat (Roddier et al., 2010) was a pilot-project that successfully tested a floating turbine in average-deep water. The pre-commercial project (WF2) is expected to start operating in 2017.

The first offshore wind energy project in Portugal was Windfloat (WF1), also called DEMOFLOAT.[14] It was begun in 2011 with a prototype installed 6km from the coast (the nearest villages are Aguçadoura and Apúlia) and 12km from Póvoa de Varzim.

The purpose of this project was to demonstrate performance in the long run, including operation, maintenance, reliability, and platform accessibility and integration feasibility in the network on a modular basis to impact on system availability and therefore in the cost of energy produced.

Windfloat is an experimental project to test a floating turbine for installation in deep waters (depths greater than 40m). This is a way to harness wind energy at sea for conversion into electricity.

The location of the project is the same as that of the Aguçadoura Waves Park project marked on nautical charts, enabling the use of submarine cable connection to the electrical substation on land and its own power substation.

On 2nd June 2016 the project WF1 was decommissioned. The company "Principle Power" announced that the five-year test campaign for the project had come to an end. The final stages of the technological demonstration will involve the decommissioning of the system. At this date, WF1 provides approximately 17GWH of energy to the local grid whilst operational (www.4coffshore.com -on 29/06/2016).

The second phase of the offshore wind project (pre-commercial), “Windfloat Atlantic” will be based 20 km from the Viana de Castelo coast, in a water depth of 85-100m. It is expected to be ready in 2019, with a 25MW total capacity (3 turbines).

[14] http://www.demowfloat.eu/

Following the trial period of the WF1, WindFloatproject,SA continues to develop the production of offshore wind energy in Portugal. Windfloat is located in the union of parishes of Viana do Castelo municipality (Santa Maria Maggiore and Monserrate and Meadela), 20km from the coast.

In Portugal, wave energy research started in 1978 at the Instituto Superior Técnico(IST) in Lisbon and it was joined in 1983 by the Instituto Nacional de Engenhariae Tecnologia Industrial (INETI). Since 1986, Portugal has been successfully involved in the planning and construction of the shoreline wave energy converter "Oscillating Water Column" in Pico (Azores), supported by the government, the EU Programme Joule and companies in the Azores and the mainland (Clément et al., 2002:412).

5.3.2 Pico Island

The Pico EU Wave Energy Pilot Plant in Pico Island named Pico OWC (Oscillating Water Column) was built to show the technical viability of wave energy.

The project started in 1992 and was concluded in 1999, partially supported by the EU Joules Program,[15] EDP (Electricity of Portugal - mainland), EDA (Electricity of Azores- regional) and the Portuguese government.

Several technical problems and a lack of funding to address them after construction caused interruption of the project for several years. The situation of the Pico plant has worsened since 2012, when the EU Wavetrain2[16] project finished.

This project partially financed the Pico plant human resources costs. In 2013 some Pico plant activities were financed by the EU MariNET project.

The year of 2013 was marked by efforts by the Regional Government of the Azores to obtain funding for the Pico plant.

[15] http://cordis.europa.eu/programme/rcn/188_en.html
[16] http://cordis.europa.eu/result/rcn/58426_en.html

5.3.3 Aguçadoura

"A wave energy pilot zone off the coast was created in January 2008"

Palha et al. (2010:62)

1st phase

The EU-funded Aguçadoura project started in 2003, and is the result of over 20 years of research at Lisbon's Superior Technical Institute.

The global financial crunch of 2008 made the financing of the generators' re-installation more difficult. The wave farm has been shut down since then. The project had an investment of more than 8.8 million euros.

The maritime zone was located on the west coast off São Pedro de Moel, and was named Pelamis Wave Power. Aguçadoura Wave Farm is the world's first commercial wave energy project, and was installed at a depth of between 30m and 90 m of water, with an area of 320 sq. km, 5km from the Póvoa de Varzim coast.

The system had an electric tariff of €0.245/KWh, more than 2.5 higher than wind energy.

Table 27– Aguçadoura Pelamis Suppliers (2003- 2008)

PARTNERS	PRODUCTS FROM SUPPLIERS	NACE	ORGANISATIONS	NUTSIII
Babcock&Brown	Electricity generation,distribution and commercialization	3511	Enersis	AML
Pelamis wave power	Electricity generation,distribution and commercialization	3511	EDP	AML
Efacec	Electricity generation,distribution and commercialization	3511	Azores Electricity	Azores Islands
EDP	Engineering services	3511	Profabril	AML
	Civil construction	43290	Marques, SA	Azores
	Electronic Systems	71120	Efacec	AMP

source: www.wavec.org

2nd phase

The second phase of wave energy is related to the second project installed in 2010 on the *Peniche Coast*, named *waveroller* technology. The option for this location is related to geographical features and the national electric network. Peniche municipality presented positive points, such as local know-how related with maritime economy, dry assembly and sea activities and the proximity of partners with know-how. In 2009, a consortium consisting of local authorities, scientific entities and a company was formed and led by AW-Energy, the WaveRoller developer. The project called "Simple Underwater Renewable Generation of Energy" or SURGE was financed by the FP7, an EU funding scheme. The electricity utility company is Enéolica SA. The wave energy farm consists of three 100kW WaveRoller units (total nominal capacity of the farm 300kW) and was deployed in 2012.

Table 28– Peniche WaveRoller Project

PARTNERS	PRODUCTS FROM SUPPLIERS	NACE	ORGANISATIONS	NUTSIII
Peniche dry dock	Coordinator	35113	AW- ENERGY OY	AMP
WAVEC	Electric system draw	----	ABB FINLAND	-----
Hydrographical institute	Wing draw	-----	Multimart Oy (Finland)	------
Peniche Municipality	PTO system draw (power take off)	-----	Bosh- Rexroth (Germany)	------
	Technical optimization and wing manufacturing	30111	Dry Dock Peniche	Oeste
	Final design of the foundation, laying the WaveRoller	64202	Lena Group	PinhalLitoral
	Final design of the foundation, laying the WaveRoller	35113	Eneólica	PinhalLitoral
	Environmental monitoring	----	IMIEU- Germany	------
	Local administration	84113	Peniche Municipality	Oeste

	Sedimentary studies	72190	Hydrographical Institute	AML
	Technical monitoring operation of energy conversion unit and dissemination of results	35113	WAVEC (Wave Energy Centre)	AML

source: www.wavec.org

5.3.4. Planned Offshore Energy Projects

The Portuguese Government has approved *The Industrial Strategy for Ocean Renewable Energies (EI-ERO) (DR, 1ª série, nº 227, 24 de novembro de 2017)* with the aim of developing the country's offshore wind potential.

Based on the more conservative scenario, the government projects that by 2020 the ocean energy sector could generate, EUR 280 million in gross value added and EUR 119 million in trade, as well as 1,500 new jobs starting from a EUR 254 million in investment.

According to EI-ERO, ocean renewable energies have the potential to supply 25% of the electricity consumed annually in Portugal and create a new export chain in these new technologies.

The potential for offshore wind installation in the country is much more significant for floating turbines (40 GW), than for fixed ones (1.4 to 3.5 GW), according to EI-ERO, due to the distance to the coast needed for the reduction of the visual impact of the turbines and due to the slope of the continental shelf.

Looking at export opportunities, Portugal plans to secure a portion of the offshore wind market expected to be valued at EUR 227 billion by 2030. Portugal sees its chance in sectors which the country is already active in, such as the production of foundations and turbine towers, which is expected to be worth EUR 39 billion year by

2030. The government projects that potential exports could increase current employment in the active sectors by ten times, with the greatest potential for exports seen in the development of floating wind technology.

In terms of active offshore wind projects in Portugal, in November 2016, the Council of Ministers in Portugal gave the green light to the development of the WindFloat Atlantic (WFA) project in Viana do Castelo, 20km off the coast of Northern Portugal, which is scheduled to be operational next year.

When it comes to the developments in the country's supply chain, ASM Industries has signed a concession agreement with the Port of Aveiro Administration (APA), and will start building a new industrial production unit dedicated to offshore wind in January 2018. The company will also set up ASM Offshore, an autonomous business unit for manufacturing offshore wind towers and foundation.

One of the main issues is to create an industrial strategy which supports offshore renewable energy. The Portuguese Government (DR, 1ª série, nº 227, 24 de novembro de 2017: 6180 *)* set up areas with which the industry needs to deal:

1- to stimulate export from value added investments: to be competitive based on floating technology; to attract investments for wave energy based on competitiveness of R&D; to diversify and differentiate secondary renewable offshore energy business models.

2-*to reduce risks in industry*: to reduce technological risks with the renewable energy *Port Tech clusters*; to increase the development cycle; to reduce investment risks with the cooperation between public and private organisations; to simplify licences for Pilot-Zones.

Both strategies aim exporting offshore renewable innovative technology, creating intellectual property and qualified employment.

Therefore, the following *value chain for floating renewable offshore energy* is expected*:*

Planning– preparatory studies;

Turbine– design and engineering services; turbine construction; tower construction; installation, wind turbine blades construction;

Platform– design and engineering services; platform construction; assembly of platform; anchoring systems; inter-array cable construction;

Installation –anchoring system; cables; tugboat pier and support installations;

Network system connection– installation and network connection;

Services maintenance – turbines and platforms.

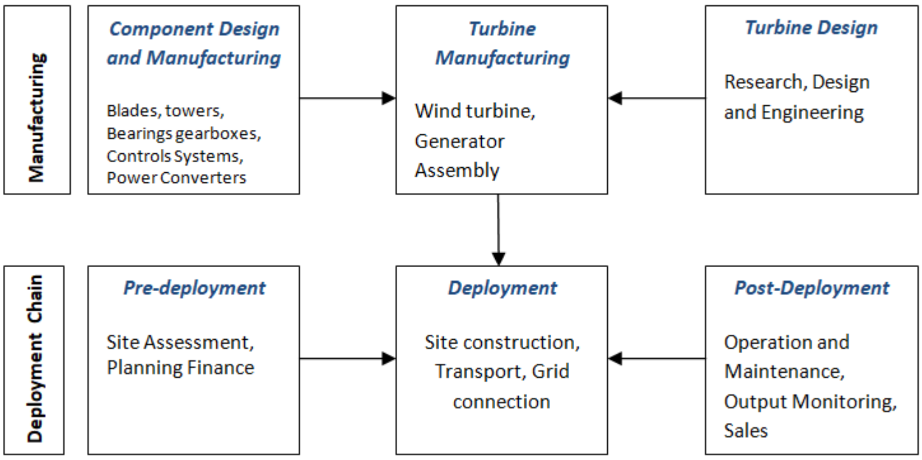


Figure 38– The Basic Wind Industry Value Chain
Source: MackKinnon (2018:8)

According to the *DR, 1ª série, nº 227, 24 de novembro de 2017*, it is possible to present a potential offshore energy cluster in Portugal with the following vectors:

Organisations, Port tech Clusters, Portuguese Government and Financial institutions.

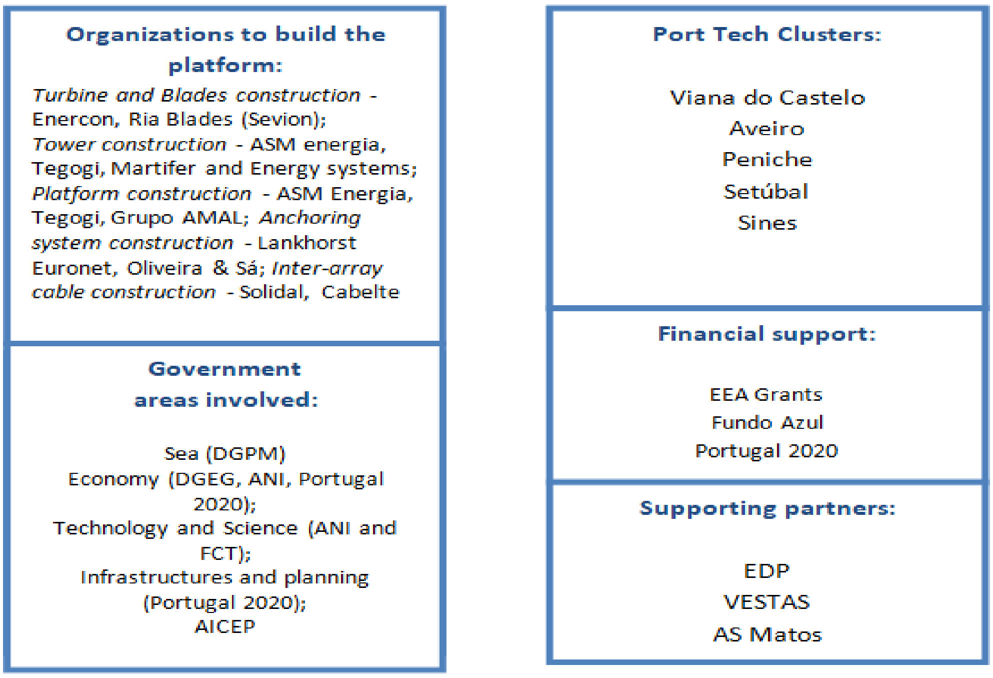


Figure 39 - The Potential Offshore Wind Farm Intervenient

It is expected that the Industrial Strategy for Ocean Renewable Energies (EI-ERO) will promote exportation with high technological intensity, and will develop a new value chain based on sustainability, employment and value added investment.

On the other hand, EI-ERO will be responsible for network port connections based on economic and industrial innovation with specialized jobs, growth and customers.

Moreover, it is expected that a new type of jobs, knowledge and cooperation will bring a new challenge for this emerging industry.

CHAPTER 6– A GEOGRAPHICAL ANALYSIS OF THE PORTUGUESE OFFSHORE COAST

The chapter six is a geographical analysis of the Portuguese offshore coast. This chapter analyses why offshore energy production is influenced by the continental shelf, wind and wave features. Therefore, wave and wind potential and factors in the region where the offshore wind project is implemented are analysed.

6.1 WIND AND WAVE RESOURCES

The best way to study a geographic region is to study the natural resources features. Offshore energy in Portugal is influenced by the continental shelf, wind and wave features.

However, to make predictions about offshore projects and its success it is necessary to analyse the physical features. Offshore projects are dependent on the impacts of climate change and energy technologies. These two factors are the supporting information to make offshore investment decisions in the future.

The energy production from renewable is completely safe from climate change point of view (Hassan, 2004:3) and its contribution to emissions of carbon dioxide are low or nule (Esteban et al., 2011).

Therefore, variables such as: temperature, rain, wind velocity, storms, floating and dry weather, sea level, and radiation and nebulosity perform the expectations for offshore projects in the future (Alves, 2013).

For this research the *wind and wave resources* were considered because they are the main factors which influence offshore energy production in Portugal.

For offshore wind and wave, the climate change variables are considered: temperature growth, storms and sea level.

In both cases it is expected that production of wind and wave will decrease (Alves, 2013); firstly the temperature will decrease the potential output because of low air density; secondly, storms will conduct the wind system and wave system to low levels of production, and thirdly, the increase in the sea level will change electric production.

6.1.1 Wave resources

Wave energy is considered as one of the renewable energy sources with potential development over the coming years (Mota and Pinto, 2014) due to the various several technological solutions and intensive research work (Tabuada and Lemu, 2016).

Tabuada and Lemu (2016) present the relationship between wind and waves towards a useful exploitation of renewable offshore resources. From this point of view, the best wave resources occur in areas where strong winds have travelled over long distances.

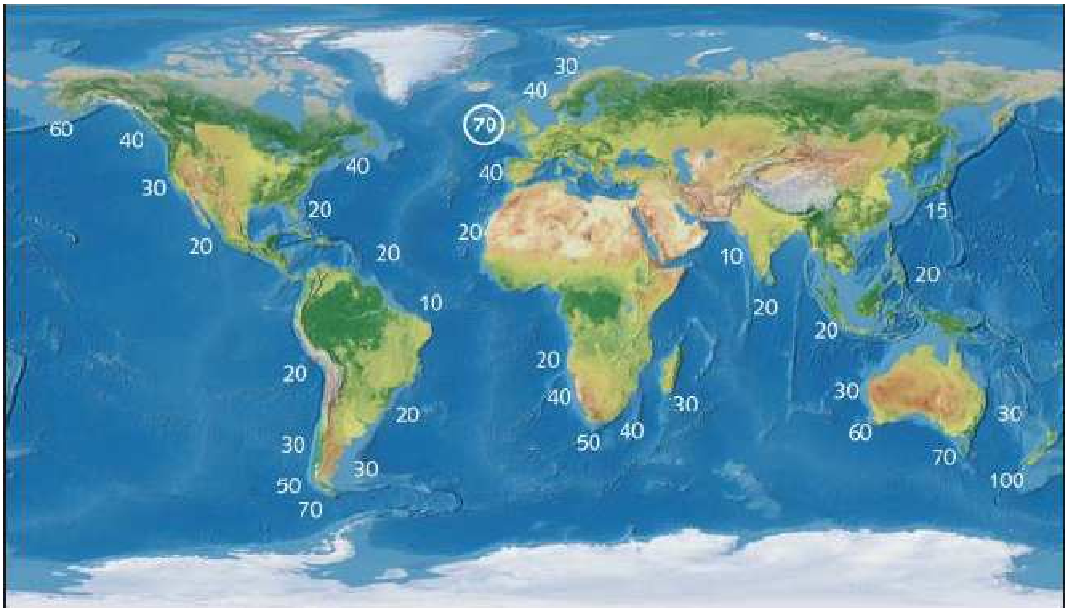


Figure 40– International Distribution of Wave Power Potential[17]
Source: Taboada and Lemu (2016:2)

The same study presents the relationship between wave speed and water depth in the ocean in order to create energy. This means that the energy associated with the motion of water particles has both kinetic and potential forms due to the respective orbital and vertical motion of the particles. Studies show that the total energy, which is proportional to the square of the wave height, is equally divided between kinetic and potential energy forms (Taboada and Lemu, 2016: 3).

[17] the legend refers to the potential wave power in the different regions in kW/m or MW/km,

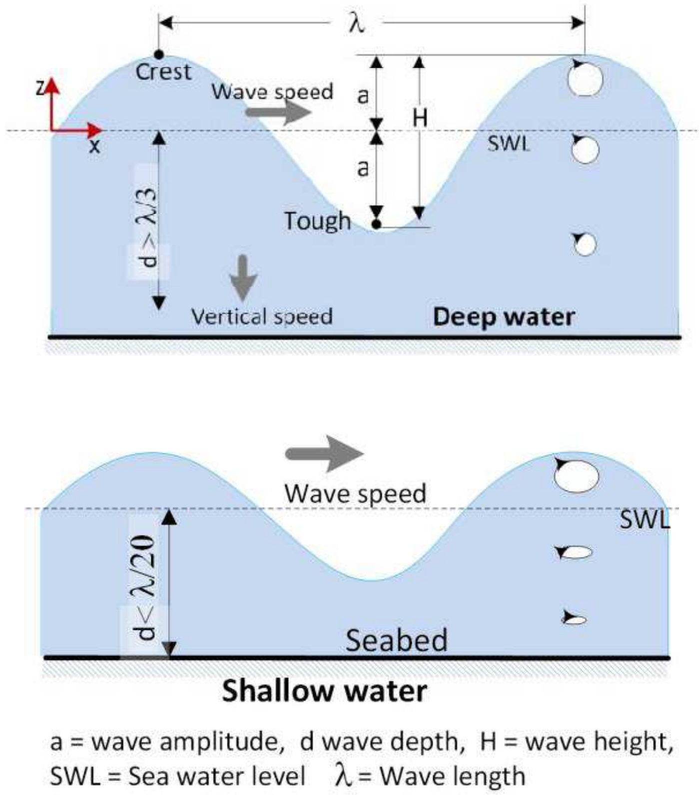


Figure 41– Wave Characteristics and Changes in Orbital Motion of Water Particles in Deep Water (top) and Shallow Water (bottom)
Source: Taboada and Lemu (2016: 3)

To conclude, the typology of waves in ocean is presented according to the World Meteorological Organization's (WMO) code for sea state, including wave heights and their descriptive characteristics.

Table 29– WMO Sea Code, Corresponding to Wave Height

WMO code	Wave height	Characteristics
0	0	Calm (glassy)
1	0 to 0.1	Calm (rippled)
2	0.1 to 0.5	Smooth (wavelets)
3	0.5 to 1.25	Slight
4	1.25 to 2.5	Moderate
5	2.5 to 4.0	Rough
6	4.0 to 6.0	Very rough
7	6.0 to 9.0	High
8	9.0 to 14.0	Very High
9	Over 14.0	Phenomenal

Source: Taboada and Lemu (2016: 3)

6.1.2 Wind resources

"Wind speed changes are mainly due to the thermal and pressure changes in the atmosphere"

Lu and Yang (2011:119)

According to Tuller and Brett (1984:124), a number of studies in recent years have investigated the fitting of specific distribution to wind speed data for use in such practical applications as air pollution modelling, estimation of wind loads on buildings and wind power analysis. In recent years, energy production from wind (offshore and onshore) has become popular, especially in Europe, where wind conditions are favourable and suitable for offshore production.

Table 30– The Relationship between the Beaufort and Douglas Scales

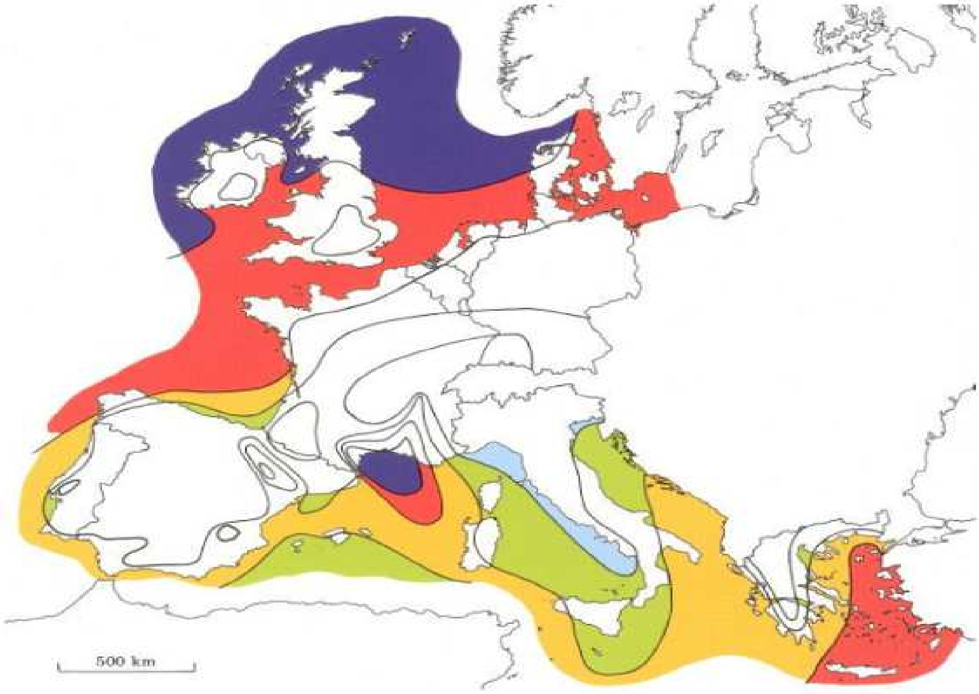
	Beaufort (wind)	**m/s**	***Douglas (Wave)***	**High (m)**
0	*Calm*	0.0-0.2	*Calm-glassy*	0
1	*Light air*	0.3-1.5	*Calm-Rippled*	0.00-0.1
2	*Light breeze*	1.6-3.3	*Smooth*	0.2-0.35
3	*Gentle breeze*	3.4-5.4	*Smooth* *Slight*	0.35-0.5 0.5-1
4	*Moderate breeze*	5.5-7.9	*Slight* *Moderate*	1-1.25 1.25-1.5
5	*Fresh breeze*	8.0-10.7	*Moderate*	1.5-2.5
6	*Strong breeze*	10.8-13.8	*Rough*	2.5-4
7	*Near gale*	13.9-17.1	*Very rough*	4-5.5
8	*Gale*	17.2-20.7	*Very rough* *High*	5.5-6 6-7.5
9	*Strong gale*	20.8-24.4	*High* *Very high*	7.5-9 9-10
10	*Storm*	24.5-28.4	*Very high*	10-12
11	*Violent Storm*	28.5-32.7	*Very high* *Phenomenal*	12-14 14-16
12	*Hurricane, Typhoon*	>=32.7	*Phenomenal*	>16

Source: www.institutohidrografico.pt, in 10/02/2017

The study of wind conditions follows the Beaufort scale and can be linked with the Douglas scale.

The relationship between these scales is important due to the need for a precise location for offshore equipment, related with wind, waves and tides.

The next figure shows the wind resource over sea. Offshore energy projects in Europe are mostly where there are exceptional wind conditions, such as Scotland, Denmark and Germany.



Wind resources over open sea (more than 10 km offshore) for five standard heights										
	10 m		25 m		50 m		100 m		200 m	
	$m s^{-1}$	Wm^{-2}	$m s^{-1}$	Wm^{-2}	$m s^{-1}$	Wm^{-2}	$m s^{-1}$	Wm^{-2}	$m s^{-1}$	Wm^{-2}
	> 8.0	> 600	> 8.5	> 700	> 9.0	> 800	> 10.0	> 1100	> 11.0	> 1500
	7.0-8.0	350-600	7.5-8.5	450-700	8.0-9.0	600-800	8.5-10.0	650-1100	9.5-11.0	900-1500
	6.0-7.0	250-300	6.5-7.5	300-450	7.0-8.0	400-600	7.5- 8.5	450- 650	8.0- 9.5	600- 900
	4.5-6.0	100-250	5.0-6.5	150-300	5.5-7.0	200-400	6.0- 7.5	250- 450	6.5- 8.0	300- 600
	< 4.5	< 100	< 5.0	< 150	< 5.5	< 200	< 6.0	< 250	< 6.5	< 300

Figure 42– Values of Sea Winds at Different Heights More than 10 km from the Coast (European Offshore Wind Atlas)

Source: Santos (2012:19)

Wind typology is divided into two categories, constant and continental (Mourão, 2010: 5-7).

- The constant are: *Alisios Winds*–winds caused by the mass displacement of high pressure zones (tropics) follow pressure zones (equator); *Contra-Alisios Winds*–winds blowing from the equator to the poles at altitude, originated by the rise of the trade winds when they reach low pressure (equator); *West Winds*–winds blowing west from subtropical areas tosub-polar areas; *Polar Winds*–winds blowing from the poles to temperate zones.
- The continental are: *Sea breeze*–breeze is the generic name given to airflows due to the difference between nearby surfaces; *Mountain and*

Valley Breeze– this circulation of breeze occurs due to the topographical features. At a given level of pressure in the valley, the atmospheric air is found to get away from the ground; *Circulation in the Lakes and Towns Neighbourhoods*–the breeze circulation described above has its origin in factors that produce horizontal temperature gradients; *Thermal Depressions*– this phenomenon has particular relevance because it helps to understand certain wind regimes that occur in Continental Portugal.

6.2 PORTUGUESE OFFSHORE GEOGRAPHY

"O mar português (porção do oceano associada a Portugal) é constituído pró camadas de água que se sobrepõem: - águas profundas (mais de 300 m de profundidade) e frias (3ºC) do Atlântico Norte, provenientes de áreas da Noruega e Gronelândia; - água de origem mediterrânica, quente, que circula entre os 400 e os 1500 m de profundidade; - água central do Atlântico do nordeste, que constitui a camada superficial, com um ramo subtropical e outro subpolar"

Ramalho et. al (2010:180)

Portugal has good natural and weather conditions for offshore wind energy: average to large depth of waters and fast winds, even if the winter winds are moderate across the Atlantic façade (Costa&Estanqueiro, 2006).Climate change is already evident and expected for the twenty-first century and it will have a significant impact on energy systems in southern Europe, particularly in Portugal (Alves, 2013:IV).

The case study (offshore energy projects) relates two main climate variables, the wind and the waves on the western coast.

Offshore energy projects started on the NW Portugal coast. Both wind and wave projects were installed due to the favourable climate conditions. Therefore, authors such as: Cruz and Sarmento (2004); Santos(2012); Mota and Pinto (2014) clarify the importance of climate features on waves and wind for these areas and their relation with the infrastructure implemented.

6.2.1 The Continental Shelf

"The continental shelf of a coastal State comprises the seabed and subsoil of the submarine areas that extend beyond its territorial sea throughout the natural prolongation of its land territory to the outer edge of the continental margin, or to a distance of 200 nautical miles from the baselines from which the breadth of the territorial sea is measured where the outer edge of the continental margin does not extend up to that distance"

Article 76, nº 1, UN Convention on the Law of the Sea

The importance of presenting the continental shelf in this study is related to the implementation of offshore energy projects. Therefore, three main areas are discussed: 1- territorial sea; 2- contiguous zone and 3- exclusive economic zone (EEZ) (figure 45).

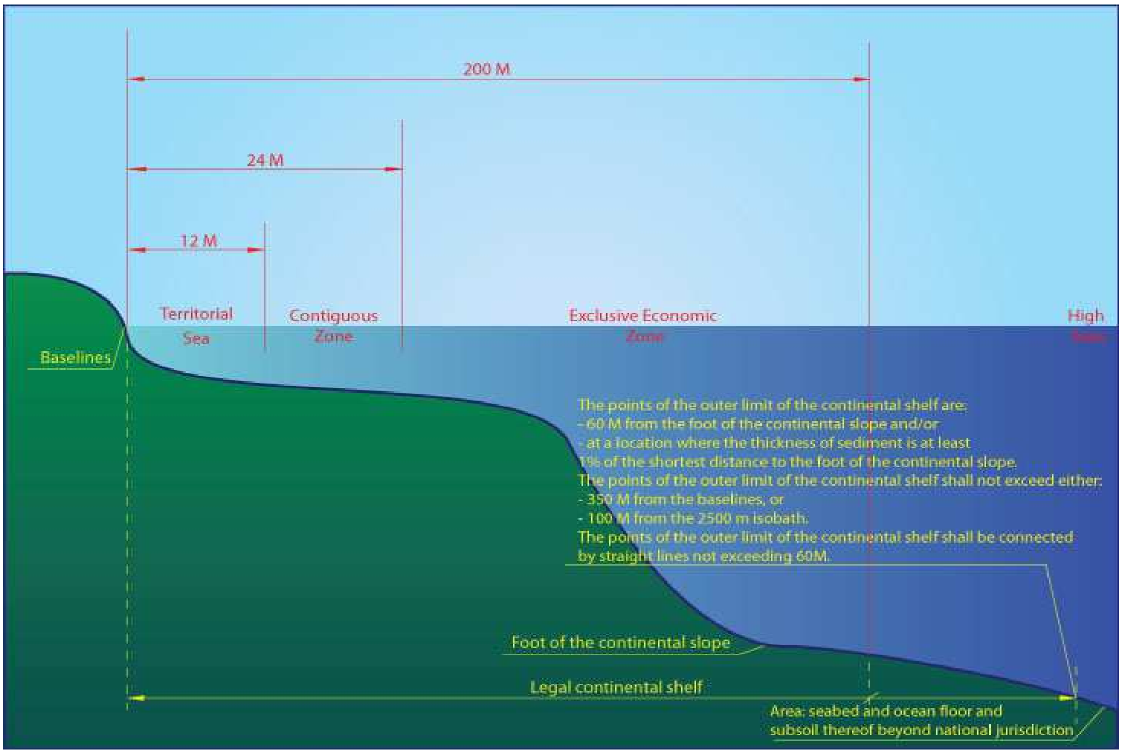


Figure 43– The Continental Shelf
Source: http://www.un.org/Depts/los/clcs_new/marinezones.jpg -on 22/01/2017

The exclusive economic zone (EEZ) is an area beyond and adjacent to the territorial sea, subject to the specific legal regime established in this Part, under which the rights and jurisdiction of the coastal State and the rights and freedoms of other States are governed by the relevant provisions of this Convention (UN Convention on the Law of the Sea, art 55:43).

The exclusive economic zone is an area beyond and adjacent to the territorial sea, extending seaward to a distance of no more than 200 nautical miles (370 km) out from its coastal baseline.

The exception to this rule occurs when exclusive economic zones mayoverlap; that is, state coastal baselines are less than 400 nautical miles (740 km) apart. The exclusive economic zone stretches much further into sea than the territorial waters, which end at 12 miles (22 km) from the coastal baseline (if following the rules set out in the UN Convention on the Law of the Sea).

The EEZ include the contiguous zone. States also have rights to the seabed of what is called the continental shelf up to 350 nautical miles (648 km) from the coastal baseline, beyond the exclusive economic zones, but such areas are not part of their exclusive economic zones.

The legal definition of the continental shelf does not directly correspond to the geological meaning of the term, as it also includes the continental rise and slope, and the entire seabed within the exclusive economic zone.

Portugal has the 10th largest EEZ in the world.

Presently, it is divided into three non-contiguous sub-zones: Continental Portugal 327,667 km^2; Azores 953,633 km^2; Madeira 446,108 km^2; Total: 1,727,408 km^2.

Portugal submitted a claim to extend its jurisdiction by an additional 200 miles, which means over2.15 million square km of the neighbouring continental shelf in May 2009, resulting in an area with a total of more than 3,877,408 km^2.

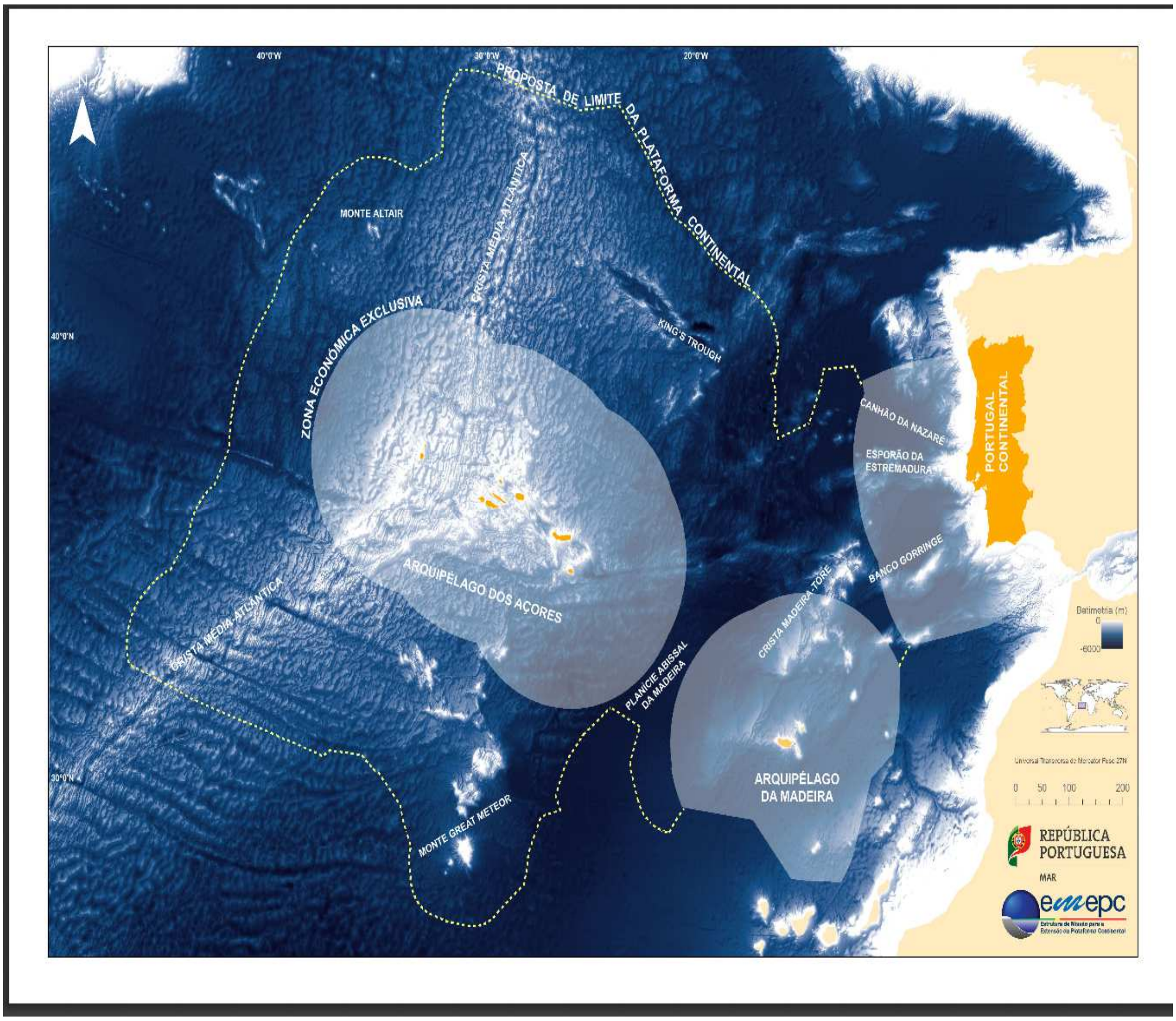


Figure 44– The Exclusive Economic Zone of Portugal
Source: http://www.emepc.pt/images/pdf/MapaPortugalMar.pdf -consulted in 21/10/2017

The Continental Shelf Extension Project (CSEP) gives Portugal sovereignty over the soil and subsoil in the area beyond 200 nautical miles. The benefits arising from the Continental Shelf Extension Project shall be felt to their maximum extent by future generations. The process to extend CSEP will be finished in 2021.

The exploitation of mineral resources, one of the cornerstones of developing any society, and this new sovereignty over more territory, will provide new opportunities for accessing natural resources with high economic potential. Apart from these, the CSEP was and still is an opportunity to:

- Increase the international influence of Portugal – better know-how and greater visibility with the demonstration of knowledge and scientific and technological capacity in the broad field of marine sciences;
- Unequivocally strengthen the position of Portugal in matters relating to the sea and oceans;
- Acquire and develop new equipment and new technologies, increasing operational capacity for accessing the deep sea;
- Investment in innovative research and development initiatives;
- Contribute to scientific development, particularly in areas such as hydrographical, geology, geophysics, oceanography, biology, robotics and international law, supporting research projects and establishing partnerships with laboratories, institutes and universities at national and international level;

The CSEP will allow Portugal to an increasingly position itself as a major European maritime nation, and will constitute at the same time a legacy for future generations, who will be able to enjoy and sustainably exploit this vast maritime domain, creating more wealth and providing a better quality of life for the Portuguese.

6.2.2 Wave conditions in Portugal

"As wave energy is considered as one of the renewable energy sources with a development potential over the coming years, several technological solutions are under intensive research"

Taboada and Lemu(2016:1).

Wave conditions on the offshore Portuguese coast result from a 15-year (1995 to 2010) wind-wave simulation (Mota and Pinto, 2014:10).

Maritime shaking is directly related with the wave features defined by the wind speed (IPMA, 2004).

In Portugal there are four main typologies in the western sea:

a) Northwestern sea (NW): the sea conditions are a result of NW wind from the North Atlantic and local winds (N and NW).During the winter time, the waves are between 2.5m/9s north of Cabo Raso, and 2m/8s south of Cabo Espichel. During the summer time, the waves are between 1-1.5m/7-8s in Cascais Barra do Tejo and Cabo Espichel- Barra do Sado.

b) Southwest sea (SW): the sea conditions are related to depressions or front surfaces in the SW Iberian Peninsula, normally during winter or transition time. Normally the waves are between 3-4m/9-10s, and sometimes the waves can reach 7m. The regions Cascais Barra do Tejo and Cabo Espichel- Barra do Sado have lower waves than the rest of the coast.

c) Western storm: the sea conditions are related to the polar front which gives rise to west strong waves or very strong waves. The SW wind is strong and the sea is ruffled. This type of weather conditions is typical in winter time. The waves are between 8 m (north) and 7 m (south)/16 s.

d) Out sea: the sea conditions are related with weak wind and the waves can come from long distances. Usually the waves have NW and W directions (winter time). The waves are between 1-1.5m/14s. The waves' condition is directly related to the seabed, and more and deeper waves can be created.

e) Sea bath: the sea conditions are related with weak wind. Normally, this situation occurs in just 4% in the north region and 10% in the south during the year. The waves are between 0.5-1 m with NW and WNW direction.

The study presented by Mota and Pinto (2014:11) states that the Portuguese west coast has essentially two distinct broad regions concerning offshore potential wave energy; the north and centre west coast corresponding to grid points 1 and 5, with an average wave power density ranging from 28.11 kW/m to 30.90 kW/m, and the southwest coast represented by grid points 6 and 7, with an average wave power density of 21.51 kW/m and 22.96 kW/m, respectively.

The contribution to offshore wave energy by regions is presented in the next figures (figure 45 and 46).

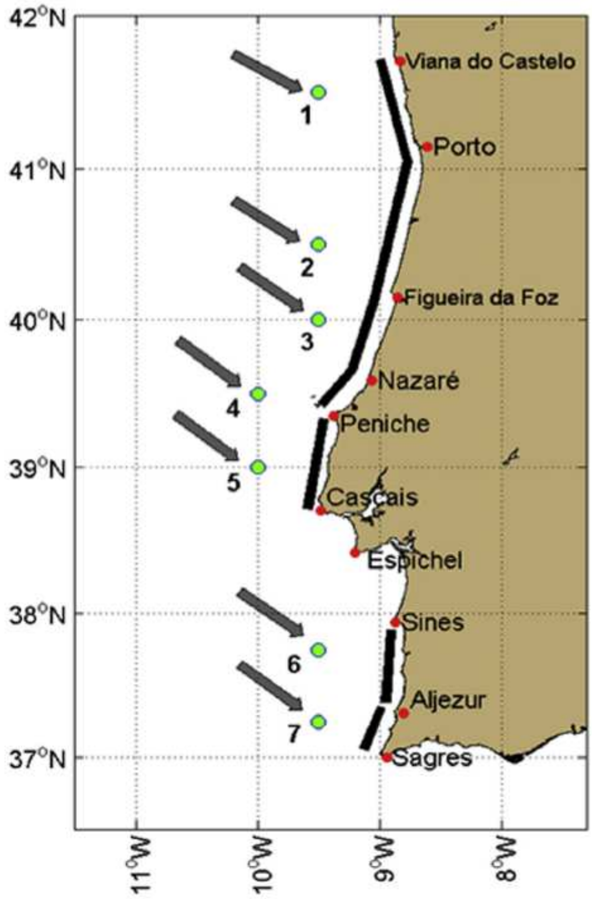


Figure 45– Location of the Offshore Model Grid Points and Nearshore Linear Sectors.
Source: Mota and Pinto (2014:10)

According to the author the figure 45 presents the offshore locations and the nearshore linear sectors considered in this study. The first five offshore sites, covering the north and center west coast, match computational grid model points while the two southwest offshore sites are staggered grid model points. The selected shoreline segmentation follows the main geometric characteristics of the Portuguese west coast, identifying local coastline orientation for estimate shoreward wave transformation. Due to its complexity, the nearshore sector between Cascais and Sines was not considered in this analysis. However, the shielding effect of the Raso Cape (Cascais) and Espichel Cape prevents direct incidence of the dominant NW waves and, as a consequence, relatively declining in wave energy resource is expected along this sector.

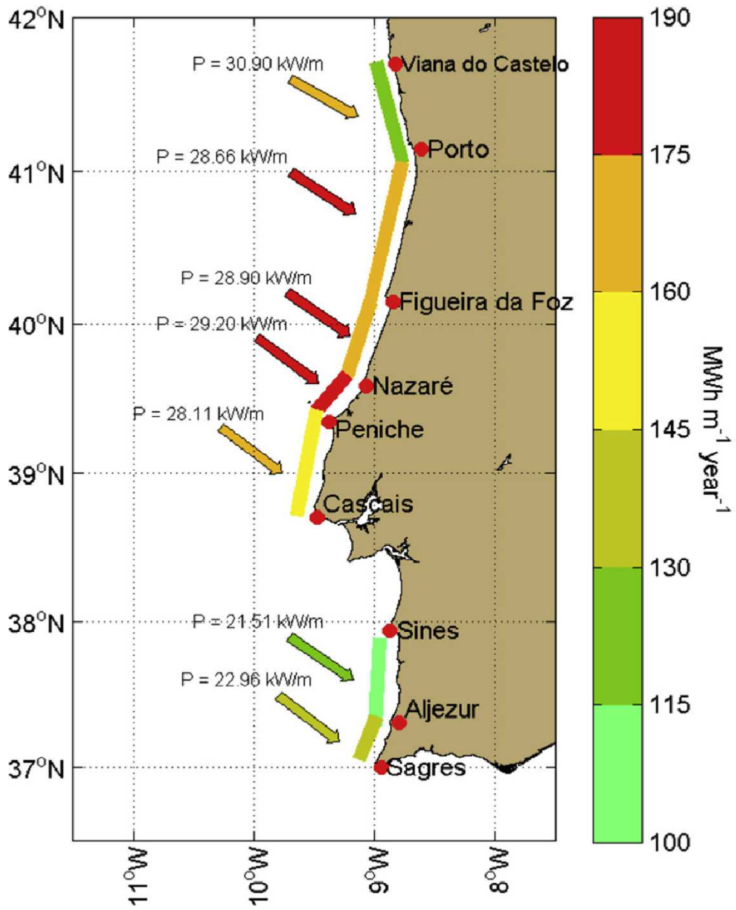


Figure 46– Average Annual Offshore Wave Power Density in Each Offshore Site and Wave Energy Potential in Sections Parallel to the Coastline (Coloured Segment) and Along the Annual Mean Wave Direction (Coloured Arrow).

Source: Mota and Pinto (2014:14)

The next figure (figure 47) presents the wave features and their implications on energy production. It is clear that the regions with most impact are in north region, as was explained due to the climate features.

This means that the north region can be considered the region which is related positively with the wind and waves and therefore, with good parameters for offshore energy production.

The coastline between Nazaré and Peniche appears to be the most suitable for wave energy recollection, as it presents very few losses per metre of total annual energy in all situations. It presents offshore wave power density and 50 m depth annual wave energy flux in each site, for sections parallel to the coastline and sections normally oriented to the annual mean wave peak direction.

The relationship between the coastline orientation and the available wave energy parallel to the coastline is visible in the section between Nazaré and Peniche, where a suitable coastal orientation clearly benefits the local available wave energy flux.

On the other hand, the section between Viana do Castelo and Porto, characterized by a shoreline orientated towards the southwest quadrant, showed a significant energy flux reduction parallel to the coast (Mota and Pinto, 2014: 14).

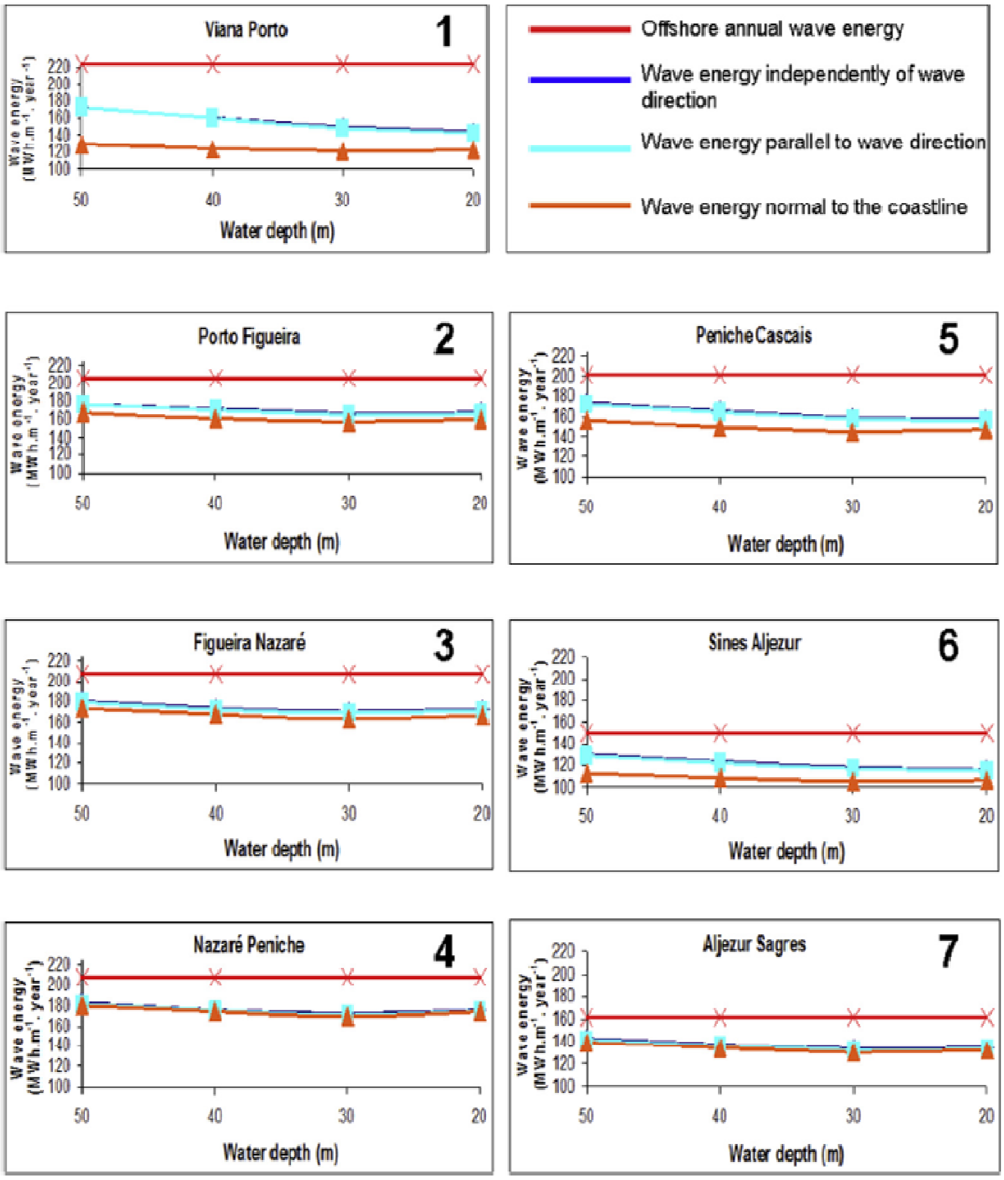


Figure 47– Annual Wave Energy Flux Offshore and at 50, 40, 30 and 20 m Depth Considering Self-Orientating WEC, Fixed WEC Deployments Orientated with the Mean Annual Peak

Source: Mota and Pinto (2014:15)

6.2.3 Offshore wind conditions in Portugal

"Marine geotechnical studies are still innovative in Portugal, especially offshore, where marine resources have the greatest potential"

Pombo et al. (2015: 399)

The point stresses the importance of wind conditions in Portugal as a main factor to explain the project "offshore wind farm in Portugal- EI-ERO". The study presented by Silva (2011) refers to the main geographic features in areas with potential for offshore wind farms in Portugal.

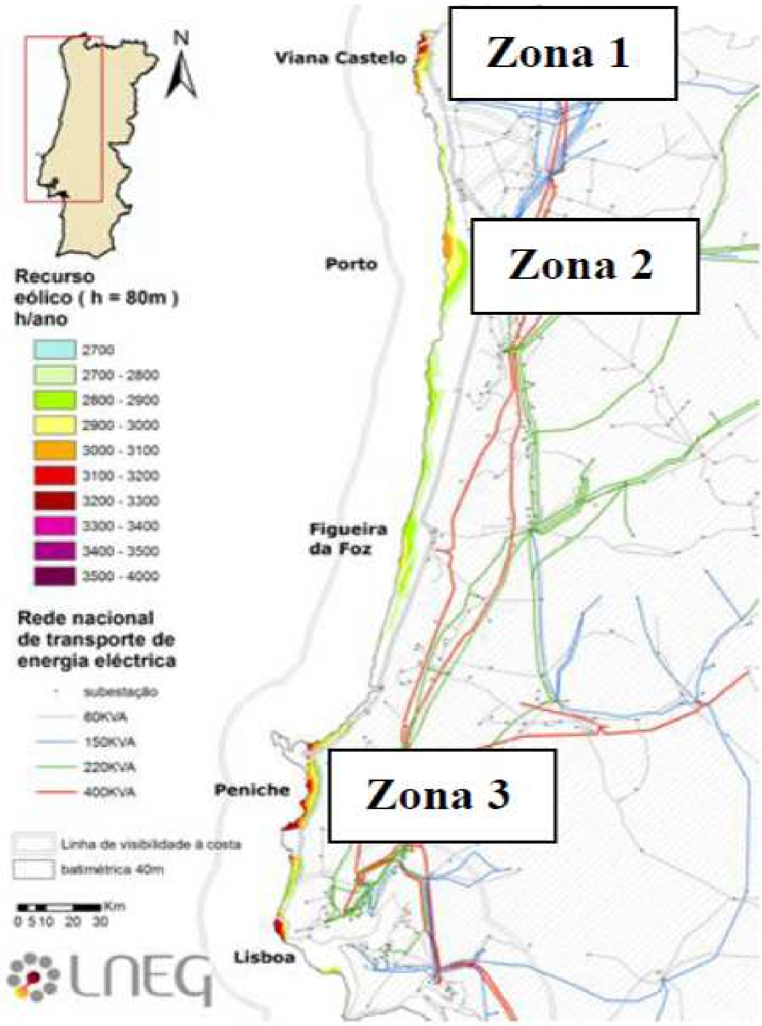


Figure 48– Portuguese Areas with Potential for Offshore Wind Farms
Source: Silva (2011:16)

The main climate features which influence implementation are based on wind and waves. Therefore, the infrastructure for these projects was based on the following factors: variation of speed with height; the roughness of the terrain, which is characterized by vegetation, land use and buildings; the presence of obstacles in the vicinity; the relief which may cause effect of acceleration or deceleration on the flow of air (Lopes, 2009:38).

Table 31–Wind speed 100 m high (m/s)

zone	IRIE Model	Wind Atlas
Zone 1	**5.73**	**7.58**
Zone 2	6.43	7.39
Zone 3	6.51	7.53

Table 32- Wave height (m)

zone	WaveWarch III	Ondatlas
Zone 1	**1.16**	**2.01**
Zone 2	1.24	2.00
Zone 3	1.35	2.13

Source: Silva (2011:11)

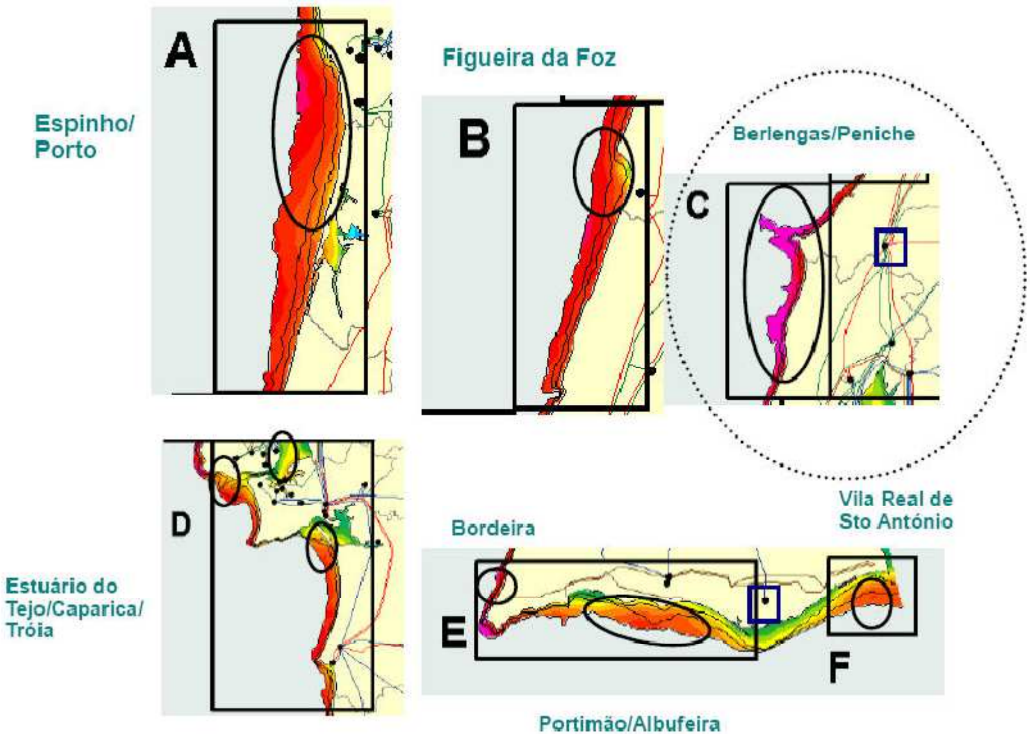


Figure 49– Places Most Conducive to the Use of Sea Winds on the Portuguese Coast[18]
Source: Santos (2012: 28)

Table 33- Electric Production by Portuguese Region

Area	Region	Production Estimates (NEP's) GEWE 1,5 SL (h/year)	Production Estimates (NEP'S) VESTAS V80 (h/year)	Distance from the coast (km)
A	Espinho/Porto	2600-3000	2600-2800	5
B	Figueira da Foz	2600-3000	2600-2800	5
C	Berlengas/Peniche	3400-3700	2800-3200	10 to 15
D	Estuário do Tejo	2400-2600	2000-2400	0.5 to 7
	Caparica	2600-3000	2200-2600	5 to 7
	Setúbal/ Troia	2600-3000	2000-2600	5
E	Bordeira	2600-3400	2800-3000	2 to 3
	Portimão/Albufeira	2600-3000	2200-2600	5
F	Vila Real de Santo António	2600-3000	2200-2600	10 to 15

Source: Santos (2012: 29)

[18] The legend is the same as the figure 50 (energy production/year).

As the author points out that the offshore areas reflects a potentiality for all regions in terms of energy production.

In terms of climate conditions the option for Ei-Ero- project was the Zone 1, where there are wind conditions for its implementation. The document (DR, 1ª serie , nº 227, 24/11/2017) which supports the EI-Ero project don't mention directly the natural impacts from EI- ERO project.

CHAPTER 7– THE INPUT-OUTPUT MATRIX

"Leontief was extremely critical of most economic theorists, especially of those who failed to understand economics as an empirical and applied science"

Dietzenbacher and Lahr (2004:9)

The chapter seven focuses on a theoretical model where the input-output matrix is presented along with its importance on this research based on an analytical analysis and the usefulness of the IO matrix, as well as, its advantages and limitations. To complete the analysis, this research is applied to the presentation of economic impact scenarios based on IO matrix. As such, some indicators are discussed and the total of type I and type II multiplier is presented. To finish the chapter, the Portuguese IO matrix for energy sector is presented.

7.1 THE INPUT-OUTPUT MATRIX

"One of Leontief's major contributions to economics, of course, was to economic theory"

Dietzenbacher & Lahr" (2004:9)

Economic policies face a dual problem, the empirical and theoretical research which performs the macroeconomic data; a mixed economic structure composed by national accounts and input-output (IO) sectors consistent with solving economic problems based on linkages between them. The economic model which allows the study of these linkages is the Input-Output matrix.

Wassily Leontief (1905- 1999) was the founding father of IO model economics. (Dietzenbacher and Lahr, 2004:1).The work presented in 1936 by Wassily Leontief allowed analysis of the interdependence of industries in the economy and became a major tool in quantitative economics. Needless, to say, developments in input-output analysis have been crucial for the evolution of economics as a science. The IO model developed by Wassily Leontief (1936) helped to create its own set of followers and revive the classical Ricardian and Marxian theories through the analysis of the linear production systems used in neo-Walrasian theory (Dietzenbacher and Lahr, 2004:xix).

Miller and Blair (2009:1) and Dietzenbacher and Lahr(2004)described the IO matrix developed by Wassily Leontief as a system of linear equations, each one of which describes the distribution of an industry's product throughout the economy.

The basic Leontief IO matrix is generally constructed from observed economic data for a specific geographic region (nation, state, county, etc.).One is concerned with the activity of a group of industries (inputs) in the process of producing each industry's own output. The fundamental information used in IO analysis concerns the flows of products from each industrial sector, considered as a producer, to each of the sectors, itself and others, considered as consumers.

This basic information from which an IO model is developed is contained in an interindustry transaction table. The basis of any input-output system is a transactions table: a two-way ordering of all interindustry sales and purchases during a given time period (usually a year). To complete the system a column of sales to ultimate users (or final demand) is added on the right-hand side of the transaction table, and a corresponding row, called value added (or payment sectors), is included at the bottom of the table (Dietzenbacher and Lahr, 2004:90).

The rows of such tables describe the distribution of a producer's output throughout the economy (Miller and Blair, 2009:2). This is the raw material of an input-output model, from which a number of coefficients are calculated and used for a variety of analytical purposes (Dietzenbacher and Lahr, 2004:90).

The columns describe the composition of inputs required by a particular industry to produce its output.

These interindustry exchanges of goods constitute the shaded portion of the table (Figure 6.1) (Miller and Blair, 2009:2).

The mathematical structure of an IO system consists of a set of a *n* linear equations with *n* unknowns; an IO model is constructed from observed data for a particular economic area; the necessary data are the flows of products from each of the sectors (as a producer/seller) to each of the sectors (as a purchase/buyer); these interindustry flows, or transaction (or intersectoral flows – the terms *industry* and *sector*are often used interchangeably in IO analysis) are measured for a particular time period (usually a year) (Miller and Blair, 2009:10). A production matrix is restricted to information on domestic output of industries by product (Eurostat, 2008:89).

Table 34– Input-Output Transaction Table

		PRODUCERS AS CONSUMERS								FINAL DEMAND			
		Agric.	Mining	Const.	Manuf.	Trade	Transp.	Services	others	Personal Consumption Expenditures	Gross Private Domestic Investment	Govt. Purchasases of Goods & Services	Net Exports of Goods & Services
PRODUCERS	Agric.												
	Mining												
	Const.												
	Manuf.												
	Trade												
	Transp.												
	Services												
	others												
VALUE ADDED	Employees	Employee compensation								GROSS DOMESTIC PRODUCT			
	Business Owners and Capital	Profit -type and capital consumption allowance											
	Government	Indirect business taxes											

Source: Miller and Blair (2009: 3)

Table 35– The IO table

Industries/	Industries			Final uses			Total
Products	Agriculture	Industry	Services activities	Final consumption	Gross capital formation	Exports	
Agricultural products Industrial products Services	Intermediate consumption by product and by industry (x_{ij})			final uses by product and by category (y_{ij})			Total use by product (x'_{ij})
Gross Value Added	Value added by component and by industry (z_j)						Value added (z_n)
Total	Total output by industry (X_n)			Total final uses by category (y_n)			$\mathbf{X'_n}$

Source: Eurostat (2008:20)

The compilation of supply and use tables has often been associated with the construction of symmetric input-output tables. This approach has led to a practice in many countries where supply and use tables (SUT) are calculated after the compilation of the national accounts has been completed (Eurostat, 2008: 51).Despite the problems that come with national accounts aggregation, the goal is to provide the ideal framework guaranteeing the consistency of supply and demand in the system at current and constant price and the overall quality of national accounts.

According to Eurostat (2008: 51) the recommendation for compiling SUT as an integral part of production of national accounts can be formulated in general terms as follows: supply and use tables are the most efficient way to incorporate all basic data – aggregated or detailed – into the national accounts framework in a systematic way; supply and use tables effectively ensure the consistency of results at a detailed level and thereby improve the overall quality of national accounts; the SUT's framework provides the natural statistical framework to include the components of the production, income and the expenditure approaches to measuring GDP, thereby enabling a coherent and balanced estimate of GDP both in current prices and constant prices to be achieved; the balanced STU's provide consistency and coherency between the first three accounts for a National Accounts framework: Goods and Services

Accounts; Production Accounts by industry and sector; and Generation of Income Accounts by industry and sector.

Table 36– Classification of Products and Industries in Empirical Tables

Products (P6)

Nº	Reference CPA[19] 2002	Description	Products (short term)
1	A+B	Products of agriculture, hunting and forestry, fish + other fishing products	Products of agriculture
2	C+D+E	Products from mining and quarrying, manufactured products, energy products, gas and water	Products of industry
3	F	Construction work	Construction work
4	G+H+I	Wholesale and retail trade, repair services, hotel and restaurant services, transport and communication services	Trade, hotel, transport services
5	J+K	Financial intermediation services, real estate, renting and business services	Financial, real estate, business services
6	L TO P	Other services	Other services

Source: Eurostat (2008: 59)

The CPA comprises approximately 3150 products. Ideally each product should be balanced in terms of supply and demand in the system of national accounts. For each product, the total supply is estimated from total output basic prices, CIP[20]

[19] CPA (Statistical Classification of products by activity in the European Economic Community). The CPA is the European version of CPC (central product classification). Whilst the CPC is merely a recommended classification, the CPA is legally binding in the European Community (Eurostat, 2008:553)

[20] CIF price (i.e. cost, insurance and freight price) is the price of a good delivered at the frontier of the importing country, including any insurance and freight charges incurred to that point, or the price of a service delivered to a resident, before the payment of any import duties or other taxes on imports or trade and transport margins within the country; in SNA (System of National Accounts) 1993 this concept is applied only to detailed imports (Eurostat, 2008:551)

imports and the corresponding trade and transport margins and the net taxes on the specific product.

The goal is to achieve a better performance from national accounts and homogeneity within European countries.

7.2 THE IO MODEL AND ANALYTICAL ANALYSIS

"Input-Output models when applied correctly can be powerful tools for estimating the economy-wide effects of an initial change in economic activity"

Bess and Ambargis (2011:2)

Assume that the economy can be categorized into *n* sectors. If we denote as*xi* the total output (production) of a sector I and as *fi* the total demand for sector *i's* product, the zij terms represent interindustry sales by sector i (also known as intermediate sales) to all sectors j (including itself, when j=i), we may write a simple equation accounting for the way in which sector I distributes its product through sales to other sectors and to final demand:

$$xi = zi1 + zi2 + \ldots\ldots + zij + fi = \sum_{j=1}^{n} zij + fi$$

Considering the correspondent matrix:

$$x = \begin{pmatrix} x1 \\ \ldots \\ xn \end{pmatrix},\ Z = \begin{bmatrix} z11 & \cdots & z1n \\ \vdots & \ddots & \vdots \\ zn1 & \cdots & znn \end{bmatrix} \text{ and } f = \begin{pmatrix} f1 \\ \ldots \\ fn \end{pmatrix}$$

The *interindustry matrix* will be:

Table 37– Buying and Selling Sector

		Buying sector					
		1	**2**	**…**	**j**	**…**	**n**
selling sector	**1**	z11	z12	…	z1j	…	z1n
	2	z21	z22	…	z2j	…	z2n
	…	….	…	….	…	…	….
	i	zi1	zi2		zij	….	zin
	…						
	n	zn1	zn2		znj		znn

The primary inputs together are termed the value added in sector *j*. The imported goods may be purchased as inputs by sector j. All of these inputs (value added and imports) are often lumped together as purchases from what is called the *payments* sector, whereas the *z's* on Table 3 serve to record the purchases from the *processing* sector, the *interindustry inputs* (or *intermediate inputs*). Since the equation from the table includes the possibility of purchases by a sector of its own output as an input to production, these ***inter***industry inputs include ***intra***industry transactions.

The magnitudes of these interindustry flows can be recorded in a table, with sectors of origin (producers) listed on the left and the same sectors, now destinations (purchases), listed across the top. From the column point of view, these show each sector's inputs; from the row point of view, the figures are each sectors outputs; hence the name input-output table. *These figures are the core of input-output analysis (*Miller and Blair, 2009: 12).

Table 38– Expanded Flow Table for a Two-Sector Economy

		PROCESSING SECTORS			FINAL DEMAND			TOTAL OUTPUT (x)
		1	2					
PROCESSING SECTORS	1	z11	z12	c1	i1	g1	e1	x1
	2	z21	z22	c2	i2	g2	e2	x2
PAYMENT SECTORS	VALUE ADDED (v')	l1 n1	l2 n2	lc nC	lI nI	lG nG	lE nG	L N
	IMPORTS	m1	m2	mC	mI	mG	mE	M
TOTAL OUTLAYS (x')		x1	x2	C	I	G	E	X

Source: Miller and Blair (2009: 14)

The components part of final demand vector for sectors 1 and 2 represents, respectively, consumer (household) purchases, purchases for (private) investment purposes, government (federal, state and local) purchases, and sales abroad (exports). These are often grouped into domestic final demand (C+I+G) and foreign final demand (exports, E). The fi= c1+i1+g1+e1 and similarly f2= c2+i2+g2+e2.

The components parts of the payment sector are payments by sector 1 and 2 for employee compensation (labour services, l1 and l2) and for all other value-added items, for example, government services (paid for in taxes), capital (interest payments), land (rental payments), entrepreneurship (profit), and so on. For this example (two sectors) these other value-added payments are by n1 and n2; then total value-added payments are v1=l1+n1, and v2=l2+n2. Finally, assume that some (or perhaps all) sectors use imported goods in producing their outputs. One approach is to record these import amounts in an import row in the payments sector as m1 and m2. Total expenditures in the payments sector by sector 1 and 2 are l1+n1+m1=v1+m1 and l2+n2+m2=v2+m2. However, it is often the case that the exports part of the final demand column is expressed as *net exports* so that the sum of all final demands is equal to traditional definitions of gross domestic product, i.e., net of import. In that case, a distinction is often made between imports of goods that are also produced (competitive imports) and those for which there is no domestic source (non competitive imports), and all the competitive imports in the imports row will have been netted out of the appropriate elements in a gross exports column.

The elements in the intersection of the value-added rows and the final demand columns represent payments by final consumers for labour services and for other value added. The imports row and final demand columns represent imported items that are re-exported.

To sum up, the total output column, total gross out, throughout the economy, X, is found as:

$$X = x1 + x2 + L + N + M \text{ or } X = x1 + x2 + C + I + G + E$$

The relationship between sectors in terms of input and output for one unit to be produced is called the *technical coefficient*: **aij= Zij/Xj**.

This means that the *aij* are viewed as measuring fixed relationships between a sector's output and inputs. Economies of scale in production are ignored; production in Leontief systems operates under what is known as constant returns of scale.

Production functions relate the amounts of input used by the sector for the maximum amount of output that could be produced by the sector with those inputs.

$$xj= f(zij, z2j, \ldots, znj, vj,mj)$$

Using the definition of the technical coefficients, the Leontief model became:

$$xj= \frac{z1j}{a1j} = \frac{z2j}{a2j}= \ldots= \frac{znj}{anj}$$

The impact on the economy from the IO matrix is estimated through the *Leontief inverse or the total requirements matrix (Miller and Blair, 2009:21)*, given by this equation:

$$(I-A)^{-1}=L=[lij]$$

Starting from a diagonal matrix with the elements of a vector along the main diagonal, it is then possible to construct the following matrix:

$\hat{x}= \begin{bmatrix} x1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & xn \end{bmatrix}$ from the basic definition of an inverse $(\hat{x})(\hat{x})^{-1}$ = I, it follows that

$$\hat{x}^{-1} = \begin{bmatrix} 1/x1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & 1/xn \end{bmatrix}.$$

Also, post multiplication of a matrix, **M**, by a diagonal matrix, $\hat{d}$, creates a matrix in which each column j of **M** is multiplied by dj in $\hat{d}$. Therefore, the n x m matrix of technical coefficients can be represented as:

$$\mathbf{A= Z\ \hat{x}^{-1}\ or\ x= Ax+f}$$

Let **I** be the **nxn** identity matrix - ones on the main diagonal and zeros elsewhere;

I= $\begin{bmatrix} 1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & 1 \end{bmatrix}$ so then **(I- A)** = $\begin{pmatrix} (1-a11) & -a12 & \vdots & -a1n \\ -a21 & (1-a22) & \vdots & -a2n \\ \vdots & \vdots & \ddots & \vdots \\ -an1 & -an2 & \vdots & (1-ann) \end{pmatrix}$

Then the complete *nxn* system shown is

(I-A) x=f

For a given set of f's, this is a set of n linear equations in the n unknowns, x1, x2, xn and hence it may or may not be possible to find a unique solution. In fact, whether or not there is a unique solution depends on whether or not (I- A) is singular; that is, whether or not (I-A) -1 exists. ***The matrix A is known as the technical coefficient matrix*** (Miller and Blair, 2009, 21).

7.3 THE USEFULNESS OF THE IO MODEL

"Ideally, in constructing a regional input-output model, one would want to carry out a detailed survey of the regional economy, to establish the strength of the inter-relationships that exist among sectors"

Flegg and Webber (1996:1)

The IO model is one of the main analytical instruments to study the relationship between industrial sectors and the impact of those on the economy.

Dorfman (1954:121) briefly describes the first studies made following Leontief's IO methodology, pointing out four main areas of study: the development of dynamic models; interregional models; capital production requirements and determinants of investment in real capital; production functions and determinants of household consumption.

Over the years many authors have extended the IO model to various issues, such as energy, the environment, tourism, health, and others related with economic activity. Flegg and Webber (1996:2) point out that the main issue of an IO matrix is the transaction matrix, which shows the extent to which each sector depends on itself and others for its output.

As Flegg et al (1995:1) point out IO analysis has become a routine tool for impact analysis.

The IO model describes how economy works in a certain geographical area, and reflects the economic changes between agents and their interdependency (Matias et al., 2011:72) with some restrictions: each sector has his own product with its own input structure (homogeneity); the technological conditions are stable; the prices are constant; the production function is linear (economies of scale), and the input supplies are elastic (infinite) (Haddad et al., 2011; Henriques, 2008).

The importance of using IO tables in regional performance has gained impact with geographers and economists when studying regional performance (e.g. Aujac, H.; Paelinck, J., Kuenne, R., Ozaki,I., Skishido, S.,quoted in Dietzenbacher and Lahr (2004)).

Additionally, regional input-output models are powerful and readily available, but have only recently begun to enjoy widespread use. Though they may initially seem daunting, they can provide crucial information to help regional economies thrive. In the end, regional development is all about fostering innovation, staying competitive, increasing wealth, and raising quality of life. Input-output is just another tool to use for that goal (Leontief and Strout, 1963).

Isard (1951:328) argues that IO models permit the study of space economy problems, such as changing regional and interregional structure, based on a set of restrictive assumptions (constant production coefficients, interregional views and mean unchanging supply channels).

Bathelt & Glückeen (2003:130) argue that as regional agents are interrelated in the same value chain through regional IO linkages, knowledge between firms, spill over effects and learning processes increase. Variables such as GVA, wage, wage growth and employment growth (Porter, 2003) were important to study economic activities and their distributions in regions. The model still allows multipliers to be calculated which show the effects of GVA, employment, investments, etc. It can also estimate the effects of exports and on the price structure in wage and profit rates exchange (Dorfman, 1954:131).

From the cluster perspective, the use of IO tables in vertical clusters can be useful for studying their industry linkages (Bijnen, 1973; Titze et al., 2011:4).

However, it is important to compare the positive aspects and limitations when using an IO matrix. The option for this research is the IO model's usefulness to study a social science phenomenon.

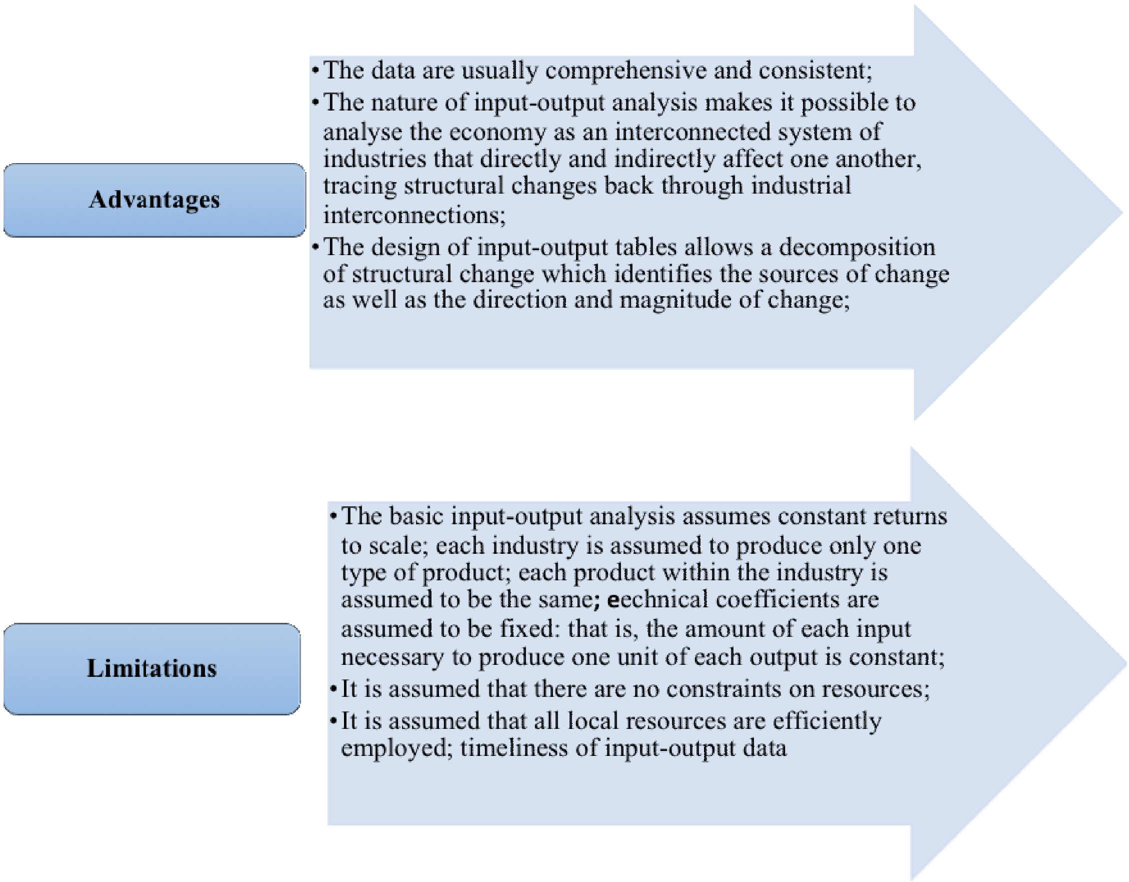


Figure 50– Advantages and Limitations of using IO tables
Source: Fatemi, A. S. (2002)

However, to study an economic sector, the IO model needed to be desegregated according the research objective, regional policy or other specific problem to be studied, based on decision-making and regional planning.

Henriques (2008:35) argues that for a specific sector the IO tables should be desegregated into *n* sub-sectors. Each sector is seen as an equal sector in row and column in the inter-industrial matrix. One of the problems that the IO matrix faces is the fact of its aggregation by sectors. The level of detail in which to study a specific problem in the economy needs to be analysed in order to better assess the relevance of the sector which is considered. According to Miller and Blair (2009:160), the number of industrial sectors defined in an input-output table is usually decided in the context of the problem being considered; this means considering a specific industrial sector aggregated with other or not. The same authors point out some studies made on this aggregation problem, including: Hatanaka (1952), Balderston and Whitin (1954), McManus (1956), Malinvaud (1956), Theil (1957), Ara (1959),Morimoto (1970)and more recently Kymn (1990), Cabrer, Contreras et al.(1991) and Olsen (1993). Today's IO matrix aggregation (number of sectors or regions) is related to multiregional or interregional models where there is unavailability of data or when it is difficult or prohibitively expensive to obtain the data.

7.4 THE IO MODEL AND ECONOMIC IMPACT SCENARIOS

The interesting thing about the IO model is deducing the impact on the economy and therefore creating scenarios for economic development. From this perspective, the IO model is an instrument with which is possible to estimate the regional performance in the short run and the economic policy to be carried out.

The next figure is composed by the four steps with which it is possible to settle the effects on the economy from the IO matrix. The following matrix describes how it is possible to achieve economic effectsfrom the IO model. This is also important to estimate the potential sectors with major impact and also the direct, indirect and induced effects from any sector.

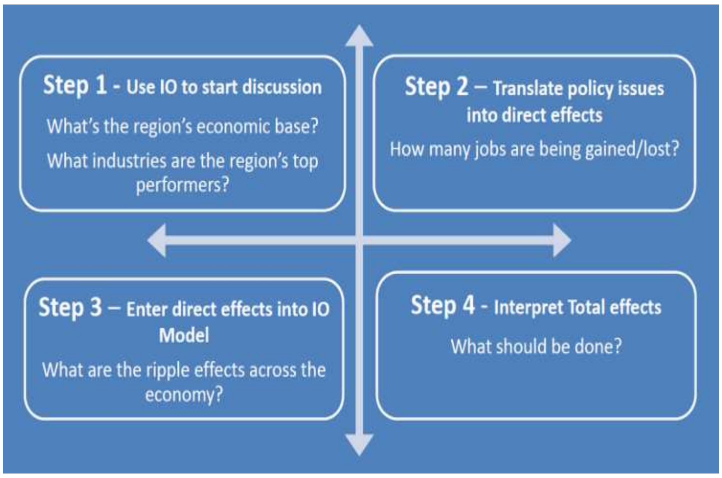


Figure 51– How to use an IO model
Source: Leontief and Strout (1963)

Considering the sectors impact on the economy, the *Location Quotients* (LQs) are both useful and simple location coefficients and cross-industry quotients (Flegg and Webber, 1996:5). These quotients are used to adjust national coefficients to produce a regional table, where the rationale or choice for using LQ is examined (Mayer and Pleeter, 1975). Alternative approaches are evaluated by Round (1983). The simple type of LQ is defined as the ratio between the regional and national proportions of output or employment attributable to a particular sector (Flegg et al., 1994: 5).

For most industries, LQs consist of the ratio of an industry's share of regional earnings to the industry's share of national earnings. If the LQ for the industry is one or greater, then the industry's national coefficients are used for the region. If the LQ for an industry is less than one, then the national coefficients are reduced by the ratio to account for the linkages (Bess and Ambargis, 2011: 9).

Flegg et al. (1994:6) and Bess and Ambargis (2011: 9) point out that the use of the LQs to adjust national coefficients may, however, produce seriously misleading results. The use of cross-industry location quotient's (CILQs) goes some way towards overcoming the shortcomings of LQs. For example, employment based CILQ for sectors i and j is defined by the formula:

$$\frac{\dfrac{Regional\ employment\ in\ sector\ i}{National\ employment\ in\ sector\ i}}{\dfrac{Regional\ employment\ in\ sector\ j}{National\ employment\ in\ sector\ j}}$$

Analytically, sector i is presumed to be supplying inputs to j. The logic behind this formula is that, where the supplying sector is relatively small regionally compared to the purchasing sector (so that CILQ is <1), some of the required inputs will have to be met by imports from outside the region. This means that the national coefficient will need to be adjusted downwards by multiplying it by the CILQ, with a corresponding upward adjustment being made to the relevant import coefficient. As in this case of the simple LQs, no adjustment is made if CILQ is ≥ 1.

Additionally, Flegg et al (1994:8) put forward another indicator, where it is possible to refine the CILQs coefficients for a better regional adjustment. This means estimating *trading coefficients*, which measure the proportion of any given commodity supplied from within the region. In effect, trading coefficients (t_{ij}) measure the degree of self-sufficiency of a region, where0 <t_{ij} < 1 will be a function of the following variables:

1- The relative size of the supplying sector i;

2- The relative size of the purchasing sector j;

3- The relative size of the region;

Location quotients can be estimated mathematically, according to the following:

$$LQ_i^k = (E_i^k / \sum Ek) / (E_i^N / \sum EN)$$

$$R_j^k = \begin{cases} LQ_i^k \text{ if } LQ_i^k < 1 \\ 1 \text{ if } LQ_i^k \geq 1 \end{cases}$$

$$A_k = \hat{R}\, A_n$$

Where:

LQ= Location quotients
E= earnings
R= regionalizing Index
A= Direct Requirements Matrix
K = Region
i= Industry
N= Nation

Source: Bess and Ambargis (2011: 7)

According to McGilvray (1977:49) recently, the concept of linkages has attracted considerable interest, as a means of identifying "key sectors" in a strategy of industrial development.

Another type of measurable impact of the IO model is the backward and forward linkages from the production of a particular sector (Chang et al, 2008:338).

Linkages are descriptive measures of the economic interdependence of industries (McGilvray, J., 1977:50*)*.

The concept of linkages drives from the study of multiple market imperfections, whereas public benefits from a project may be not equal to private benefits. This conception involves the *Hirschmanian* concept of "linkages," of which there are two varieties:

1. The input-provision, derived demand, or backward linkage effects, i.e., every non-primary economic activity will induce attempts to supply through domestic production the inputs needed in that activity.

2. The output-utilization or forward linkage effects, i.e., every activity that does not by its nature cater exclusively to final demands will induce attempts to utilize its outputs as inputs in some new activities (Jones, 1976:323).

There are two important features underlying Hirschman's argument:

1- in the rest of developing countries there are imperfections in factor and product markets; 2- there is a shortage of entrepreneurial talent (McGilvray, 1977:52).

Sonis et al. (1995: 243) put forward the analytical procedures to estimate the Rasmussen/Hirschman Approach, where the work of Rasmussen (1956) and Hirschman (1958) led to the development of indices of linkage that have now become part of the generally accepted procedures for identifying key sectors in the economy.

Hirschman-Rasmussen (HR) indexes allow the study of the linkages of a sector relative to other buyers or suppliers sectors. Thus, the HR connections rates, also called "backward" and "forward" coefficients, indicate the strength of chaining across the various economic sectors. The values of these indicators express how a particular industry demand inputs or offers outputs to the remaining sectors. "Forward" or "backward" linkages with higher unit values (above average) represent the key sectors for economic growth (Salvador et al., 2016: 28).

The "backward" index is interpreted as the total variation (direct and indirect) in the production of all necessary economic structures to meet a value unitary variation in final demand of sector j. The "forward" index describes the direct and indirect impacts on the sector i resulting from a value unitary variation on final demand in each of the remaining production sectors (Salvador et al., 2016: 29).

Impact models can measure the effect which an industry's production has on other industries in the economy in two ways. If an industry increases its production, there will be increased demand on the industries that produce intermediate inputs. Models that measure impacts based on this type of relationship are called backward linkage models. If an industry increases its production, there will also be increased supply of output for other industries to use in their production. Models that measure impacts based on this type of relationship are called forward-linkages models (Bess and Ambargis, 2011: 7).

One of the criticisms of the above indices is that they do not take into consideration the different levels of production in each sector of the economy. The concept and the determination of key sectors in an economy can be presented in different ways, and the basic need is to explore the insights provided by each kind of analysis, rather than focusing on the real or apparent advantages any one technique might offer (Sonis et al, 1995: 243).

The same author points out that the HR indices and the field of influence approach were used to see how the internal structure of the economy behaved, without taking into consideration the level of production in each sector. This analysis is important if the internal structure of the economy is overlooked in defining key economic sectors. On the other hand, the level of production in each sector is also important as it helps to determine which sectors will be mainly responsible for changes in the levels of GNP and other macro level measures of the economy (Sonis et al, 1995: 247). However, the importance of normalized link indexes relies on the fact that they are independent of measurement units, allowing for inter-sectorial, inter-regional and inter-time comparisons. As such, the “scattering indexes”, aim to quantify the dispersion of an economic impact. A relative measure of the variation coefficient allows the comparison of distributions, as the result is the standard deviation per unit of average. A low dispersion value means that the impact is disseminated by a large number of economic sectors; a high dispersion value means that the impact is concentrated in a reduced number of sectors (Salvador et al., 2016: 29).

Mathematically the **HR** can be calculated considering:

Define b_{ij} as a typical element of the Leontief inverse matrix, B; B* as the average value of all elements of B, and if B_{j*} and B_{i*} are the associated typical column and row sums, then the indices may be developed as follows:

Backward linkage index (power of dispersion):

$$U_j = B_{*j}/n/B^*$$

Forward linkage index (sensitivity of dispersion):

$$U_i = B_{*i}/n/B^*$$

The **"scattering indexes"** are given by the coefficients of variation, resulting from the ratio between the standard deviation and the average of each sector, both from the perspective of the buyer and supplier. The "backward" (V_j) and "forward" (V_i) "scattering indexes" dispersion formulas are the following:

Dispersion index link "forward"

$$V_i = \sqrt{\frac{1}{n} - \sum_{j=1}^{n}(bij - 1/n \sum_{j=1}^{n} bij)^2} \; / \; 1/n \sum_{j=1}^{n} bij$$

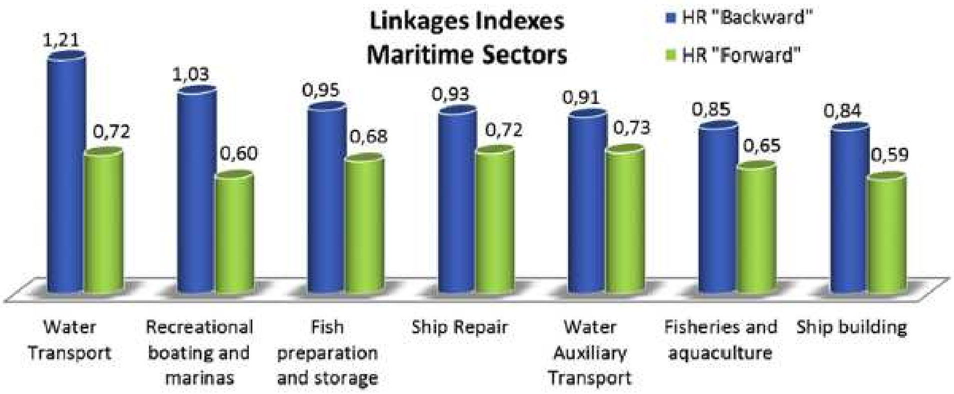
Dispersion index link "backwards"

$$V_j = \sqrt{\frac{1}{n} - \sum_{i=1}^{n}(bij - 1/n \sum_{i=1}^{n} bij)^2} \; / \; 1/n \sum_{i=1}^{n} bij$$

with(i,j= 1,2,…n) being the number of industries.

Source: Salvador et al (2016: 29)

The study presented by Salvador et al (2016) describes the seven maritime sectors with most impact on the Portuguese economy, using the HR and scattering index.



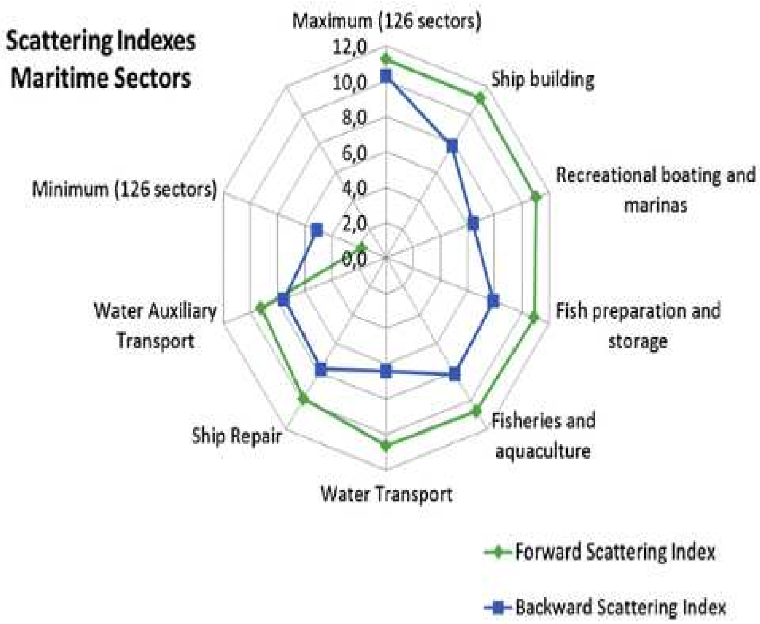


Figure 52– Links and Scattering Index
Source: Salvador et al (2016: 30)

The conclusion about the Portuguese maritime economy was that HR fails to identify the major impacts that would result from additional investments. It also does not specify which coefficients, when changed, would have greater economic impact. In order to correct these shortages, different approaches to the calculation of inter-sectoral linkages were adopted. The calculation of a scattering index allowed the following features to be concluded: a) the “recreational boating and marinas” sector has a significant field of influence that confirms its importance in terms of both supplier and consumer services; b) the “fish processing and preserving” sector has the least significant value (0.555) in commercial transactions; c) the importance of “auxiliary services to water transportation”(maritime ports) as a supplier of services to other sectors –in fact, the most significant field of influence value(9.734)–lies in the purchases by the “water transport” sector from the former sector; d) it is important to stimulate the “maritime transport” sector, as a major consumer of goods and services from other sectors, with a great propagation potential in the economic system.

According to Miller and Blair (2009: 303) the heart of any input-output analysis is the table of input-output coefficients describing the relationships between inputs and outputs for a particular economy.

The literature on the calculation of IO multipliers traces back to Leontief (1941), who developed a set of national-level multipliers that could be used to estimate the economy-wide effect that an initial change in final demand has on economy. Other economists have developed research on Keynesian multipliers and their application on the economy, such as Moore and Peterson (1955), Isard (1951), Richardson (1985), Coughlin and Mandelboun (1991), Hall (2009) and Bess and Ambargis (2011:4).

There are four measures of change in total economic activity that can be estimated by Keynesian multipliers, namely gross output, value added, earnings, and employment. The Keynesian multipliers are divided into Type I and Type II. Type I multipliers account for the direct and indirect impacts based on how goods and services are supplied within a region. Type II multipliers not only account for these direct and indirect impacts, but they also account for induced impacts based on the purchases made by employees.

Table 39– Composition of Total Impact

Type I multiplier	Type II multiplier
Final-demand change + direct impact +indirect impact	Final-demand change + direct impact + indirect impact + induced impact
Total impact	Total impact

Source: Bess and Ambargis, 2011:7

7.5 THE INPUT-OUTPUT MATRIX AND THE ENERGY SECTOR

"The evolution of inter-industry relations has now become, once more, a major interest for economic analysis"

Sonis et al (2008:153)

The study of energy in IO tables started to be significant when countries realized that energy consumption was a critical factor of production for many industries in many regions. As such, researchers and government policy makers began focusing on the role of energy in the economy.

IO tables were extensively developed during the oil crises in the 70s and early 80s in the wake of the Arab oil embargoes and their effects on the US economy.

There has been resurgence in their use in recent years to analyse the relationships between energy and climate change (Cumberland, 1966; Strout, 1967; Ayres and Kneese, 1969; Bullard and Herendeen, 1975b; Griffin, 1976; Blair, 1979 and 1980) (quoted in Miller and Blair, 2009:400).

Recent studies associate energy with energy accounts and environmental activities (Miller & Blair, 2009: 400).

The use of IO tables in the energy sector determines the total amount of energy required to deliver a product to final demand, both directly as the energy consumed by an industry's production process and indirectly as the energy embodied in that industry´s inputs.

Therefore, the analysis can be made through primary resources; the first round of energy inputs is the direct energy requirements; subsequent rounds of energy inputs comprise the indirect energy requirements, with the sum of both being called total energy requirements.

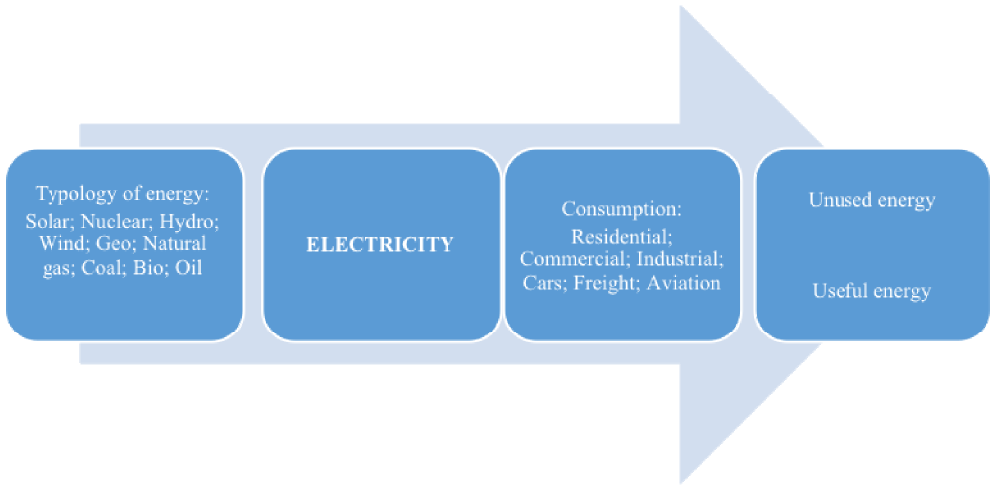


Figure 53– Energy Use
Source: adopted from Miller and Blair (2009:402)

From the initial IO table the following is considered for energy IO energy requirements:

$$\alpha_{kj}x_j = \sum_{i=1}^{n} \alpha_{ki}z_{ij} + g_{kj}$$

where α_{kj} is the total amount of energy of type k required to produce a dollar's worth of sector $_i$'s output; x_j is the total dollar output of sector $_{j;}$ and z_{ij} is the euro value of sector $_i$'s product consumed by sector $_{j.}$.

The term gkj is the total of energy output of an energy sector and we define all elements of the (m×n) matrix $G=[g_{kj}]$ as g_k for elements where energy sector k and industry sector $_j$ refer to the same industrial sector and 0 otherwise.

Most elements of G are zero, except for those corresponding to total energy output for the energy sector designated by the row index (Miller and Blair, 2009:404).

On the other hand, the structural differences between the new technologies and systems for the use of renewable energy sources and the fossil fuel technologies seem to call for the definition of their own vector.

The technologies for the use of solar, geothermal and wind energy require new and different input combinations from different sectors compared to the respective sectors for the fossil fuel industries in the system (Lehr et al., 2008: 111).

From the multiplier perspective, the IO model can measure the impact of the renewable energy industry on the Gross Value Added (GVA) and employment (direct effect, indirect effect and induced effect).

Therefore, there are a number of factors which affect the estimate of GVA and jobs: capital and labour intensity of renewable energy, costs and investment, counting job losses and treatment of the labour market, job quality and job skills and gross vs net employment. However, there is some dependence on model assumptions: changes in demand of the conventional energy sector, energy prices changes, changes in industries investment and increase in investment in renewable energy (Lambert and Silvia, 2012).

7.5.1 The IO matrix for renewable energy in Portugal

The first approach to the research about IO matrix renewable energy in Portugal was presented by Pego et al. (2016). The study considered not the production itself of the sector but the impact from the energy sector on the economy. These impacts measure the direct or indirect influence of investments on the GVA and employment in the economy, through Keynesian multipliers.

In general, authors (Benito et al, 2003; Wijnolst, 2006) agree that a good indicator of a cluster's relevance can be assessed by analysing the strength of the connections (agglomeration economies) between its members, namely by the trade transaction figures that are at stake.

In general terms, sectors in a successful cluster have a strong dependence on one another and on the way buyers and suppliers are related. In fact, there is a debate whether it is more important to have these connections between the same or different sectors (Titze et al., 2011), or whether the development of clusters is more benefited by a larger range of activities (Porter, 2000).

The best methodology to estimate inter- and intra-sectoral connections is the IO model of Leontiev (Salvador & Guedes Soares, 2008 and 2010).

Starting from the "Input-Output Matrix of Domestic Production" (431p x 123p – INE, 2013), at basic prices, one symmetric matrix [A1] (97 x 97) has been derived that was previously inverted, taking into account that Leontief's inverse matrix multiplied by a change in final demand yields a change in total output:

$$\mathbf{(I\text{-}A)^{-1}\, \Delta Y = \Delta X}$$

The next step was the creation of the corresponding technical coefficient matrix [A2], whose elements allow an assessment of the strength of the linkages between the industries (Simões et al. 2012; Simões & Salvador, 2013; and Simões et al., 2015) and the impact of past or near future investments.

In fact, IO analysis is especially well suited to assess how changes in one or more sectors of the economy will impact the total economy (Kweka & Blake, 2003: 338). As the offshore renewable energy industry ("Nomenclature Statistique des Activités Économiques dans la Communauté Européenne – NACE", Rev. 2,35113) still has very poor data due to its being an emerging industry, a working hypothesis has been adopted that NACE 35113 follows the same pattern has NACE 351, the larger group which it is part of. Results show that sector 351 (electric power generation, transmission and distribution) has a strong relationship with itself (€6,400M of intra-commercial relations).

Table 40– Suppliers with Higher Technical Coefficients

NACE	INDUSTRY	TECHNICAL COEFFICIENTS
351	Electr. Prod.	0.45
352	Gas Distr.	0.06
69 + 70+71	Services (Law, Manag, Archit.)	0.03
64	Financial Serv.	0.02
27	Electric Equip.	0.01
33	Mach & Eq Services	0.01
42	Civil Engen.	0.01
82	Other Serv.	0.01

This probably is due to the large size of the main company (EDP) and the concentration of activities (energy production, distribution and commercialisation).

Taking into account all the 97 sectors' technical coefficients of the Leontief matrix [a_{ij}], it can be concluded that there are just a small number of "average linkages" (technical coefficient > 0.02) between "Energy Production" and the rest of the economy.

Table 41– Electricity Production (351) Main Suppliers and Clients

SUPPLIERS (€M)			CLIENTS (€M)		
NACE05	Mining	261	NACE 23	Non-metallic products	132
NACE19	Coal & Refined Petroleum	303	NACE 24	Basic Metallic Manufacturing	101
NACE 351	Manufacture of gas; distribution of gaseous fuels through mains	6392	NACE (46+47)	Wholesale & retail trade	448
NACE 352	Gas Production &Distribution	834	NACE (55+56)	Hotels + Restaurants	256
NACE 64	Financial service activities, except insurance and pension funding	242	NACE (84+86)	Public Admin. + Health Service	424

The table presents the main suppliers and clients of sector NACE 351 (electric power generation, transmission and distribution).

The Type-1 Keynesian multiplier measures the effect over the total output (or employment) that results from a unitary change in final demand, meaning that it is given by the change in total output (employment) to the change in that final demand. Its value adds direct and indirect effects resulting from that unitary increase in demand and, as such, it is estimated through the following expression:

$$\mathbf{[(I\text{-}A)^{-1} - I]\ \Delta m}$$

where, A is the technical coefficient matrix (ag); and $(I\text{-}A)^{-1}$ is the Leontief matrix, i.e., the matrix whose elements give the "total" impact (direct + indirect) on a sector as a result of an increase in final demand from another sector (Δm).

The Type-2 Keynesian multiplier measures the sum of direct, indirect and induced effects that result from a unitary change in the maritime cluster output (employment) and the associated effects in all the other economic sectors. Its expression is the following:

$$\mathbf{\Delta x - v\ [(I\text{-}A)\ \Delta m]}$$

wherev is the GVA line vector per output unit. Taking into account the values from Table 6, this means that the Windfloat investment (2011), in an amount of about €23M had €58.2M of direct and indirect effects and €73.1M of total (direct + indirect + induced) effects. Concerning the effects on employment, a number cannot be added, as the number of workers at Windfloat is not available.

Table 42– Energy Production (351) Keynesian Multipliers (GVA)

Multiplier Type 1 (Output)	Multiplier Type 2 (Output)	Employment Multiplier
2.53	3.18	2.11

7.5.2 Conclusions

In summary, the study made on IO matrix analysis shows that the IO matrix on offshore renewable sector is an important economic instrument because it can explain the economic impact within the sector and outside the sector.

Moreover, it is possible to conclude about the offshore energy cluster. The same study indicates a relevant conclusion about the pre-commercial farm in Portugal. It is possible to conclude that there is a possibility of an emergent cluster, due to the linkages between the production sector (aij <1) and the high impact on economy (multiplier factors).

CHAPTER 8 – THE OFFSHORE ENERGY CLUSTER IN PORTUGAL. AN ECONOMIC AND GEOGRAPHICAL ANALYSIS

"The methodology is the process of constructing knowledge from the researcher, as well as the set of procedures and research methods used to acquire the knowledge"

Matos (2006:91)

The chapter eight presents the methodology and the results from the electronic questionnaire (qualitative analysis) and the IO matrix results (quantitative analysis). The qualitative analysis allowed concluding about the Porter Diamond Model and SWOT analysis to offshore energy cluster. The IO matrix presents the typology Type I and II for the offshore energy cluster EI-ERO project and makes a comparison with the energy sector.

8.1 INTRODUCTION

"Sampling is the acquisition of information about relatively small part of a larger group of population, usually with the aim of making inferential generalizations about the larger group. Sampling is necessary because it is often not possible, practicable or desirable to obtain information from an entire population".

Cliford et al. (2016:230)

The offshore wind cluster in Portugal is an emergent cluster. It was considered the **EI-ERO-project[21] (see point 5.3.4)** and the first study about offshore wind clusters in Portugal (Pego et al, 2016).

The main subject of EI-ERO- Project is to set up the rules for the construction of offshore energy export sector in Portugal as an emergent cluster based on natural, scientific and technological resources.

It is expected that the EI-ERO- project contributes to increase the high technology exports, valuate the SEA, to create a sustainable value chain and employments. At the same time the EI- ERO project will promote the Ports in terms of new investments, employment and new stakeholders. The development of the methodology was based on the intervention of the EI-ERO Project and others with relevant action in the emergent cluster. The research also considered SWOT analysis to confirm results from both methods.

For the qualitative analysis, an electronic questionnaire was used and the sample was direct suppliers (EI-ERO Project) and others stakeholders which are directly and indirectly related. For the quantitative analysis Type I and II Keynesian multipliers were used (IO matrix 2013) for offshore wind farm direct suppliers.

Regarding the confrontation with a qualitative (Porter's Diamond Model) and quantitative (IO matrix) methodology, there is a strong possibility for credible results. The complexity of both analyses confirms that there is ***an emergent offshore energy cluster in Portugal.***

[21]EI-ERO Industrial Strategy for Ocean Renewable Energies- *DR, 1ª serie, nº 224, 24 de novembro de 2017*

8.2 QUALITATIVE ANALYSIS

"There are two things to be considered with regarding any scheme. In the first place, 'Is it good in itself?' In the second, 'Can it be easily put into practice?'"

Jean-Jacques Rousseau (quoted in Dunleavy, P., 2003:44)

"Qualitative researches, broadly, is based on the methodological pursuit of understanding the ways that people see, view, approach, and experiences the world and make meaning of their experience as well as specific phenomena within it"

Ravich and Carl (2016: 7)

The qualitative findings were separated into two parts, first Porter's model and its applicability to offshore energy sector and then the SWOT analysis.

The qualitative analysis was based on an electronic questionnaire (see appendix).It tested opinions about the future of the offshore energy cluster in Portugal and how future organisations are involved in the cluster. The questionnaire was sent to suppliers, government entities and others which can influence positively the potential energy cluster in Portugal. The total of inquires was 14 organisations, divided by private organisations (60%), universities (13%), research centres, public organisations, the government and NGOs (7%). The list of inquiries is presented in the Annex 1.

8.2.1 Porter's Diamond Model and the offshore energy cluster

Regarding the proposed methodology, and as was discussed in Chapter 4, Porter's Diamond model is a good instrument to check the competitiveness in the energy sector.

The importance of studying the offshore cluster begins with the awareness of the relationships between organisations towards ***competition and cooperation***.

Therefore, it is important to discuss business organisation, meaning if they act alone in the market or if they are aggregated.

PARTNERSHIP

The results showed that 36% of the companies were independent or included in an international group; 21% were included in a national group and just 7% were considered as "other", such as research centres and universities. In the cases where organisations are included in a group, the main organisation are in the USA, Esposende, Braga, Lisbon, Azores University, Oporto, Ponta Delgada, Munich, Spain and the Baltic Sea region.

Also, this partnership is through training (75%), institutions (67%) and business organisations (regional/national or European) (67%). The data also showed that the training is mainly with private organisations and research centres (50%) and the 75% of the public institutions applied for partnership.

The sample is not representative of the potential cluster, although it was inquired the main companies which compose the EI-ERO project.

COOPERATION AND SERVICES INDUSTRIES

To evaluate the cooperation and services within the offshore energy sector we studied the services inside or outside the organisation, main services and goods supply, cooperation and technological cooperation:

a) The first point, **services** from the sector, is divided into three points: in organisation, inside the council and outside the municipality:

1- Innovation (100%), financial services (100%), marketing (67%), market prospect (75%), legal services (50%), and repair and equipment maintenance (50%) are *inside the organisation*;

2- *The services from outside* are from specialised organisations inside the council, namely, legal services (50%), marketing and publicity (33%) and repair and maintenance equipment (25%);

3- From specialised organisations outside the council, we can point out market prospect (25%) and repair and maintenance (25%);

b) The second point, **main services and goods supply** from the sector, showed that the interviewees are mainly supplied by EU organisations: components (100%); raw materials (67%), machinery, accessories and advance services (technical assistant, drawing, software) (75%).

c) The third point, **cooperation with others:**

1- The organisations cooperated with other organisations (75%); in this point organisations pointed out that the necessity to cooperate with others is related to products that cannot deliver the necessary characteristics or new systems; technological cooperation with other institutions, and commercial (50%) between organisations in the same sector and others– consultants (25%);the types of services which are involved in this cooperation with organisations are mainly R&D activities, technology transfer, training skills and consultancy. Vertical cooperation is applied, for example in knowledge transfer.

d) In the fourth point, **technological cooperation,** the interviewees stated that with organisations, technological cooperation is in process production and in new products (50% each), whereas with institutions, technological cooperation is mainly in the adoption of new products; one interviewed stated that this technological cooperation is with manufacturers and developers of the components which works with our new designed products.

PUBLIC POLICIES GOVERNANCE

Legislation, policies, financial incentives and taxation are part of this emergent cluster, namely Portugal 2020, Interface Program and Blue Fund. Other government areas are Sea (DGPM– Direção Geral da Política do Mar); Economy (DGEG– Direção Geral de Energia e Geologia; IAPMEI– Instituto de Apoio a Pequenas e Médias Empresas,and Portugal 2020), Science and Technology plus Economy Ministry (ANI– Agência Nacional de Inovação) and Facilities and Planning (Portugal 2020).

In terms of investment support for offshore activity, the interviewees considered that the development of new products, inter-business cooperation and transnational cooperation, and products improvements are supported by European programs and National programs, such as, REN21, IEA, World Bank, WWEA (World Wind Energy Council), reporting Portuguese electricity data, and policy-making.

National programs support the development of new productive processes (100%), introduction to new commercial techniques (100%), and exportS (100%). Moreover, financial support is also related to training, knowledge transfer and SME support.

FACTORS CONDITIONS

The existence of good natural conditions, electricity grid and EI-ERO program are the main factors to implement the offshore wind energy project.

These conditions are also associated with expert work and R&D activities. Therefore, these factors confirm the interviewees’ needs about the main factors for production: expert work, financial support and equipped and accessible spaces. Testing facilities were also was mentioned, because there is always the need to be tested outside Portugal.

STRATEGY, STRUCTURE AND RIVALRY ORGANISATION NETWORK ANALYSIS

The interviewees strongly agree that the network can be made through business networks and financial support with public or private funds. On the other hand, they also considered technical management, knowledge transfer and public consulting services to be important.

The analysis on cooperation leads to a conclusion about its motives; the interviewees considered technological costs and development risk the least significant, and market entrance and scale economies the least important. Cooperation difficulties are less important when organisations develop strategies, face internal problems or with other institutions, unrealistic "timings", and low capital resources. However, cooperation in difficulties is very important for the sector, when they face low human resources.

The development of the energy sector depends on the role of cooperation in the market towards more competitiveness. The factors which the interviewees thought important for its performance are technological planning, selecting possible stakeholders, support for exchanging knowledge between stakeholders, prototype support and scale-up, regulation support, and product valuation. The actors thought the all role cooperation, the infrastructures for pilot test, intellectual property and financial support for product testing to be the most important.

Therefore, the strategy is to cooperate in new products, new processes, efficiency and intellectual property. Less important to set up a strategy between the organisations are new markets, profits, and employment and export quotas.

Due to the fact that the offshore energy sector is an emergent sector, players need to set up a market strategy to follow the energy sector. The interview considered a few vectors which comprise this set-up. The important thing is to increase competitiveness in the value chain first in the national market, and then in the EU market. Therefore, the market strategy is to follow these premises: energy production is related to cooperation, capital transfer, specialized human resources and technology; offshore wind organisations might join others within the same sector and internationalize it; organisations can cooperate with other actors and promote initiatives/activities related with R&D in renewable energy. Moreover, it is important to have a competitive energy cost associated with a system with national and international networks for price adjustment.

The market strategy is also related to an energy value chain and quality of human resources, associated competitive advantages (lower energy costs and a differentiated product).

Nevertheless, the firms' strategy faces other specific related strategies, according to the interviewees, such as:

a) Geographical location and recycling and waste management are considered ***very important*** factors;

b) energy network proximity, climate conditions, good network transport systems, the proximity of university and research centres, credit facilities, business networks, competitive business capacity, capital and knowledge transfer, competitive business capacity, environment quality, cooperation between stakeholders, foreign capital facility and environment sustainability are considered ***important*** factors;

c) Business consulting access is considered a ***less important*** factor;

HISTORY

Due to renewable investments in Portugal (Pego, 2016), the new wind offshore project (2017) will improve technologies adjusted to natural conditions, as well as private investments based on a renewable energy market strategy (**EI-ERO Program**).

GEOGRAPHICAL ANALYSIS

"Creations realized at the price of a great deal of work must in spiteof the truth appear easy and effortless... the great rule is to take much trouble to produce things that seem to have cost none"

Michelangelo Buonarotti (quoted in Dunleavy, 2003:89)

From the EI-ERO - Project it was possible to identify the stakeholders geographic areas. This means that suppliers and other cluster supporters are in a different geographic location, mainly in AMP (Área Metropoliana do Porto), AML (Área Metropoliana de Lisboa), Aveiro in Portugal, and the Azores Islands.

Figure 54– Offshore Energy Stakeholders Interviewed Geographical Areas

From the questionnaire it was possible to verify the variables which comprise the Porter's Diamond Model. The analysis made allowed us to conclude that we are in a presence of an emergent cluster with high standards in technology, human resources and capital. It was also possible estimate the strategies which organisations have to promote linkages to other sectors and regions in order to develop business, innovation and knowledge. The analysis showed also that the Porter Diamond Model is related with an innovative cluster and operates in different sectors (vertical value chain).

Additionally, it is also possible to discuss its competitiveness because of its competitive advantages (costs and differentiation advantages) and industrial attractiveness (conditioning factors', related and supporting industries and firms' strategy). The emergent cluster contains few companies; it is heterogeneous and has low efficiency of networking between stakeholders.

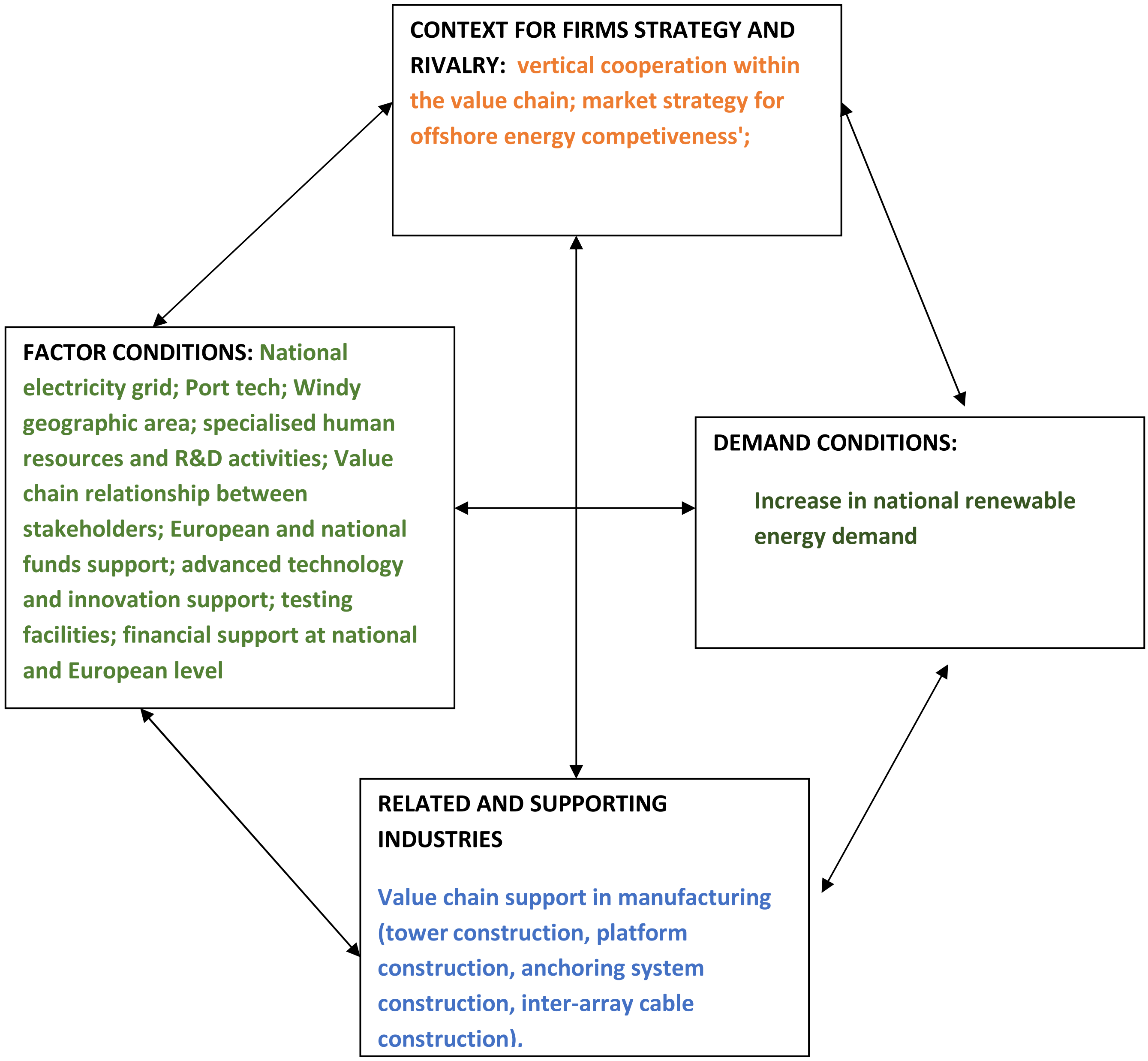


Figure 55– Portuguese Porter's Diamond for offshore energy cluster

8.2.2 SWOT analysis of the offshore energy sector

The cluster' SWOT analysis made from the questionnaire enabled conclusions about strengths, weakness, opportunities and threats that the cluster will face in near future in Portugal.

The emergent Portuguese offshore energy cluster has now started to make the first steps towards a competitive European energy offshore cluster. Nevertheless, from the analysis it is possible to make conclusions about its performance and capacity in the market and its behaviour in the economy.

The SWOT analysis drives it into an innovation sector, with high R&D activities, based on expert knowledge and being environment friendly. The strengths will lead the sector to high competitiveness within the Portuguese energy sector in terms of innovation and performance.

However, the sector faces weak points related to its strategic planning to set up linkages between organisations. The inexistence of a road map to deliver a strategy and regulation within the sector, the lack of communication between the stakeholders, and the high level of investment are other negative points which the sector will face when in the market.

The SWOT analysis also refers to the opportunity for new investments and R&D activities, such as economies of scale and emerging markets (opportunities).

Additionally, the sector faces threats related to its capacity to compete with other energy sources, and the direct costs related with its production, as well as funding levels and priorities.

To summarize, the SWOT analysis demonstrates a sector with a high capacity of employment of expertise, development technologies and R&D activities. However, because it is an emergent sector in the Portuguese economy, it will need competitiveness with other energy sources, cooperation between suppliers and high level of investment. The SWOT analysis also showed that this sector capable of being a cluster if the stakeholders and others make the compromise to cooperate in the long run in technology, expertise and knowledge. Moreover, internationalisation of energy production is also expected in this sector, which will lead to a better relationship with other European partners.

The SWOT analysis allowed us to describe the expectations of the stakeholders about the potential cluster itself and its relationship within the energy market. Therefore, the capacity for staying in the market depends on its capacity to promote renewable energy with lower production costs, and short investment return. Also, human resources specialization, knowledge transfer and innovation constitute important decision variables for sector competitiveness.

To conclude, it is to be expected that the emergent offshore energy sector will constitute a cluster because of its potential in human resources, knowledge transfer and investments. However, vertical and horizontal decisions need to be consistent with a competitive sector based on key initiatives such as standardization and certification, minimizing the environmental impact of offshore wind farms, grid integration, and offshore development based on collaboration and cooperation.

Table 43– Offshore Energy Cluster in Portugal- SWOT analysis

	Most positive points (>50% of responses)	***Less positive points (<50% of responses)***		***Most negative points (>50% of responses)***	***Less negative points (<50% of responses)***
STRENGTHS	**Innovation; extensive R&D development activities;** **environmentally friendly and expert knowledge**	**public interest; efficient government support, investment return, and geographic diversification; network investments and human resources; good natural resources**	**WEAKNESSES**	**lack of strategic plan;**	**No road map; high level of investment and communication between stakeholders; security, environmentally unfriendly, data challenges**;
OPPORTUNITIES	**R&D activities;** **Investment opportunities**;	**Economies of scale; emerging market;**	**THREATS**	**Competition with other energy sources; price of energy from offshore energy production; funding levels and priorities**	**Environment regulations; environmental risks.**

The offshore energy cluster SWOT analysis is completed, when a comparison is made with the literature review (Chapter 4). The offshore energy clusters in other countries presented the same problems and benefits, and as such, it is possible to confirm the analogy that this sector presents in accordance with its development and implications in the economy. The major benefits for all countries including Portugal are innovation and technology, energy production, green technology potential, and knowledge transfer. The negative points according to the questionnaire are the lack of connections between the stakeholders and the government, as well as the deficient regulatory laws and roadmap.

8.3 QUANTITATIVE ANALYSIS

"Positivism is related to formal mathematic models, laboratory experiments, field experiences and field studies"

Matos (2006:93)

The quantitative analysis was based on the production IO matrix 2013. The analysis was made taking in account the offshore energy suppliers for platform construction in 2018 (EI-ERO- project).

In the chapter 7 the quantitative analysis was presented for the offshore energy prototype. The results showed that there are weak linkages within the sector and the economic impact on GVA and employment from this sector is very low. Another conclusion is that the suppliers are mainly located in "Área Metropolitana do Porto" and "Área Metropolitana de Lisboa" .

Although, it was a prototype project, the Keynesian multipliers put in evidence that there are an economic impact in these regions in employment and GVA.

Table 44– WF1 – Offshore Wind Project Suppliers prototype (Windfloat Project)

PARTNERS	PRODUCTS FROM SUPPLIERS	NACE	ORGANISATIONS	NUTSIII
EDP	Steel manufactures structure	25110	ASM	AVEIRO
REPSOL	Certificated entity	74900	ABS	LMA
Portugal Ventures	Repair and maintenance of ships/dry dock assembly	33150	Lisnave	PENÍNSULA SETÚBAL
AS Matos	Tugboats	52220	Rebova	PENÍNSULA SETÚBAL
Others	Tugboats	52220	Tinita	ALTO MINHO
	Speedboats	71120	Multisub	PMA
	Electric cable	27320	Solidal	CÁVADO
	Turbine install	5220	Porto Sines	ALENT LITORAL
	Turbine	28110	Vestas	DENMARK
	Offshore installer	50200	Bourbon Offshore	FRANCE
	Geophysical studies	72190	Hydro graphic institute	LMA
	Know-how/windfloat environment	35113	Wavec	LMA

Source: EDP (2012)

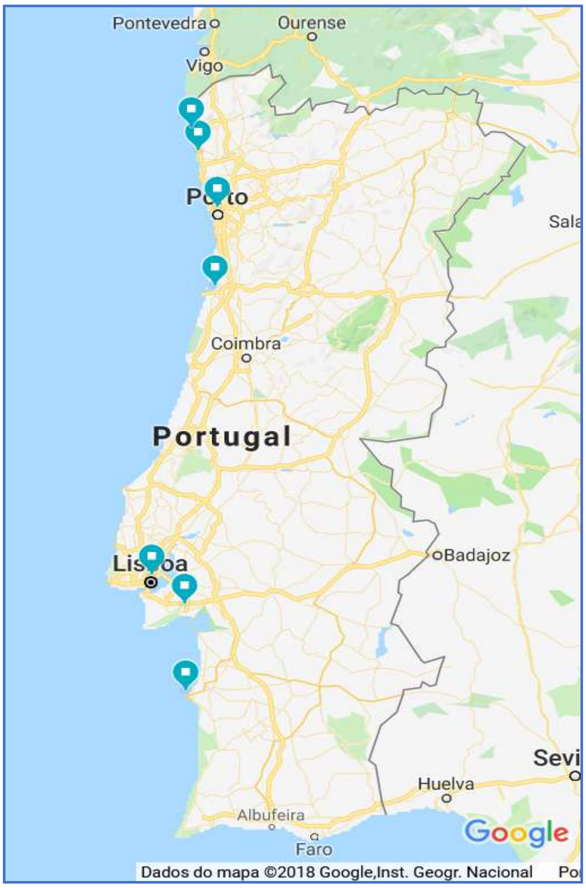


Figure 56 - WF1 Suppliers Location

The initial quantitative methodology (7.5.1) was extending to the EI-ERO project. The following tables analyse the e offshore energy platform suppliers and its impact on the energy sector. For employment, we considered the total employment for the electric sector due the fact of a missing value (k=2.11).

Table 45– Supporting Suppliers technical coefficients (EI-ERO Project)

NACE	PRODUCTS	COMPANIES	LOCATION (NUT III)	**TECHNICAL COEFFICIENTS**
27110	***Turbine and blade construction***	Enercon	ALTO MINHO	0.02
32996		Ria Blades (Sevion)	BAIXO VOUGA	0.0
25110	***Tower construction***	ASM energia	AVEIRO	0.01
25110		Tegopi	AMP	0.01
25110		Martifer	DÃO- LAFÕES	0.01
46690		Energy systems	ALTO MINHO E AML	0.0
25110	***Platform construction***	ASM energia	AVEIRO	0.01
25110		Tegopi	AMP	0.01
25110		Amal- construçoes metálicas, SA	PENÍNSULA DE SETÚBAL	0.01
25110	***Anchoring system construction***	Lankhorst Euronet	AMP	0.01
25931		Oliveira & Sá- cordoaria de arame	AMP	0.01
27320	***Inter-array cable construction***	Solidal	CÁVADO	0.02
27320		Cabelte	AMP	0.02
			wages	**0.36**
			Total	0.14

Table 46– Supplier Port Technical Coefficients (EI- ERO Project)

NACE	PORT	LOCATION (NUT III)	**TECHNICAL COEFFICIENTS**
258359	VIANA DO CASTELO	ALTO MINHO	0.01
63220	AVEIRO	AVEIRO	0
52220	PENICHE	CENTRO - OESTE	0.01
63220	SETÚBAL	PENÍNSULA DE SETÚBAL	0
52220	SINES	ALENTEJO LITORAL	0.01
		TOTAL	0.03

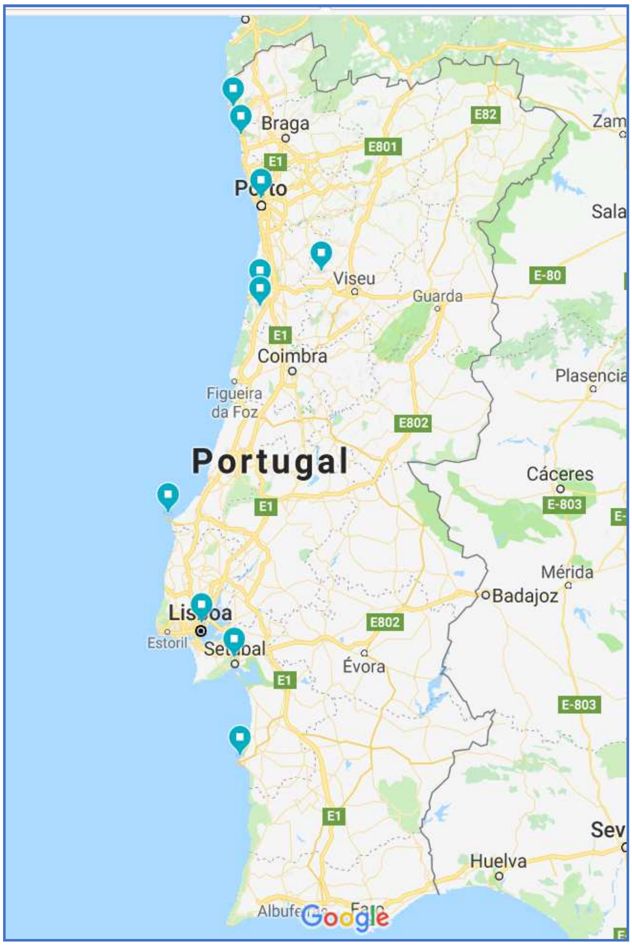


Figure 57 - Supporting Suppliers Location and Ports

Few aspects should be pointed out:

1- The EI-ERO project has contributed to include others stakeholders different from the prototype project (WF1);

2- The analysis made through the IO matrix is characterized by a low impact between the sectors (suppliers and port tech), all presented aij<1;

3- The economic structure from IO matrix (2013) is the same, therefore the EI-Ero project has the same multiplier as WF1, where multiplier type I=2.53 and multiplier type II= 3.18, this means that the Ei-ERO investment, in an amount of about 254 M. € had 642.6 M.€ of direct and indirect effects and 807.72 M. € of total (direct + indirect + induced) effects. On what concerns the effects on Employment, one cannot add a number, as the number of workers at Ei-ERO is not available (the wind farm will be finished in 2020).

4- It is not possible to confirm that there is an offshore energy cluster in Portugal, but an emergent sector;

5- The IO matrix 2013 is not disaggregated for offshore energy sector; thus the impact from the multiplier reflects the total of the energy sector;

6- In terms of employment, it was considered the same multiplier as the electric sector because the lack of data, thus for k=2.11, 1500 jobs are expected in this sector, which will make an impact of 3165 jobs in the offshore energy sector.

CHAPTER 9– CONCLUSIONS AND RECOMMENDATIONS

"The best way to inform your reader is to tell them what they are likely to want to know– no more and no less”

Robert J. Sternberg (quoted in Dunleavy, 2003:84)

“All good things which exist are the fruits of originality”

John Stuart Mills (quoted in Dunleavy, 2003:26)

"I am not afraid of failure... if you are learning anything new; you have got to get through humiliation"

Eddie Izzard (quoted in Dunleavy (2003:34))

The analysis made along this research work and its conclusion allowed dressing a few aspects about the initial research question: Is there an offshore energy cluster (wave and wind) in Portugal?

The results presented in this thesis are related with the offshore wind project (EI-ERO), because, the wave project was decommissioning in 2012 (5.3.2) and offshore wind farm comprise a recent cluster for maritime energy in Portugal.

The recent offshore energy farm in Portugal is considered one of the greatest investments in terms of innovation, knowledge and technology. The offshore energy sector holds the potential to generate externalities, creating jobs and economic growth. This industry is also related to innovation, production processes and policy attention.

In order to analyse the cluster, an electronic questionnaire was sent to all suppliers, public organisations and research centres which are related with EI-ERO project. To conclude the study, phone calls were made where the reason for the study was explained. Some of the suppliers were not available to answer and others organisations said it was not possible to answer because it was "private".

However, of those organisations which answered, some want conclusion of the offshore energy cluster; they stated that it is highly important to their organisation because it is their strategy to be in the electricity market.

From the qualitative analysis and the qualitative results, it was possible to confirm the emergent offshore energy cluster in Portugal.

The emergent offshore energy cluster and its features allow us to conclude about the economic impact from the sector, management performance and direct and indirect investments.

Therefore, a number of points must be addressed to understand the offshore energy cluster and its impact on the Portuguese economy. The analysis made through the mixed methodology has contributed to the following aspects:

1*. The IO matrix showed that the impact on GVA and employment and the supplier's contribution to the economy are high;*

2- The linkages between sectors are weak;

3- The sector needs a high investment and skilled human resources;

4- There is no road map for this sector;

5- The strategy to stay in the market according to the stakeholders is not yet defined;

6- There are threats (competition with non renewable energy prices) and weaknesses (a plan to stakeholders to be in the market) which are considered negative points to cluster implementation and development;

7- The sector has a high impact on R&D activities and expert activities;

8- The government has set up new strategies for the offshore sector (EI-ERO program) in order to bring about more innovation, production processes, knowledge development and transfer, and legitimacy.

9- It is expected that all sectors in the value chain will contribute positively to the sector's development;

10- The offshore energy sector is considered an innovative sector and therefore will contribute to smart grid projects (INOVGRID EDP);

11- The geographical location is heterogonous and the suppliers are mainly in AMP and AML;

12- The offshore energy sector is considered a top down and downscaling sector;

The conclusions about the offshore energy cluster follow the initial research questions:

1- Which factors can contribute most to the offshore energy cluster in Portugal?

The analysis revealed the following factors for cluster development: capacity of a potential cooperation between the organisations; government support to new investments; expert human resources; windy geographic areas; R&D activities', and a smart electricity grid. From the port perspective, Viana do Castelo, Aveiro, Peniche, Setúbal and Sines, constitute an important hub for the offshore energy cluster development because its services support; the ports constitute also an important geographic point to develop a business strategy for the sector.

From the financial perspective, the Portugal 2020, the Fund Azul and the EEA Grants assume the principal instruments for its implementation.

2- What are the direct, indirect and induced impacts of the offshore energy sector on investment and employment?

From the IO matrix it was possible to estimate the investments impact (€254M) in GVA and in employment in the sector.

3- What lessons can be used in Portugal from the offshore energy clusters in other European countries?

The offshore energy cluster in Europe is consistent with a number of premises: less energy dependence from the EU; European countries with strong potential for renewable energy production can contribute to a global European offshore cluster (the most important factor);the European offshore cluster promotes innovation, human resources specialization and technology transfer due the fact of cooperation between organisations (where Portugal can contribute positively), as well as contributing to environmental solutions and the circular economy. Other less important factors, also considered by the interviewees: maximization of public and private utility; the role of public institutions; business conditions, distribution and logistics centres; vertical cooperation; the adjustment of Energy Policy 2020 to consumer's needs and satisfaction; the European countries can contribute to relevant cooperation between stakeholders.

The research carried out in this field is the first in Portugal, therefore, it can be a good instrument to implement a market strategy for the sector and also create analogies with onshore energy clusters, or other sectors with the same features.

The research can promote a political debate about the future of an ocean energy cluster and its linkages to other sectors. In geographic terms, it is possible to make comparisons with other sectors and to draw conclusions about the cluster's proximity needs. Moreover, the emergent cluster and the emergent market about clean energy, smart grids, green economy and ecosystem is good for debate to understand climate change, consumers' needs and adjustments to the economy for welfare.

Additionally, this study will contribute to bring closer the debate about European clusters and their capacity to maximize the consumers' and organizations needs associated with European goals for energy.

Despite the fact of being an emergent cluster, the Portuguese offshore energy is a competitive sector, a business model based on innovation, investment opportunities and skilled workers, and related to the Portuguese ecosystem. On other hand, the cluster promotes large scale demonstrations as proof of concepts for the above scientific, technical, market/regulation and social issues (EEGI, 2013: 102).

In summary, although it appears that the offshore energy cluster brings benefits to the national economy and it will be a potential industry in the near future for energy supply in Europe and in the world, it is clear that there are many unanswered questions. Future suggestions lie in the debate: how can the government promote positive externalities in the economy, and which networks should be established? How can prices be determined in the market to be competitive? Can it be developed for suppliers? And how can offshore energy be stored for consumers' needs?

The answer to these questions can contribute comprehensively to the understanding of the offshore energy cluster' new challenges.

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ANNEX 1– INTERVIEWEES AND ELECTRONIC QUESTIONNAIRE

LETTER SENT TO THE INTERVIEWEES

Dear Sir/ Madam

You are invited to participate in a research study titled "The offshore energy cluster in Portugal. A cluster perspective".

In this study, you will be asked to complete an electronic survey. Your participation in this study is voluntary and you are free to withdraw your participation from this study at any time.

The survey should only take 10 minutes to complete. There are no risks associated with participating in this study. The survey collects no identifying information of any respondent. All of the responses in the survey will be recorded anonymously.

If you have any questions regarding the survey or this research project in general, please contact Ana Pego (doctoral candidate) at anapego@campus.fcsh.unl.pt.

By completing and submitting this survey, you are indicating your consent to participate in the study. Your participation is appreciated.

Yours faithfully,

Ana Pego, doctoral candidate, CICS Nova, FCSH, UNL

Professor Regina Salvador, CICS Nova, FCSH, UNL, Jean Monet Chair

Please click on the survey link below and provide us with your feedback no later than 30/04/2018

https://kwiksurveys.com/s/ZAi9wfqJ

The survey content and findings are the sole responsibility of the individual conducting the survey.

LIST OF INTERVIEWEES WHO AGREED TO PARTICIPATE IN THIS SURVEY

Name	Activity Code CAE	Person who answered	Email	NUTS II	typology
APCER- Serviços de Certificação, Educação e Formação, Auditoria e Inspeção, Energia, AgroFood.	71200	Carlos Vila	info@apcer.pt	AMP	d
APREN - Associação Portuguesa de Energias Renováveis		João Graça Gomes	joão.gomes@apren.pt	AML	d
A Silva Matos Metalomecânica , SA	25110	A Silva Matos Metalomecânica , SA	Asm-metal@asilmatos.pt	Sever do Vouga	a
Cabelte - Cabos Eléctricos e Telefónicos, S.A:	27320	Mario Pais de Sousa	marketing@cabelte.pt	AMP	a
IEP- Instituto Elétrico Português	94995	Modesto de Morais	cm@iep.pt	AMP	d
IST- Instituto Superior Técnico	85420	Henrique Matos	henrimatos@tecnico.ulisboa.pt	AML	c
Lankhorst Euronete Portugal, S. A.	13942	Alberto Leão	info@lankhorsteuronete.com	AMP	a
MARE - Centro de Ciências do Mar e do Ambiente	85420	José Lino Costa	José.costa@mare-centre.pt	AML	c
MARE - Centro de Ciências do Mar e do Ambiente (AZores)	85420	Paula Lourinho	paula.lourinho@mare-centre.pt	Azores	c
Polish Maritime Cluster	12345	Marek Grzybowski	Klaster@klastermorski.com.pl	Pomerania (Baltic Sea Region)	d
Porto Peniche	52220	Serrano Augusto	capitaoporto.peniche@amn.pt	Centro	b
SENVION	42220	Rui Carvalho	ruicarvalho@senvion.com	AMP	a
SIEMENS	27110	Filipe Rodrigues	Filipe.mrodrigues@simens.pt	AML	a
TEGOPI	25110	Diana Vasconcelos	info@tegopi.pt	AMP	a

a= Suppliers; b= Ports; c= Research Centre/University; d= Public Institutions; others public institutions as municipalities council didn't agree in participated

ELECTRONIC QUESTIONNAIRE

1- Identification

Name
Email
City
Country
Person who answered

2- Economic activity - 5 dig ______

3- **Type of organisation**:

Public organization; Government; Private Organization; Research Centre; University; Municipality Council; Other;

4- NUTS II location :

Norte; Centro; Lisboa e Vale do Tejo; Alentejo; Algarve; Açores; Madeira; Other;

5- Identify NUT III ____

6- Relationship with other organization:

Independent; Integrated in a National Group; Integrated in an International Group; Other;

7- If the organization is integrated in a group the main organization is located in

Portugal; Portuguese District; Other Country;

8- Number of employees

Total; Senior Management; Number of Skilled Workers; Number of No Skilled Workers;

9- Partnerships

Option	*Scale of values*
Training (go to question 10); Institutions (go to question 11); Business Organisation (regional/national/European) (got to question 12);	Yes/No;

10- Training

Option
Universities; Training Institutions; Private Organisations; Research Centers; Other;

11- Institutions

Option
Apply; not apply; Other;

12- From the following services indicate which services are inside or outside the organization

Option	*Scale of values*
Innovation Process; Marketing and Publicity; Financial Services; Legal Services; Market Prospect; Repair and Maintenance Equipments; Others;	In organisation; From Specialized Organizations Inside the Council; From Specialized Organizations Outside the Council; Foreign Organizations';

13- Principal services and good suppliers

Option	*Scale of values*
Components; Raw Materials; Machinery; Accessories; Advance Services (technical assistant, drawing, software); Other;	Local; Regional; National; EU; Other Countries;

14- Cooperation

Option
Between Organization in the Same Sector; Between Organization in the Same Value Chain; With Public Agents; Technological With Other Organization; Technological With Other Institution; Commercial; Other;

15- Technological cooperation

Option	*Scale of values*
With other Organization; With Other Institution; Other;	In Process Production; In New Products; In New Commercial Techniques; Adoption to new Products; adoption to Existent Products;

16- Financial support and incentives

Option	*Scale of values*
Developing New Products; Developing New Productive Process; Introduction to New Commercial Techniques; Products Improvement; Export; Training; Inter-Business Cooperation; Transnational Cooperation;	Regional Programs; National Programs; European Programs;

17- Cooperation with stakeholders

Option	*Scale of values*
Stakeholders; Type of Relationship;	Regional Level; National Level; European Level; International Level;

18- Production factors availability and technical conditions

Option	*Scale of values*
Expertise Work; Financial Support; Equipped and Accessible Spaces; Transport Infrastructures; Other Infrastructures;	Positive; Negative; Needed; Problems;

19- Cooperation with organizations

Option
Training skills; Consultancy; Investment Support; Infrastructures; Technological Transfer; Human Resources; R&D Activities; Other

20- Cooperation with organization

Option
Vertical; horizontal;

21- Vertical cooperation

22- Horizontal cooperation

23- Intuitional expertise areas

Option
Environment; Quality; Human Resources; Sustainability; Other;

24- Investment support to organizations

Option	*Scale of values*
EU Funds; National Funds; Regional Funds; Other;	No important at all; Unimportant; Neutral; Important; Very Important;

25- Production factors availability and technical conditions

Option	*Scale of values*
Expertise work; Financial Support; Equipped and Accessible Spaces; Transport and Infrastructures; Other infrastructures;	Positive; Negative; Needed; Strongly Agree;

26- Network with private or other organization in renewable energy can be made with:

Option	*Scale of values*
Business Network; Technical Management; Financial Support with Public or Private Funds; Knowlodge Transfer; Public Consulting Services;	Strongly Disagree; Disagree; Neutral; Agree; Strongly Agree;

27- Organization Typology

Option
Technology Centre; R&D Laboratory; University; Research Organization;

28- Cooperation motives

Option	*Scale of values*
Less Technological Costs; Less Market Entrance Costs; Less Technological Development Risks; Less Market Entrance Risks; Scale Economies; Reduce the time on new Products; Promote the Knowledge and Learning;	Very Insignificant; Insignificant; Neutral; Significant; Very Significant;

29- Cooperation difficulties

Option	*Scale of values*

Strategies/Goals; Problems with Organization; Asymmetric Relationship With Organization; Unreal "timings"; Low Human Resources; Low Capital Resources; Other;	Very Unimportant; Unimportant; Neutral; Important; Very Important

30- Organization role

Option	*Scale of values*
Technological Planning; Select the Possible Stakeholders; Change Knowlodge Support Between Stakeholders; Infrastructure for Pilot Test; Prototypes Support and Scale-UP; Regulamentation Support; Intellectual Property; Financial Support for product Testing; Evaluated Product; Other;	Very Unimportant; Unimportant; Neutral; Important; Very Important

31- Cooperation Results

Option	*Scale of values*
New Products; New Process; New Markets; Profits; Employment; Export Quota; Efficiency; Intellectual Property; Other	Very Ineffective; Ineffective; Neutral; Effective; Very Effective

32 -

Option	*Scale of values*
The Renewable Energy Costs are Competitive; Energy Production is Related With Cooperation, Capital Transfer, Specialized Human Resources and Technology; There are a Possibility of the Organization Join Other from the Same Sector; The Organization Cooperates with Public Institutions, Universities and Other Organizations Towards Better Services; The Organization Develop Research Activities and Innovation; The organization intend to be Internalized; The Use of Information and Technology Systems are important for Competiveness; A system With National and International Networks Constitute an Important factor for energy prices; The Energy Value Chain is Fundamental for the Organization Performance; The Quality of Human Resources and Technology Constitute an Important Vector for Competiveness; Organization Work Together for Market Needs;	Strongly Disagree; Disagree; Neutral; Agree; Strongly Agree;

33- Specify other Market Strategy if Necessary

34

Option	*Scale of values*
Geographical Location; Energy Network Proximity; Climatic Conditions; Good Network Transport System; Universities and Research Centers Proximity; Credit Facilities; Network Business; Competitive Business Capacity; Capital and Knowlodge Transfer between Organizations; Business Consulting Access; Environmental Quality; Cooperation Between Stakeholders; Foreign Capital Facility; Environmental Sustainability; Recycling and Waste Management;	Very Unimportant; Unimportant; Neutral; Important; Very Important

35 - Other development factor not listed

36- Which factors comprise the offshore energy cluster in Europe?

Option
The energy policy 2020 on renewable (offshore energy) is adequate to EU needs and promotes consumer satisfaction; The strategies followed by the renewable energy intend to maximize private and public consumers utility; The renewable energy promotes less energy dependency; The offshore cluster will promote innovation, human resources and technology transfer, because cooperation it will established between organizations; European countries with strong potential for renewable energy production can contribute for a global European offshore cluster; European countries with high offshore energy production can contribute for relevant cooperation between stakeholders among European countries; Portugal can cooperate with other offshore European clusters; Accessibility, employment, social affairs, economic and social development, natural resources and energy efficiency are important factors; Public Institutions, business conditions, distribution and logistics centers have an important role on offshore energy cluster; Vertical cooperation among offshore energy cluster is more suitable than horizontal because the government should have an important role; Offshore energy cluster will comprise environment solutions and contribute positively for circular economy;

37- Portuguese Offshore energy cluster strengths

Option
Environmental Friendly; Innovation; Public Interest; Efficient Government Support; Expertise Knowlodge; Investment Return; Extensive R&D Development Activities; Geographical Diversification; Other;

38- Portuguese offshore energy cluster weakness

Option
Security; Data Challenges; High Level of Investment; No Road Map; Communication Between Stakeholders; Technology Training/Orientation; Lack of Strategic Plan; Other

39- Portuguese offshore energy cluster opportunities

Option
Economies of Scale; Integration of Information System; Network Investments and Human Resources; Infrastructure Management; Investment Opportunities; Employment Expertise; R&D activities; Emerging Market, Other;

40- Portuguese offshore energy threats

Option
Environmental Regulation; Funding Levels and Priorities; Competition With Other Energy Source; Price of Energy from Offshore Energy Production; Value Chain; other

ANNEX 2– IO MATRIX 2013

	27	28	29	30	31	32	33	351	352	353	36	37+38+39	41	42	43	45	46	47	49	50	51	52	53	55
	Equip. eléctrico	Máq. e equip., n.e.	Veíc. Autom., reboques e semi-reboques	Outro mat. Transp.	Mobiliário	Prod. div. indúst. transform.	Serv. rep e instal. máq e equip	Produção, transporte, distribuição e comércio de electricidade	gaz natural distribuido	Produção e distribuição de vapor, água quente e fria e ar frio por conduta; produção de gelo	Captação, tratam. e distrib. água	Serv. Saneam., descontamin. e valoriz. de materiais	Constr. edifícios	Trabalhos engenharia civil	Trabalhos de construção especializ.	Vendas p/ gros. e ret. e serv. rep. Autom. e motocic.	Vendas p/ grosso, exc. veíc. Auto. e motociclos	Vendas a retalho, exc veíc. Autom. e motoc.	Serv. Transp. terrestre e por cond. (pipelines)	Serviços de transporte por água	Serviços de transporte aéreo	Serv. armaz. e auxil. dos transp.	Serviços postais e de courrier	Serv. Alojam.
01	0,0	0,7	9,3	0,0	0,0	0,1	0,1	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,3	0,0	47,8	17,1	0,0	9,3	0,0	0,0	0,0	40,3
02	0,0	0,0	0,0	0,0	1,7	1,5	0,1	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,9	0,0	2,7	3,1	0,0	0,0	0,0	0,0	0,0	0,0
03	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,8	0,0	0,0	0,0	0,0	0,0	0,0	5,5
05	0,0	0,0	0,0	0,0	0,0	0,0	0,0	260,46	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
061	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
062	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00	1358,4	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
07+08+09	0,7	0,7	0,0	0,0	0,0	0,5	0,1	0,00	0,4	0,0	5,0	1,3	58,2	40,0	40,4	0,1	5,2	0,4	0,7	0,0	0,0	3,3	0,0	0,2
10	0,1	0,0	0,0	0,0	0,0	2,8	0,0	1,16	0,0	0,0	0,1	0,2	0,6	0,5	0,2	0,4	76,0	147,2	0,8	0,0	0,0	0,9	0,1	223,8
11	2,0	2,5	2,9	0,3	1,6	1,1	2,6	1,18	0,1	0,0	0,5	4,6	14,0	3,7	6,5	8,3	70,2	22,5	6,7	1,7	0,3	3,5	0,4	91,6
12	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
13	0,4	0,2	139,9	1,5	103,2	13,8	1,3	0,00	0,0	0,0	0,0	0,0	9,8	2,4	3,5	1,1	19,7	3,7	0,3	125,7	1,5	0,1	0,0	16,4
14	0,2	0,2	1,2	0,1	0,1	2,9	0,4	0,28	0,0	0,0	0,3	0,9	1,0	0,3	1,0	0,7	3,5	11,9	1,0	0,8	0,1	1,3	0,0	1,2
15	0,0	0,0	53,5	1,8	40,1	1,5	0,2	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,9	2,2	0,0	53,5	1,8	0,8	0,0	0,0
16	14,2	3,2	3,7	1,5	266,7	22,7	1,1	0,00	0,0	0,0	1,3	1,5	211,3	70,7	148,0	0,1	21,3	29,2	2,2	1,5	1,5	3,6	0,0	4,1
17	8,5	6,9	13,7	1,6	14,0	6,8	3,6	3,30	0,0	0,0	0,7	2,1	3,2	2,7	3,9	4,1	43,6	23,2	6,6	13,1	1,6	4,6	1,2	7,3
18	0,9	1,5	1,2	0,7	1,9	2,4	0,7	26,17	0,2	0,0	1,0	1,8	2,1	0,9	1,1	8,4	73,5	51,8	7,3	0,3	0,7	4,7	1,8	5,3
19	14,3	14,8	8,2	1,5	16,9	13,4	23,9	302,28	0,9	7,0	12,7	59,8	131,4	136,3	182,7	65,2	371,5	161,8	1442,5	6,1	1,5	37,6	11,7	21,4
20	182,3	50,6	177,9	15,1	62,3	38,1	21,4	17,44	0,0	0,0	39,4	12,4	127,3	46,8	72,3	30,9	102,1	59,5	18,5	171,5	15,1	1,9	0,4	64,3
21	0,1	0,1	0,1	0,0	0,0	0,0	0,1	1,97	0,0	0,0	0,3	0,6	1,3	1,1	0,2	0,2	67,5	3,5	1,0	0,1	0,0	3,1	0,2	0,8
22	84,2	67,0	192,0	14,7	30,7	118,3	19,4	3,49	0,0	0,4	6,8	2,4	125,6	79,2	114,8	382,5	49,6	80,9	36,4	144,1	14,7	2,4	0,1	0,7
23	20,9	11,4	43,5	0,9	13,0	10,6	4,0	0,03	0,0	0,0	9,0	1,6	672,7	357,3	363,4	24,9	30,2	16,4	12,0	15,2	0,9	4,8	0,0	16,0
24	612,7	414,2	326,5	32,9	44,5	42,5	28,7	4,07	0,1	0,0	3,9	0,0	103,2	109,6	87,8	10,9	11,2	3,3	2,3	277,2	32,9	2,5	0,0	0,8
25	85,0	163,8	149,4	44,3	46,6	12,1	91,3	18,16	0,0	0,0	1,6	15,6	394,6	73,7	272,5	25,9	140,1	75,4	28,2	115,0	44,3	9,0	0,7	22,2
26	56,6	8,6	186,6	2,0	0,2	9,6	56,9	18,47	0,1	0,0	4,0	0,0	4,9	2,5	9,9	30,7	238,5	11,6	6,3	162,1	2,0	1,3	0,0	0,0
27	377,0	61,9	164,0	3,3	1,0	13,9	93,0	94,31	0,0	0,0	0,0	0,0	152,2	34,6	143,6	56,9	32,0	27,3	22,1	145,1	3,3	0,1	0,0	25,3
28	73,9	445,1	80,6	8,0	2,3	4,1	54,0	15,13	0,0	0,0	17,6	1,0	72,7	90,5	88,4	45,9	13,8	8,3	12,1	61,7	8,0	0,3	0,0	10,7
29	2,4	3,5	3120,1	1,4	0,0	3,4	0,7	0,00	0,0	0,0	0,0	0,7	0,0	0,0	0,2	496,8	2,5	3,9	14,6	1279,1	1,4	0,0	0,0	0,0
30	0,0	0,1	1,9	125,1	0,0	5,1	27,5	0,00	0,0	0,0	0,0	0,0	0,0	0,3	0,6	7,5	8,7	6,4	0,5	1,9	125,1	0,0	0,0	0,0
31	0,1	1,4	0,7	0,1	54,7	3,2	0,0	0,00	0,0	0,0	0,0	0,0	24,2	0,0	18,4	0,4	9,5	1,1	0,6	0,3	0,1	0,2	0,0	17,8
32	1,2	1,1	2,0	0,1	1,0	26,2	1,1	0,60	0,0	0,0	0,5	91,4	2,0	1,3	2,5	2,2	8,5	55,5	3,1	1,3	0,1	2,4	0,6	7,7
33	13,5	13,1	17,3	2,6	11,1	6,6	196,2	71,89	3,9	0,9	5,6	13,1	8,5	6,9	10,8	18,3	14,1	10,3	142,7	13,1	2,6	13,9	7,1	32,8
351	20,6	18,6	33,9	4,2	28,5	7,7	11,6	6394,11	0,3	1,7	31,2	70,4	13,3	9,3	9,5	32,5	132,4	315,1	75,5	24,8	4,2	64,7	6,0	110,0
352	3,3	4,5	9,4	0,6	1,4	0,7	0,7	833,87	104,9	0,1	0,5	3,6	6,3	4,1	2,9	3,3	8,3	3,4	11,5	5,4	0,6	3,5	0,1	33,6
353	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00	0,0	0,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	14,2
36	0,5	0,4	0,6	0,1	0,3	0,2	1,7	1,01	0,0	0,8	169,3	36,1	3,3	0,8	0,6	3,0	5,6	10,9	7,5	0,4	0,1	3,7	0,2	17,7
37+38+39	0,6	32,3	0,6	0,7	0,9	0,3	0,7	1,14	0,0	0,1	145,9	892,9	3,3	2,1	0,7	8,9	12,2	13,5	6,3	0,5	0,7	3,6	0,2	17,8
41	10,3	8,8	17,4	4,0	5,9	3,1	18,6	0,00	0,0	0,0	3,6	26,7	565,7	392,6	0,0	18,8	132,2	96,7	8,8	15,5	4,0	2,2	18,2	42,8
42	0,0	0,0	0,0	0,0	0,0	0,0	0,0	114,61	7,6	0,3	9,5	16,1	344,6	1451,7	0,0	0,0	0,0	0,0	180,8	0,0	0,0	106,4	0,0	0,0
43	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00	0,0	0,0	0,0	0,0	942,8	428,5	751,8	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
45	5,3	3,5	7,5	0,9	2,3	1,2	8,1	23,26	0,9	0,2	7,9	10,5	6,9	6,4	7,9	20,8	46,5	76,9	80,4	6,1	0,9	10,1	3,0	17,0
46	15,3	5,2	6,0	0,8	7,6	2,1	2,4	0,76	0,6	0,1	1,0	0,9	1,6	1,3	1,9	8,8	647,9	71,3	10,0	5,9	0,8	5,7	0,1	1,6
47	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
49	27,4	30,2	55,8	7,8	18,0	12,1	11,6	5,58	115,0	0,1	1,0	19,1	15,3	27,6	21,1	70,4	527,8	218,6	1033,6	43,3	7,8	58,9	18,7	3,9
50	1,3	0,7	1,9	0,3	0,6	0,4	0,2	0,10	0,3	0,0	0,0	0,7	0,5	0,6	0,6	1,5	3,4	2,9	1,0	1,5	0,3	1,9	1,3	0,1
51	2,5	3,0	2,5	0,4	1,8	1,0	3,9	1,41	0,1	0,0	0,3	1,4	7,7	8,4	8,1	5,9	27,5	13,8	18,7	1,8	0,4	13,9	0,5	8,4
52	31,4	21,7	18,8	5,5	11,4	10,9	4,7	27,96	66,1	0,0	10,5	6,9	22,4	11,1	6,6	42,1	372,2	229,9	176,7	18,4	5,5	1144,9	8,2	11,3
53	1,1	1,4	1,2	0,2	1,5	0,8	1,4	6,20	0,3	0,0	2,6	3,2	3,0	2,0	3,2	8,3	44,6	38,5	8,9	0,9	0,2	3,5	228,9	5,9
55	2,4	2,9	2,3	0,4	1,7	1,0	3,7	1,35	0,1	0,0	0,2	1,4	7,5	8,1	10,2	6,1	43,7	17,3	19,3	1,7	0,4	3,6	0,4	181,0
56	1,8	1,4	3,9	0,6	2,5	1,5	4,4	3,75	0,2	0,0	4,5	9,4	4,3	4,1	1,4	4,8	33,8	31,8	8,9	3,2	0,6	6,5	5,8	10,7
58	0,8	1,4	2,1	0,1	0,8	0,4	1,9	1,26	0,1	0,0	0,5	0,9	3,0	1,0	0,9	8,8	23,7	25,7	5,9	1,5	0,1	4,0	0,4	4,9
59	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,3	0,0	0,1	0,0	0,0	0,1	0,0	0,0
60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
61	5,8	8,6	7,6	1,1	8,7	4,1	9,3	27,02	1,7	0,1	18,6	15,8	18,1	11,4	19,8	49,4	175,9	112,2	46,1	6,1	1,1	29,3	7,9	56,5
62	5,9	4,0	8,9	1,1	2,3	1,7	10,2	52,25	8,1	0,1	10,7	6,2	14,1	12,0	6,2	18,1	62,3	49,7	20,7	7,5	1,1	34,6	4,4	16,7
63	1,4	0,9	3,7	0,2	0,5	0,5	2,6	8,35	1,6	0,0	1,2	0,8	0,9	0,7	0,3	4,9	12,8	12,4	3,7	3,2	0,2	6,7	1,1	6,8
64	25,5	23,5	24,1	4,2	19,8	7,4	17,8	241,79	6,6	0,1	67,0	66,7	365,2	228,7	54,9	85,2	448,1	261,9	187,2	13,8	4,2	421,2	17,4	177,0
65	3,9	3,0	4,1	0,9	5,0	1,8	3,2	8,36	1,7	0,1	2,9	6,1	8,5	19,5	10,5	6,4	31,5	19,0	30,2	3,2	0,9	10,5	3,5	7,7
66	2,5	4,0	2,0	0,4	1,2	1,9	2,4	4,51	0,4	0,0	0,1	0,4	1,0	1,5	0,9	1,8	12,6	23,5	1,3	1,3	0,4	0,6	0,0	2,0
6801+6802	9,6	11,5	15,9	3,4	12,5	5,9	36,7	16,05	1,3	0,2	7,5	14,9	90,9	10,3	3,6	74,2	332,2	532,6	8,9	14,5	3,4	85,4	22,6	93,8
6803	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
69	13,6	8,9	15,8	5,3	6,6	3,4	21,4	103,53	9,0	0,6	6,6	11,2	30,4	47,5	20,4	31,6	59,7	75,5	53,0	13,9	5,3	68,1	7,3	39,3
70	14,4	10,1	22,2	3,5	6,0	4,0	53,3	104,23	8,3	0,6	9,4	8,6	43,4	56,3	25,7	37,2	256,5	239,6	34,9	19,5	3,5	93,4	11,4	49,4
71	14,3	8,9	19,4	3,2	5,5	3,3	24,0	116,82	8,0	0,2	11,7	11,9	41,4	54,5	23,2	38,9	122,2	58,5	39,7	15,8	3,2	88,7	8,6	31,3
72	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,00	0,0	0,0	0,0	0,5	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
73	9,8	5,0	6,2	1,2	8,1	7,2	3,2	15,74	2,5	0,1	2,4	8,7	10,6	3,7	5,1	110,1	695,0	313,2	14,4	4,8	1,2	7,3	4,2	44,5
74	1,5	0,8	1,9	0,1	0,6	0,4	3,0	14,92	0,6	0,0	3,9	9,3	14,5	5,8	4,8	2,6	9,4	3,9	11,7	1,7	0,1	16,9	2,8	3,4
75	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
77	16,1	13,5	32,2	2,6	7,4	23,0	12,1	20,41	0,9	0,0	2,9	7,7	20,8	39,2	24,3	30,3	256,3	330,7	87,5	31,6	2,6	53,1	13,2	77,7
78	18,4	7,5	141,7	0,5	0,1	0,4	4,6	1,68	0,0	0,0	1,5	5,2	0,9	4,0	7,8	6,8	58,6	20,7	20,5	141,5	0,5	8,9	6,8	11,4
79	1,0	0,6	0,4	0,1	0,6	0,3	1,1	0,18	0,0	0,0	0,1	0,4	0,4	0,6	0,6	1,5	6,4	3,2	4,9	0,3	0,1	1,1	0,1	1,3
80	8,4	1,8	5,7	0,8	1,1	0,8	3,6	9,96	0,8	0,0	2,8	14,2	6,6	4,9	4,0	9,3	22,2	77,2	18,9	4,6	0,8	43,3	2,8	10,6
81	2,2	1,3	3,9	0,3	0,8	0,8	3,0	8,94	0,1	0,0	3,0	16,1	11,9	22,3	1,8	8,0	22,6	35,8	17,6	2,7	0,3	42,7	3,0	29,0
82	26,4	21,9	29,2	4,8	7,1	4,3	23,0	145,10	9,3	0,5	6,8	51,3	66,5	71,8	37,7	89,6	377,3	188,2	126,0	21,6	4,8	141,0	24,2	31,3
84	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00	0,0	0,0	0,1	4,0	0,5	0,9	0,8	0,0	0,0	0,0	0,7	0,0	0,0	1,0	0,0	0,0
85	1,2	0,8	2,3	0,2	0,4	0,3	1,5	0,19	0,1	0,0	0,6	0,5	1,8	1,9	2,4	4,7	10,6	7,2	1,9	1,4	0,2	8,4	0,1	1,2
86	0,8	0,8	1,3	0,2	0,6	0,5	1,0	0,70	0,4	0,0	0,4	0,7	6,4	1,6	5,4	3,3	20,5	11,2	3,7	1,1	0,2	1,9	0,5	4,6
87	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
88	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
90	0,3	0,3	0,3	0,0	0,2	0,1	0,0	0,14	0,1	0,0	0,0	0,1	0,0	0,0	0,0	0,8	1,5	3,2	0,7	0,1	0,0	0,7	0,8	0,6
91	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
92	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
93	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,0	0,0	0,1	0,3	0,0	0,0	0,6	0,0	17,6
94	1,3	0,8	0,6	0,2	0,5	0,3	0,5	2,80	0,1	0,0	0,2	0,6	4,9	2,8	2,7	3,8	22,5	8,4	8,1	0,5	0,2	2,8	1,1	5,5
95	1,6	1,0	2,9	0,2	1,0	0,6	2,8	8,48	0,3	0,0	1,3	5,5	5,4	4,8	3,3	2,4	15,7	10,6	17,3	1,8	0,2	9,4	1,3	3,5
96	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,6
97	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,00	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
total	1861,6	1548,2	5212,3	320,5	895,4	479,7	944,2	9168,90	1722,9	14,8	660,4	1578,6	4837,6	4027,7	2667,6	2087,3	6561,6	4402,4	4182,3	3042,9	320,5	2716,6	461,5	1822,5
Produção do ramo	2440,9	2285,9	6372,5	453,2	1489,2	808,3	1604,4	14293,65	3687,4	4027,2	1440,8	2561,2	7367,0	6170,4	4746,6	4023,7	17989,1	12969,6	7022,7	3807,9	453,2	5520,2	918,9	4464,7
VAB	579,4	737,7	1160,2	132,7	593,7	328,6	660,3	3387,07	1289,3	1773,4	780,4	982,6	2529,4	2142,7	2079,0	1936,4	11427,5	8567,2	2840,4	765,0	132,7	2803,6	457,4	2642,2
remuneraçoes	372,5	394,0	697,3	110,4	344,7	186,3	460,6	445,15	304,5	760,5	272,7	485,5	1675,5	1052,7	1432,5	1261,5	4241,9	4513,0	1749,9	501,6	110,4	1029,0	343,3	918,0

	56 Serv. restauração e similares	58 Serviços de edição	59 Serv prod filmes, vídeos e prog TV, grav som e ed mús.	60 Serviços de program. e radiodif.	61 Serviços de telecomunicações	62 Consult. e prog informát. e serv. relac.	63 Serv. de informação	64 Serv. financ., exc. seguros e fund. pensões	65 Serv seguros, resseg e f. pensões, exc. Seg soc. Obrig.	66 Serv. Auxil. de serv. Financ. e de seguros	6801+6802 Serviços imobil. excl. rendas imput. em habit. próp.	6803 Rendas imput. em habit. Próp.	69 Serviços jurídicos e contabil.	70 Serv. sedes soc.; serv. Consult. de gestão	71 Serv arquit. e de eng.; serv. de ensaios e de anál. Técn.	72 Serviços de investig. e desenv. Científ.	73 Serv. publicidade e estudos de mercado	74 Out serv consult., científ., técn. e simil.	75 Serv. Veterin.	77 Serviços de aluguer
01	233,0	0,0	0,2	2,7	0,0	0,1	0,1	0,0	0,0	0,0	0,8	0,0	0,1	0,5	2,0	0,0	1,8	2,8	0,4	0,1
02	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
03	81,4	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
05	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
061	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
062	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
07+08+09	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,9	0,0	0,0	0,0	1,0	0,3	0,1	0,0	0,0	0,0
10	1646,0	0,0	0,6	0,1	0,1	0,1	0,0	0,0	0,0	0,0	1,6	0,0	0,0	0,2	0,1	0,4	0,2	0,7	0,6	0,2
11	970,8	1,4	0,7	8,0	1,4	3,2	0,4	1,0	0,0	1,5	16,2	0,0	3,5	7,5	8,4	0,5	5,7	1,1	0,2	1,3
12	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
13	8,9	0,1	0,1	0,2	0,0	0,0	0,0	0,0	0,0	0,0	2,5	3,4	0,0	0,0	0,0	0,2	0,1	0,2	0,0	0,0
14	2,1	0,0	0,6	0,1	0,0	0,1	0,0	0,0	0,0	0,0	0,3	0,0	0,2	0,4	0,2	0,0	0,0	0,0	0,0	0,1
15	0,0	0,1	0,1	0,9	0,0	0,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,6	0,0	0,0	3,8	0,1	0,0	0,0
16	4,2	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	12,3	0,0	0,0	0,0	1,8	0,2	0,7	0,6	0,0	3,9
17	4,0	61,1	1,2	5,6	0,4	8,0	0,8	23,7	11,2	6,0	12,0	0,0	10,3	10,2	20,1	1,0	5,8	3,5	0,5	1,5
18	3,9	107,6	2,6	2,2	8,9	13,5	0,9	0,1	5,7	6,9	47,5	0,0	0,9	28,8	1,9	0,6	22,1	3,3	0,0	5,7
19	31,6	3,9	3,0	1,8	10,1	10,9	1,0	47,3	8,4	12,8	10,2	0,0	16,0	18,4	25,8	4,6	7,0	6,3	1,7	30,1
20	19,5	13,4	2,8	5,2	0,2	14,2	0,7	0,0	1,2	0,3	2,4	51,1	2,2	5,5	12,3	5,0	2,7	2,2	1,3	0,8
21	0,2	0,0	0,1	0,0	0,2	0,2	0,0	0,1	0,0	0,2	1,3	0,0	0,1	0,6	0,1	1,2	0,1	0,0	11,5	0,3
22	21,5	0,9	3,9	6,1	0,0	8,0	0,4	0,0	0,0	0,0	6,0	12,1	0,0	1,8	35,1	0,3	6,8	10,7	0,0	0,9
23	28,1	0,3	0,1	0,6	0,1	0,3	0,0	0,0	0,0	0,1	4,4	47,0	0,2	1,0	3,4	2,0	1,7	0,3	0,0	0,5
24	2,2	0,2	0,4	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,9	0,0	0,0	3,9	0,8	0,5	0,1	0,0	0,0
25	25,9	1,7	4,4	2,2	0,9	9,1	1,3	0,2	0,0	1,7	6,4	0,0	2,5	4,5	39,3	0,6	12,4	2,9	0,8	17,5
26	0,1	3,6	2,2	4,9	413,4	64,3	2,9	0,0	0,0	0,4	2,0	0,0	0,1	4,3	5,2	0,5	0,4	1,2	0,0	4,3
27	12,1	0,1	3,8	1,5	108,3	23,8	0,1	0,0	0,0	0,0	0,9	7,3	0,1	3,3	9,8	0,2	1,4	1,1	0,0	1,6
28	4,9	0,1	0,2	0,2	0,1	1,8	0,0	0,0	0,0	0,0	4,4	28,3	0,1	0,3	6,0	0,4	0,2	0,3	0,1	0,9
29	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,7
30	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
31	8,1	0,0	0,4	0,0	0,0	0,0	0,0	0,0	0,0	1,1	7,5	40,1	0,0	2,1	0,3	0,4	0,1	0,1	0,1	0,2
32	4,9	0,7	0,8	1,6	0,4	1,8	0,3	0,0	0,0	0,0	1,7	0,0	1,5	2,0	1,9	0,9	1,5	1,1	10,5	0,8
33	6,9	3,1	2,9	1,2	55,1	31,4	3,6	7,0	2,9	1,0	15,4	0,0	15,1	12,2	9,1	0,3	2,3	2,9	0,8	27,7
351	148,6	2,7	4,6	5,0	48,8	8,8	1,7	31,9	14,4	3,6	21,2	40,4	9,6	15,6	7,3	3,1	2,7	2,3	1,1	2,3
352	65,9	0,0	0,1	0,2	0,1	0,1	0,1	0,0	0,0	0,0	2,8	0,0	0,3	0,8	0,6	1,8	0,1	0,1	0,1	0,8
353	9,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
36	18,5	0,1	0,2	0,5	0,4	0,3	0,0	2,4	0,7	0,4	2,5	3,9	0,8	0,9	0,7	1,2	0,1	0,2	0,1	0,3
37+38+39	18,0	0,3	0,2	0,1	0,4	0,4	0,0	1,1	0,6	0,2	4,8	0,1	0,9	1,0	0,7	0,2	0,2	0,2	0,1	0,3
41	14,4	2,4	1,9	2,3	0,0	26,9	3,2	48,2	19,7	4,2	130,2	209,2	16,5	10,2	15,7	1,5	2,9	2,3	0,6	24,1
42	0,0	0,0	0,0	0,0	77,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,6	0,0	0,5	0,0	0,0	0,0	0,0
43	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
45	6,3	1,2	0,8	1,5	6,3	8,6	1,4	0,0	0,0	0,0	6,5	0,0	3,4	4,8	7,7	0,3	1,3	1,7	0,5	10,4
46	0,6	3,3	0,9	0,2	22,2	5,0	0,2	0,0	0,0	0,0	2,0	0,0	0,7	4,9	1,5	0,2	1,6	1,3	0,1	10,8
47	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
49	5,3	8,0	3,4	0,8	7,5	11,5	1,0	10,6	4,7	5,9	2,9	0,0	6,1	39,3	11,5	1,9	3,8	5,1	0,2	27,0
50	0,2	0,3	0,1	0,0	0,3	0,3	0,0	0,0	0,0	0,1	0,1	0,0	0,1	0,9	0,3	0,2	0,1	0,2	0,0	0,6
51	3,6	2,7	2,5	0,9	2,3	13,9	0,8	15,1	7,1	5,9	3,4	0,0	10,9	17,2	9,8	1,6	2,8	4,2	0,2	1,3
52	6,0	1,4	1,6	1,0	7,1	12,1	1,6	9,0	0,0	11,2	7,7	0,0	3,4	8,8	4,5	4,9	1,8	3,1	0,2	14,7
53	6,9	8,3	1,6	1,9	8,2	9,0	2,3	18,5	7,2	1,7	4,4	0,0	10,7	15,5	6,2	1,9	2,8	2,3	0,4	2,2
55	3,4	2,5	2,3	0,7	2,1	13,3	0,7	11,4	4,7	4,5	3,5	0,0	9,3	15,0	9,3	1,1	2,7	4,0	0,2	1,3
56	11,5	9,4	3,9	4,9	1,7	7,0	1,8	43,1	14,9	26,2	5,3	0,0	2,7	3,7	1,9	5,1	1,8	4,9	0,3	3,0
58	3,8	42,2	1,0	0,6	21,1	1,7	0,8	2,3	0,0	1,4	0,8	0,0	5,2	1,9	3,9	12,1	140,8	0,9	0,2	0,8
59	0,0	0,4	141,1	229,3	0,1	1,2	0,0	0,1	0,0	0,0	0,1	0,0	0,5	0,0	0,0	0,0	13,9	0,0	0,0	0,0
60	0,0	0,0	0,0	9,7	138,5	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	428,6	0,0	0,0	0,0
61	35,4	17,4	4,7	7,1	1115,4	47,9	11,9	144,8	69,9	15,5	21,4	1,3	97,6	70,6	27,9	3,9	10,3	20,1	2,4	7,2
62	15,4	9,9	8,6	4,3	70,2	400,6	9,6	383,2	0,0	27,2	15,1	0,0	42,0	45,3	29,4	16,8	8,5	8,5	0,8	7,1
63	3,9	8,4	3,2	3,9	20,4	50,4	49,8	19,1	0,0	0,2	4,4	0,0	14,1	7,2	1,4	1,0	5,4	3,6	0,3	2,1
64	70,0	15,4	5,7	8,1	46,7	32,8	4,7	2021,9	113,6	164,7	335,9	-528,2	31,7	732,0	43,0	3,4	15,5	13,6	1,2	46,3
65	4,8	2,0	1,7	0,9	5,6	6,0	1,3	17,8	493,7	131,8	8,4	14,2	7,1	7,0	8,4	0,3	1,4	2,4	0,5	13,1
66	0,5	0,5	0,6	0,6	3,5	0,6	0,1	286,4	834,2	15,9	0,6	0,0	1,9	2,6	0,9	0,1	0,3	0,3	0,0	1,7
6801+6802	24,0	16,1	28,1	10,8	58,3	51,3	6,1	253,5	92,3	21,6	159,7	24,0	54,5	14,8	8,8	5,7	4,4	12,5	2,8	7,3
6803	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
69	10,2	18,4	12,4	2,4	137,1	89,2	9,7	212,8	0,0	6,1	48,1	4,6	127,9	95,8	52,1	1,4	8,3	36,2	1,9	14,9
70	9,9	22,1	15,0	5,0	186,5	142,9	15,6	212,2	24,1	27,3	58,0	0,0	94,9	528,1	91,3	2,1	15,3	40,4	2,2	32,5
71	14,0	18,5	12,5	8,7	147,9	66,1	10,0	34,8	0,0	8,7	43,5	0,0	62,5	88,6	411,8	9,1	8,7	13,4	1,4	10,6
72	0,0	0,0	0,0	0,0	0,0	0,0	0,0	13,3	0,0	1,3	0,0	0,0	0,0	0,1	0,0	55,5	0,0	0,0	0,0	0,0
73	25,4	53,9	8,9	2,2	148,8	26,3	2,5	312,8	45,6	6,4	26,8	0,0	24,7	34,1	24,5	1,1	223,4	19,7	0,4	41,0
74	2,9	1,4	1,5	1,2	8,5	6,9	1,0	78,3	0,0	17,0	5,3	0,0	3,9	6,3	3,6	1,1	1,4	6,7	0,1	3,9
75	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,8	0,0
77	108,9	37,7	25,5	19,6	72,1	134,7	3,0	64,8	6,7	7,8	30,3	0,0	19,4	48,3	62,7	3,4	15,0	7,0	0,8	190,3
78	49,1	2,1	0,4	0,6	293,1	5,4	0,1	0,0	0,0	0,0	4,9	0,0	7,7	9,1	3,5	12,6	4,4	1,0	0,1	1,8
79	0,2	1,0	0,5	0,4	0,7	2,4	0,4	0,0	0,0	0,0	0,8	0,0	2,4	2,7	0,9	0,6	1,0	1,0	0,0	0,5
80	10,2	1,1	1,1	2,1	11,2	3,3	0,8	52,3	0,0	0,4	17,1	16,0	2,1	7,1	2,3	11,8	0,8	0,4	0,1	1,1
81	33,2	1,0	1,8	2,9	3,6	3,0	0,6	29,0	0,0	3,1	9,3	17,3	3,6	4,4	3,3	9,5	1,0	0,7	0,3	2,3
82	8,0	28,5	3,6	4,5	69,9	37,9	29,0	136,3	29,6	22,5	45,0	0,0	23,3	141,9	79,9	7,2	5,8	71,8	0,5	70,7
84	0,0	0,0	0,0	0,0	94,4	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
85	0,8	0,7	0,1	0,8	3,7	5,6	0,1	12,4	0,0	0,9	1,0	0,0	3,1	6,7	1,8	0,5	0,2	0,4	0,1	0,3
86	5,2	3,3	5,7	1,2	4,1	7,8	1,1	39,4	0,0	2,6	5,7	0,0	31,0	11,0	9,7	0,6	2,8	4,1	0,5	0,9
87	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
88	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
90	0,2	42,5	10,1	15,6	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,7	0,0	0,6	0,0	0,0	0,0
91	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,2	0,0	0,0	0,0	0,0
92	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
93	8,2	0,0	5,6	33,4	0,0	0,0	0,0	0,4	0,0	0,0	0,3	0,0	0,0	0,2	0,0	0,1	33,8	0,0	0,0	0,0
94	2,1	1,2	0,6	0,4	1,9	2,2	0,2	0,0	0,0	0,0	5,3	0,0	6,8	6,0	2,2	0,3	0,8	0,7	0,1	0,5
95	4,5	0,4	0,3	0,4	9,9	3,5	0,6	86,7	0,3	7,0	4,4	0,0	1,3	1,7	1,5	0,5	0,5	0,4	0,1	2,6
96	1,2	0,0	0,4	0,6	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,0	0,0
97	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
total	3891,3	587,1	356,1	442,4	3457,5	1437,9	186,5	4685,7	1813,5	585,6	1206,5	-6,0	797,5	2116,9	1141,1	207,0	1055,0	339,1	50,3	658,1
Produção do ramo	8810,0	948,6	542,3	782,6	6036,7	3019,6	354,6	10242,2	3719,7	1378,0	6961,4	12812,3	2362,2	3465,0	2164,1	720,0	1515,0	640,2	109,9	1478,2
VAB	4918,7	361,5	186,2	340,2	2579,2	1581,7	168,1	5556,5	1906,2	792,4	5755,0	12818,3	1564,7	1348,1	1023,0	513,0	460,0	301,1	59,6	820,2
remuneraçoes	2632,6	298,6	87,3	176,8	660,9	1245,0	134,8	3329,7	493,3	279,0	418,2	0,0	707,7	1412,2	685,0	221,2	267,1	194,0	37,3	174,0

	78 Serviços de emprego	79 Serv. ag. viagens, op. Turíst. e out. serv. rel.	80 Serv. segurança e investig.	81 Serv p/ edific. e Plant. e manut. jardins	82 Serv. Admin. e de apoio prest. às empresas	84 Serv. Admin. pública, defesa e seg. social obrig.	85 Serviços de educação	86 Serviços de saúde humana	87 Serv. apoio social c/ alojam.	88 Serv. apoio social s/ alojam.	90 Serviços criativos, artísticos e de espectác.	91 Serv. Bibliot., arquiv., museus e out. serv. Cult.	92 Serv. lotarias e outros jogos de aposta	93 Serv. desport., de diversão e recreat.	94 Serv. Prest. por organiz. Associat.	95 Serv. Rep. Comput. e de bens pessoais e dom.	96 Outros serviços pessoais	97 Serv. Fam. Empreg. de pessoal doméstico
01	0,0	0,1	0,0	30,1	2,5	22,9	2,3	1,9	38,8	17,5	0,1	0,4	0,2	0,6	0,0	0,0	27,6	0,0
02	0,0	0,0	0,0	0,4	0,0	5,5	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
03	0,0	0,0	0,0	0,0	0,0	2,0	0,2	0,1	1,2	0,6	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
05	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
061	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
062	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
07+08+09	0,0	0,0	0,0	1,7	0,0	7,0	1,1	0,2	0,0	0,0	0,0	0,0	0,0	0,8	0,0	0,0	0,0	0,0
10	0,1	0,0	0,0	0,0	2,6	27,6	8,7	7,1	322,5	134,5	0,1	0,0	0,3	0,3	0,1	0,0	0,0	0,0
11	0,6	1,6	0,8	1,5	5,5	0,9	3,9	12,9	5,3	3,7	0,6	0,1	2,6	2,6	1,0	0,5	1,6	0,0
12	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
13	0,0	0,0	0,0	0,3	1,4	0,2	3,9	25,5	6,7	3,0	0,1	0,0	0,1	0,2	0,0	0,5	1,6	0,0
14	0,3	0,0	2,7	0,3	0,3	4,9	2,7	3,2	7,4	3,0	2,7	2,5	0,1	33,8	0,3	0,1	0,2	0,0
15	0,0	0,0	0,1	0,0	0,6	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,1	4,4	0,0	1,7	0,0	0,0
16	0,0	0,0	0,0	0,2	6,6	0,1	1,7	0,3	0,0	1,0	0,0	0,1	0,4	1,2	0,0	0,3	2,2	0,0
17	0,5	1,0	1,4	1,1	16,5	21,1	61,9	19,6	2,7	1,5	0,4	0,2	0,2	1,1	9,3	2,1	1,5	0,0
18	0,6	67,3	1,0	0,4	23,4	16,7	26,0	32,5	2,0	2,4	0,6	0,3	1,9	7,9	16,3	0,5	6,5	0,0
19	2,9	14,8	7,5	20,3	28,3	210,4	51,9	82,0	99,6	63,3	3,4	4,4	0,3	23,8	19,2	4,4	11,7	0,0
20	0,2	0,4	1,2	36,7	4,7	27,4	48,0	504,1	10,5	4,6	3,8	0,1	0,9	7,8	11,4	1,5	108,0	0,0
21	0,2	0,1	0,0	0,1	0,4	13,5	2,2	1358,5	26,9	7,2	0,0	0,0	0,1	0,2	0,2	0,0	1,0	0,0
22	0,0	0,0	1,5	18,3	52,6	10,1	2,5	19,0	1,0	0,5	0,3	0,1	0,7	1,8	0,2	7,3	1,1	0,0
23	0,0	0,1	0,1	0,7	1,7	24,2	2,5	3,3	0,0	0,0	0,1	0,0	0,2	1,8	0,3	0,4	0,6	0,0
24	0,0	0,0	0,0	0,0	0,8	5,9	0,9	0,1	0,0	0,0	0,0	0,0	0,0	1,3	0,0	0,0	1,7	0,0
25	0,3	0,5	2,7	2,9	9,1	25,2	12,1	15,9	12,3	2,1	1,9	0,7	1,0	12,6	1,6	5,7	7,1	0,0
26	0,1	0,0	1,1	0,0	16,2	3,7	2,3	25,6	0,0	0,0	5,7	0,2	0,4	2,5	1,2	3,7	0,0	0,0
27	0,0	0,0	16,0	0,3	7,2	1,5	0,7	0,4	0,3	0,2	0,5	0,0	1,8	1,7	0,4	0,2	0,0	0,0
28	0,0	0,1	0,5	1,7	1,7	22,0	1,3	3,0	13,9	2,1	0,1	0,0	0,2	0,3	0,1	1,6	0,5	0,0
29	0,0	0,0	0,0	0,0	0,2	11,9	0,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0
30	0,0	0,0	0,0	0,0	0,0	0,6	1,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	4,8	0,0	0,0
31	0,0	0,1	0,0	0,0	1,0	1,2	1,5	0,9	0,8	0,3	0,0	0,5	0,1	0,1	2,9	0,0	0,2	0,0
32	0,2	0,8	0,4	1,1	1,7	19,3	33,9	193,7	13,5	4,2	0,9	0,1	1,0	26,0	9,3	0,3	6,2	0,0
33	1,0	7,0	2,9	3,9	17,8	14,6	21,0	76,8	2,4	2,0	1,3	1,4	2,7	8,3	3,2	0,9	5,4	0,0
351	1,1	2,5	1,2	1,7	20,8	289,3	96,3	134,5	31,6	13,9	1,6	11,0	3,9	35,6	55,0	1,2	41,4	0,0
352	0,1	0,1	0,1	0,2	1,4	0,0	4,8	5,1	6,0	2,2	0,4	0,1	1,2	5,5	1,2	0,0	5,2	0,0
353	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
36	0,1	0,5	0,1	0,4	0,8	79,2	27,8	36,6	14,4	5,5	0,2	6,7	0,3	13,0	8,7	0,1	3,7	0,0
37+38+39	0,1	0,4	0,1	0,5	0,9	245,5	9,7	13,7	5,1	2,0	0,1	5,3	0,4	9,0	3,4	0,1	3,2	0,0
41	0,7	3,2	2,2	4,1	13,3	285,5	94,5	81,0	1,9	8,7	2,4	6,4	3,0	17,6	31,2	0,7	2,4	0,0
42	0,0	0,0	0,0	0,0	0,0	226,7	0,0	0,1	0,0	0,0	0,0	0,0	0,0	7,5	0,0	0,0	0,0	0,0
43	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
45	0,6	2,3	1,7	3,1	7,6	28,4	6,4	14,8	31,9	3,1	1,5	2,4	2,3	8,3	3,9	0,5	3,6	0,0
46	0,6	19,7	0,1	0,3	7,2	15,4	13,8	5,1	0,2	0,1	1,2	0,1	1,4	3,2	0,5	0,3	0,7	0,0
47	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
49	2,6	1,9	1,5	2,5	12,0	50,3	29,7	15,0	0,2	3,5	1,6	0,3	2,7	6,8	22,9	3,0	3,4	0,0
50	0,1	1,6	0,0	0,1	0,3	2,1	0,5	0,2	0,0	0,0	0,0	0,1	0,1	0,1	0,1	0,1	0,1	0,0
51	2,0	90,1	0,8	1,4	7,9	78,2	16,6	22,8	0,2	1,8	1,9	0,2	0,3	3,4	4,6	0,4	1,4	0,0
52	4,6	2,1	1,3	0,8	8,3	584,7	8,2	9,9	0,6	0,5	1,1	0,6	1,3	6,4	8,1	0,2	4,1	0,0
53	0,7	3,0	1,5	2,4	12,3	73,8	23,1	13,7	3,5	1,5	2,0	0,5	1,5	5,1	40,5	0,6	2,6	0,0
55	1,9	2,0	0,8	1,3	7,6	10,0	9,7	17,4	0,3	0,3	2,0	0,1	0,3	3,5	2,4	0,4	9,7	0,0
56	1,6	3,5	1,7	1,9	1,5	230,7	129,8	139,5	76,7	26,6	6,2	2,7	1,1	14,0	16,1	0,6	6,7	0,0
58	0,4	1,0	0,7	0,6	4,2	9,6	29,9	7,4	0,4	0,4	1,0	0,3	1,7	2,6	2,8	0,2	6,5	0,0
59	0,0	0,0	0,0	0,0	0,1	5,4	16,6	0,1	0,0	0,4	3,0	0,0	0,0	0,0	0,3	0,0	0,0	0,0
60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
61	3,3	10,5	7,7	7,2	61,3	220,7	58,5	148,2	10,9	7,2	4,1	3,3	8,0	14,5	44,6	3,0	25,5	0,0
62	1,9	3,0	1,3	2,6	29,5	64,3	45,1	97,5	7,3	6,2	3,5	1,1	1,0	12,8	18,9	0,6	3,9	0,0
63	1,0	1,0	0,3	1,0	6,9	0,1	2,3	4,8	0,4	0,6	3,2	0,2	1,0	3,0	1,8	0,4	3,7	0,0
64	2,9	13,0	4,6	7,5	44,8	248,2	39,4	86,1	52,0	32,7	4,0	2,0	11,9	41,0	27,5	1,7	11,4	0,0
65	1,5	2,6	3,4	3,3	4,8	24,2	6,3	8,0	5,2	2,7	1,2	0,3	2,4	3,5	1,0	0,8	2,8	0,0
66	0,5	0,0	0,3	0,4	1,8	0,0	0,4	0,9	0,0	0,0	0,7	0,2	0,5	1,4	0,0	0,0	0,1	0,0
6801+6802	9,7	14,6	6,4	9,6	18,0	185,7	75,5	115,6	15,1	9,0	9,1	2,5	3,7	16,5	18,1	4,8	25,4	0,0
6803	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
69	3,5	5,9	2,7	8,2	56,6	71,3	57,3	138,3	2,9	9,9	6,4	3,3	2,0	23,0	21,5	1,1	11,1	0,0
70	3,3	10,0	3,1	10,4	72,7	51,2	51,3	311,5	4,7	6,7	7,8	4,3	2,2	35,7	88,1	1,3	14,9	0,0
71	2,5	11,2	2,5	9,1	59,2	48,7	32,8	112,0	3,0	3,2	9,5	2,1	1,4	21,3	28,3	1,0	10,2	0,0
72	0,0	0,0	0,0	0,0	0,0	7,5	0,3	0,0	0,0	0,0	0,0	0,0	0,0	0,2	0,3	0,0	0,0	0,0
73	1,6	29,2	2,9	5,9	28,5	74,7	26,6	77,8	3,9	4,0	2,5	5,7	17,2	29,1	35,1	3,2	18,1	0,0
74	2,0	1,0	0,5	0,5	4,6	79,2	17,5	64,4	0,3	2,8	4,5	2,1	0,5	5,2	7,3	0,1	2,8	0,0
75	0,0	0,0	0,0	0,0	0,0	1,3	0,0	0,0	0,0	0,0	0,0	0,9	0,0	0,0	0,0	0,0	0,0	0,0
77	3,5	5,1	10,6	10,5	21,5	41,7	24,1	84,8	6,9	7,3	10,5	2,2	6,5	27,6	28,1	1,8	19,5	0,0
78	60,6	0,0	0,7	0,2	132,5	0,0	0,6	3,6	1,5	0,6	0,0	0,0	0,3	0,7	0,2	0,0	0,2	0,0
79	0,8	34,4	0,3	0,5	4,4	8,1	0,9	1,5	0,1	0,1	0,8	0,0	0,0	9,5	0,8	0,1	0,7	0,0
80	0,2	0,6	18,3	0,7	6,5	109,9	36,7	56,8	5,8	8,4	1,6	3,4	2,6	11,7	3,7	0,1	0,9	0,0
81	1,2	1,2	0,6	41,0	6,1	121,5	46,6	76,5	40,0	13,9	3,1	7,1	1,3	40,3	13,0	0,2	6,0	0,0
82	2,9	26,0	5,2	9,9	540,3	396,4	102,5	185,5	6,6	11,3	19,0	9,7	21,0	34,0	50,4	0,6	13,2	0,0
84	0,0	0,0	0,0	0,0	0,0	36,2	1,4	0,0	0,0	0,2	0,0	0,8	0,0	1,0	0,0	0,0	0,0	0,0
85	1,4	0,3	0,3	0,4	1,7	58,9	112,7	3,2	0,1	5,0	0,2	0,1	0,1	0,4	0,5	0,1	0,3	0,0
86	0,7	0,9	0,5	1,3	6,1	116,6	37,4	639,1	12,0	10,6	5,5	0,6	0,1	6,6	6,1	0,2	5,3	0,0
87	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	8,4	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
88	0,0	0,0	0,0	0,0	0,0	2,0	3,1	0,0	0,0	1,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
90	0,0	2,3	0,0	0,1	1,0	26,6	15,2	0,1	0,2	0,1	53,5	0,0	0,1	0,1	93,9	0,0	0,2	0,0
91	0,0	0,0	0,0	0,0	0,0	36,0	6,0	0,2	0,0	0,1	0,0	1,2	0,0	0,0	0,0	0,0	0,0	0,0
92	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
93	0,0	0,0	0,0	0,0	6,8	24,7	7,2	0,1	0,0	0,8	10,9	2,7	0,0	96,8	69,1	0,0	0,0	0,0
94	0,3	1,7	0,3	0,4	1,1	0,3	1,8	3,6	0,2	0,1	0,1	0,2	0,6	1,0	29,1	0,1	0,6	0,0
95	0,1	0,6	0,5	0,9	2,3	25,2	12,8	17,0	0,5	1,8	0,8	0,9	0,7	2,2	11,3	6,3	1,0	0,0
96	0,0	0,0	0,0	0,0	0,0	6,8	1,0	7,8	0,0	0,5	11,2	2,3	0,0	41,3	13,0	0,0	19,3	0,0
97	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
total	129,3	403,0	126,8	274,5	1427,8	4803,4	1634,7	5148,5	929,0	471,9	222,9	107,3	121,6	762,9	890,5	72,3	476,6	0,0
Produção do ramo	1204,4	637,3	725,7	865,2	2958,0	16988,3	11088,1	12069,4	2067,3	1684,0	448,1	245,9	302,0	1274,8	1519,3	263,5	1760,3	1128,6
VAB	1075,1	234,3	598,9	590,7	1530,3	12184,9	9453,5	6920,8	1138,2	1212,2	225,2	138,7	180,4	511,9	628,8	191,2	1283,7	1128,6
remuneraçoes	999,0	177,1	552,5	507,8	791,5	9333,2	8112,2	5289,2	862,6	1104,9	83,0	113,4	83,6	512,4	712,1	79,9	279,8	1128,6

ANNEX 3– LIST OF PUBLICATIONS DURING THE RESEARCH RELATED TO THE OFFSHORE ENERGY SECTOR

Pego, A. (2015). *Clusters, análise e fundamentos. Uma abordagem teórica***.** *X CONGRESSO DA GEOGRAFIA PORTUGUESA*. Valores da Geografia. Lisboa: Universidade Nova de Lisboa

Pego, A. (2016). The importance of Mix Methodology for Studying Offshore Energy sector.*International Journal of Humanities and Social Science Invention*, 5 (11), pp. 06-08ISSN (Online): 2319 - 7722, ISSN (Print): 2319 - 7714

PEGO, A., MARQUES, M., SALVADOR, R., SOARES G., MONTEIRO, A. (2016).*The potential offshore energy cluster in Portugal. Progress in renewable energy offshore. Guedes Soares (Ed).* London: Taylor & Francis., pp 867- 873. ISBN 0 978-1-1-138-03000-8

PEGO, A. (2016). *Os sistemas e tecnologias de informação e os clusters. Uma abordagem ao cluster de energia offshore em Portugal*. Ibero American Conference, Lisbon, 10-11 December, pp. 310-314.. ISBN: 978-989-8533-59-3.

PEGO, A. (2018).*The pentagonal problem and the offshore energy sector in Portugal. Why does it matter?* Entrepreneurship along the Industry Life Cycle: The changing role of Entrepreneurial Activities and Knowledge Competencies. Edited by S. Cubico, G. Favretto, J. Leitão, and U. Cantner. Springer Book, 313-327.

PEGO, A., & BERNARDO, M. D. R. M. (2019). *The Role of Urban Living Labs in Entrepreneurship, Energy, and Governance of Smart Cities. In L. Carvalho, & P. Isaías (Eds.),* Handbook of Research on Entrepreneurship and Marketing for Global Reach in the Digital Economy (pp. 203-221). Hershey, PA: IGI Global.

For further questions related with my thesis:

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