

# Postgraduate Studies in Biosystems Engineering to acquire a Doctor degree in Spain

E. Ayuga<sup>(1)</sup>, C. González<sup>(1)</sup>, M.A. Grande<sup>(1)</sup>, J.M. Fuentes<sup>(2)</sup>, A. Ramírez<sup>(3)</sup>, F. Ayuga<sup>(2)</sup>

<sup>(1)</sup>Escuela Técnica Superior de Ingenieros de Montes. Universidad Politécnica de Madrid. Ciudad Universitaria s/n. 28040 – Madrid. [esperanza.ayuga@upm.es](mailto:esperanza.ayuga@upm.es)

<sup>(2)</sup> Escuela Técnica Superior de Ingenieros Agrónomos. Universidad Politécnica de Madrid. Ciudad Universitaria s/n. 28040 – Madrid.

<sup>(3)</sup> Escuela Universitaria de Ingeniería Técnica Industrial. Universidad Politécnica de Madrid. Ronda de Valencia 3. 28012 – Madrid.

## Abstract

The Doctoral Programs in Biosystems Engineering (BE) developed under the Bologna Declaration exhibit considerable diversity not only across different countries in Europe, but also across universities within the same country and across faculties and other Institutions within the same university. At this moment, Spain, Portugal, Flanders, Bulgaria, Hungary and Poland are introducing the new structured third cycle studies according with the Bologna Process. In this paper a compared review of different programs of the postgraduate studies of BE in Spain and other European countries has been made. This study also include an analysis of programs (oriented to the European Higher Education Area) of the postgraduate studies in the context of Biosystems Engineering, offered by the different universities in Spain.

Keywords: Doctoral Studies, Spain Legislation, EHEA, Biosystems Engineering.

## 1. Introduction

Biosystems Engineering (BE) is a science based in engineering and the physical sciences that reflects the wide range and the interdisciplinary nature for understanding or modelling of the performance of biological systems for sustainable developments in land use and the environment, agriculture and amenity, bio-production processes and the food chain (University Studies of Agricultural Engineering in Europe (USAEE) & Education and Research in Biosystems Engineering in Europe (ERABEE) Thematic Networks).

The Doctoral Programs developed under the Bologna Declaration exhibit considerable diversity not only across different countries in Europe, but also across universities within the same country and across faculties and other Institutions within the same university.

The fulfilment of the objectives set out in the University curriculum will be measured in European credits (ECTS). There are some countries were the ECTS credits have not been applied to the doctorate studies (European University Association, 2005; Crosier et al. 2007).

Currently, in Spain 2478 different doctoral programs are offered in 69 different Universities. The 9% of these programs are related to the topic of Biosystems Engineering. About 58% of the titles on the topic are not verified by the Spanish National Agency for Quality Assessment and Accreditation (ANECA) and 42% are verified and adapted to the European Higher Education Area (EHEA). In this paper the overall situation of the third cycle university degrees in Spain and other European countries is analyzed. The future trends in these studies in the context of Biosystems Engineering are also presented.

## 2. Structure of the Postgraduate Studies in Europe and in Spain in particular

The Postgraduate studies exhibit considerable diversity across the different European countries, but also across universities within the same country or faculties within the same university. Despite that the ECTS System was established in 1988 under the Erasmus Program, there are some countries, like Germany or the Czech Republic, where the ECTS credits have not been applied yet to the doctorate studies. Other European countries such as Spain, Portugal, Flanders, Bulgaria, Hungary and Poland are still adapting their third cycle studies to the Bologna process, at present (Crosier et al. 2007).

Most European countries have passed national regulations on postgraduate studies, completed with some particular rules of each specific university (e.g. Bulgaria, the Czech Republic, Denmark, Estonia, Greece, Hungary, Italy, Latvia, Lithuania, Norway, Poland, Portugal, Romania, Turkey, Spain, Sweden and the United Kingdom). Nevertheless, in some other cases, rules are provided only by the Universities such as in Flanders, Finland or Germany or only by the national government as in France, Ireland or Slovakia (Briassoulis et al, 2009).

In Spain, the successive governments, from year 2003, have enacted legislation regarding EHEA (the first, about European Diploma Supplement, Royal Decree -RD- 1044/2003, relating to European Credit Transfer System, RD 1125/2003), the last passed in 2007 (RD 1393/2007), establishes the organization of official University education according to the European Commission guidelines. ANECA was set up as a public Agency on 19 July 2002 ([www.aneca.es](http://www.aneca.es)). The ultimate goal of the Agency is to contribute to the quality improvement of the higher education system through the assessment, certification and accreditation of university degrees, programs, teaching staff and institutions.

Specific 'Doctoral Schools' are not yet very common in Europe, although some countries such as France, Hungary, Italy, Belgium or the Netherlands offer this kind of organization. Most of the European countries still offer structured postgraduate studies under the organization of Schools or Faculties where 1st and 2nd cycle degrees are also attended. Structured programs usually include advanced courses divided into compulsory and optional ones. Compulsory courses are mainly general topics regarding research principles or management, while optional courses usually refer to specific research topics. Nevertheless, the main part of the training and research period is devoted to research activities and the completion of the Ph.D. Thesis.

In the majority of the countries the duration of the period to complete the doctoral thesis varies between 3 and 4 years. Most European countries require a 2nd cycle or a traditional long cycle degree for admission to the postgraduate studies. In a few cases this pre-requisite can be waived by an entry examination (Flanders), acceptance based on honours (e.g. Ireland or the United Kingdom), approval of a board (Turkey) or completion of 300 ECTS of 1st and 2nd cycle studies (Spain). Additional prerequisites such as some minimum grades, letters of recommendation, interviews, language skills, entrance examination, preliminary research activity or publications are sometimes also expected. The ways to recruit candidates are basically based on advertisement, personal contacts and/or selection of the best students on the 2nd cycle studies.

In many countries scholarships are available offered by the State on a competitive basis, research projects or companies. This is a mode of entry to the third cycle studies, associated with part-time employment as a PhD student on a regular salary, such as in Denmark, Finland, France, the Netherlands, Norway, Portugal. In other countries, both students with scholarships and students at their own expenses are common.

The particular structure of the third cycle studies on Biosystems or Agricultural Engineering in Spain and other European countries is summarized in Table 1, according to Ayuga et al (2009):

Table 1.- Structure of third cycle studies in Spain and other European countries

Country	Third cycle years	Compulsory Courses (ECTS)	Optional Courses (ECTS)	Training Activities	Publications
Spain	2-5	Yes	Yes (60-120 considering compulsory and optional)	Research activities	Not required
Flanders (Belgium)	4	Attend one seminar	NO	-Deliver two seminars -Teaching activities	At least one paper and active participation in an international conference
Bulgaria	3-4	Structured program Individual Training -Free Ph.D. Studies (<20)	Yes (< 24)		At least 75 % of the work should be published before defending the thesis
Denmark	3	Yes (30)		210-840 hours of teaching	
Finland	3-5	Yes (>15)	Yes (>45)		Article based thesis. Typically 4 articles
France	3	Yes (20-30 Hours per year)			1 scientific paper 2-3 international conference papers
Germany	3-6	No	No		1 peer-reviewed paper
Greece	3-5	Yes (Depending on the candidate)			Part of the thesis published or accepted for publication in a journal or conference
Ireland	3	No	No	Normally one year of teaching and educational training	Research based on papers or a written thesis
Italy	>3	Yes (No)	Yes (No)		Not required
Portugal	3	Yes (<30)			Research based on papers or a written thesis
Slovakia	3-5	Yes (60)		Research activities	Publications are assigned with ECTS accordingly with a table. A minimum is required (120 ECTS)
Sweden	> 4	Yes (45)	Yes (15-45)	Research activities	Thesis based on 3 to 5 scientific papers or a monograph
United Kingdom	3 full time Pro-rate part time	No	Yes	Seminars	Strongly encouraged to deliver a paper to an international conference

All over Europe the end of third cycle studies consists in the public defence of the thesis work. This is an original and relevant research work. The thesis research work is supervised by one or more senior academic staff or researchers and there is a board of examination

appointed by the university. Details on the structure of the PhD thesis and the final exam to achieve the doctorate degree are shown in the Table 2.

Table 2.- Structure of thesis work and its defence in Spain and other European countries

Country	Kind of thesis	Supervisor	Number of members of the board	Foreign members	Opponents	Supervisor in the board	Preliminary defence
Spain	Monograph. Article based possible	Researcher	5 (At least 3 must be external)	Possible	No	No	Yes (3 reviewers)
Flanders (Belgium)	Monograph	(Professors, lecturers or doctorates with 3 years experience) Two assessors	6-7	Recommended	No	Yes	Yes
Denmark	Monograph	2-3 supervisors, being the main the leader of the project	Evaluation committee		Yes		
Finland	Article based or monograph		4-5	Usually	Yes	No	Yes
France	Monograph	Full professor	5-8		No	No	No
Germany	Monograph		5		No	No	No
Greece	Monograph	Full or associate or assistant professor	7 (3 of them full professors of the university)	Possible	No	No	No
Ireland	Article based or monograph	One or several supervisors and advisors	3-4	Usually	No	No	No
Italy	Monograph	Professor or full researcher	3 (2 of them external)	Possible	No	No	No
Portugal	Article based or monograph	Generally a professor	7-9 (Half external)	At least one	No	No	No
Slovakia	Monograph	Approved by the scientific board of the faculty	5	Possible	No		3 reviewers
Sweden	Article based or monograph	At least two, the main supervisor being professor or associate professor	3 or 5 (1 external)	Usually	Yes	No	No
United Kingdom	Monograph	Two supervisors, the main one with at least two successful THIRD cycle research degrees completed	2		No	No	No

### **3. Topics in BE postgraduate studies in Spain and comparison with other European countries**

Biosystems Engineering is a science-based engineering discipline that integrates engineering science and design with applied biological, environmental and agricultural sciences, broadening in this way the area of application of the Engineering sciences not strictly to Agricultural sciences, but to the Biological sciences in general, including the Agricultural sciences. In accordance, the programs of studies in Biosystems Engineering represent an evolution and an extension of the traditional Agricultural Engineering programs of studies (Briassoulis et al., 2008).

The rapid developments in the field of the Bio-engineering science and technology in the sector of the agriculture lead to necessary changes in the research lines and in the contents of the postgraduate studies, introducing new topics about the new emerging disciplines. These emerging disciplines are usually based on biological sciences that are not limited to or do not correspond to the agricultural sciences. The transition from the traditional Agricultural Engineering studies to the new Biosystems Engineering studies is already at a very advanced stage in USA and Canada and in other countries. However, very few third cycle programs of studies in Biosystems Engineering have been initiated in Europe. Despite this lack of experience about third cycle studies in "Biosystems Engineering" many disciplines related to the Biosystems Engineering have been incorporated in the programs of studies of the European Universities (e.g. third cycle of traditional Agricultural Engineering programs of studies). Nevertheless, some European countries have found some difficulties to establish doctorate studies in Biosystems Engineering because of the lack of professors (experts) in these emerging fields.

For the last years, the Postgraduate studies in the Agro-forestry area show some changes in the research topics, which reflect the evolution from the traditional Agricultural Engineering discipline towards the emerging Biosystems Engineering one.

At present in Spain doctoral studies ruled by the previous legislation, (RD 778/1998) and new degrees ruled by RD 1393/2007 coexist in Spain. The offer is quite extensive and Ph.D. with the same name, but ruled by different regulations can be found. At present there are 189 third cycle studies programs that contains topics related to the Biosystems Engineering discipline (MEC, 2010, [www.mec.es](http://www.mec.es)).

The only experience in Spain of a Doctorate Degree in Agricultural Engineering that has evolved to a Postgraduate studies in Biosystems Engineering is the recently verified Research Master in Biosystem Engineering (BE) of the University of Leon ([http://www.unileon.es/ficheros/acceso/master/triptico\\_master\\_inv\\_biosistemas.pdf](http://www.unileon.es/ficheros/acceso/master/triptico_master_inv_biosistemas.pdf)).

The new research topics that are different to those ones of the previous doctorate program in Agricultural Engineering are: 'Quality, security and environment management', 'Local varieties of crops in eco-compatible agrarian systems', 'Numerical methods in engineering', 'Experimental tests on new materials, recycling of materials, quality of the electric supply', 'Agri-food industries technology', 'Geomatic techniques applied to Biosystem Engineering', 'New technologies applied to the treatment of organic waste products', 'Biotechnology applied to the agriculture', 'Minimization of the environmental impact', 'Genetic resources and genetic technologies' and 'Wood diseases, fungus and mycorrhizes'.

Of the remaining 188 doctorate programs with some topics in Biosystems Engineering, most of them (88) contain courses about 'Environmental engineering technology'. This particular topic is a part of the BE curricula in Bulgaria, the Czech Republic, Denmark, Finland, France, Greece, Hungary, Ireland, Lithuania, Portugal and Sweden.

'Food engineering' is a part of the curricula in 31 Spanish Ph.D. programs. It is also a part of the BE curricula in other European countries, for example in Flanders and Ireland.

Twenty one Ph.D. programs in Spain have courses in 'Agricultural production'. This topic is a part of the BE curricula in Flanders, Finland, Greece, Ireland, Lithuania, Italy, Netherlands and Sweden.

Topics related to 'Biotechnology' are present in 14 Ph.D. programs in Spain. This course is a part of the BE studies in Denmark, Finland, France, Hungary and Ireland.

Topics related to 'Renewable energy' are present in 10 Spanish Ph.D. programs, as they are in Bulgaria, Czech Republic, Denmark, Finland, France, Greece, Hungary, Italy, Lithuania, Norway, Portugal and Romania.

Courses related to 'Forestry production' are present in 5 Ph.D. programs in Spain. They are also present in Bulgaria, Hungary and Italy.

In Spain, 18 Ph.D. programs have courses in 'Management of the rural territory'. This particular topic is not included in other European Doctorate studies. Only in Sweden there are some third degree courses in 'Integration of urban and rural activities', 'rural development' and 'reuse of existing rural structures'.

In Portugal, 'Waste management activities' courses play a major role in the third cycle degrees.

In Turkey and the United Kingdom there is no a Ph.D. degree in Biosystems Engineering.

#### **4. Analysis of current postgraduate studies in BE and adapted to the EHEA in Spain**

At present, 2478 different doctorate programs are offered in 69 different Universities in Spain. The 9% of these degrees are related to the BE topic. About 58% of the degrees in this area are not verified by ANECA and 42% are verified and adapted to the EHEA.

The 94.5% of the 189 Spanish Ph.D. degrees in BE are taught at public universities and the remaining 5.5% are taught at private ones. Table 3 shows the universities in Spain where more than five different Ph.D. degrees are offered.

Table 3 – Spanish Universities with more than five Ph D titles

<b>University</b>	<b>Ph.D.</b>	<b>Type</b>
Universidad Politécnica de Cataluña	15	Public
Universidad de Córdoba	10	Public
Universidad Politécnica de Madrid	10	Public
Universidad del País Vasco	9	Public
Universidad de Santiago de Compostela	8	Public
Universidad Politécnica de Cartagena	8	Public
Universidad Politécnica de Valencia	8	Public
Universitat de València (Estudi General)	8	Public
Universidad de Cantabria	7	Public
Universidad de Vigo	6	Public

In Spain, Ph.D. studies in Biosystems Engineering are most frequently offered by Polytechnic Universities (Fig. 1)

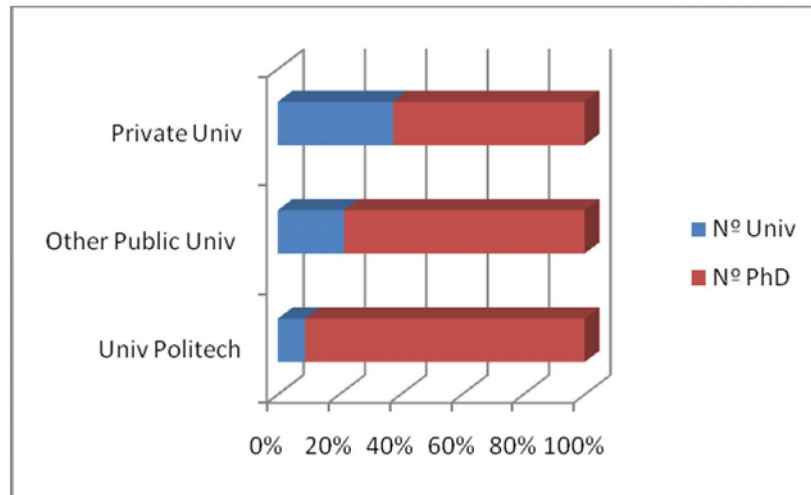


Fig. 1: Percentage of Ph.D. degrees according to the type of university

There are many differences in the number of students and academic staff in the different Spanish universities. The number of professors by Ph.D. degree ranges from 7 to 142 and the number of students who holds a grant ranges between 1 and 15.

There is not many information about the quality of the Ph.D. programs in BE. At present, 50 degrees are quality recognized by ANECA (26.5%) and 6 more are in the process to be recognized.

The University of Extremadura (in three of its Ph.D. degrees) and the University of Burgos (just in one) have some kind of internal systems to assess the quality of the studies and they also conduct a students' survey program to assess the courses.

The Polytechnic University of Valencia (in two of its Ph.D. degrees) and the University of Castilla la Mancha (in one) have some kind of internal quality assessment systems, but they do not conduct surveys to the students. Other three universities (Universidad de Alicante, Universidad de Barcelona and Universidad Politécnica de Cataluña) conduct surveys to the students, but do not have an internal system to assess the quality of the Ph.D. programs.

The international projection of the BE Ph.D. studies of the Spanish Universities is quite low:

- Only 10 of the Spanish Ph.D. programs in BE are collaborative degrees with a non-Spanish university (Table 4).

Table 4 – Number of collaborative Ph.D. degrees with no Spanish Universities

University	PhD	Num. Other University
Politécnica de Madrid	1	6
Pablo de Olavide	2	4
Politécnica de Cartagena	2	2
de Cantabria	1	Unknown
de Córdoba	1	Unknown
de Extremadura	2	Unknown
de Valladolid	1	Unknown

The international projection of the BE Ph.D. studies of the Spanish Universities by visiting professors from other non-Spanish universities:

- Only the University Pablo de Olavide and the University of Extremadura provide six degrees where non-Spanish speakers are mentioned (a maximum of 3 per Ph D).

Information about the courses in Internet is offered in more than one language in 102 Ph.D. degrees in BE, corresponding to 25 different universities in Spain. Of them, those that include information in more than one language but have no information about how many are 44%. Only two universities offer information about the Ph.D. studies in four different languages: Universidad Politécnica de Cataluña and Universidad Rey Juan Carlos (Fig. 2).

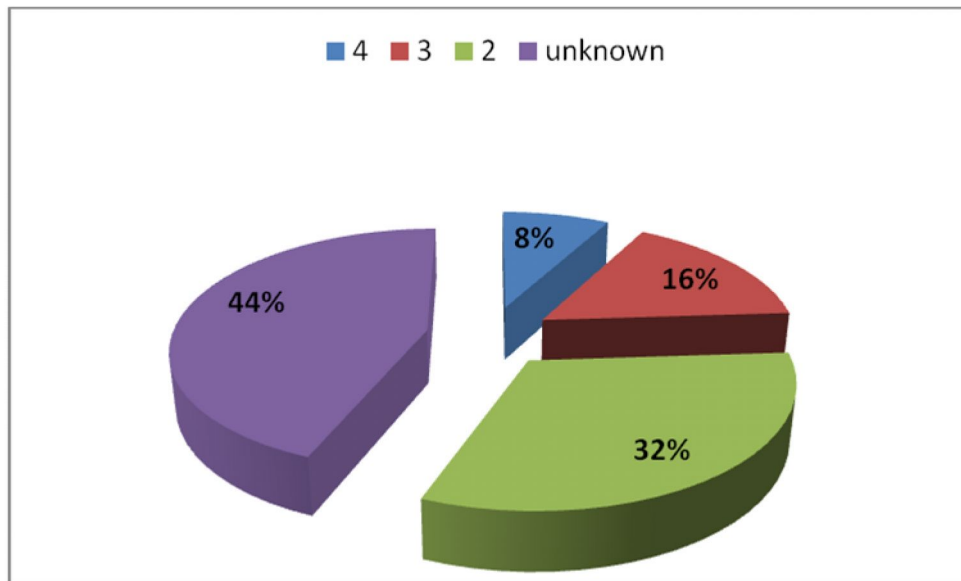


Fig. 2: Universities with information in several languages

Only 26 doctorate programs in BE offer information about the chance to achieve an European Ph.D. degree.

## 5. Conclusions

The main difficulties to prepare a common international doctorate are due to the low language skills of professors and students, the limited financial support and the differences and rigidity of the internal regulations. Some universities, like the Czech University of Life Sciences of Prague, trying to overcome the difficulty of the language, are developing third cycle Studies programs on Agricultural Engineering in English language.

Some European countries have already initiated third cycle studies programs in Agricultural or BE adapted to the recommendations of the EHEA. Italy, Greece and Spain have developed European studies on Agricultural Engineering oriented to the research. In Scandinavia (Denmark, Sweden and Norway) a network for cooperation between Nordic forestry, veterinary and agricultural universities (NOVA, [www.nova-university.org](http://www.nova-university.org)) exists. The task of this network is to initiate, administrate and promote cooperation between the member institutions in MSc and PhD education in the field of Biosystems Engineering.

In Spain, there will be a tendency to increase the offer in Ph.D. degrees for the next coming years, although the degrees ruled by the RD 778/1998 will be destined to disappear.



A major challenge for the next future is to increase the quality of the Ph.D. programs. The implementation of systems to assess the quality of the courses is increasingly important for the effective adaptation of the doctorate programs to the EHEA principles.

Progresses must be made for the internationalization of the doctorate studies in Spain. At present there are not many collaborative programs with other European Universities.

## References

Ayuga, F.; Briassoulis, D.; Aguado, P.; Farkas, I.; Griepentrog, H. & Lorencowicz, E. (2009) Third cycle studies on the new emerging discipline "Biosystems Engineering" in Europe. An ERABEE thematic network survey. In: Proceedings of the International Conference of Education Research and Innovation ICERI-2009. Madrid (Spain), 16-18 Nov 2009.

Briassoulis, D.; Panagakis, P.; Nikopoulos, E. & Ayuga, F. (2008). The emerging evolution from Agricultural Engineering to Biosystems Engineering studies in Europe. In: Proceedings of the International Technology, Education and Development Conference INTED-2008. Valencia (Spain), March, 2008.

Briassoulis, D.; Panagakis, P. & Nikopoulos, E (Editors). (2009). Third Cycle University studies in Europe : Current schemes and possible structured programs of studies in Agricultural Engineering and in the Emerging discipline of Biosystems Engineering. In: Proceedings of the third ERABEE Workshop. Uppsala (Sweden), 4-5 May 2009.

Crosier, D.; Purser, L. & Smidt, H. (2007). Trends V: Universities shaping the European Higher Education Area. An EUA Report. Brussels (Belgium), European University Association. Available on-line at:  
[http://www.eua.be/fileadmin/user\\_upload/files/Publications/Final\\_Trends\\_Report\\_May\\_10.pdf](http://www.eua.be/fileadmin/user_upload/files/Publications/Final_Trends_Report_May_10.pdf)

Education and Research in Biosystems Engineering in Europe (ERABEE) Thematic Network,  
<http://www.erabee.aua.gr/>

European University Association (2005) Doctoral Programs for the European Knowledge Society. Final Report on the EUA Doctoral Programs Project (2004-2005). Brussels (Belgium), European University Association. Available on-line at:  
[http://www.eua.be/eua/jsp/en/upload/Doctoral\\_Programs\\_Project\\_Report.1129285328581.pdf](http://www.eua.be/eua/jsp/en/upload/Doctoral_Programs_Project_Report.1129285328581.pdf)

Royal Decree 185/1998, de 23 de enero, por el que se regula el tercer ciclo de estudios universitarios y la obtención y expedición del título de Doctor y otros estudios posgraduados. BOE num. 104, May 1, 1998.

Royal Decree 1044/2003, de 1 de agosto, por el que se establece el procedimiento para la expedición por las universidades del Suplemento Europeo al Título. BOE num. 218, Sep. 11, 2003.

Royal Decree 1125/2003, de 5 de septiembre, por el que se establece el sistema europeo de créditos y el sistema de calificaciones en las titulaciones universitarias de carácter oficial y validez en todo el territorio nacional. BOE num. 224, Sep. 18, 2003.

Royal Decree 1393/2007, de 29 de octubre, por el que se establece la ordenación de las enseñanzas universitarias oficiales. BOE num. 260, Oct 30, 2007.

University Studies of Agricultural Engineering in Europe (USAEE) Thematic Network,  
<http://www.hostforce.co.uk/nondrup/usaee/usaee-tn.htm>