

**Theory and Practice of European  
Co-operative Education and Training  
for the  
Support of Energy Transition  
2019**



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‘Europe needs qualified personnel to master energy transition. This is the very idea of the EC SET Plan Education and Training Roadmap to which eseia experts have contributed two final thematic reports, one by Michael Narodoslowsky on bioenergy. Participation in this European policy initiative led to a new EU funded undertaking entitled BioEnergyTrain (BET), an ambitious project carried by business, higher education, and research from 2015-2019. Thanks to the joint effort of eseia members, both Master degree programmes with 19 new courses, and the collaborative learning formats will live on beyond BET. This present publication is about lessons learnt from BET soon to be published in the Springer Open Access Journal Energy, Sustainability, and Society. Thank you to the authors for their collective effort.’

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In the European Union the transition towards a sustainable future is an important topic. Research and education are crucial for the design and implementation of the required social and technical changes. Following the SET-Plan, Education and Training Roadmap initiated by the EU, the BioenergyTrain (BET) Consortium led by eseia, consisting of universities and industry, explored, tested and implemented new and alternative teaching formats needed for training of new generations of bioenergy and biorefinery professionals. University - industry collaboration is essential in order to transfer state of the art knowledge quickly and effectively from university to industry and knowledge requirements from industry to university. This collaboration is also important to enable young future professionals to achieve working experience. Thanks to financial support from the EU, the BET project was able to provide the platform for experimenting new collaboration formats between (higher) education and industry. In the course of the BET project, the University of Twente and Graz University of Technology in collaboration with other consortium partners developed and implemented two new biobased master programs linking renewable materials and energy technologies with biobased economy. These T-shaped education programmes enable engineering professionals to design and implement the new systems and settings needed for the progress towards more sustainable resource and energy utilization within the EU's economy.

The BET project led to several lessons learned. Most importantly, the project showed the added value of co-operation between university and industry in the education and training of next generations of energy and biorefinery professionals. Learning in an industrial environment turned out to be highly motivating for students and a stimulus for their creativity. BET also showed the importance of exploring a more structural collaboration between university and industry concerning education. Summer Schools and Student Camps are still considered as additional to standard curricula, but as structural part of university programmes they could add to practical and problem-oriented learning.

We are happy to present this journal full of inspiring examples of innovative educational collaborative formats practiced in BET. We would like to express our thanks and gratitude to the European Commission, to all who supported the BET project and to the BET consortium for exploring new ways of innovative and inspiring learning for future generations of bioenergy and biorefinery engineering professionals in order to motivate them to make the transition towards a sustainable future happen.

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### Abstract

#### Background

European visions such as the European Commission's Strategic Energy Technology (SET) Plan and the SET Plan Roadmap Education and Training encourages Higher Education Institutions (HEI) and business to establish adequate co-operative education and training approaches in the face of the challenges posed by the energy transition necessary to achieve European Union's climate goals. The development of an integrated co-operative education, training and learning systems is a fundamental strategy to foster co-operation between academic institutions and business.

#### Methods

The research was carried out by means of a literature study and a database search on existing co-operative education formats. This was complemented by an analysis of actual case study reports regarding examples drawn from the BioEnergyTrain (BET) project commissioned under the European Union's Horizon 2020 programme.

#### Results

Co-operation for educational purposes between HEI and business exists on the curricular, course and internship level. Considering the total number of studies on a curricular level in Europe only very few co-operative education programmes exist. On the curricular level most of the appropriate formats are dual studies with Bachelors' programmes, fewer are dual studies with Master's' programmes. Co-operation formats on the course level don't follow institutionalised rules and are case-specifically applied. The studies presented in this journal dealing with practical examples emphasize the high potential for improving student's skills and insight into business that such co-operative formats offer to universities and business partners. Co-operation on an internship level has a long tradition of exposing students to the business environment they will later work in. Internships, however, do not provide high intensity co-operation between business and HEIs. Therefore, it is outside the focus of this paper's attention.

### Conclusions

There is not much available data on co-operative study programmes. This may be due to the fact that co-operation in education and training between academic institutions and business plays only a minor role in the overall education system.

Apart from dual study programmes, co-operative education and training formats usually are not defined unambiguously because the number of co-operative education programmes directed towards meeting the challenges posed by the energy transition is low. Although both the SET Plan Roadmap Education and Training developed within the SET Plan process and the Action Agenda for European Universities developed by the European University Association (EUA) identify co-operation between HEIs and business as crucial to meet these challenges [Borrell-Damián and Narodoslowsky, Case study 1]: much remains to be done in this respect. There is a need for institutions all over Europe which are able and willing to provide a platform for such co-operation and co-ordinate the development of co-operative learning formats, especially on the course level, across sectoral boundaries.

### Keywords

Co-operative education and training, Dual learning, Energy turn, Energy transition.

### Background

The development of integrated co-operative education, training and learning is a fundamental necessity to foster co-operation between academic institutions and business. This is particularly important in fields bound to experience major technological, economic and social transitions and that at the same time are crucial for human development. One of these fields is the energy sector. Co-operative education and training must be promoted for the good of the Energy transition.

The European Union has defined very general prevailing conditions for the development of energy technologies and relevant education in Europe [1] which is supplemented by the more detailed Strategic Energy Technology (SET) plan [2] as part of which the Roadmap on Education and Training [3] has been determined.

### EU 2020 strategy

From the perspective of European policy the 'Europe 2020 strategy' emphasizes smart, sustainable and inclusive growth. The European Commission defined five targets for a top-down stimulation for the fulfilment of basic requirements [4]:

- Employment: 75% of people aged 20–64 to be in work.
- Research and development (R&D): 3% of the EU's GDP to be invested in R&D
- Climate change and energy: Greenhouse gas emissions 20% lower than 1990 levels, 20% of energy coming from renewables, 20% increase in energy efficiency.
- Education: Rates of early school leavers below 10%. At least 40% of people aged 30–34 having completed higher education.
- Poverty and social exclusion: At least 20 million fewer people in – or at risk of – poverty/social exclusion.

This strategy includes measures to halt climate change. Because education is not regulated on the EU level, national education and training approaches need to be comprehensively linked to energy transition which is necessary to meet the Union's climate goals. The targets related to climate change come within reach most unevenly across the EU's 28 member states [5].

In 2002, the Council of the European Union started the EU cooperation in education and training (ET 2020) in order to provide the strategic framework for co-operation in education and training up to 2020. ET 2020 is defined as a fundamental pillar to meet '...the many socio-economic, demographic, environmental and technological challenges facing Europe and its citizens today and in the years ahead...' [6].

### **Strategic Energy Technology (SET-Plan) and Roadmap Education and Training**

Facing the challenge of developing a low-carbon, secure and affordable energy technology system, the European Union (EU) promotes a fundamental energy transition. For this purpose, it devised the SET-Plan which promotes an increased use of renewables ('...accelerate the development and deployment of low-carbon technologies...') and the development of an innovative cost-competitive and efficient energy system [7].

In order to create a framework to support the 'availability and mobilisation of appropriately skilled human resources', the SET Roadmap Education and Training was established [8]. This was a consequence of the recognition that '...one of the key elements in supporting energy technology innovation at EU level is the availability and mobilisation of appropriately skilled human resources' [9]. In the Education and Training Roadmap, the European Union mentions '...that one of the key elements in supporting energy technology innovation at EU level is the availability and mobilisation of appropriately skilled human resources...' and 'challenges for the education and training institutions and their legal frameworks will be to ensure a workforce flow of researchers, engineers and technicians who are able to generate new knowledge and to meet the requirements of evolving technologies and labour markets. In parallel, training for managers and decision-makers in the field is needed to design and implement appropriate frameworks for the development and deployment of new energy solutions.' [10]

In their analysis of this special issue, Narodoslowsky and Borrell-Damián [Case study 1] highlight the need for intensified promotion of collaborative education formats on the basis of this Roadmap on Education and Training [11] and the Action Agenda for European Universities (AAEU, [12]). The latter document provides a strategy for European universities to cope with the challenges of the energy transition. The analysis mentioned above reveals that the EU and the European universities consider co-operation in and shared responsibility for education of the future workforce as critically important to be able to meet the education and training challenges posed by energy transition.

The authors identify a strong tradition of co-operative education in vocational training in many European countries. However, they miss an equally strong endeavour in the field of educational co-operation between business and universities. They find that neither academia nor business has taken common responsibility for the education of future experts and that both have not deployed the substantial resources necessary for true common educational efforts.

In order to develop adequate co-operation formats Narodoslowsky and Borell-Damián list the requirements to breach the walls between business and universities. The changes necessary for the energy transition with its varying requirements have to be put into effect in order to train the future workforce in an appropriate education environment including efficient high-quality training networks. Thus co-operative learning formats can '...become major drivers for innovation in the education of future workforce...' as they fulfil '...the need to educate students in the complexities

and interconnected nature of the energy systems in relation to our societies, at local as well as global levels ...'. The development of a future-oriented European education programme aligned to the challenges posed by the energy transition is an essential part of the EU 2020 plan in order to keep Europe in the role of a technology leader while at the same time contributing to the effort to curb climate change.

On a global scale, the United Nations (UN) defined within its set of Sustainable Development Goals sub goal 4 – quality education - which asks for education including issues like sustainable development and sustainable lifestyles [13]. The UN misses to directly discuss the development of environmentally clean energy technologies as one important aspect to reach this goal [14]. There is an obvious lack of integration of all 17 Sustainable Development Goals into an educational context.

UN and EU may set the frame. The effective implementation of educational goals has to be realised on a national and regional level because the ultimate competence lies there. An integrated development of co-operative education and training formats has to be executed by national institutions and businesses. Certainly co-operation is not only needed across sectors but also across national borders as the challenges of the energy transition are international and so are the challenges of technology development and implementation.

Finally, the motivation for developing co-operative education formats needs to be adapted to the motivation driving their implementation.

### **Motivation for the development of co-operative education formats**

Quality of students' learning increases in a work-study-environment with strong relationship to effective mentors [15]. This also increases a student's understanding of her/his future work environment. Students benefit from workplace supervisors who create an authentic environment confronting them with real-world problems strengthening their self-confidence by exchanging ideas at an eye-level. Thus academic supervisors add to the student's theoretical knowledge. The implementation of these changes into educational practice forces educational institutions as well as entrepreneurs to intensify their collaborations [16].

Healy et al. measured benefits academic institutions were able to derive from university-business co-operation resulting in co-creation and co-production of knowledge [17]. Possible benefits for students are:

- Increased employability
- Acquisition of soft/technological skills and up-to-date knowledge
- Better understanding of the business world
- Mutual learning with employees
- Joint courses on modern technologies
- Participation of lecturers with business experience
- Acting in an integrated system as a “motor of innovation” for society
- Extended social networks

Students, university and business can benefit mutually from a well-co-ordinated co-operative education format. Optimal co-operation results in an exchange of skills between all beneficiaries, enhanced chances for students on the job market, increased research portfolios for universities and better qualified employees as well as in innovation advantages for business, to name only the most important impacts. There is a wide variety of possible formats, ranging from dual study programmes on the curricular level to various co-operative course formats, internships and thesis programmes funded by business. However, design and intensity of the co-operation are dependent on the desired results.

### Definition of co-operative Education and Training

In general terms, Ricks suggested that co-operative education should foster an integrated educational and work experience, self-directed learning, reflective practice and transformative learning [18].

The quality of co-operation between education institutions and business/industry can differ vastly. A co-operation format can be defined as less satisfactory when it just includes defining topics for Bachelor's or Master's theses and providing internships in industry. Better results can be reached when the co-operative aspect includes lecturers from industry and joint courses for students and industrial employees. Results can further improve when business co-operates in the development of curricula and theoretical learning phases and HEIs are intertwined with practical phases in a business or industrial environment and when business and HEIs take joint responsibility for the learning outcome of students. Conventional co-operative education and learning formats are defined in different ways. A common feature of these definitions is an integrated learning approach which links theoretical education with practical work experience as described by the platform Co-operative education and work-integrated learning Canada [19], or as the World Association for Cooperative Education, an NGO linking HEIs, employers and public authorities, defines [20]:

'Cooperative & Work-Integrated Education (CWIE) includes: cooperative education (all disciplines); clinical rotations; community research; internships (all disciplines); international work (co-op) exchanges; learning-integrated work; undergraduate & graduate research; service-learning; and practica, and other forms of learning where education is integrated with work experience.'

An US legal document describes purpose and definition of co-operative education as follow [21]:

#### (a) Purpose

It is the purpose of this part to award grants to institutions of higher education or consortia of such institutions to encourage such institutions to develop and make available to their students work experience that will aid such students in future careers and will enable such students to support themselves financially while in school.

#### (b) Definition

In this part the term 'cooperative education' means the provision of alternating or parallel periods of academic study and public or private employment to give students work experiences related to their academic or occupational objectives and an opportunity to earn the funds necessary for continuing and completing their education.

These definitions of co-operative learning emphasise duality between an academic study area and a vocational training area. Additionally, agreements and co-operation concerning adjustments of education contents and education goals must be reached. The mentioned definitions clearly build on traditional vocational training structures.

### Roots of vocational training

Vocational training has a far more co-operative tradition than tertiary education. In vocational training there was no clear differentiation between theoretical and practical education. Apprentices were employed by a company and learned their trade from experienced workers in practical training. This is still practiced in many European countries, e.g. Austria and Germany. Today this practical training is usually complemented with formal vocational training at special vocational schools.

In some professions requiring tertiary education this traditional principle of dual education is still standard practice: Medical doctors go through clinical rotation, and in many countries (e.g. Austria) lawyers are required to undergo an internship at a court before they are granted the right to practice their profession.

### Co-operation via placements and internships

Concerning placements and internships which are less regulated, co-operation between academia and business is widely practised. The World Association for Cooperative & Work-Integrated Education (WACE), a professional association dedicated to promoting co-operative and work-integrated education, lists a total of 913 institutions they co-operated with in 52 countries worldwide [22].

This type of co-operation allows students to experience the work environment they will later work in. However, the quality of this experience differs widely, depending on the company that offers the internship, the position the student takes and the ability of the student to integrate into this environment. Usually there is no educational structure at the site of the placement, and academic supervision accompanying these internships is rare.

A particular type of internships involves placements where students write reports or theses which are required academic output of their curricula. In these cases, co-operation between business and academia is closer: business usually defines the problems students have to address in these reports and theses. Assessment of the quality of these products usually remains with the academic teachers. The usability of the results evaluated by the business side may or may not become a factor in this academic assessment. This type of placements usually involves a certain amount of academic supervision and co-operation between the academic and business supervisors. This co-operation is not only beneficial to education but also enriches research as business and industrial problems are jointly researched by academia and business experts.

Although internships and placements are most valuable for student's experience and research co-operation, they lack comprehensive integration into the educational structure of academic curricula. Responsibility for as well as planning of educational aspects of internships and placements are not often shared between academia and business; usually business takes responsibility for the student's work for the company while academia evaluates the quality of output according to their own standards only.

### Co-operative learning formats on the curricular level (Dual Studies)

Based on the tradition of co-operative education in vocational training, there is a type of curriculum that combines theoretical education and practical training, usually performed in a company. Examples for these curricular-level co-operative learning formats are particularly described in North America and Europe. Dual study models in tertiary education emerged in Germany in the 1970s [23]. Awareness of these models had some ups and downs over time

[24]. This led to a lack of a clear or consistent definition of dual tertiary education approaches [25]. However, terms like work-integrated learning (internships, service-learning, clinical placements); sandwich education (interspersed education in Great Britain and Canada) or learning factories [26] exemplify the development towards a similar goal but with heterogeneous designs.

In Europe, dual programmes in the course of tertiary education are seen as possible drivers for employability [27]. In the German-speaking part of Europe this type of co-operative education and training approach is more clearly defined than in the English-speaking part where definitions are less clear which allows a more flexible application of specific education programmes and thus more adaptability in designing specific learning formats.

In Austria, the first dual tertiary education programme was developed at the University of Applied Sciences FH Joanneum. The goal was to find an alternative to traditional education programmes to solve ever more complex demands of the industrial sector [28]. 'The integration of work place experience has become an important element of diversification of higher education' [29]. The Austrian dual study programmes have since grown to curricula at six Universities of Applied Sciences (Fachhochschulen) with over 250 business partners [30].

Organisational set-up for co-operative education formats on the curricular level differs considerably. Haas differentiates them by three criteria [31]:

- Role of business
- Type of rotation
- Salary and legal issues

### **Role of business**

Companies interact differently with universities that provide dual education curricula. An intensive level of interaction can usually be recognised within the German dual learning concepts in the course of which companies select and send students to university or comparable tertiary education institutions thus playing a major role in the process. In the USA and Canada, companies offer internships, usually for a period of about 4 months. Students select and apply for these internships independently. Therefore, the role of business is restricted to provide these internships. An intermediate level of interaction can be found in France and Austria where companies choose available first-year students who are then employed. Here the students select the curriculum and are not sent to the institutions by the companies.

Business partners take over other responsibilities within dual education curricula as well:

- Defining topics for courses and student projects
- Providing experts as lecturers
- Holding regular courses with business partners
- Defining course set-up with academic partners
- Providing infrastructure for courses and projects

### **Type of rotation**

The schedule for rotation between theoretical education at HEIs and practical training in industrial or business environments differs between countries. In the USA, Canada, Germany (DHBW Duale Hochschule Baden-Württemberg, 'Berufsakademie') and Austria (University of Applied Sciences – FH Joanneum) rotation usually takes place after 3 to 6 months. In Germany, with its 'Duale Studiengänge', a variety of rotation systems is to be found additionally. In Spain

and Italy, students spend 2 to 3 days per week in the HEI. The French ‘Formation en Apprentissage’ knows various rhythms – e. g. 2.5 days in a business environment and 2.5 days in a training centre (or alternatively 2 days of business and 3 days of training) [32].

### Salary and legal issues

Ideally, dual curricular students receive payment similar to remuneration for apprenticeship. Another possibility is to hire the student as part time employee for the duration of the programme and to postpone payment until the successful passing of the curriculum.

In a global context, the application of dual curricular formats is increasing. According to a recent study, the basic ideas behind the dual study system were exported from Germany to countries like Brazil, France, Qatar, Mexico and USA as it was described by Graf et al. [33].

Dual studies usually answer to a specific skills profile defined by the business sector. They offer a particularly intense form of co-operation between business and HEIs. However, they are restricted to a relatively small number of curricula and institutions. In Germany, 7.2% or 1,432 of a total number of 19,822 study programmes are dual study programmes [34]. Based on an extensive literature search, European co-operative dual study master’s curricula were listed (Table 1) and complemented with additional information and a performance evaluation for each study. In Europe, there are 73 master’s study programmes based on dual education which amounts to 0.2% of a total of 34,283 masters’ programmes in the year 2018. 38 studies or 52% of the master’s studies based on dual education have a business or management background, 9 studies or 12% a technical one, 7 studies or 10% one connected with health service, and 26% have various other backgrounds<sup>1</sup>.

Table 1: Existing dual studies with master’s programmes in Europe [35]

Study	Academia	Language	Country	Location	Co-operative study (incl. placement)	Extra occupational (parallel to employment)	Distance learning	Full-time	Part-time	Degree
Advanced Nursing Practice	Rotterdam University of Applied Sciences	Dutch	NL	Rotterdam	x					M.Sc.
Automotive Mechatronics Management	FH Upper Austria	English	AT	Wels	x					M.Sc.
Brand and Luxury Goods Marketing	accadis Hochschule Bad Homburg	English	DE	Bad Homburg	x	x		x	x	M.Sc.
Business Administration	AKAD University – AKAD Hochschule Stuttgart	German	DE	Stuttgart	x	x	x			M.Sc.

1 These are computer science, law, sports, communication, systems sciences, architecture/design, religious science, archaeology, social studies, space technology, natural sciences and civic education.

## Part I Meta study

Study	Academia	Language	Country	Location	Co-operative study (incl. placement)	Extra occupational (parallel to employment)	Distance learning	Full-time	Part-time	Degree
Business Administration	Nuremberg Institute of Technology Georg Simon Ohm	German	DE	Nuremberg	x			x		M.Sc.
Business Administration	SABI University	English	FR	Paris	x		x			M.Sc.
Business and Organisation	Hochschule für Wirtschaft, Technik und Kultur (HWTk)	English, German	DE	Baden-Baden, Berlin	x		x	x		M.Sc.
Business Development Management	Europäische Fachhochschule (EUFH)	German	DE	Aachen, Brühl, Neuss	x	x				M.Sc.
Business Management	Provdavis Hochschule Frankfurt am Main	English, German	DE	Frankfurt a.M.	x	x				M.Sc.
Communication and Information Studies: Discourse and Argumentation Studies	University of Amsterdam	English	NL	Amsterdam	x					M.Sc.
Computational Design and Fabrication Technologies in Architecture	Middle East Technical University (METU)	English	NL, TR	Delft, Ankara	x					M.Sc.
Controlling	IUBH University of Applied Sciences	German	DE	Düsseldorf, Munich	x					M.Sc.
Design for Interaction	Middle East Technical University (METU)	English	NL, TR	Delft, Ankara	x					M.Sc.
Digital Business Management	CGI Deutschland Ltd. & Co. KG	German	DE	Düsseldorf	x	x				M.Sc.
Dutch Law	University of Groningen	Dutch	NL	Groningen	x			x	x	M.Sc.
Education and Communication in Mathematics and Natural Sciences	University of Groningen	Dutch	NL	Groningen	x			x	x	M.Sc.
Elektrotechnik	Hochschule Stralsund	German	DE	Stralsund	x			x	x	M.Sc.
Engineering and Production Management	FH JOANNEUM	English, German	AT	Graz	x					M.Sc.
Entrepreneurship und Innovation (MBA)	AKAD University – AKAD Hochschule Stuttgart	German	DE	Stuttgart	x	x	x		x	M.Sc.

## Part I Meta study

Study	Academia	Language	Country	Location	Co-operative study (incl. placement)	Extra occupational (parallel to employment)	Distance learning	Full-time	Part-time	Degree
Evangelische Theologie (protestant theology)	Evangelische Hochschule Tabor	German	DE	Marburg	x			x		M.Sc.
Leadership and organisation	University of Applied Sciences Osnabrück	German	DE	Lingen	x					M.Sc.
General Management - Dual	IUBH University of Applied Sciences	German	DE	Düsseldorf, Munich	x					M.Sc.
General Management – dual	Berlin School of Economics and Law	German	DE	Berlin	x	x				M.Sc.
General Management (MBA)	AKAD University – AKAD Hochschule Stuttgart	German	DE	Stuttgart	x	x	x		x	M.Sc.
German-Turkish Social Sciences	Middle East Technical University (METU)	English	TR, DE	Ankara, Berlin	x					M.Sc.
Global Management and Communication	AKAD University – AKAD Hochschule Stuttgart	German	DE	Stuttgart	x	x	x		x	M.Sc.
Global Marketing Management	accadis Hochschule Bad Homburg	English	DE	Bad Homburg	x	x		x	x	M.Sc.
Global Sports Management	accadis Hochschule Bad Homburg	English	DE	Bad Homburg	x	x		x	x	M.Sc.
Heritage Studies: Preservation and Presentation of the Moving Image	University of Amsterdam	English	NL	Amsterdam	x					M.Sc.
HR-Management und Talentmanagement (MBA)	AKAD University – AKAD Hochschule Stuttgart	German	DE	Stuttgart	x	x	x		x	M.Sc.
Human Resource Management	IUBH University of Applied Sciences	German	DE	Düsseldorf, Munich	x					M.Sc.
Infection Biology (AMIBA)	Medizinische Hochschule Hannover	English	DE, AR	Hanover, Córdoba				x		M.Sc.
Informatik (informatics)	Hochschule Stralsund	German	DE	Stralsund	x			x	x	M.Sc.
Informatik dual (informatics dual)	University of Applied Sciences Darmstadt	German	DE	Darmstadt	x					M.Sc.
International Football Management	accadis Hochschule Bad Homburg	English	DE	Bad Homburg	x	x		x		M.Sc.
International Health Care Management	accadis Hochschule Bad Homburg	English	DE	Bad Homburg	x	x		x	x	M.Sc.

## Part I Meta study

Study	Academia	Language	Country	Location	Co-operative study (incl. placement)	Extra occupational (parallel to employment)	Distance learning	Full-time	Part-time	Degree
International Management	accadis Hochschule Bad Homburg	English	DE	Bad Homburg	x	x		x	x	M.Sc.
International Retail Management	ALDI SÜD Dienstleistungs-GmbH & Co. oHG - Unternehmensgruppe ALDI SÜD	English, German	DE	Reutlingen	x	x				M.Sc.
Internationale Betriebswirtschaftslehre (international business administration)	University of Applied Sciences Darmstadt	German	DE	Darmstadt	x	x				M.Sc.
IT-Management	AKAD University – AKAD Hochschule Stuttgart	German	DE	Stuttgart	x	x	x		x	M.Sc.
Luft- und Raumfahrttechnik (Aerospace engineering)	Fachhochschule Aachen	German	DE	Aachen	x			x		M.Sc.
Maatschappijleer (Teaching Master, Civic Education)	University of Groningen	Dutch	NL	Groningen	x			x	x	M.Sc.
Management	AKAD University – AKAD Hochschule Stuttgart	German	DE	Stuttgart	x	x	x		x	M.Sc.
Management von kleinen und mittleren Unternehmen (KMU) (small and medium-sized enterprises (SMEs))	Hochschule Stralsund	German	DE	Stralsund	x			x	x	M.Sc.
Marketing and Sales	IUBH University of Applied Sciences	German	DE	Düsseldorf, Munich	x					M.Sc.
Maschinenbau (mechanical engineering)	Hochschule Stralsund	German	DE	Stralsund	x			x	x	M.Sc.
Maschinenbau Mechatronik (machine construction mechatronics)	University of Applied Sciences TH Mittelhessen	German	DE	Friedberg	x			x		M.Sc.
MBA Service Management (120 ECTS)	ISS International Business School of Service Management	English	DE	Hamburg	x	x				M.Sc.
Medizintechnische Systeme (medical technology systems)	Hochschule Stralsund	German	DE	Stralsund	x			x	x	M.Sc.
Notarial Law	University of Groningen	Dutch	NL	Groningen	x			x	x	M.Sc.

## Part I Meta study

Study	Academia	Language	Country	Location	Co-operative study (incl. placement)	Extra occupational (parallel to employment)	Distance learning	Full-time	Part-time	Degree
Petroleum Engineering	TU Clausthal	English	DE	Clausthal-Zellerfeld	x			x		M.Sc.
Pharmacy Practice	King's College London	English	UK	London	x					M.Sc.
Physician Assistant (algemeen)	Rotterdam University of Applied Sciences	Dutch	NL	Rotterdam	x					M.Sc.
Physician Assistant (Klinisch Verloskundige)	Rotterdam University of Applied Sciences	Dutch	NL	Rotterdam	x					M.Sc.
Project Management	IUBH University of Applied Sciences	German	DE	Düsseldorf, Munich	x					M.Sc.
Prozessmanagement (process management)	University of Applied Sciences TH Mittelhessen	English, German	DE	Wetzlar	x					M.Sc.
Public Administration	SABI University	English	FR	Paris	x		x			M.Sc.
Sport science and management (Sportbeleid en sportmanagement)	Utrecht University	Dutch	NL	Utrecht	x					M.Sc.
Sprint	CGI Deutschland Ltd. & Co. KG	English, German	DE	Düsseldorf	x					M.Sc.
Steuerberatung (tax consultancy)	Nuremberg Institute of Technology Georg Simon Ohm	German	DE	Nuremberg	x			x		M.Sc.
Strategic Leadership	Donau-Universität Krems	English	AT	Krems	x				x	M.Sc.
Strategic Supply Chain Management	accadis Hochschule Bad Homburg	English	DE	Bad Homburg	x	x		x		M.Sc.
Systemisches Management und Nachhaltigkeit (systemic management and sustainability)	AKAD University – AKAD Hochschule Stuttgart	German	DE	Stuttgart	x	x	x		x	M.Sc.
Systems Engineering	University of Applied Sciences TH Mittelhessen	German	DE	Wetzlar	x					M.Sc.
Technischer Vertrieb (technical sales)	University of Applied Sciences TH Mittelhessen	German	DE	Wetzlar	x					M.Sc.
Technisches Management (technical management)	AKAD University – AKAD Hochschule Stuttgart	German	DE	Stuttgart	x	x	x		x	M.Sc.

Study	Academia	Language	Country	Location	Co-operative study (incl. placement)	Extra occupational (parallel to employment)	Distance learning	Full-time	Part-time	Degree
Technologieanalyse, engineering und management (technology analysis, engineering and management)	University of Applied Sciences Osnabrück	German	DE	Lingen	x	x				M.Sc.
Technology Based Business Development	Aarhus University	English	DK	Herning	x					M.Sc.
Wertschöpfungsmanagement im Maschinenbau (value-added management in mechanical engineering)	University of Applied Sciences and Arts	German	DE	Hanover	x					M.Sc.
Wirtschaftsinformatik (Business informatics)	Hochschule Stralsund	German	DE	Stralsund	x			x	x	M.Sc.
Wirtschaftsinformatik (Business informatics)	Hochschule für Telekommunikation Leipzig	German	DE	Leipzig	x					M.Sc.
Wirtschaftsingenieurwesen (industrial engineering)	Hochschule Stralsund	German	DE	Stralsund	x			x	x	M.Sc.
Wirtschaftsingenieurwesen (industrial engineering)	AKAD University – AKAD Hochschule Stuttgart	German	DE	Stuttgart	x	x	x		x	M.Sc.

Regarding the content of the dual studies in Europe, dealing with the energy transition huge deficiencies can be identified. Unquestionably, many dual study programmes exist already but their focus usually is not on low carbon energy systems.

### Conventional co-operative learning formats on the course level

Compared to the numbers regarding dual studies mentioned above, the selection of academic curricula is huge. 103,246 bachelor's degree studies and 72,207 master's degree studies are available world-wide [36]. A recent study by the European University Association (EUA) mapped activities of European universities in the field of energy [37]. The EUA mapping gives an overview of education programmes compatible with the SET-Plan. Most of the selected master's programmes in priority areas of the SET-Plan are related to energy (61.5% of 447 programmes).

In order to push European universities towards intensifying activities concerning energy issues the EUA developed a Roadmap for European Universities in Energy [38]. This roadmap includes 13 actions clustered around research and education, collaboration and effect. In this respect, collaboration includes actions to foster university networks and co-operation between universities and organisations in different sectors [39]. One of its particular goals is a stronger mobilisation of university and business co-operation. If co-operation between HEIs and business really shall contribute to establishing the highly qualified workforce necessary to reach the ambitious goal of a carbon-free energy system,

it must not be restricted to dual study curricula. It must in fact become the new standard and part of each and every curriculum educating future engineers and energy experts in various fields. It must also become the basis for re-training and qualifying the current workforce to meet the challenges posed by the energy transition as described in the SET plan.

Available data on co-operative learning formats on the course level is poor and anecdotal. This is due to the facts that there are many different approaches to co-operation in education and training between academic institutions and business and that it plays only a minor role in the particular national education systems. There is even less information on co-operative education programmes with a focus on energy, not to mention energy transition.

The most prevalent and traditional form of co-operation between HEIs and business on the course level is the participation of experts from business as guest lecturers in courses. In some cases, business experts may even be invited to conduct the courses entirely. Such co-operative learning formats expose students to business positions as well as to approaches and methods to solve problems used in business. This input by business experts certainly complements teaching by academic lecturers and may expand student's horizon. It may also help students to throw their acquired knowledge into perspective by revealing how to use these skills in practice.

Even more intensive co-operative learning formats are seminars and design courses in which business define specific real-world problems and business experts help students to approach and solve these problems and give feedback on the applicability of the proposed solutions. In these seminars and courses business experts are directly involved in course planning and implementation as well. Such learning formats provide students with practical insight into how to use their knowledge and skills. These seminars and design courses, moreover, provide students with access to supervision and feedback by academic as well as business instructors.

An ever increasing number of HEIs offer lectures held by business experts as well as seminars and design courses with participation of business instructors. Although they provide considerable advantages for both students and academic teachers and form an important link between business and academia, they do not provide exposure of students to business working environment, they contradict the general approach that tertiary education is exclusively planned, provided and evaluated by HEIs and that there is only indirect added value for business partners, mainly by generating a more qualified work force that benefits not only business involved in the co-operation but also the competitors not involved.

### **Innovative co-operative learning formats on the course level**

As the arguments above indicate, there is ample room for improvement, in particular for co-operative learning formats on the course level. This publication provides insight into some new approaches to such formats, based on case studies carried out in the course of the BioEnergyTrain (BET) project commissioned by the European Union under the Horizon 2020 programme. BET is put into effect by a consortium of HEIs, research centres, professional associations and industrial stakeholders. Its goal is to develop two new pilot master's curricula in fields specifically identified by the European Union's SET Plan Roadmap for Education and Training (SRMET) as critical to implementing the SET plan, namely the master's programmes Biorefinery Engineering at the Graz University of Technology in Austria and Bioresource Value Chain Management at the University of Twente in the Netherlands. The consortium is headed by the European Sustainable Energy Innovation Alliance (eseia), a cross-sectoral association. According to the guidelines of SRMET, the project is also tasked with the development and application of innovative co-operative learning formats.

### Student Camps



*Student Camp on Biorefineries and Biobased Industrial Products, 25 - 28 February 2019 in Linz, AT/ Credits: Wood KPLUS*

Arentsen, Kienberger and Bauer [Case study 2] (from the viewpoint of academic teachers) and Ortner and Foxhall [Case study 3] (from the viewpoint of business partners) describe a co-operative learning format known as 'student camp'. The general idea of this format is to assemble an interdisciplinary and international group of students and academic teachers at the site of a business partner. Academic teachers and business partners mutually select the problems to be discussed by the students, which are organised in interdisciplinary groups. These problems should be of strategic importance and highly relevant to the further development of the business partner.

The student camps have a duration of one to two weeks. In the beginning, the business partner should introduce the company and define the problems. He should also appoint a camp leader and company experts who should provide the student groups with advice and data.

Student camps are designed as student centred learning formats. The students are responsible for dealing with the specific problems, and academic teachers and company experts are prepared to be of assistance. Regular reports of the groups to the assembly of student camp participants allow exchanging of information. At the end of the student camp the students should report their findings to company staff and academic teachers. Evaluation is done jointly by academic and business supervisors.

Feedback from students, academia and business is mainly positive. Students are highly motivated and can apply their knowledge to strategic real-world problems, thus gaining confidence in their skills. They experience interdisciplinary and international co-operation in a team, dealing with a specific and demanding task, as well as exposure to a business environment. Business partners derive profit from out-of-the-box thinking of students and unconventional approaches to problems which are relevant to further company development. A particularly important aspect is that students also represent customers of the future, providing company managers with an insight into possible future preferences of their clients.

### Pilot Plant Research Labs

Arentsen, Kienberger and Bauer [Case study 2] report on experiences with this format, in course of which a student group was allowed to operate pilot plant installations at the site of a business partner. The research plan for this operation was prepared in co-operation between academic teachers and business experts.

This format provides students with hands-on experience in operating industrial plants. They are confronted with the challenges and difficulties of real-world technological development.

The benefit for students is obvious. Academic teachers have the possibility to gain access to research infrastructure that is not available within HEIs. Business partners come to know possible future employees and are able to evaluate their skills in practice.

### Open Summer Schools

The third co-operative learning format described by Arentsen et al. [Case study 2] is known as 'open summer school'. These summer schools bring together interdisciplinary international student and academic teacher groups with business experts and address a specific topic. Although this format is closest to conventional co-operative course formats with teacher-centred instruction and supervised student exercises, it features some innovative aspects. Prominent among them is the fact that students are invited to bring their own tasks to the meeting. They are encouraged to take advantage of the interdisciplinary set-up of supervisors and of the access to business experts to get assistance in solving their specific problems.

Arentsen et al. [Case study 2] say that the innovative value of these three co-operative formats results from:

- linking industry to education in a new way
- gaining an extended and deeper involvement with immediate industrial issues including problems and state-of-the-art knowledge and technology
- fostering student-centred learning
- performing a more interactive, reflective and group-centred learning

### Distance learning methods and co-operative design courses

Distance education is no recent phenomenon but with the digital revolution instant information and knowledge sharing increased significantly. Social media and online-learning like Massive Open Online Courses (MOOCs) for an unlimited participation of people, Small Private Online Courses (SPOCs) for privates and Corporate Open Online Course (COOCs) for companies, contributed to sharing and spreading teaching content online. Joan-Marc Joval [Case study 5] reports on such a professional online learning platform. Professional digital education services and the passive role of learners are discussed. Co-operative design courses represent a chance for a co-creation of knowledge, and teacher-learner boundaries become less rigid when students are allowed to co-determine the design of a course. Moreover, online courses allow business partners not only to contribute to education on an equal footing with other actors, they also provide interesting tools for re-training and qualifying the existing work force, a point particularly highlighted by SRMET as crucial for implementing the SET plan and a successful energy transition.

The article Structural Aspects of Co-operative Learning Formats states that experiences with co-operative learning formats are mainly positive. SRMET and the Action Agenda for European Universities AAEU attach great importance to the improvement of co-operation between business and HEIs. Krozer [Case study 6] emphasizes the importance of co-operative learning formats for the regional utilization of bio-resources and the energy transition. Actually, the progress in developing and implementing these learning formats is rather slow. Structural hindrances and structural pre-conditions for wider implementation will have to be discussed.

Oswald [Case study 4] points out a particular barrier for co-operation between academic education and business acquainted with vocational training: while academic education relies on workload-based evaluation, exemplified by the ECTS system in Europe, vocational training uses skill-based evaluation in the EQVET system. He argues for a comprehensive and flexible education system combining academic and vocational training elements based on the needs of the market.

While such a comprehensive education system may still be a vision for the future, Sakulin et al. [Case study 7] inform on advantages of regional clusters between HEIs, business and regional public and civil society actors. Experiences and potential benefits for participants from collaboration of regional administrations with HEIs regarding co-operative learning formats are presented in a case study about a regional student camp in Austria and co-operative master's thesis supervision in Romania.

The latter report as well as the experiences gathered in the course of the BET project point out an important structural element for accelerated implementation of co-operative learning formats in existing and future curricula: the participation of mediating actors. The development of co-operative learning formats is not part of the core business of universities and companies. Moreover, these two actors follow very different rules and incentives. While scientific excellence and high educational standards secure public funding of universities, enrolment fees and research grants, business is driven by profit and shareholder value. Particular goals and planning horizons as well as management structures and decision making differ considerably. All these differences are formidable barriers to co-operation between universities and business exceeding the level of temporary, clearly defined research projects. There is no indication for a change on this matter in the foreseeable future although this would be necessary to strengthen co-operation in education required by the energy transition. If co-operative learning formats are to contribute to ensuring a workforce qualified to meet the future challenges, mediating actors are required. Experience from BET shows that mediating actors must have some general characteristics:

- They must integrate stakeholders coming from universities, business and, perhaps, from the public sector and the civil society;
- They must be dedicated to a particular future challenge; in the present case this would be the energy transition;
- They must have a track record of co-ordinating co-operation between the stakeholders.

The clusters discussed in Sakulin et al. [Case study 7] as well as by eseia which co-ordinates the BET project have these characteristics and, therefore, were able to co-ordinate and implement co-operative learning formats in their own specific environment. The examples of successful and innovative learning formats established within the BET project, however, show another aspect: these formats are the result of an interdisciplinary and international innovation process that answered to the specific challenges for education posed by the energy transition as stated in SRMET. Only inter-sectoral actors like eseia who operate internationally and are actively involved in the changing process necessary for the energy transition are able to succeed in getting things done in this respect.

### Conclusions

The energy transition requires a future workforce dealing with low carbon energy systems that is not only considerably larger than the current one, but also capable of handling new technologies and complex systems and of pushing ahead innovation. The European Union's SRMET has recognised that considerable changes in education and training will be necessary. SRMET calls for close co-operation between educational institutions and business to meet the formidable quantitative and qualitative challenges to establish the large and highly qualified workforce for the energy transition. The same call comes from European universities in their action agenda AAEU in order to increase relevance and quality of academic education in the field of low carbon energy systems. Co-operative learning formats are vital for the energy transition as well as for improved academic education.

There is already a certain tradition of co-operation between universities and business in the form of internships and placements of students in companies during their education. While this is an important way to expose students to their future work environment, it usually lacks educational structure and joint responsibility for the learning outcome.

On the curricular level, dual studies offer a more structured form of co-operative education. In these curricula, theoretical instructions at HEIs and practical work and on-the-job-training take turns. They usually answer to immediate demand by business for qualified employees in a particular and narrow field. Dual studies, however, represent only a tiny minority of studies offered by HEIs.

In order to influence the shape of the majority of existing curricula and to design innovative new curricula aimed explicitly at pushing ahead the energy transition, broad co-operation between academia and business on the course level is required. Guest lectures by business experts within regular curricula as well as seminars and design courses with the participation of industry are existing types of co-operation that can form the basis for closer linkage in future. In order to achieve both, deeper collaboration and higher quality of education, innovative types of co-operative learning formats on the course level have to be developed. Examples of such formats show that they are advantageous for business, students and academic teachers.

An analysis of the experiences made in the course of the BET project points out the importance of mediating actors who facilitate the co-operation between business and universities. Mediating actors are necessary as there are fundamental differences in goals, intentions and management structures of academia and business. They must integrate members from both sides and already have a positive track record of co-operation concerning specific projects connected with the energy transition in order to succeed in meeting the ambitious goals for co-operative learning formats described in SRMET and AAEU alike. Given the urgency of implementing a low-carbon energy system in the face of climate change, efforts to bring business and HEIs together for the purpose of educating the future and re-training the existing workforce have to increase dramatically.

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### Authors' contributions

Michael Narodoslawsky reviewed and contributed to the meta study and the case studies. Stephan Maier did the literature review and prepared the manuscript for the meta study.

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The authors declare that they have no competing interests.

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### Supplementary material

This publication refers to supplementary material in the format of case studies available as additional files 1 – 7 in an extra section (Part II).

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### **Case Study 1 Co-operative Learning Formats – an important Link in the Chain to implement the SET Plan**

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#### **Overview**

##### **Background**

The Energy Transition as envisioned in the Strategic Energy Technology Plan of the European Commission requires a dramatic increase in the workforce skilled in low-carbon energy technologies and innovative energy systems. Educating and training this workforce will force higher education institutions (HEIs) and business to pursue new and co-operative approaches to education and training.

##### **Method**

The paper analyses key documents, in particular the Strategic Energy Technology (SET) Plan Roadmap on Education and Training, and the Energy Transition and the Future of Energy Research, Innovation and Education: An Action Agenda for European Universities, in order to establish the role of co-operative learning formats in the quest for educating future generations of energy experts. The former document represents the view of the European Commission, based on a broad stakeholder consultation process. The latter document states the view of HEIs concerning their particular agenda in a highly dynamic process of shaping the future workforce that drives the energy transition.

##### **Results**

The analysis of these key documents clearly indicates that co-operative learning formats are pivotal for the qualitative and quantitative challenges of educating future energy experts and re-training the current workforce in the face of a profound transition of the European energy system. Innovative formats in which HEIs and business share the responsibility for content as well as execution will become crucial elements in future curricula, exposing students early on to real world problems and interdisciplinary approaches to solve them.

##### **Conclusions**

Co-operative learning and teaching formats may well become major drivers for innovation in the education of future workforce and the training of current practitioners. Given the importance of education and the size and scope of the necessary innovation, they may finally become also much needed drivers for the energy transition itself.

Co-operative learning and teaching also supports the acquisition of new skills and competencies of students. Ensuring and mainstreaming co-operation with other stakeholders including industry, policy, NGOs, territorial governance bodies and other energy-related organisations is an integral part of this new approach.

### Introduction

Co-operative learning formats are educational approaches that link business and education institutions in an effort to provide knowledge that is particularly relevant for coping with the challenges of present and future jobs. These formats are on the one hand designed for students and trainees to experience the job environment they will work in after passing their final exams. On the other, hand they confront students and trainees with problems arising in their future professional life in order to encourage them to apply their accumulated knowledge from different disciplines to solve these problems and to motivate them to strengthen their skills in those fields they identify as crucial to these problem solutions. Finally, these formats also inform students and trainees about the resources business can utilize and restrictions business faces in solving real world problems.

Whereas co-operative learning formats have a strong tradition in the vocational training in many countries of the EU (e.g. Germany and Austria), co-operation between business and educational institutions is far less developed at the level of higher education. Increasing the share of co-operative learning formats in higher education, however, requires substantial extra effort from HEI and business as well. Currently business sees academic education as the main responsibility of HEI and not as a shared effort to guarantee the workforce of experts required by future challenges. Conversely, universities are particularly concerned with maintaining academic excellence in education and research. Both business and institutions of higher education are firmly anchored in their respective silos with their own competition and definition of excellence. Breaching the walls in order to install co-operative learning formats of these silos requires strong incentives and common motivation. This article investigates driving forces on both sides that call for an increase in co-operative learning formats before the particular background of the Energy Transition and the answer to this challenge given by the European Strategic Energy Technology (SET) Plan. In short, the article answers the question 'If co-operative learning formats are the answer, what exactly were the questions and are these questions central to implementing the SET Plan'.

In order to analyse these driving forces for co-operative learning formats we concentrate on two key sources: The Strategic Energy Technology (SET) Plan Roadmap on Education and Training [1] (SRMET) as the most concise statement of relevant stakeholders on what the implementation of the SET Plan requires in terms of training and education and Energy Transition and the Future of Energy Research, Innovation and Education: An Action Agenda for European Universities [2] (AAEU) as an agenda for the development of institutions of higher education to meet the challenges posed by the Energy Transition.

### Intensifying Co-operative Learning Formats – Why now?

Within the UNI-SET [3] project commissioned by the EU under Horizon 2020 [4] and coordinated by the European University Association (EUA), a comprehensive survey covering over 200 (mostly) European universities also asked for co-operation between universities and other stakeholders in educational terms. A preliminary overview [5] shows that a considerable number of universities engage already in educational co-operation with industry and other important stakeholders. A closer look reveals, however, that the largest part of this co-operation consists of student placements. This is particularly obvious in the relation between universities to industry, where more than 44 % of the universities report that they place students with industry and only about 30 % report other educational co-operation, mostly excursions and lectures from industrial experts.

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While there is no doubt that student placements are (and will remain) important means to expose students to their future work environment and that lectures from industry experts and excursions to industry provide students with insights to the way problems are solved in business, these modes of co-operation do not require business or universities to breach the walls of their respective silos: universities remain firmly in control of evaluation and content while industry, although providing considerable resources, is not required to strongly participate in developing educational formats and to take main responsibility for skills acquisition of their interns. The assessment of this current situation, therefore, is that in the field of educational co-operation business and universities have reached the stage of reaping the 'low hanging fruits' but so far have neither taken common responsibility for the education of future experts nor deployed the substantial resources necessary for true common educational efforts.

Progressing beyond the 'low hanging fruits' in educational co-operation between business and universities requires significant steps in breaching the walls separating the silos these actors are in. It requires from business the realisation that education of its future expert workforce cannot be 'outsourced' to institutions of higher education. Conversely it requires from universities the recognition that they do not hold a monopoly on formulating educational goals and learning formats as well. Both have to commit considerable manpower, financial and infra-structural resources to develop and realise learning formats that provide students with the skills necessary to meet the challenges of the future. Above all, it requires both actors to take shared responsibility in education and training of the experts that keep business competitive and guarantees sustainable ecological, economic and social development. Business needs to become a "prosumer" instead of a mere customer with regard to skills of the employees it hires, actively engaging in skills development. Universities need to develop into team players in the quest to form highly skilled and enthusiastic people who will re-structure the way society interacts globally and with its natural environment.

This transformation is radical and painful for both, universities and business. It is obvious that both will not engage in this transformation without strong pressure from current and future challenges and major other actors. One of these actors is the European Commission. Its Conclusion of the European Council from May 22<sup>nd</sup>, 2013 [6] made it clear that Europe faces an energy revolution that can only be met by profoundly transforming the energy sector and by increased efforts to energy innovation. The European Commission, following this European Council Conclusion, embarked on up-dating its Strategic Energy Technology (SET) Plan. The Joint Research Centre (JRC) was tasked with moderating the stakeholder process of the development of the SET Plan Road Map. The subsequent overview presented by the JRC states ([1], page 41): 'There is a need to update education and training programmes for professions in the energy sector at all levels with new research-based and industrial knowledge and to provide adequate interdisciplinary integration of knowledge from relevant fields.'

Following that, it explicitly demands ([1], also page 41): 'Furthermore, interaction among higher education and training institutions, businesses and research institutes should be encouraged in terms of curricula development, mobility programmes and access to research and industrial infrastructure such as laboratory, pilot projects and test facilities for practical training in real environment.'

This means that the European Union stipulates close co-operation between business and HEI as a key means to achieve its ambitious energy and climate goals. A rationale for this demand, cited in this document, is given by the SRMET: it is expected, that the workforce in low-carbon energy technologies will have to double from its level of 9 million people in the EU 28 in 2012 until 2030 (JRC, 2014 a, page 11, [1]). The same document states in a rough estimate the number of researchers and engineers that are currently employed in low-carbon energy technologies with 5-10 % respectively 20-32 % of the workforce. A doubling of workforce, under the conservative assumption of keeping these

relations constant, would require 2.4 to 3.8 million graduates with a STEM background entering the low-carbon energy technology sector. This has to be contrasted with the current total number of persons in the science and technology sector on the tertiary education level in the EU of roughly 14.4 million in 2017 [8] and the annual rate of 1.097 million graduates from engineering or STEM curricula in Europe in 2015 [9]. This means that implementing the SET Plan requires a substantial part of current engineering and STEM graduates to enter the low-carbon energy technology sector. In addition to the demand for highly skilled young graduates, SRMET also highlights the need for re-training the existing workforce (JRC, 2014a, page 12, [1]): ‘While new professionals will enter the market, the existing workforce will also have to undergo quick and effective re-training in order to be able to respond to new requirements. Building the right re-training programmes becomes an important pre-requisite for facilitating movements across fields.’

Given the sustained and probably even increasing demand for STEM as well as engineering Bachelors, Masters and Doctors coming with the digital revolution and the quest for European global leadership in technology, this is only possible if the capacity of higher education in these fields increases dramatically. This can only be achieved if business actively engages in a co-operation with universities to guarantee a highly skilled workforce for the future. Co-operative learning instruments may become key instruments to foster this common effort of business and universities.

### Reasons for Business to engage in Co-operative Learning Formats

There are a number of challenges in the business sector beyond the pure technological aspects, including interaction with end-users, environmental, economic, social and ethical dimensions. Employers are increasingly interested in graduates able to meet the continuously evolving challenges through a holistic approach. For example, the UNI-SET Employers Survey demonstrated that employers need people with strong technological backgrounds while being aware of social issues, regulations and policies. Industries are also keen to employ graduates with the ability to be flexible and familiar with business processes, and are increasingly interested in hosting students to provide them an early exposure to business dynamics while still engaged in educational programmes. In a context of an ‘open’ society, bottom-up approaches are necessary to address societal problems and the challenge on energy is perhaps the most fundamental priority. These approaches need to be established through dialogue between educators, business people and civil society. We need to ensure that technological approaches do not overrule environmental considerations while guaranteeing supply of the ever-increasing energy needs of our modern societies.

Business partners therefore need to become contributors to the education and training of graduates, not only by identifying the skills needed, but also, for example, by providing real case studies based on their own experiences and hosting students to give them the opportunity to learn about business strategies and processes before they go into the labour market. Such practices should become mainstream in the business sector. One possible approach to channel the efforts can be the application of the model known as ‘Lean Development’ in innovation processes. The ‘Lean Development’ method, used in fast-changing environments, is characterized by the following: experimentation upon business-driven hypothesis, iterative product releases, quick feedback cycles, validation of learning [7]. In the context of the SET-Plan, many actors can provide input in a coordinated way, as the UNI-SET project demonstrated. Subsequently, universities and industries can work together to prepare educational units (modules or short programmes) that can be tested swiftly, and thus engage in a dynamic process of development and continuous update. These types of processes will ensure quality of the educational material as well as relevance to the business sectors and to the society at large.

As clearly stated in the JRC report (JRC, 2014a, page 13, [1]), a major reason for business to engage in co-operative learning formats lays in increasing the efficiency of education and training by the possibility to establish: ‘...new ways of teaching and learning, addressing both students and current professionals in the field.’

In a time of rapid technological development and multidisciplinary challenges for developing, planning, implementing and operating low-carbon energy technologies, current employees must be retrained at the same time as a large number of students have to be prepared for their future workplace. Co-operative learning formats that address both groups and possibly bring them together in person would substantially increase the efficiency of the training: they would pool the knowledge of academic teachers and business experts and foster peer-to-peer learning between current employees and students, thus transferring business experience efficiently to students.

SRMET also points out another aspect that would add to increasing the efficiency of training: utilizing the best laboratories and facilities, including those owned and operated by business. Among other objectives, co-operative utilisation of high-quality research and development infrastructure may (JRC, 2014a, page 17, [1]) “...have the following guiding objectives:

- To build joint education and training programmes, projects and exchanges among research infrastructures/ industrial installations and relevant education and training providers.
- To ensure quality education and training by engaging a broad range of experts from education and training bodies, research and industry.
- To provide a platform for practice-oriented education on all levels (students, engineers, researchers, etc.)”.

SRMET here clearly points to a challenge for co-operation in educating students as well as current employees for a rapid transformation of the European energy system: as technologies become more complex and their implementation and operation more systemic, training at ‘the real thing’ becomes crucial. Neither business nor universities can provide this on their own. Business lacks the educational capacity to fully exploit the possibilities of high quality experimental facilities and laboratories. Universities lack resources to establish them and don’t have access to most existing sites. This calls for co-operative learning formats to incorporate up-to-date practical experience and engagement in research and business environment into the learning experience.

Besides, this rationale to increase the efficiency and thus speed up education and training of students and current employees alike, co-operative learning formats that take advantage of high quality laboratories, pilot plants and living lab situations have another interesting aspect for business: students are among the most creative people and are not fenced in by routine and professional prejudice. This makes them valuable partners for thinking ‘out-of-the-box’ and searching for innovative solutions. Co-operative learning formats therefore do not only provide students with rich insights into business perspectives. They are also a possible source for creative solutions at a time when the transition of the energy system is on the way.

Another reason for business to engage in co-operative learning formats is that they can increase mobility of academic teachers, researchers, business experts and students. SRMET again formulates the objectives (among others) of co-operation between business and universities in this respect (JRC, 2014a, page 16, [1]):

- ‘To allow students to move to business and/or research facilities within their curricula, and gain practical experience and orientation in the field.
- To facilitate mobility, practical experience and knowledge exchange for business/research and teaching staff in education and training organisations, research institutions and industry.
- To allow business and research staff to teach at higher education institutions and training institutions, transferring their know-how into knowledge for graduate students or lifelong learners.’

Student mobility to business work environment and their gain of practical experience and orientation is important to reduce ‘transformation time’ from study-mode to job-mode when graduates enter the work force. However, there is another, not explicitly mentioned reverse effect of co-operative learning formats addressing both, students and employees: they lower the barrier for current professionals to accept the education and training services of universities. On the one hand, this allows universities to increase their reach in the field of lifelong learning. On the other hand, it helps business to provide high quality training for its staff at a time when technological and systemic change becomes dynamic.

Another important aspect mentioned in this part of SRMET is the mobility of experts and knowledge from business to educational institutions that is fostered by co-operative learning formats. This must not be seen as mistrust into the knowledge capacity of academic teachers but as an important new dimension in the learning experience of students. Experts from business can confront students with the complexity and multidisciplinary of real-world problems. This allows students to integrate knowledge that they have acquired throughout their curricula and to apply it in a problem-oriented way. On top of this, co-operative learning formats may increase the focus of academic teachers and researchers on challenges along the path to development and implementation of innovative energy systems, which are part of the content provided by their business partners.

In various places, SRMET also alludes to the objective of joint efforts by universities and business to adapt curricula to the challenges to the future European workforce in the field of low-carbon energy technologies: ([1], page 15): ‘... establish a flexible framework for developing new and upgrade of existing curricula in the respective evolving technology field, including blue-sky research, and involving of a broad range of experts from academia, research organisations and business’; ([1], page 17): ‘...develop and update quality curricula and teaching materials, integrating work-based learning and responding to labour market needs.’ Co-operative learning formats will on the one hand be essential parts of such innovative curricula. On the other hand, they provide important platforms from which joint efforts in curricula development may be started.

A major field where co-operative learning formats may provide interesting chances for business is virtual learning. SRMET points out some possible objectives that co-operative learning formats may serve in this respect (JRC, 2014a, page 18, [1]):

- ‘...to establish virtual education and training programmes and modules as well as other open educational resources, allowing the inclusion of expert lecturers via a virtual faculty exchange.
- to provide access via distance learning tools to remote research infrastructures, test facilities, data banks, and other valuable components in education and training.
- to enable the quick implementation of programmes for continued education, including “train the trainers” programmes.’

In this respect, business may profit from co-operation with universities by common development of content of virtual learning modules. This will increase the quality of these modules while at the same time facilitate their use in business for retraining employees and trainers as well. Co-operative virtual learning formats may also allow integrating resources such as large data banks and remote test facilities into education and training efforts of business and universities alike. A condition sine qua non for commonly exploiting virtual learning tools, however, is that these tools are developed in co-operation between business and universities.

### Reasons for Universities to engage in Co-operative Learning Formats

The very fact of publishing AAEU clearly indicates that European universities are keenly aware of the necessity of change if they want to live up to the challenges posed by the energy transition: AAEU acknowledges that the energy transition triggers a transformation of the universities engaged in education, training and research in the energy related fields. As much as SRMET indicates that business needs to engage in education and training, AAEU calls for European universities to open up to business and to adopt co-operative approaches in order to achieve this transformation.

A major reason for the transformation universities have to undergo is the insight that challenges of the energy transition become increasingly interdisciplinary. AAEU ([2], page 9) states that university education has to keep up with this rapid change that ‘...requires energy programmes to expose students to current thinking, new ideas and new methods, and can be achieved by using the effective approaches advocated in this Agenda:

- More widespread use of case/challenge-based teaching including more multi-disciplinary courses and work. Real-life challenges tend to be multi-disciplinary and to cross the boundaries encountered regularly in discipline-based courses. Multi-disciplinary approaches bring groups of students with different backgrounds together to understand the various angles from which a specific discipline looks at such challenges. They also help develop inter-disciplinary communication skills.
- Move towards more skills-development based education that uses case/challenge-based approaches, changing the role of teacher to that of a facilitator.’

This strong emphasis on case-based learning is a powerful driver for universities to engage in co-operative learning formats. Business can provide real-world cases that also fulfil another requirement formulated in AAEU for energy related programmes ([2], page 10); they should ‘... be designed to give students insight into the complexities and interconnected nature of the energy system and our societies deeply embedded and constantly evolving relationship with energy.’

Supplying students with real world cases is, however, only one side of the coin. Of equal importance is to provide them with approaches and knowledge of business experts but also exposing them to opportunities and restrictions of practical work environment. Co-operation between business and universities must, therefore, go many steps further from just formulating attractive cases for students to solve: innovative co-operative learning formats must integrate realistic challenges to students, business experience and facilitating support by teachers.

Universities, according to AAEU, are well aware of the fact that business values experience of practical work environment and exposure to up-to-date knowledge ([2], page 10): ‘Employers value projects focussed on problem-based or challenge-based learning, particularly those that address real economic and business issues and include social/human contexts (e.g. ethics and user interactions). Practical or applied experience is often seen as more important than a student’s academic achievement’.

Co-operative learning formats allow integrating this experience into regular curricula while at the same time guaranteeing alignment of content with the rest of the program. Contrary to placements whose effect on the skills of students are always contingent on the individual work place setting, co-operative learning formats offer the possibility to provide students with this experience in a controlled and systematic way.

Another aspect pointed out in AAEU refers to the extraordinary scope and size as well as long term character of the energy transition. Rapid technological development and changing societal and legal context requires constant re-training of experts in the field. This is only possible by ([2], page 10): ‘...a life-long commitment to a successful low-carbon society. This Agenda’s approach should empower continuing professional reflection and development allowing professionals to generate new skills and acquire new knowledge at any stage of an energy-related career. Lifelong learning should therefore be embedded, as some aspects may already apply to energy industry professionals.’

Given the considerable task of educating and training a huge new workforce while at the same time keeping professionals in the field abreast with the latest technological, social and legal opportunities, efficient utilization of the resources available becomes of vital importance. Co-operative learning formats that address both students and professionals in the field offer two advantages with respect to efficient teaching: (a) they pool resources from business experts and academic teachers and (b) they offer particularly efficient learning environs by teaming up experienced practitioners with students that may provide out-of-the-box solutions to cases of interest to other actors.

AAEU, moreover, identifies a field where co-operative learning formats can offer distinctive advantages ([2], page 10): ‘The most common challenge in moving forward is communication. More open, constructive, communication to benefit everyone is essential for any of these changes (e.g. to support co-operation within and across universities as well as with other partners). Improved communication should also help support resource-sharing, avoiding the duplication of work to free time for developing improved frameworks for co-operation and interdisciplinary education and research. Technology helps, but it will be essential to ensure standardisation, at least at European level.’

Communication across sectors and particularly between universities and business is best improved by common activities with shared responsibility. Co-operative learning formats offer an opportunity for common action that is beneficial to both sides and that requires intense and extended communication between universities and business. They also serve the other objectives raised in this quote, namely resource sharing and avoidance of duplication of work. Co-operative learning formats are a prime tool to improve trust between academia and business and build a durable fundament on which joint efforts of the energy transition may be built.

This improved communication is prerequisite to innovation in the field of curricula offered by universities. AAEU points to ongoing efforts in this respect ([2], page 10): ‘... new education programmes are proposed and approved by organisations outside universities, including government departments; so providing a good spread of university programmes becomes an important aspect for new programme design.’

Business is a vital partner in the establishment of innovative curricula that support the dynamic process of energy transition. Integration of aspects important to business however can only be achieved via open and trusted communication and requires mutual insight in the aspirations of the partners. Co-operative learning formats can crucially contribute to this mutual understanding.

Recalling the initial examples provided above, co-operation can be implemented through a range of activities including placements, projects, guest teaching, focus groups, training, advisory boards, social engagement and the provision of cases and challenges by these extra-academic actors. The active and experiential learning is an important contribution to skills development. Given the importance of energy at all levels, public outreach and engagement with companies, communities, citizens, politicians as well as debating and facing controversies is also essential. The innovative education programmes are to use the latest pedagogical methods including one or more types of tools, namely online, blended or distance approaches (e.g. e-learning, flipped classrooms, teamwork, design-thinking).

For example, case-based modules require students to imagine solutions to a problem that has already been solved, and check their ideas against the solution provided by the case. The work can be done individually or in teams depending on the complexity of the case. Challenge-base modules, also known as project-base, normally involve teamwork to address an unsolved challenge, including laboratory or field work and a significant inter-sectoral component. Both types of modules can include business, societal, technical, political and market considerations.

This type of education aimed to build skills rather than just teach knowledge is changing the traditional role of the teacher to that of a facilitator. Students then engage in a journey in which they are almost in the driving seat, and their progress lies more around self-study and shared or individual experiences giving them the opportunity to explore areas of interest in more detail. To keep up with rapidly changing requirements of the energy transition and the systemic transformation including technology, markets, politics and more, universities should engage in co-operative learning formats and adapt the knowledge backgrounds and skills of professionals, engineers and scientists. University learning and teaching in relevant subjects need to be up to date, adaptive, agile and challenge-driven. Approaches such as case/challenge-based methods, short-duration programme and online learning are some of the options available to universities. These can integrate systemic, interdisciplinary perspectives on specific cases and/or challenges, and/or make new knowledge available faster for a diverse set of learners. Furthermore, the systemic and fast-paced transition makes intersectoral and interdisciplinary collaboration, also with the SSH disciplines, a sine qua non for maintaining the relevance of education and research activities.

### Conclusions

The short analysis of two key texts regarding education and training for the energy transition reveals that co-operative learning formats may play a pivotal role in innovating educational programmes to meet the formidable challenges of a low-carbon energy system in Europe. In order to play this role, co-operative learning formats have however to fulfil some requirements, in terms of content and form as well.

In terms of content, both reports emphasize the importance of co-operative, real-world case-oriented learning courses for a good education system supporting the energy transition. Specifically, both texts demonstrate the need to educate students in the complexities and interconnected nature of the energy systems in relation to our societies, at local as well as global levels (SRMET ([1], page 12) and AAEU (EUA, 2017, page 10, [2])). Co-operation between business and academia concerning these learning formats must go down to the operational level and responsibility must be shared. As important as placements of students are (and will remain), the level of co-operation in this format is not sufficient to meet the challenges of educating a huge workforce for as dynamic a process as the energy transition.

- (1) A certain division of labour between business and universities is suggested: while business can contribute real-world cases and provide insight into work environment and business approaches to solving problems, academia can provide quality assurance, theoretical insights and educational know-how.
- (2) From educational as well as efficiency aspects, involving practitioners and students side by side in co-operative learning formats is required. On the one hand, education of a highly skilled future workforce and training of current employees can be achieved likewise. On the other hand, peer-to-peer learning between students and practitioners is an efficient means to expose students to business ideas and to open up current employees' minds to innovative approaches.
- (3) Cases should not only be realistic but also of interest to real actors who have to be involved in the formats. Participants in the learning formats must experience the interest of actors in their solutions. Involved actors may be presented with innovative, out-of-the-box approaches to solve their problems in exchange for their efforts.

Co-operative learning and teaching formats that live up to these requirements may well become major drivers for innovation in the education of future workforce and the training of current practitioners. Given the importance of education and the size and scope of the necessary innovation, they may finally become also much needed drivers for the energy transition itself.

Co-operative learning and teaching also supports the acquisition of new skills and competencies of students. Ensuring and mainstreaming co-operation with other stakeholders including industry, policy, NGOs, territorial governance bodies and other energy-related organisations is an integral part of this new approach.

New education and training formats are developing that make the traditional model 'teacher – student' evolve towards a model in which the professor is a knowledgeable guide providing students with tools enabling them to find relevant information and promoting their personal development thus facilitating the study journey.

The economic and political stability and prosperity of modern societies will require new professionals not only addressing energy but also poverty, hunger, health and well-being and many other topics (using the first three of 17 UN

Sustainable Development Goals as examples). A close collaboration between universities, business and other relevant stakeholders is crucial for building the capacity to develop an adequate education - the primary resource needed to succeed in all these challenges.

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### Overview

#### Background

The transition to a renewable and sustainable energy economy in Europe requires the development of adequate co-operative learning formats. This demands the involvement of different institutions including public institutions as well as non-governmental organisations and the general public. A linkage which is especially lacking is an integration of industry and technological research and education.

#### Methods / Case Study Description

The case study describes experiences made by lecturers during the BioEnergyTrain project (BET). The analysed co-operative learning formats are open Summer Schools, interdisciplinary Student Camps and Pilot Industrial Research Labs.

#### Results

The innovative value of these co-operative formats is described as an option to link industry in a new way to education in order to get a deeper insight into industrial issues, problems and state-of-the-art solutions. It includes a more interactive and reflective student-centred group learning.

#### Conclusions

Lecturers found it challenging to select adequate contents for specific curricula; well-prepared and well-balanced learning surroundings turned out to have positive influence on the quality of the courses' output.

### Background

The transition to a renewable and sustainable energy economy in Europe is a critical developmental process requiring the integration of research and technology, education and training, industry and business, government and non-governmental organisations and the general public. Of these, the linkage between industry and technological research and education is quite under-developed in Europe. Most crucially, the SET-Plan identified gaps in linking education to practice, noting 'Educational and training programs need to be coupled to Europe's best laboratory facilities, including (...) industrial technology pilot and demonstration facilities (...) such co-operation frameworks with research and industrial infrastructures would enhance the overall quality and agility of the system, and facilitate innovation developments.'

BET took this challenge as starting point to develop and examine several co-operative learning formats during the project.

### Methods / Case study description

#### The Co-operative Learning Formats examined in the course of the BET Project

**Open Summer Schools:** Within BET, a series of two-week (4 ECTS) summer schools have been organized all dedicated to resolve problems at the cutting edge of bioenergy and bioeconomy development and to provide interdisciplinary approaches to solutions by convening high quality experts from different academic fields and businesses as lecturers. BET organized Summer Schools in Lisbon (PT), Braşov (PL) and Dubrovnik (HR).



*International Summer School at University of Zagreb, HR, 25 June - 1 July 2017/ Credits: UNIZAG*

**Interdisciplinary Student Camps:** interdisciplinary groups of students were assembled in order to solve complex real-world problems. The topics were defined jointly by academic instructors and experts from the hosting industry. Students learned how to co-operate in teams with members from different backgrounds, nationalities and disciplines to find novel solutions, and they had to defend their results against other student teams in front of a jury of experts and instructors. Within BET, three Student Camps were organized, one in co-operation with the company BRP, one regional in collaboration with the Styrian regional government (AT) and one in collaboration with KPLUS [1] (AT).

**Pilot industrial research labs:** this innovative interaction mechanism made students work in groups in pilot industrial labs of industry partners, providing them with hands-on experience in the operation of real-world installations and exposure to the development tasks they will face in their professional lives. Research plans for these labs have been developed by academic instructors, students, and experts from industry. Within BET, research labs have been organized at the site of BAV [2] (DE) and at the site of Green Tech Cluster Styria [3] (AT).

### Results

#### Innovative Value of Co-operation Formats

According to the Austrian economist Joseph Schumpeter innovation in the economic process means new combinations of technology, markets, organizations, products and inputs. Schumpeter's conceptualization is still authoritative and, applying it to the educational formats, it can be argued that they can be considered as innovative in teaching and learning.

First, all three formats link industry to education at universities in a new way. University collaboration with industry in research is quite common. Apart from specific research projects, the research collaboration also covers master's thesis research by students. This type of collaboration is in a way a combination of research/teaching collaboration and not really new. However, it should be noted that in this type of combined collaboration research is dominant. The learning component is dominated by the demonstration aspect of master's thesis research because students should show their performance as researchers in this part of the programme. In the three co-operative learning formats mentioned above, the learning component is dominant, and students are forced to work in groups. Group work ensures that students learn from each other and not from industry and academic advisors. Due to the interdisciplinarity and internationality of the groups, students are able to discover a variety of approaches to solve specific problems.

Second, all three formats send a clear signal to industry that it has a definite responsibility for the education and training of the next generation of professionals. Currently, universities exchange information on industrial requirements in terms of demands on labour force in different ways, such as surveys among alumni, analysis of domain specific requirements, focused labour market research, etc. These can be helpful, but they do not require substantial involvement by industry. The three educational formats, however, force industry to invest in the development of knowledge and skills of future professionals by challenging them in their own industrial environment and by providing excellent conditions from an industrial point of view.

Third, the three education formats supply industry with vital information concerning state-of-the-art knowledge and technology. Students have this knowledge generated by science and research and transfer it to the industry. Thus industry is able to compare the present state of company knowledge with the current state of research.

Fourth, the teaching approach of the three co-operative formats is innovative and far from conventional/traditional teaching at universities with students in a passive role of listening to the academic teacher. The teaching approach in the three educational formats reflects what is called Student Centred Learning (SCL) [4].

'As part of this approach students are given the opportunity to compare their ideas with their peers and their teachers, whilst contributing to developing their curricula in a meaningful manner. In this context, the student is encouraged to ask questions and be inquisitive and the academic is seen as a facilitator and guide, rather than as the main source of knowledge. This approach therefore changes the role of the teacher, from being entrusted with the "transmission of knowledge to supporting and guiding self-regulated student learning" [5].'

Of the three co-operative formats, the Summer School in a way reflects the traditional way of teaching where the teacher is the main source of knowledge most. But even the lectures during Summer School lead to increased interaction between lecturers and students and among students, which is a significant improvement compared to the one-way traditional teaching. The Student Camp and the research lab provide an excellent environment for student-centred

learning. Students collaborate in teams in order to experience and also to solve real life problems in industries or in regions. In the research labs students also experience the daily routines in company's laboratory work and routines. The Student Camp is most suitable for student-centred learning. Students work in teams on real-life problems of a company or a region. They are supported by academic and industrial staff members, but the students are the problem owner. This learning approach is rather innovative in academic teaching across Europe, but based on the experiences made in the course of the BET project.

Fifth, the three co-operative formats expose students to teaching and learning in completely new settings which adds to their motivation to learn and also adds to their learning progress. All three teaching formats allow students to visit exciting places all over Europe but also create new multidimensional learning environments. Multidimensionality is particularly generated by the diverse backgrounds of the students and the involved staff. Students work together in groups for a couple of days, which leads to productive group dynamics. Students are confronted with various academic disciplines. Finally, students experience new ways of co-operating with academic and industrial staff.

### Conclusions

We now would like to summarize the results of the study as recommendation for those who consider integrating one or more of the co-operative formats in a curriculum.

1. Apart from the basic motivation to participate in collaborative educational formats, the advantages possibly to be derived from the curriculum are important for the student's (voluntary) decision to participate or not. So the best way to motivate students to take part is to offer a challenging programme in an exciting business environment and student loans.
2. A challenging programme requires very good preparation from both industry and university. The programme should comprise knowledge exchange, teamwork, feedback sessions and the presentation of results. It also should support adequate communication between company staff and students throughout the programme.
3. The programme should start with a detailed presentation of the hosting company, its vision, its strategy, the key information on products, finances and human resources, etc. The presentation should be conducted by a member of the management thus showing students the importance the company attaches to the student camp.
4. The programme should clearly add to the student's regular curriculum. Therefore, it is most important to communicate the general idea and the contents of the programme precisely.
5. It is essential to keep the costs the participating students have to carry as low as possible.
6. The programme should contribute to productive group dynamics. In order to create a pleasant atmosphere, leisure time is very important. In one of the BET camps, students had access to a flight and race simulator, which turned out to be a stimulus to productivity.

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## Case Study 3 Requirements and Potential Benefits for the Industry from Cooperative Learning Formats with HEIs

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### Overview

#### Background

A stronger linkage between business and Higher Education Institutions (HEIs) is not just needed in view of severe real-world problems but can also contribute to a win-win situation between industry, companies and HEIs.

#### Methods / Case study description

The case study describes experiences, requirements and benefits for industry from cooperative learning formats with HEIs during a Student Camp in the course of the project BioEnergyTrain (BET).

#### Results

Experiences with a focus on Life Cycle Assessment (LCA) on real-world problems were collected at an engine (powertrain) company. It included the research for alternative combustion engines and fuel systems for the company.

#### Conclusions

Similarly to experiences in Case study 2 adequate surroundings and student access to academic and industry partners were seen as crucial requirements.

### Background

It has been proven that bridging the gap between industry and companies and HEIs is beneficial for both parties [1]. The benefits students derive from integrating real-world challenges through cooperative industry projects into the education in engineering and non-engineering disciplines have been evaluated profoundly ([2], [3]).

The studies showed that students thus develop competences that imply key importance for their professional life. They achieve professional competences such as complex problem solving in a short time frame, contextual understanding and judgement, personal competences like the ability to work in a team, self-management and communication skills. Furthermore, the cooperative learning formats lead to greater confidence regarding career planning and to relatively higher post-graduation salaries. The benefits for companies range from access to new work force, presenting themselves as attractive employers and gaining profit from new and innovative ideas and unbiased and fresh views on their work.

However, the SET-Plan identified gaps in linking education to practice, noting 'Educational and training programmes need to be coupled to Europe's best laboratory facilities, including (...) industrial technology pilot and demonstration facilities (...) such cooperation frameworks with research and industrial infrastructures would enhance the overall quality and agility of the system, and facilitate innovation developments' [4]. Considerable efforts to fill these gaps have been made when during the project BioEnergyTrain cooperative learning formats between business and HEIs were developed which integrate student exposure to industry adapted to bioenergy practice. Innovative mechanisms for exposing students to real world work environments and problems are, for example, the so-called Interdisciplinary Student Camps.

### Methods / Case study description

#### Interdisciplinary student camps

Student Camps convene interdisciplinary groups of students for one to two weeks in order to solve complex real-world problems related to bioenergy together with experts from an industrial partner or sponsor. Topics of the Student Camps are defined jointly by academic instructors and experts from the sponsor, and students learn to cooperate in teams with members from different backgrounds and disciplines to find novel solutions and have to defend their results against other student teams before a jury of experts and instructors. For BioEnergyTrain curricula students these camps are eligible as electives with 3 ECTS, but are also open to students from vocational training partners.

### Results

#### Case Study: BET Student Camp at BRP-Rotax in Gunskirchen, Austria

In March 2017, a number of 23 participants from over 13 different countries participated in the BET Student Camp hosted by BRP-Rotax in Gunskirchen, Austria. The Student Camp allowed the participants an insight into the activities, strategies and objectives of the company and challenged them to solve real-world problems thus connecting the students' fields of expertise with the needs of the company.

The definition of the challenges and the detailed programme were provided in co-operation between academic instructors and BET business partners within the general topic of bio-fuel provision and utilization. The Student Camp attendance was free of charge, but a cost covering fee of 380 Euros including a hotel room for the entire duration of the course and the lunches at the BRP-Rotax Cafeteria was charged.

The Student Camp focused on LCA for BRP-Rotax; the participants were divided into four groups with specific research questions, as follow:

- Group 1: 'Alternative Engine/Fuel Systems for Karts' analysed the life cycle structure of kart operation and the major factors influencing ecological performance.
- Group 2: 'Alternative Engine/Fuel Systems for Light Aircraft' analysed the life cycle structure of light aircraft operation.
- Group 3: 'Alternatives for Recreational Mobility (off-road, snow mobility, water sports)' analysed the impact of and defined major value chain characteristics for recreational mobility.
- Group 4: 'Urban Applications for Internal Combustion Engines (ICE) based on bio/syn-fuels' analysed possible future applications for ICE in urban contexts and the connected major value chain characteristics for providing syn/bio-fuels.



*BET Student Camp on Bio-fuel provision and Utilisation participant, 7 - 11 March 2016 at Guns kirchen, AT/ Credits: BPR-Powertrain*

### Conclusions

Feedback on the camp showed satisfaction from both industry and student side. Key success factors were the right mixture of students' backgrounds and progress in their studies (Master level, PhD or graduates), multidisciplinary (Engineering / Marketing / Environmental) and a clear definition of the 'real world problem' and clear deliverables for the group tasks.

Necessary requirements for an industry partner when hosting a group of 30 students for one or two weeks are a suitable infrastructure of accommodation, catering, public transport and facilities for evening sessions of the groups in the surrounding area.

It is recommended to work together closely with an experienced HEI when defining the 'real world problem' and the weekly programme which should consist of a mixture of lectures, group work, site-visit, etc. Presentations by Industry experts on their business fields were much appreciated and are essential for the follow-up group tasks.

An important lesson learned during the camp was that it is essential that the students have not only access to their academic partners but also to the industry partners. This was achieved by having a 'question board/ topic saver' for the industry partner which was filled up by the students during the day, and either on the same day or the next morning these questions were reviewed and discussed with the students.

It is a challenge to find a balance between 'delivering' and 'learning'. Students usually prefer more learning lectures, whilst the industry is after the maximum output from the camp. To gain maximum profit from such a camp the industry needs to consider not only the benefit of generating solutions to real world problems in a short time scale but also: a) creating relationships for the future with universities, and b) creating recruitment opportunities (involving the HR department).

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## **Case Study 4 Lifelong Learning with the ‘Education and Training Paths by WKO’ (Austrian Economic Chambers)**

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### **Overview**

#### **Background**

Most young school leavers in Austria attend vocational training as a preparation for their further career after finishing compulsory school. It is supported by an Initial Vocational Education and Training (IVET).

#### **Methods / Case study description**

The case study describes a national example of lifelong learning: the ‘Education and Training Paths by WKO’ (Austrian Economic Chambers).

#### **Results**

The programme ‘Education and Training Paths by WKO’ offers effective educational options oriented towards a needs-based and end-to-end approach. Thus possibilities for adequate qualification are offered in order to educate highly skilled future professionals.

#### **Conclusions**

The author considers education and training paths by WKO to be a useful addition to traditional education.

#### **Keywords**

Vocational Education and Training (IVET), Apprenticeship programme, Apprenticeship occupation, National Qualifications Framework (NQF), Lifelong learning, Education and training paths.

### Background

#### Initial Situation

IVET is an important instrument to educate young school leavers in the tenth school year in Austria where it has a long tradition [1]. After completing their compulsory school period, about 35% of young people in Austria are trained in a trade requiring an apprenticeship, another 41% opt for a VET school or college. This means that about 76% of Austrian pupils follow a vocational and training pathway (see Figure 1).

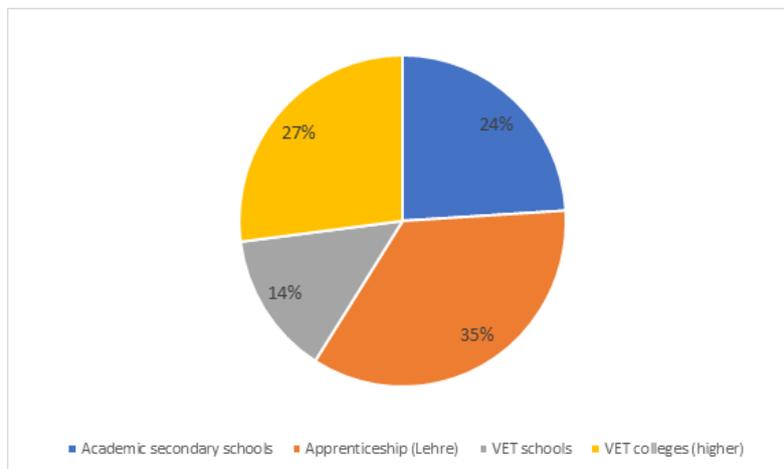


Figure 1: Respective share of young people in educational systems in year 10 (school year 2015/16) [2]

### Methods / Case Study Description

#### The Problem – Increase the Attractiveness

Substantial changes – digitalisation, for one – pose huge challenges for individuals and organisations. At the same time numerous opportunities to improve education standards arise. Education and training paths were designed and established by the WKO to pave the way. They specifically give attention to areas where skilled professionals are needed and point out options for professional and personal development for numerous industries.

According to surveys carried out by the WKO, approximately 90% of the Austrians consider lifelong learning as very important. Furthermore, 77% attach increasing importance to the permeability of educational pathways.

In order to increase attractiveness and to enable the systematic continuation of educational careers, the programme 'Education and Training Paths by WKO' [3] was developed. This programme provides end-to-end opportunities in education and training which promote lifelong learning and the continuing expansion of competencies. This system undergoes a continuous development process, as standing still is not an option when it comes to remaining one of the best in the field.

### Results

#### End-to-End Education and Training Paths to Success

The National Qualifications Framework (NQF), which was enacted as Federal Law in 2016, provides the means for making formal and non-formal levels of education comparable. Qualifications and competencies are becoming transparent – no matter where and how these qualifications have been achieved. This transparency and the equal value of educational content strengthen vocational education and training and underline its status as educational system in its own right besides general and academic education.

In line with the NQF and complementing the public educational system, the programme 'Education and Training Paths by WKO' offers needs-based, end-to-end and effective educational options which provide possibilities for adequate qualification in order to educate highly skilled future professionals.

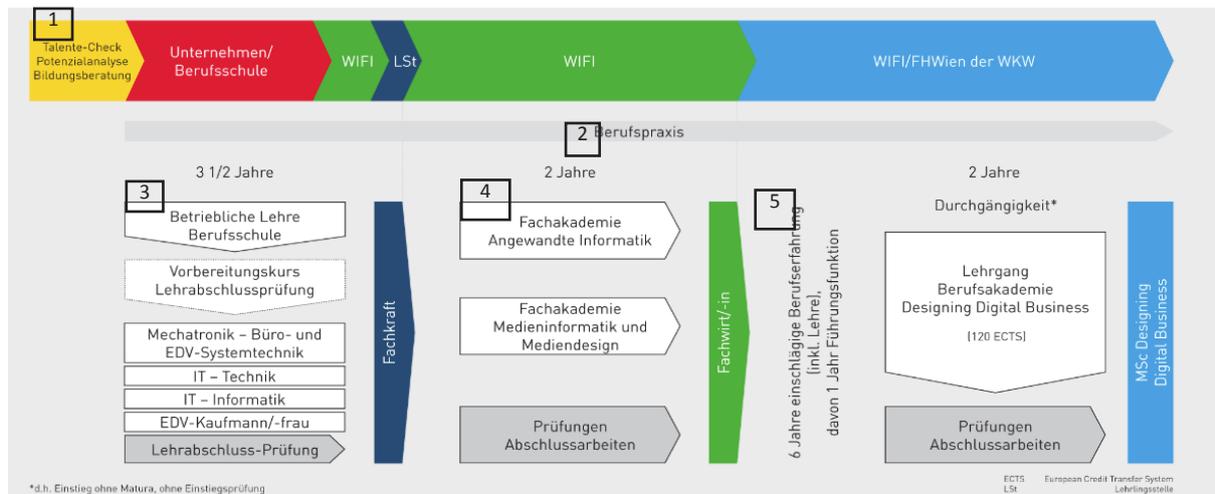
#### Conclusions

The options offered by the programme 'Education and Training Paths' were provided by WKO in a specific sequence. Starting with talent checks, analysis of potential and vocational guidance provided by the Austrian Economic Chambers, the education and training paths support both the professional and the personal development of skilled professionals in Austria.

The WKO education and training paths are as flexible as the requirements professionals are faced with and as distinctive as their preferences. They enable innovative and transparent further education and training which create numerous and diverse perspectives and possibilities.

More than 100 of these educational paths have been developed so far in Austria. The following graphic shows an example of such an educational path (see Figure 2):

# Case Study 4 Lifelong Learning with the 'Education and Training Paths by WKO' (Austrian Economic Chambers)



## Translations

1: Talente- Check, Potentialanalyse, Bildungsberatung = Talent check, potential analysis, educational guidance

WIFI = Business Promotion Institute

FHWien der WKW = University of Applied Science (Austrian Economic Chambers,Vienna)

2: Berufspraxis = professional practice

3: 3 ½ Jahre = 3.5 years

Betriebliche Lehre, Berufsschule = Initial vocational education and training

Vorbereitungskurs Lehrabschlussprüfung = Preparation course for apprenticeship-leave examination

Mechatronik Büro- und EDV-Systemtechnik = (Mechatronic engineering?)

IT-Technik = Information technology

IT-Informatik = Computer technology

EDV Kaufmann/-frau = IT expert

Lehrabschlussprüfung = Apprenticeship-leave examination

4: 2 Jahre = 2 years

Fachakademie angewandte Informatik = Advanced technical college for applied computer science

Fachakademie Medieninformatik und Mediendesign =Advanced technical college for media informatics and media design

Prüfungen, Abschlussarbeiten = Exams, theses

Fachwirt/-in = Expert

5: 6 Jahre einschlägige Berufserfahrung (inkl. Lehre), davon 1 Jahr Führungsfunktion = 6 years of relevant work experience (including apprenticeship), at least 1 year in a management job

2 Jahre Durchgängigkeit = 2 years continuity

Lehrgang Berufsakademie = (Professional training course)

Figure 2: Training paths developed by the Austrian Economic Chambers

### Conclusions

#### Unprecedented Opportunities through Vocational Education and Training in Austria

Having absolved an apprenticeship, skilled professionals can achieve high professional positions and educational levels – and even meet university entry requirements.

#### From Apprenticeship to the Highest Educational Levels

The education and training possibilities offered by the programme “Education and Training Paths by WKO” enable skilled professionals to pursue high-quality education goals and career paths – in line with their needs, the requirements defined by the business community and the demands of specific industries. They provide opportunities for careers in numerous industries and fields of work but have one common feature – after having completed one stage of education in a given path an individual is entitled to start tackling the following stage in the respective path.

The WKO continuously develops new needs-based education and training paths and publishes them on a platform [4]. Many of these paths start with an apprenticeship programme. This frequently lays the foundation for a professional career that offers excellent perspectives. Completion of an apprenticeship programme is the most common basis for achieving entrepreneurial and management jobs. Approximately 40 per cent of all top management jobs in the business community are held by professionals who started their education in an apprenticeship programme.

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# Case Study 5 Professional Online Learning at InnoEnergy – A lean Approach to Creating activating Online & Blended Learning

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## Overview

### Background

Digital education services are massively spreading in the form of instruments like MCQs, MOOCs and SPOCs. Numerous efforts in the realisation of the graphical output in turn leave open gaps in the research-based principles for effective pedagogy.

### Methods / Case Study Description

The case study describes an existing professional online learning system developed by InnoEnergy. It discusses a professional digital education service and the passive role of learners.

### Results

For the planning of the digital learning design of project partners a digital course canvas was implemented in the design. This included the development of guidelines for a more active and outcome-based learning environment to meet quality requirements set at the beginning of the project.

### Conclusions

The new process allows a higher degree of control over the collaborative production process, to get quicker results and market response based on real end user feedback and to lower the financial risk.

### Keywords

Professional digital education services, Learning technologies, Massive Open Online Course (MOOC), Small Private Online Course (SPOC), Course development projects, Collaborative production process.

## Background

Under the umbrella of its professional digital education services, the Institute of Sustainable Energy (InnoEnergy), supported by the European Institute of Innovation and Technology (EIT), promotes the development of online courses, mostly in the form of MOOCs (Massive Open Online Course) and SPOCs (Small Private Online Course). Traditionally, the production of MOOCs and online courses involved a long development process and bringing them to the market only at the end of the full development cycle often meant the end result did no longer meet the actual needs of the target audience.

Furthermore, the focus in many MOOCs on the use of instructional video combined merely with Multiple Choice Questions (MCQ) testing knowledge favours a traditional teacher-directed instructional approach, in which the learners take a mostly passive role in their learning process. Many affordances of learning technologies for learner activation and innovation are thereby underexploited and research-based principles for effective pedagogy are ignored. In the course creation process, most of the resources are spent on video production to the detriment of a carefully planned learning design.

## Methods / Case Study Description

### Lean Course Production Approach

In order to avoid any future mismatch between demand and offer and to have a higher degree of control over the course development projects that it supports, InnoEnergy has started implementing a lean course production approach. This approach provides a framework for ensuring the EIT label quality requirements for active learning and aligned teaching are met throughout the development process in collaboration with InnoEnergy partners.

Lean production implies the implementation of shorter and iterative development cycles where the production of a minimum viable product allows teams to bring a product to the market at a much earlier stage and to get feedback from potential target users very early in the process. This feedback helps to define the value for the customer and at the same time to reduce 'waste' (e.g. by developing contents or features for which there is no real demand, i.e. no value). A central objective of a lean approach is that nothing is created unless the customer asks for it. So the question is how this fits into an educational context.

In the present case study the following 6-step process for course development projects was implemented (Figure 3):



Figure 3: 6-step process for course development projects

The first course proposal step consists of performing an analysis among an identified target audience of the need for training on an innovative subject. The aim is to define the target customers and to identify the value they attach to the proposed training to develop a product that best addresses that value. In order to define the business opportunity, desk research is complemented with the development and testing of a minimum viable product, usually in the form of a webinar facilitated by subject matter experts. Marketing actions to promote the webinar are launched in this early stage. For a high-level planning of the digital course design, during step 1 the digital course canvas is filled in and included in the webinar contents. This webinar try-out creates a first feedback loop that allows the project team to evaluate and revise course concept, approach, contents and marketing.

## **Case Study 5 Professional Online Learning at InnoEnergy – A lean Approach to Creating activating Online & Blended Learning**

Proposals that pass the viability evaluation at first stage gate are invited to elaborate a detailed project design for the full development of an online course offering during step 2. This includes a project risk and mitigation plan and a definition of roles between all parties involved. The degree of InnoEnergy support depends on the outcomes of the digital learning readiness scan at the first stage gate review. During this step, the digital learning design of the course is planned into detail, and validated at the 2<sup>nd</sup> stage gate together with the project plan and revised market value proposition before the start of the development of a first test module.

During this partial development and test release phase professional video lectures and learning and assessment activities are produced and implemented in the online delivery platform. Marketing actions (including a video teaser) are set up to attract learners for a partial course release. Through an online or face-to-face (F2F) training offering such as a bootcamp, the learning module is tested with a friendly audience to gather feedback. As in the previous stage gates, results are presented to an InnoEnergy 'Asset Owner Support' committee before launching the full project execution or course production on the basis of the test module and proposed changes. Frequent project meetings with InnoEnergy are organized for a close follow-up and quality evaluation, as well as to enable coordinated marketing actions.

A pilot-run of the full course at step 5 allows both the project partners and InnoEnergy to evaluate the outcomes based on the activity data of full learner cohorts and make amendments to the course contents and promotion.

The final release step is defined as the first public course run, involving continued course facilitation, user management (now including certification), course promotion and feedback loops.

For each step, InnoEnergy follow-up is ensured and an instructions package with support documents and methodologies is provided such as the Role and Responsibility Charting (RACI) roles matrix and the course canvas which will be elaborated in the next step.

### **Results**

#### **Digital Course Canvas**

To enable project partners to start planning the digital learning design from the start of the production process, a digital course canvas was developed based on the well-known business canvas by Osterwalder [1] and adapted from the University Carlos III of Madrid's MOOC canvas. Criteria for active learning and aligned teaching advocated by InnoEnergy were incorporated. This one-page overview provides course partners with a planning tool, requiring them to reflect on a balanced learning design and to align its different components. It also supports the dialogue around design, production and course facilitation both internally, with all parties involved in the development process, and with InnoEnergy (see Figure 4).

# Case Study 5 Professional Online Learning at InnoEnergy – A lean Approach to Creating activating Online & Blended Learning

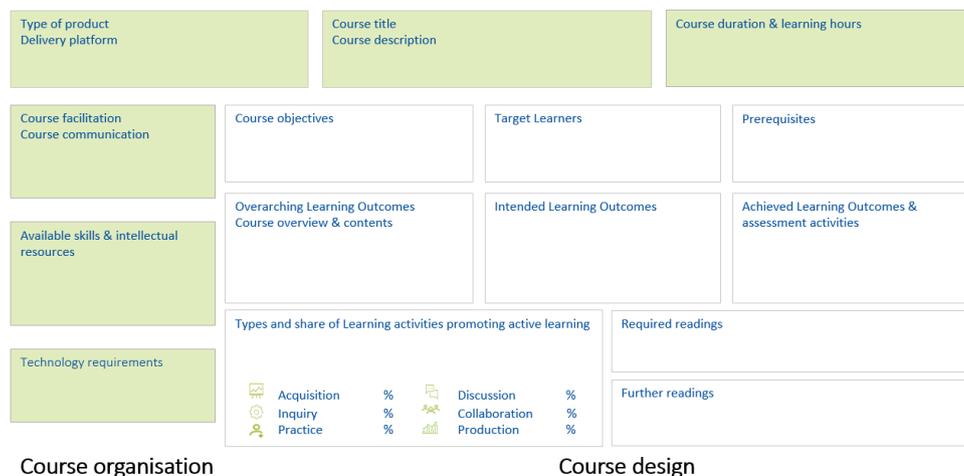


Figure 4: Dialogue around design, production and course facilitation

The green building blocks contain information about the organization of the course such as the type of product and chosen learning platform, the course duration and total planned learning hours and the human and technological resources that are at the disposal of the course development team or of which some might need to be outsourced. The white boxes refer to course design choices, starting with the learning objectives of the course or its central storyline (what’s in it for the learner), the description of the target learners and requirements for taking the course. Central to the design is the definition of overarching and specific Intended Learning Outcomes (ILOs) to be formulated in clear and measurable language aligned with an assessment strategy that can establish if and to what extent the learning outcomes have been achieved. Together with the canvas, clickable instructions and references to support tools are provided, as well as tips for implementing effective pedagogical practice. Examples of support tools are a link to Bloom’s taxonomy with associated action verbs for writing ILOs for all cognitive skills and a checklist of quality criteria for instructional videos.

Video lectures are typical examples of learning through acquisition. However, digital learning environments and technologies are also particularly well-suited for different and more activating learning experiences, more specifically for learning through inquiry (e.g. investigate alternative online resources to reflect on what you have learned), through practice (e.g. exercises, simulations), through discussion (e.g. discussion forum assignments), through collaboration (e.g. project wiki, virtual reality) and through production (e.g. develop prototype as outcome of challenge assignment, blog) [2].

At the example of the learning designer tool of the UCL Knowledge Lab [3], course development teams are invited to define the types of learning activities they plan to develop and to indicate the approximate share of each type in the entire course. Different types of learning will lead learners to more active learning and to engaging with others to different extents (learner-content interaction, learner-tutor interaction, learner-learner interaction). By quantifying the distribution of types of learning in the course canvas, pedagogic decisions (e.g. to offer more collaborative learning or more active learning at the expense of lectures) are represented in an explicit way [4].

Finally, the last elements of the course canvas refer to the types and contents of required and optional reading material.

The course canvas is used during step 1 for a first draft planning and further elaborated into detail after the webinar feedback during step 2, complemented with a course outline with ILOs at module and lesson levels. From step 3 onwards it serves as a blueprint (but still subject to change) for the further course development shared by the different course team collaborators.

### Conclusions

InnoEnergy's aim of implementing a lean approach to online course production was to develop guidelines for conforming to the EIT label requirements of more active and outcome-based learning. By focusing on learning design we want to provoke a more explicit reflection about variety and balance in learning and assessment activities to be included in online courses and to interact more explicitly about quality requirements to be met from the start of a project.

The new process allows us to take a higher degree of control over the collaborative production process and to get quicker results and market response based on real end user feedback. As such, in the end the approach also leads to lower financial risk.

Of course, this transformation will require more resources and involvement from InnoEnergy as an organisation. To build a solid EIT InnoEnergy© education brand, a coordinated effort including evaluation and quality assurance, more intense communication with developing partners and a well-aligned marketing strategy is needed.

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# Case Study 6 How Learning Materials based on regional Challenges can help to build Communities for the Energy Transition

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## Overview

### Background

The development of a sustainable resource use is linked to solar income. Fed from this the surface-limited but renewable bioresources play a key role in the race to conserve the natural environment. Awareness must also be raised for the suitability of bioresources for the provision of various goods and energy as well as the regionally diverse availabilities and potentials of bioresource. For a practical implementation of bioresources in sustainable development business activities must be stronger linked with know-how and innovations on bioresources.

### Methods / Case study description

This case study includes a desk research on bioresource use and observes case studies carried out in the course of the BioEnergyTrain (BET) project.

### Results

The realisation of a sustainable development urgently needs a prioritisation of resource use like the example of second generation biofuels shows along with an adequate implementation of policies.

### Conclusions

Fostering interactions between knowledge hubs and business throughout regions and an orientation on best practice examples shall link the attention to the development of the adequate integrated education system.

### Keywords

Energy Transition, Bioresources, Community Building, Conservation of Natural Environment, Integrated Education System, Sustainable Resource Use.

## Background

Bioresources provide various materials of biological origin for products and services such as food, energy, paper, durables and other products, as well as leisure, tourism, education and other types of services. The bioresources are widely considered to be non-exhaustible renewable resources because residues disposed after the use into environment recreate new cycles of life and replenish biodiversity as soil fertilizers for plants, food for animals, enrichment of ecosystems, storage of greenhouse gases and other pollutants and various other functions in nature. In addition to the functions in nature, the bioresources can satisfy demands for products and services in a more sustainable manner compared to rivals based on the exhaustible, non-renewable minerals and fossil fuels which cannot be recreated within the framework of human history and do not recreate cycles but dissipate after use as waste and pollution. The use of bioresources for the production of bioenergy can contribute to a strengthening of the regional economy, less fossil and nuclear energy consumption, pollution reduction and biodiversity due to innovations generated by linking entrepreneurial activities with sound know-how on bioresources as aimed by the project BioEnergyTrain (BET).

### A challenge

Bioresource-based products cover about 30% of all global material consumption compared to about 50% minerals and 20% fossil fuels whose shares are growing [1]. A faster growth of bioresource production and consumption than the present 2.2% annual average would mitigate climate change and reduce waste and pollution, but experts also have doubts about the development of bioresources with regard to the limited space on earth. It is pinpointed that nearly 29% of all available biomass above ground is already captured for human uses leaving little living space to all other species, which risks extinction of species and degradation of ecosystems [2]. Economics also deteriorate as the agricultural production is locked-in into cultivation of monocultures on huge areas of land that deliver low-value biomass: the global value has increased by only 0.7% a year compared to the biomass increase by nearly 2% mainly due to more inputs of costly mineral fertilizers and persistent pesticides. The monocultures expand at a similar rate as the decrease of forests with high biodiversity because the natural forests are cleared [3]. This pattern delivers cheap biomass for the material-intensive products but undermines ecosystem qualities that are demanded for valuable services in tourism, education, arts and other knowledge-based services although the bioresource-based services outperform the agriculture: the value of international tourism alone is larger than agriculture, it grows four times faster and the services capture less space.

New patterns emerge aiming to satisfy demands for bioresources along with biological diversity. In energy, innovations invoke the decarbonization of energy resources due to substitution of coal, oil and gas for modern renewable energy based on bioenergy, geothermal, wind and solar resources along with the valorisation of energy products through substitution of fuels for electricity entailing distributed energy systems with storage. Experiences show that sustainable innovations generate more valuable and effective material use when education and knowledge are fostered and policies support innovators rather than vested interests [4]. Bioresource production and consumption for energy represent new areas for sustainable innovations; how to foster these is a real challenge.

### Innovative shifts

Focus on the bulky biomass deliveries detracts attention from opportunities of higher value products in better balance with biodiversity. Fostering balance of biodiversity with biomass is even pressing in the European Union where the total agriculture value does not increase despite larger biomass production and destruction of biodiversity. Differences within the European Union also enable the exchange of experiences and the generation of know-how about various innovative opportunities. While the biomass production is high in most West European countries decrease in biodiversity is deplored, whereas many regions in the Eastern and Southern European countries generate lower biomass production but maintain rich biodiversity and attract more bioresource-based services. Regional differences within the countries also exist, such as extensive ecological farming next to intensive husbandry. Present preoccupation with the bulky biomass production can turn toward downscaling of technologies for the diversity of services entailing higher productivity measured by value rather than by mass, including the bioenergy production due to reuse of low-value residues.

The downscaling of bioresource technologies implies that no size fits all. Having no silver bullets in hand, in contrast to mitigation of climate change with tangible solutions and policies, a broad range of innovative options should be facilitated. Various options for the downscaling can be mentioned based on experiences in the European Union. The capital-intensive horticulture, for instance, in the Dutch businesses, is productive and low polluting if greenhouses are well-managed with closed loops of minerals and high energy efficiency. Localized forestry, for example, in the Romanian villages, delivers valuable wood and non-wood products along with bioenergy to villagers that have few

energy resources. Ecological agriculture flourishes, for instance, in many Italian regions, and generates local quality foods and other ecosystem services based on regional biodiversity enrichment of soil with residues and local deliveries of bioenergy. Urban and local gardening, for example, in French towns and cities, is a trend for deliveries of meals and leisure, which enriches urban ecosystems and fosters public health. Residues of pulp and paper production in the Finnish industries generate chemicals and bioenergy with contribution to the business bottom-line. Agricultural diversification into the organic fibres for industries and constructions emerges, for instance, in Germany, which generates high-value bioresources that can substitute hazardous chemical compounds. Given the variety in climatic and ecological conditions across Europe, regional specializations can be promoted rather than uniformity in the bioresources production and land use. The diversified approach to bioresources enables innovation for novel products. Biobased housing, for instance, gains popularity, consumption of wooden furniture grows, fibre-based textiles are under development, afforestation increases in several European countries, natural parks generate high income from leisure services and so on. Many other opportunities and valuable initiatives can be added. These examples illustrate that more and higher value of biomass production is possible along with care for biodiversity. High-value bioresource-based products generate residues needed for bioenergy.

### Bioenergy

The global biomass production for solid, fluid and gaseous bioenergy products exceeds a 130-million-ton oil equivalent (it is 5,451 PJ or 1,514 billion kWh) which covers about 10% of the global energy consumption. The share is about half as low in the high-income countries whose energy consumption grows slowly or decreases as it does in the EU and the US. Bioenergy covers up to about 80% of all energy consumption in lower-income countries whose energy consumption grows faster than bioenergy [5]. In the EU, bioenergy production covers about 12% of all energy consumption but there are large differences between the countries. For instance, the production in Latvia, Estonia and Finland can cover more than one third [6] of all energy consumption whereas in Malta, Cyprus, Ireland and Luxemburg less than 5% can be covered with bioresources, and the annual average growth of bioenergy production of 5% in the European Union varies from 1% in Portugal to 13% in Hungary. The EU domestic production largely covers its needs for bioenergy; about 11% of all bioenergy consumption is imported, while 7% of all production is exported. Within the EU, Germany and the Czech Republic, for example, have large growing deficits while Poland and France have large growing surpluses. More energy-efficiency in the EU, for instance, due to insulation of housing and electrification of mobility as envisioned in the European policies, could reduce the imports and deficits.

The cultivation of biomass for bioenergy (1<sup>st</sup> generation biofuels) is rarely attractive within the EU because the value of bioenergy is lower than many other bioresource-based products as food, fodder and industrial applications. The cultivation for bioenergy adds to the land capture but having even low-production value it triggers rent-seeking behaviour entailing corruption and cheating aiming to cover up the excessive costs along with undermining of smallholders' income and destruction of ecosystems and environmental qualities. The cultivation for bioenergy adds to the land capture, but, having even lower-value than foods and other products, it triggers corruption to cover up the excessive costs and the destruction of farmers' income and environmental qualities. This has been made possible through massive subsidies for cultivation and tax-free biofuels. The cultivation is profitable only on the local scale when land is abundant and transport cheap, for instance, for markets in remote areas where the conventional energy deliveries need costly infrastructure.

The use of biomass residues for bioenergy is more promising. These so called 2<sup>nd</sup> generation biofuels are a large resource because of wasteful practices in agriculture, industries and households. The biomass residues are generally disposed

on land. About 1.4 billion tons a year of manure are produced and largely disposed of on land despite there is already a measurable (over-)saturation of soil and water with nitrates, phosphates, medicine, hormones and other hazardous compounds. In addition, about 20-million-tons of organic waste from households are landfilled or incinerated despite emissions of greenhouse gases that cause climate change. 244 million tons of agricultural residues are burned despite air pollution. 4 million tons of highly polluted sludge are disposed of on land entailing soil and food contamination. Although the disposal of bioresidues is sometimes believed to contribute to soil enrichment it usually causes an excess of nutrients entailing permeation through soil to pollute groundwater and surface water. Reduction of such disposal would generate bioenergy and reduce the high social costs of pollution.

Kerbside collection rather than disposal enables the reuse of organic waste for energy or compost. Sludge can be digested for biogas instead of being disposed of on land. At minimum, one quarter of the manure can be used for bioenergy rather than being spread around on land. Wood and agricultural residues can be reused for bioenergy instead of being burnt and industrial waste can be processed. Based on the conservative assumptions about the present surplus of biomass and widely available technologies for bioenergy production it should be possible to generate an additional 67-million-ton oil equivalent of bioenergy along with better soil and water quality (because less polluted) as well as to prevent some greenhouse gases. This estimation approximates about 50% of the present bioenergy production and 34% of 195-million-ton oil equivalent targeted by the European Commission for 2020; the latter is higher than the 7% assumed in the Commission's White Paper that unreasonably excludes manure and agricultural waste [7]. In addition to the reuse of waste for bioenergy, pilots on cultivation of algae and fungi show promising results for high-value products. The results show possibilities to generate bioenergy as side-product when industrial scale is reached. This 3<sup>rd</sup> generation of bioenergy generates valuable products and biofuels, which adds to the industries' and farmers' income.

### Methods / Case study description

This case study reflects on the development of bioresource use by observing the background and the case studies carried out during the project BioEnergyTrain (BET).

### Results

#### Know-how

Policies can be supportive to the sustainable development of bioresources, in particular, to bioenergy, if they change focus. The European policies are biased by preoccupation with scarcity of food and other basic products as experienced in the past during a few decades after the First and Second World War. To prevent food scarcities and hunger these policies support maximization of agricultural biomass with infrastructure, financial aid to farmers and know-how support. This policy has been very successful so that we, in the present period of abundance, have to face the fact that bioresources are massively wasted and excessively consumed entailing environmental and health problems such as obesity that has become the number one disease in Europe. Policies support the biomass production based on uniform, low-value and low-quality products by subsidizing the output maximization with € 63 billion a year [8] and by invoking excessive food consumption through low-VAT and other policy instruments. These policies also encourage wasteful practices by supporting infrastructure for low-value products rather than fostering diversity of bioresources based on the regional specializations and localized bioresources production on marginal lands in remote areas. They also trigger the lock-in abroad by subsidizing imports of biofuels and compensating for losses of farmers' income and subsidizing food prices because the production of crops for bioenergy rivals' farming.

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In the present age of abundance in Europe, the European policies should turn toward the diversification of bioresources for biobased products and biodiversity services rather than maximize the biomass production. The diversification can be reached by setting of far reaching targets and introduction of instruments that enforce payments and compensations for the social costs of health and environmental damage. The funding within the framework of the common agricultural policies can be shifted towards regional specialization in the diversification of bioresources and biodiversity services. The authorities of the EU should also be regionally decentralized because sector-related authorities tend towards impeding innovations and protecting vested interests. Regional and local organisations, due to such support, would be enabled to attain solutions that match their specific circumstances and foster the democratic decision making.

### Conclusions

Within this framework, the regional know-how about bioresource production can contribute to the support of biodiversity. This development requires education and dissemination of knowledge that is usually concentrated in urban rather than in rural areas. Moreover, know-how is developed due to interactions between experts and entrepreneurs, which usually evolves in the urban hubs, such as universities and science centres. Fostering such interactions within and across regions is possible if the interregional funds, structural funds and other regional instruments are focused on sustainable innovations. There are successful experiences in innovation cooperation between knowledge centres and entrepreneurs within regions and in clustering of stakeholders for bioresources, such as the Styrian Energy Agency (AT) and the Romanian Green Energy Cluster (RO). These experiences indicate that urban-rural networking generates diversified, innovative production and consumption of bioenergy. Creating adequate engineering and managerial education and generating knowledge capabilities on bioresources strengthen such regional practices. Master's degrees achieved within the BioEnergyTrain project support such cooperation because such education links engineering skills with management capabilities and policy making.

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## **Case Study 7 Benefits and Requirements for Regional Administration from Co-operative Learning Formats with Higher Educational Institutes (HEIs)**

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### **Overview**

#### **Background**

Regional administration wants to intensify co-operation with Higher Educational Institutes (HEIs). Administrations expect benefits from an integration of education and practice towards a sustainable bioeconomy and set requirements for its implementation into practice.

#### **Methods / Case study description**

The case study discusses the holding of a Student Camp on regional challenges in bioeconomy in Austria as well as a master's thesis mediation in Romania.

#### **Results**

A discussion based on a case study about a regional Student Camp in Austria and a bachelor's, master's and PhD theses mediation in Romania showed requirements and benefits for regional administrations from co-operative learning formats with HEIs. This discussion is also supported by a special review which describes experiences and potential benefits of joint co-operative learning formats with HEIs and regional administrations and other participants.

#### **Conclusions**

Regional administrations as well as HEIs benefit from the implementation of the cases. This includes an increased exchange between regional actors, researchers and students resulting in unconventional ideas and innovative solutions for regional problems and in recruitment opportunities.

#### **Keywords**

Higher Educational Institutes (HEIs), Sustainable bioeconomy, Student camps, Regional challenges in bioeconomy, Regional administration, Recruiting young and motivated human resources.

### Background

Linking education to practice was identified as most crucial for enhancing a sustainable bioeconomy in Europe. The focus of the BioEnergyTrain (BET) educational concept was to implement co-operative educational formats between industry, public authorities, regional administration and HEIs.

The industrial sector already uses PhD and master's theses as well as projects and excursions with HEIs for tackling their daily life challenges and for recruiting young and motivated employees. Although these co-operation possibilities with HEIs are already well exploited within industrial spheres, the co-operation potential between HEIs and regional administration actors is still not fully exploited. This leads to the discussion why regional administration co-operative learning formats should join with HEIs and what first experiences and potential benefits for all participants are.

### Methods / Case study description

This case study describes two successful examples of co-operative learning formats (regional Student Camp in Austria and bachelor's, master's and PhD theses mediations in Romania) and tries to answer the research questions.

#### Case 1: Student Camp on regional Challenges in Bioeconomy

The BET regional Student Camp was held in February 2018 in Graz (AT) and was implemented by the Energy Agency Styria (AT) in co-operation with the University of Twente (NL), the Graz University of Technology (AT), the Styrian regional government (AT), the Styrian Chamber of Agriculture (AT) and with BioEnergie Mureck (AT), a regional company.

The following four challenges were processed by 23 students (from 12 nations and four universities) in four groups within one week (26.02.2018 - 02.03.2018):

- Challenge 1 by the Government of Styria/Department for Energy and Building: 'Accomplishing Climate Protection Goals' – design of an implementation strategy of Styria's climate protection targets.
- Challenge 2 by the Styrian Chamber of Agriculture/Austrian Biomass Association: 'Biomass – Reaching the Masses' – design of an effective/positive image campaign for energetic use of biomass.
- Challenge 3 by BioEnergie Mureck: 'Circular Bio-Economy Mureck – Continuously innovative' – design of an extension concept for bioenergy facilities in the municipality of Mureck.
- Challenge 4 by the Government of Styria/Department for Waste Management and Sustainability: 'Bio-based Products from Municipal Solid Waste' – find new products made of organic residues from municipal waste.

In the initial phase of the planning of the camp, the most demanding challenge was to find partners who faced challenges where input coming from students was thought to be relevant and who were willing to join the educational format. In the end, the outcomes of the challenges were highly satisfying for all participants. The camp schedule developed in co-operation with the participating HEIs consisted of a mix of short introduction, excursion, group work and question and answer sessions (Q&A). The net time for group work on the challenges was from Tuesday afternoon until Thursday evening.



*Participants to the BET Student Camp in Graz, AT, on February 2018/ Credits: eseia*

The costs for the camp, approximately € 7,000 for accommodation, lunch, excursion and final presentation, were covered by the participation fees (60%) and the co-operation agreements with the four regional administrative institutions (40%). Personnel costs of the Energy Agency Styria, the University of Twente and the Graz University of Technology were covered by the H2020-funded project BioEnergyTrain (BET). In order to implement such a Student Camp after the BET project's lifetime, it will be necessary to provide a sustainable 'business case' to cover the personnel costs.

### **Case 2: Use of Bachelor's, Master's and PhD Theses Mediation fo solving regional Challenges in Romania**

In Romania, the Green Energy Romanian Innovative Biomass Cluster (BIO-C) was established in 2011 with the aim to link business, research organisations, universities and the public sector in order to enhance co-operation and to spread knowledge. By means of various projects the cluster intends to contribute to the development of the bioenergy sector and especially to the creation of integrated community-scale bioenergy projects.

## **Results**

### **Recommendations and Requirements based on Case 1**

The following recommendations and requirements can be defined in terms of camp structure, mix of students, learning formats and challenge definition:

- Strong motivation of students mainly arises from 'real-life challenges', where problem owners are interested in solutions and their implementation.
- Problem owners must show strong commitment throughout the whole process (being present at organisational meetings, first camp day, daily Q&A sessions and final presentation) and invest time (up to one or two working weeks).
- The challenge must be defined clearly. Problem owners must prepare their presentation in co-operation with

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academic supervisors and define a precise task. Q&A sessions with the problem owners (in person or via phone) are important for students' progress and must be arranged on a daily basis.

- Half of the participants felt that there was not enough time to meet the challenges – this impression is strongly correlated with insufficiently prepared challenge definitions. When the problem is explained and defined unambiguously, two and a half days of net group work are adequate.
- The final presentation with representatives of all problem owners in a festive atmosphere was experienced as additional motivation. It is essential for motivation that the students' efforts are recognised and appreciated.
- It is important to achieve a well-balanced mix of students. Various disciplines such as architecture, economics, psychology, chemistry, marketing, and engineering should be combined – this allows students to 'think out of the box' easier. 85% of the participants confirmed this to be beneficial for all the parties involved.
- The organisation of accommodation and lunches proved to be very complex and costly. Moreover, the fees turned out to be barriers for the students. It is, therefore, advisable to waive the organisation of such services and to offer the format without participation fees. However, this means additional responsibility for the students in terms of independent organisation of accommodation and lunches. Therefore, the organisational team should support the students by providing appropriate suggestions.

As described in Case Study 2 'BET and co-operative learning formats' by Arentsen, Kienberger and Bauer, this format provides a new way of education and links HEIs with non-industrial co-operation partners. Student camps expose students, teachers and external co-operation partners to a new and highly motivated working atmosphere and thus encourage new ways of thinking. The fruitful results of the camp form the basis to foster new co-operations with regional, non-industrial actors and to provide manifold new perspectives and insights for all participants.

### Contribution of Bachelor, Master's and PhD theses mediation based on case 2

The efforts of linking HEIs and regional administration were further extended. Up to now three bachelor's theses, four master's theses and five PhD theses were already completed in co-operation with regional authorities within the BET project's lifetime. The mediation of theses is carried out by BIO-C which functions as interface for HEIs and the public sector (PS). The cluster connects the regional public challenges and problem definitions of PS with HEIs and students in their network. One successful example of a recently conducted master's thesis is the one written by Mrs. Bálint Melinda, Babeş-Bolyai-University Cluj, in co-operation with the municipality of Lupeni, situated in Harghita County, Romania. The thesis focuses on the quantification of biomass potential in the region with an agricultural area of 8,764 hectares and woodlands of 3,238 hectares. The calculations are based on data sets coming from National Institute of Statistics Romania, the local mayor's Office, the local Agriculture Office, the local Veterinary Office, RDE Ltd. waste management company and the local Forestry Office. Since the calculation of local biomass potential was supported by the local Forest Owner Association, several local decision-makers and stakeholders were involved. A questionnaire survey was carried out in order to assess the awareness level about renewable energy sources and willingness of the local decision-makers and stakeholders for a biomass-based district heating system in the municipality of Lupeni. In total, a usable energy potential of 161,825 Terajoule per year was calculated for the municipal area of Lupeni. The calculations of the amount of the local biomass energy potential have shown that 25% of the potential comes from wood waste, 20% from solid hay waste of grasslands and, furthermore, there is a significant biogas potential provided by local beef farms. Additionally, the local public perception of renewable energy, especially of biomass energy was analysed based on a survey with promising and positive outcomes.

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As solution for efficient regional biomass utilisation, two implementation options, including the return on investment, were presented to the regional authorities:

- Installing (wood chips-based) biomass boilers in 11 public institutions of the municipality of Lupeni,
- Installing two biomass heating systems (2.1 MW waste-wood boiler and a 1.1 MW straw boiler) and a 500 kW biogas cogeneration system.

Currently, the implementation of further measures based on the master's thesis are under discussion. The co-operation with the local communities provides learning opportunities as well as challenges for the students. In the course of this process it is important that students receive support from a superordinate institution such as the BIO-C-Cluster in Romania in order to get in contact with decision-makers and stakeholders, to collect data, interviews, advice, etc. and to carry out the theses on a successful and efficient level. By these means, it is possible that all involved parties benefit from the co-operation and build a sustainable network. Although mediation of bachelor's, master's and PhD thesis cannot be considered as quite innovative, this sort of working environment (with non-industrial partners and HEIs) is novel, since a strong superior mediator (e.g. Bio-C in Romania) is needed for communicating problems and solutions.

### Conclusions

#### Benefits for HEIs and regional administration based on Case 1 and Case 2

Several benefits for regional administration and HEIs were detected throughout the implementation process of the cases:

1. A new way of creating unconventional ideas and solutions for regional problems:
  - a. Internationality and interdisciplinarity of participants create completely new, innovative inspirations and solutions for the regional actors.
    - b. Qualified inputs from outside with a neutral view – gain of new perspectives.
    - c. Ideas from students may be discussed in political committees and may lead to new regulations.
    - d. Based on the students' ideas, specific and demand-oriented solutions can be forwarded from regional administration to relevant companies/industries.
2. Collaboration in an unconventional setting – possibility to gain opinions/feedback from new audiences on ongoing campaigns, current and future projects.
3. Co-operation within educational formats can form the base for future agreements between regional actors and HEIs (e.g. vocational training and materials, research projects or implementation of other educational formats).
4. Recruitment opportunities.
5. Regional actors get insights into the study programme and education of students and are able to give direct feedback to HEIs which creates an opportunity to develop training possibilities for the own staff.

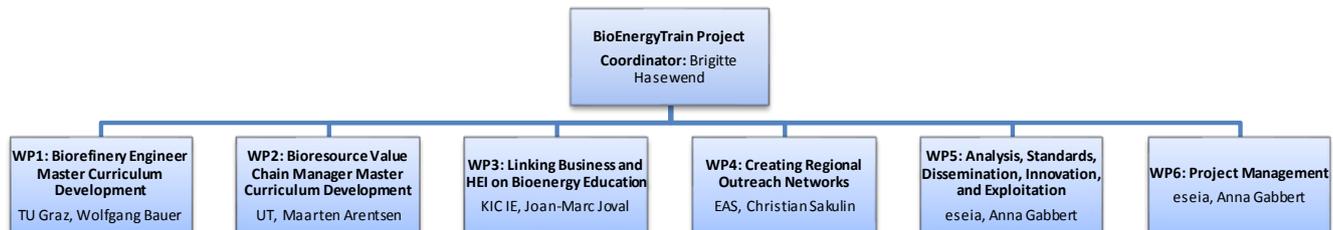
### The BET Project

The EU BioEnergyTrain project was funded in the framework of the H2020 research and innovation programme under the grant agreement N656770 for the deployment of secure, clean and efficient energy between 2015 and 2019. Coordinated by eseia, the BET Consortium included 15 international and cross-sector partners from six EU Member States. Together they created new and innovative educational formats and developed the European expertise on bioresources and bioeconomy, especially addressing technology and knowledge aspects. BET followed the strategies established by the Strategic Energy Technology Plan Roadmap on Education and Training (SET-Plan) and organised professional training events that contributed to eliminating the gap between industry and education by improving practical orientation and innovative solutions to fill out the market necessities. The BET Consortium established a network within the bioenergy value change, including research centres, universities, industry and the public sector involved in the exchange of information on educational needs.

BET project website

[www.bioenergytrain.eu](http://www.bioenergytrain.eu)

BET project on Youtube



*BET implementation structure*

### BET Results

The cooperative educational formats developed by BET partners included:

1. The two European master programmes:
  - Biorefinery Engineering at the Graz University of Technology (AT),
  - and the Bioresources Value Chain Management at the University of Twente (NL).
2. 19 BET course materials available on the e-learning platform:

<b>BET Course Materials</b>	
1 Algae Biorefineries (LNEG)	11 Bio-Resources Value Chain Optimisation (TU Graz)
2 Introduction to Biorefineries (LNEG)	12 Chemical Engineering of Bio-Based Products (TU Graz)
3 At-Line Monitoring Techniques for Microbial Processes Optimization (LNEG)	13 LCA of Bio-Resource Value Chains (TU Graz)
4 Biomass Fractionation Processes for the Biorefineries (LNEG)	14 By-Product and Waste Bioresources - Characterisation and Properties (TU Graz)
5 Cell Factories as Biorefinery Platforms for the Conversion of Non-Woody Mediterranean Feedstock (LNEG)	15 Ligno-Cellulose Bio-Resources - Characterisation and Properties (TUHH)
6 Computer-Aided Biorefinery's Processes Design (LNEG)	16 Renewable Based Energy Mixes (UTBv)
7 Novel Thermochemical Processes for the Biorefinery (LNEG)	17 Bio-Resources and Bio-Based Products (UTBv)
8 Operations Management in Bioresource Chains (LNEG)	17 Bio-Resources and Bio-Based Products (UTBv)
9 Development and Operation of Power Systems (LNEG)	19 Business Models for Bioresource Utilisation (UTwente)
10 Crop Bioresources- Characterisation and Properties (TU Graz)	

3. The three Professional Educational Formats: Interdisciplinary Student Camp, International Summer School and Pilot Plant Lab Course. In total, BET organised 9 professional training events with more than 130 participants:

<b>BET Professional Educational Formats</b>	
Student Camps	<ol style="list-style-type: none"> <li>1 Student Camp Bio-fuel Provision and Utilisation, 7-11 March 2016 at RIC BRP-Rotax (AT)</li> <li>2 Student Camp on Regional Challenges of the Bio-based Economy, 26 February-2 March 2018 at EAS (AT)</li> <li>3 Student Camp on Biorefineries and Bio-based Industrial Products, 25-28 February 2019 at Wood KPLUS (AT)</li> </ol>
International Summer Schools	<ol style="list-style-type: none"> <li>1 ISS Novel Development in Biorefineries, 18-29 July 2016 at LNEG (PT)</li> <li>2 ISS Balancing of Bio-resources and Energy Production, 25 June-1 July 2017 at UNIZAG (HR)</li> <li>3 ISS Balancing of Bioresources and Energy Production, 09-21 July 2018 at LNEG (PT)</li> </ol>
Professional Training	<ol style="list-style-type: none"> <li>1 Pilot Plant Course on Organic-waste Exploitation, 26-28 October 2016 at :metabolon (DE)</li> <li>2 Pilot Plant Course on Organic-waste Exploitation, 18-20 October 2017 at :metabolon (DE)</li> <li>3 Pilot Plant Course on Organic-waste Exploitation, 17-19 October 2018 at :metabolon (DE)</li> </ol>

4. Seven BET events, including the 2nd eseia Conference organised by TU Graz, the 3rd eseia Conference organised by TU Dublin, three BET Buying-In Events, and the BET Final Conference 9 of April 2019.

### The BET Consortium

The BioEnergyTrain project was formed by a consortium representing European Higher Education Institutions and businesses committed to the development of new post-graduate curricula in key bioenergy disciplines, as well as to set up a network of tertiary education institutions, research centres, professional associations, and industry stakeholders.

The Consortium linked these research, education and business partners along the whole value chain of bioresource utilisation in order to establish the necessary basis for a highly qualified and skilled workforce in the field of bioenergy according to the recommendations of the SET-Plan.

The structure of the BET Consortium enhanced the complementary skills of the partners, including the management and coordination expertise of the project coordinator eseia.





European Sustainable Energy  
Innovation Alliance

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