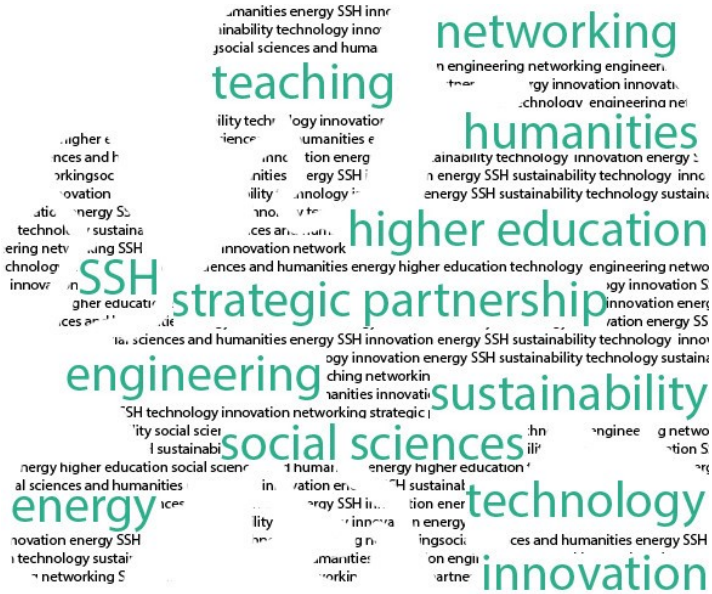
OUTPUT 1. REPORT ON RELATIONS BETWEEN SOCIAL SCIENCES AND HUMANITIES (SSH) AND TEACHING ABOUT ENERGY IN HIGH EDUCATION INSTITUTIONS PRACTICE



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The TEACHENER Project

TEACHENER aims to bring together social sciences institutes and technical universities from 4 countries with the purpose to design and validate a complex and adaptable EU teaching tool for the provision of higher education on social aspects of energy to technical students. TEACHENER project understands energy as a phenomenon interlinked with social systems and seeks to bridge the gap between technical approach of power engineering on the one hand and theories, methodologies and data of the social sciences and humanities on the other.

The integration of aspects from social science and humanities (SSH) in energy teaching is relevant seeing increasing need for science to seek for societal legitimation for research and technology development. The need to redefine the responsibility of science has been lately expressed by the demand for responsible research and innovation in EU research policy. This perspective requires consideration of ethical questions and societal needs in research and technology development. Responsibility of science towards society needs an understanding of society; knowledge from social science and humanities can build a useful basis. It seems to be advisable to achieve basic understanding of how society and technology development are related already in the education of future scientists and technology developers. This is the starting point of TEACHENER.

This conforms to the general appeal of the Horizon 2020 to embed the later in the research agenda in a way that will maximize the returns to society from investments in natural sciences and technologies. Such embedding is only feasible if it embraces processes of higher education as a place for building new competences and creating innovations.

1. Integration of SSH issues in energy teaching – Situation on the technical partner institutions

The mail goal of the first working package and output of the TEACHENER project is to give an overview over the existing relations between SSH and teaching about energy within the practice notably about the ways of including SSH aspects into energy teaching of higher education institutions that are partner in the TEACHENER project and at institutions beyond these within the partner countries. Thus, this report documents ‘the status quo’ since it describe the situation the TEACHENER project begins from. Thus, the report identify SSH issues already present in energy teaching programs as well as forms and methods of linking SSH and energy teaching in the practice of technical HEIs. The analyses also take into account existing opportunities beyond the HEI’s programs that allow students to broaden their knowledge about SSH issues related to their energy studies, such as workshops, conferences, events outside university initiatives. Profiles of teachers dealing with SSH issues – their background, disciplines they represent – will be described.

Major aim of these analyzes is to identify existing gaps in SSH in energy teaching as well as the needs and expectations of teachers and students in energy related teaching programs as regards SSH issues. It will provide the basis for further work within the TEACHENER project.

1.1 Method of data collection

The analyses of this report are based on a mixed methods approach. This approach includes the analysis of energy related curricula, interviews (consultations) with teaching staff, PhD-students and last-year MA students at the partner institutions, and an online survey of teachers at selected technical institutions (providing curricula in similar or same energy related issues as the partner HEIs).

Based on standardized questions that have been prepared by the project team, qualitative interviews were conducted with bachelor, master- and PhD students inscribed in relevant curricula (energy teaching) on each TEACHENER partner institution – university or research institution. The partner institutions were free to select relevant students and group of students. Thus at the Politechnical University of Catalunya students have been selected not only as regards their academic records but also as regards their entrepreneurship and game-changing potential. The interviewing methods chosen reach from in-deep interviews of single students (CTU, UPC, UFZ) to group discussions with up to 40 students in the frame of teaching classes (GUT). The content of the interviews and group discussions was analyzed in order to answer the guiding questions of the output.

Overview over interviewed students:

Institution	Student's degree	Student's background	Number
CTU			4
GUT	BC	Energy Technologies students	About 70
	MA	Energy Technologies students	About 20
	BC	Electrical Engineering students	About 60
	MA	Electrical Engineering students	About 40
	PhD	Electrical Engineering	4
UPC			7
UFZ	PhD	Computer science, Physics, Geoscience, Civil Engineering	5

The results of the interviews and the analyzed curricula were then prepared for the project report and are presented in the following chapters.

1.2 CTU in Prague

1.2.1 Short characterization of analyzed curricula

PhD programme "Nuclear Engineering" at the Faculty of Nuclear Sciences and Physical Engineering (FNSPE) of the CTU in Prague

Doctoral degree in Nuclear Engineering prepares our graduates for independent creative work in a wide range of scientific and research topics related to the fundamental areas of nuclear and particle physics and their industrial applications, in particular in nuclear energy and radiation detection. Area of reactor technology covers the issues of reactor physics, applied and experimental nuclear physics, neutron physics, nuclear safety and relations of nuclear energy with the environment, computational

methods and mathematical modelling methods. It also addresses the issues of control systems, accelerator-driven transmutation technologies and physics and technology of nuclear fusion. The aim of the area Physics and Technology of Thermonuclear Fusion is education of experts dealing with issues of controlled release of nuclear energy on the basis of fusion of light isotopes of hydrogen. There are also the areas focused on Dosimetry and Application of Ionizing Radiation and Experimental Nuclear and Particle Physics. The doctoral studies are carried out in close cooperation with domestic (Faculty of Civil Engineering of CTU, Faculty of Electrical Engineering of CTU, Czech Academy of Sciences – Institute of Physics, Institute of Nuclear Physics, Institute of Plasma Physics, as well as the more industrial oriented Nuclear Research Institute Rez and its Research Centre Rez) and foreign (CERN, GSI, BNL, FNAL, GSI Darmstadt) academic and scientific institutions. Active work of students (internships, data collection) at partner workplaces is very common. The doctoral theses are often linked to research activities of individual departments (workplaces) and their grant activities. As an obligatory part of the doctoral studies, albeit relatively short, successful candidates for doctoral studies must enrol to several advanced courses in a doctoral programme relevant to the thesis subject. Note that universities must hold a state accreditation for each doctoral programme of study (where advanced courses are required as a general rule), a programme may encompass several areas of studies with different curricula of advanced subjects. In total, doctoral students are obliged to pass an equivalent of approx. 16 ECTS in the advanced courses before being admitted for a committee (state, rigorous) examination. This examination typically happens at the end of the first or the second year of doctoral studies, after which the student has no other obligations to the university than working on the thesis research, including reports, presentations and journal publications. However, students can profit from additional free courses, both in the field of study and in transferable skills (languages, scientific writing, presentation and communication skills etc.). Participation in undergraduate teaching is not required, but it is encouraged. Doctoral students are entitled to some governmental scholarship for total maximum of four years, however many of them are also contracted for part-time research in the field close to the subject of the doctoral thesis, and not many of them finish their studies (i.e. defend their PhD theses) by the end of the fourth year as normally requested.

MSc programme "Nuclear Engineering" at FNSPE CTU

Students of this programme are prepared for both theoretical and experimental work in the field of reactor physics and nuclear power engineering. The knowledge obtained is also important for nuclear and radiation safety of nuclear power plants and environmental protection. This curriculum leads graduates to use their knowledge in engineering practice. The study subjects are focused on extending knowledge of students in the nuclear fields and should attain significant insight into modern nuclear power plants. The study field contains specialised laboratory courses and independent student projects on an individually-chosen topic. These projects enable each student to acquire deeper orientation within the given topic and lead usually in original results. In frame of the masters courses the students learn details in theory and construction of nuclear reactors, reactors physics, nuclear safety, fuel cycle, reactor electrotechnics, control of nuclear power plants and experimental reactor physics.

MSc programme "Physics and Technology of Thermonuclear Fusion" at FNSPE CTU

The programme of this curriculum is interdisciplinary in character and includes classical and advanced parts of physics of thermonuclear fusion. Graduates in this branch are able to use their knowledge in natural science and engineering work with the aid of modern information technology. The students of the curriculum obtain in depth and attain significant insight into state-of-the-art fusion research. The programme includes specialised laboratory courses and independent student projects on an individually-chosen topic. The projects equip the student with a firmer grasp of the field and often yield in original results publishable in scientific journals

1.2.2 SSH Topics already present in energy teaching

PhD programme "Nuclear Engineering"

Currently there are no SSH topics present in the compulsory teaching at doctoral level. In principle, students may extend their studies by some free courses on transferrable skills, which are organised for all doctoral students and young researchers at the level of the university and which to some degree brief on SSH. However, due to high research load on PhD students in this programme most of the students do not opt for any extra course and tend to postpone this to their postdoc (young researcher) contract. At present, the only opportunities in which students occasionally learn and discuss the SSH challenges are the expert seminars, general workshops and excursions.

MSc programme "Nuclear Engineering" at FNSPE CTU

The obligatory part of the programme where students meet the SSH is the course "Introduction into the power production" (minimum 2 hours per week in one semester). In this subject, students learn of the history, legal aspects, EU institutions and fact sheets of the power production. All students have to pass at least one SSH subject from the following choice: Introduction to Law, Atomic legislation, Economy of NPP, Introduction to Psychology, Rhetoric or Introduction to Economy. Besides, the students can sign in more SSH relevant courses and sometimes they do in order to gain extra credits.

MSc programme "Physics and Technology of Thermonuclear Fusion" at FNSPE CTU

This research oriented programme is very similar to the previous case (MSc in Nuclear Engineering) except the fact that there is no obligatory SSH subject besides the Introduction into the power production. However, students are encouraged to choose one of the above SSH subject as an optional course, and they often do in order to gain credits.

1.2.3 Methods of linking SSH with energy teaching within the institution

As explained above, the link to SSH issues is defined by the curriculum. Therefore, some link is provided as a part of the obligatory courses. In particular, in the undergraduate courses, where they present an implicit but important part of the course "Introduction into the power production" and where students are expected to sign in for some SSH courses. The main channel for SSH topics on the PhD level are seminars and, to some degree, excursions. In principle, these activities are not obligatory on the PhD level but the students are expected to participate in order to prove "active attendance to the joint events". The main issue, actually, is to get good quality SSH, for the CTU students are keen to obtain in-depth information on complex challenges while they are not enough trained (and, by nature, mostly not interested) in participation to broad and often not well moderated SSH discourses.

1.2.4 Profile of those who teach SSH issues

Most of the SSH issues are taught by lecturers who graduated in science and technology and who are at the same time interested in SSH issues and sometimes participate to media work and social debates in nuclear power production. Only rarely a full time SSH expert is invited to a seminar however a success of these events depend strongly on her/his personality. However, most of the SSH optional subject in the undergraduate courses and the voluntary transferrable skills subjects for the PhD students & young researchers are taught by professionals in law, economy, media relations etc.

1.2.5 Expectations in SSH issues

Students would welcome learning basics of the SSH issues, provided that the information was impartial, sufficiently demanding, thorough and up-to-date. However, due to severe time restrictions, research duties and also the bad experience they expect to spend well defined time (e.g. a seminar, a workshop) with high-level experts rather than invest their limited resources to open-ended and self-

moderated discussions. Students also pointed out that they expect their professors to provide the best possible reference so that it was proposed that the SSH training is also focused on the lecturers of the corresponding courses. Furthermore, students identified lack of their own training and abilities in media relations and public debate. They believe that the nuclear energy can strongly contribute to finding a rational and responsible solution to current challenges in power production, including SSH problems, however, they feel that in order to win a public debate the communication skills are far more influential than an adequate technical knowledge. In general, most of the doctoral students are research oriented and with this professional orientation, the SSH related knowledge is perceived as an important part of the individual's responsibility towards society, while it is not expected to play an important part in their future employment and work performance.

1.3 Gdańsk University of Technology (GUT)

1.3.1 Short characterization of analyzed curricula

Gdańsk University of Technology (GUT) is one of the oldest universities in Poland which 110 years of history. University actively collaborates with business entities. GUT hosts a number of centers in which advanced scientific research is conducted, for the development of smart specialization. One of them is LINTE^2 laboratory. LINTE^2 is strictly related to energy issues, it is a center for research into innovative electrical power technologies and for integration of renewable energy sources.
GUT is divided into 9 faculties and 41 fields of study. In 3 faculties, 5 courses related to energy issues are conducted. The most related to energy issues are interdisciplinary studies in Energy Technologies (in English) and Power Engineering (in Polish) which are conducted jointly by three faculties: Faculty of Electrical and Control Engineering, Faculty of Mechanical Engineering and Faculty of Ocean Engineering and Ship Technology. Courses Electrical Engineering and Automatic Control and Robotics are conducted in Faculty of Electrical and Control Engineering. The aim of the studies is to train specialists for needs of sustainable development of the country and rising role of problems related to ecological generation, transmission and distribution of energy. Curricula are obligatory for students at bachelor and master level. Students in every level (bachelor, master, Ph.D.) gains ECTS credit points for passing particular subjects. Ph.D. students can choose courses included in the curriculum or a course provided in bachelor or master level, for gaining ECTS points or to improve their knowledge.

1.3.2 SSH topics are already integrated into energy teaching

Courses addressed to bachelor and master students:

Psychology

The content of this course includes personality conditioning of human action, a motivation to work, interpersonal communication, the advantages and disadvantages of teamwork, processes of social perception and assessment of people and the most frequent errors of this evaluation. Issues related to stress in life and practice of stress reduction are also undertaken. The aim of the course is the acquisition of basic knowledge about the psychological mechanisms underlying human behaviors and skills to recognize the social and professional life.

Economic calculation and energy management

From this course, students gain knowledge in combined issues of technology and economics in electric power. Students are taught how to identify and define the problems of economic accounting and energy management. They learn about important, for engineers, management elements. During practice classes, students draw up a pre-investment study for a project.

Ethics
During this course, students gain knowledge about the basic concepts and theories in the field of ethics. After course, students are able to argue and critically respond to the problem of ethics.

Basics of enterprise functioning
The course is the first level in teaching about company management. After the course, students can name management functions, on which the functioning of the company is based. Students know how identifies and describe the process, structures, and models appearing in the company. During practice classes, students create a sample company and assess whether proposed company has a chance to success.

Management of company finances
The course is the second level in teaching about company management. After the course, students has knowledge in the field of energy and economic company. Students can identify the conditions for financial management and recognize the importance of investment calculation in the energy sector.

Marketing and distribution
The aim of the course is to acquaint students with the principles of the market. During the course, students gain knowledge of marketing activities related to the positioning goods and services on the market. Students learn the basics of creating an effective marketing plan.

Organization of engineer works and the basics of standardization
During the course, students learn about:

- Interpersonal communication, functions, and forms of communication, verbal and non-verbal communication.
- Technology language, the creation, and adherence to technical terminology, principles of preparing and editing theses and technical texts.
- Marketing and management in engineering activities, the basic principles of management and business, registration activities and a selection the rules of taxation.
- National and international rules of normalization and standardization. The role and importance of standardization. Creation, amendment, and verification of standards and regulations. The principle entry of goods into the market, conformity of products with the directives and standards, CE marking.
- Polish and international organizations associating engineers.
- The labor market, the principle of active participation in the labor market, forms and costs of providing employment.

Basics of personal communication
The course focuses on a wide range of soft skills issues useful in student life and career. Soft skills issues involve:

- Ethical, social and legal aspects of personal communication, problem-solving methods and searching for answers on a given topic.
- Rules of writing a theoretical, analytical, and experimental thesis. Graphic elements in written publications and public speeches. The main principles of public speaking, rhetoric, speech patterns, rules of argumentation, basic types of arguments, principles for the formulation of problems.

- Writing letters in English (arrangements of letters, useful phrases, etc.), rules of writing resumes and cover letters, the course of the interview.
- Verbal communication (rules of communication, barriers to communication, active listening, expressing opinions, asking questions, techniques, answers to difficult questions) and non-verbal communication (zone distance, the first impression, elements of non-verbal communication).
- Rules of debate and lead the litigation. Rules of negotiating.
- The most common mistakes made in the Polish language.
- Motives of human actions, the psychological mechanisms of "self-defense" against internal and external threats. Issues about psychological tests and personality tests.

Courses addressed to PhD students, include in curricula:

Methodology and technique of teaching

From this course, PhD students can correctly identify and resolve dilemmas related to work as an academic teacher. Students have awareness of the importance of professional and responsible behavior, based on the principles of ethics and ethos of the scientific community.

Research methodology with emphasis on engineering science

During the course PhD students acquire skills in the use of modern methods and techniques of teaching. PhD students understand the concepts of modern science paradigms and know how to use scientific methods in engineering. After the course PhD students are able to able to apply the principles of analysis, review and debate on scientific publications, draw conclusions and formulate fully justify opinions. They also can use tools to search scientific databases and other sources. PhD students know how to prepare a technical text in Polish and English on a chosen topic in the field of electrical engineering and automation and robotics.

Courses addressed to PhD students included in AdvancedPhD project:

The project AdvancedPhD - The Center for Advanced Studies - the development of interdisciplinary doctoral studies at the Gdansk University of Technology in the key areas of the Europe 2020 Strategy was conducted from 1st July 2013 until 31st December 2015 on Gdańsk University of Technology. Within the project, PhD students participated in new classes, which was connected to their field of research. Specific objectives of the project included inter alia implementation of a variety of modern forms of education program: workshops, “soft-skills” classes on entrepreneurship and commercialisation of research results. Within the projects, PhD students participated in courses:

Projection of intellectual property and patent databases

Schedule of the course contains issues divided to two fields of knowledge. One field is related to subjects of industrial property protection (for example, inventions, utility models, industrial designs, trade marks), the operators of industrial property rights, the procedure for obtaining exclusive rights, and a violation of industrial property rights. The second field of the course contains issues, related to patent databases, for example, a purpose of patents research, types of patent examination, and presentation of selected patent databases and work with their use.

Business English for PhD students in engineering science

The goal of the course is to develop and revise the student's use of English in a business environment with strong emphasis on engineering and scientific context. The course content includes a short insight into business lexicon and recent changes taking place in it, the relevance of some online tools for speakers of English, intensive listening training, teamwork management, solving a problem, intensive reading, business writing.

1.3.3 Methods of linking SSH with energy teaching within the institution

Only in two courses related to teaching about energy: "Economic calculations and energy management" and "Management of company finances" SSH issues are slightly included. The rest subjects, which concludes SSH issues are not related to energy issues. These courses are mainly obligatory for students. For most of the courses, lectures are the main form of teaching. Besides lectures, students participate in practice classes, project classes, and seminars.

1.3.4 Profile of those who teaches SSH issues

Courses about SSH issues related to energy issues are taught by specialists in economy and management with SSH background and without a technical background. The rest of the courses are taught by teachers with and without SSH background.

1.3.5 Expectations in SSH issues

The students from bachelor, master, and PhD studies were interviewed about expectations in SSH issues in energy teaching. Both, bachelor and master students indicate that SSH courses should be elective, not obligatory as it is now at the University. They pointed also, that there is a need to increase the number of available courses, to better conform topics of lectures with students' interests. Interviewed students suggested teaching them how to prepare to conduct an information campaign about new technologies in the energy sector and about the impact of greenhouse gas emissions.
PhD students are interested in teaching about SSH issues in the field of preparing a doctoral thesis and writing articles. Regarding SSH issues in energy teaching at PhD studies, students are interested in legal requirements of building new energy sources.

1.3.6 Table: Courses providing SSH content at Gdańsk University of Technology

Title of the course	Contact hours	Name of studies	Didactic elements	Profile of the teachers
Psychology	30	Electrical Engineering	Lecture	PhD from Faculty of Management and Economics
Economic calculations and energy management	45	Electrical Engineering	Lecture + project classes	Professor + PhD from GUT Faculty of Electrical and Control Engineering
Ethics	30	Energy Technologies	Lecture	PhD from Faculty of Management and Economics
Basics of enterprises functioning	30	Energy Technologies	Lecture	Professor from GUT Faculty of Mechanical Engineering
Management of company finances	30	Energy Technologies	Lecture	Professor from GUT Faculty of Electrical and Control Engineering
Marketing and distribution	45	Energy Technologies	Lecture +seminary	PhD from GUT Faculty of Mechanical Engineering
Organization of engineer works and the basics of standardization	30	Electrical Engineering	Lecture	PhD from GUT Faculty of Electrical and Control Engineering
Basics of personal communication	30	Energy Technologies	Seminary	Professor from GUT Faculty of Ocean Engineering and Ship Technology
Methodology and technique of teaching	15	PhD studies	Lecture	Professor from The Naval Academy Faculty of Humanities and Social Sciences
Research methodology with emphasis on engineering science	15	PhD studies	Lecture	An expert from the GUT Faculty of Management and Economics
Protection of intellectual property and patent databases	10	PhD studies	Lecture	Teachers from a team of patent attorneys.
Business English for PhD students in engineering science	15	PhD studies	Practice	Teachers from Language Centre of Gdansk University of Technology

1.4 Universidad Politècnica de Catalunya (UPC)

1.4.1 Short characterization of analyzed curricula

Universitat Politècnica de Catalunya · BarcelonaTech (UPC) is a public institution dedicated to higher education and research, specialised in the fields of architecture, engineering and technology.
The Industrial Engineering School of Barcelona (ETSEIB) is, among the schools of the UPC, the one which is more active in teaching energy related courses. Indeed, this school hosts all the Energy related MSc degrees that are taught at UPC right now.

The ETSEIB has more than 3,000 students, more than 400 teaching staff and more than 240 people working in administration and support tasks. The School was created in 1851; in 1971 it was one of the Schools that joined to conform what is now the UPC. Engineering education at ETSEIB encompasses a broad spectrum: automatic control, bioengineering, chemistry, computer science, construction, electric engineering, electronics, energy, management, materials, mechanics, transport, etc.

The MSc programs that are specifically energy related are listed below and are fully taught in English:

- **Master's degree in Energy Engineering**, with specialisations in:
  - Renewable Energies

- Electrical Energy
- Thermal Energy
- Energy Management.

The master's length is 120 ECTS credits (2 years) and includes mandatory and elective courses, along with a Final Thesis.

This programme responds to current energy problems from different perspectives: resources, production technologies, transport and energy distribution, environmental impact, energy efficiency and rational use of energy. Graduates of the programme will become professional experts with the knowledge and skills necessary to analyse case studies and manage projects of generation, transformation, distribution and consumption of different forms of energy.

- **Master's degree in Nuclear Engineering**. The master length is 90 ECTS credits (1.5 years), including mandatory courses (46.5 credits), elective courses (13.5 credits) and the final thesis in combination with an industrial internship (30 credits).

  This programme aims to provide students with the skills required to take on positions of responsibility in companies and research centres in the nuclear sector. Students will gain thorough knowledge of the theoretical and practical aspects of nuclear engineering and of the technology associated with energy production by nuclear fission chain reaction. Students will acquire a broad understanding of the entire chain of energy conversion of nuclear fuel into final energy and of the life cycle of facilities, from uranium mining and initial plant construction to spent fuel management and decommissioning. Students will become familiar with regulations and nuclear safety culture, develop a strategic view of the sector and acquire the ability to understand problems and make decisions.

  Approximately half of the lectures of the programme are taught by nuclear industry experts from companies, research centres and other universities. The industrial internship gives the opportunity to students to work with experts who will share their knowledge and expertise.

These two programs are part of the EIT InnoEnergy educational project (EIT: European Institute of Innovation and Technology). The Master's degree in Energy Engineering is partially embedded (in different amounts of participation) in four International master's degrees offered as double degrees:

- **Environomical Pathways for Sustainable Energy Systems (SELECT)**
  SELECT aims at delivering education for high competency and quality engineering skills in the field of sustainable energy systems for the future, including industrial interaction throughout the programme. Students graduating from the SELECT programme will have gained experience in the following topics:
  - Training in multidisciplinary problem analysis and solving.
  - Advanced team building in a multinational setting, along with stimulating international experience.
  - A novel and multidimensional way of learning involving real and virtual classrooms
  - Close collaboration with industry during thesis work.
  - A unique network of fellow students, SELECT alumni and industry specialists in the field of sustainable energy.

  The SELECT master's programme is presently a cooperation between the Royal Institute of Technology in Sweden (KTH), Politecnico di Torino (PoliTo), Eindhoven University of

Technology in the Netherlands (TU/e), Technical University of Catalonia in Spain (UPC) and Aalto University School of Science and Technology in Finland (Aalto).

- **Renewable Energy (RENE)**
  RENE is aligned with the objectives of the European SET plan and the objectives of EIT InnoEnergy in the field of the renewable energies. The content of the programme is focused in renewable energy technologies.
  The methodology of the programme is aligned with the concept of "learning by doing" of EIT InnoEnergy, so combining deep theory knowledge (top-down approach) with internship in industry co-advisored by the university and the industry (bottom-up approach). From the transversal point of view and the enhancement of competences, the objective is to train the students in skills such as communication, economics, business administration and, very specially, to promote the orientation to innovation and the entrepreneurship spirit by means again, of the "learning by doing" concept. The practical implementation of such concepts will be done developing applied technical valorisation and business plans.
- **Energy for Smart Cities**
  The programme aims at educating engineers with a broad background in electrical and mechanical energy systems and who are able to participate in current design and production activities of advanced systems, in designing, construction and using energy conversion machines on the one hand and in energy supply in general (technical possibilities and limitations, environmental consequences, economical aspects), on the other hand.
  The programme adds depth and breadth to the students' technical and engineering knowledge, equips them with business skills and innovation management techniques, and connects them to the latest thinking on urban development in a changing society. As a result students should be able to play a key role in developing smart, secure and sustainable energy for functional and resource-efficient urban communities.
  This programme is offered in cooperation with KULeuven, TUEindhoven, KTH (Stockholm), INSA (Lyon), INP (Grenoble) and ESADE (Barcelona).
- **Smart Electrical Networks and Systems (SENSE)**
  MSc SENSE focuses on understanding, modelling and analyzing the principles behind electric power generation, transmission, distribution and utilisation. Topics range from design, operation, control and monitoring of individual components to the power system in its entirety.
  Existing technologies make up the bulk of the course content, but strong emphasis is also given to novel and innovative technologies that may stimulate the evolution of existing power grids into a 'Smart Grid'. The innovation process itself, plus the route towards new business development in the electric power area, is addressed. Mandatory change of study country between the first and second year is needed.
  The first year has a strong focus on fundamental courses like power system analysis, power electronics, electrical machines, high-voltage engineering, etc. The second study year, the following specialisations are available: Energy Management in Buildings and Power Grids (INP); Information Systems and Electricity Market (KIT); Intelligent Transmission Networks (KTH); Power Distribution (KUL); Power Electronics as Enabling Technology for Renewable Integration (UPC); Storage (Uppsala University); Sustainable Electrical Energy Systems (TU/e).

The Master's degree in Nuclear Engineering is embedded in one international master offered as well as a double degree:

- Master's degree in Nuclear Energy (EMINE)

EMINE helps tomorrow's nuclear engineers take up the challenges that the nuclear energy industry faces in terms of safety, social acceptability and waste management. By offering outstanding technical training and addressing the economic, social and political issues of nuclear energy, this MSc programme broadens the scope of traditional nuclear education.
The uniqueness of EMINE lies in the strong involvement of its industrial partners: companies which are major players in nuclear energy take active part in the programme. CEA, and its educational body, INSTN, actively contribute to teaching activities which allows EMINE to benefit from the expertise of one of the most important research centres in nuclear energy in Europe.
The master's duration is two years (120 ECTS credits). EMINE students acquire an in-depth knowledge of the nuclear industry, through a series of unique and specialised courses in the field of Nuclear Engineering, covering a wide range of subjects. In the first year students take courses at KTH (Stockholm, Sweden) or at UPC (Barcelona, Spain).
At the end of this first year, students from both UPC and KTH gather for a three week summer school at Grenoble École de Management. During the second year, students have the choice between 6 specialties offered by Grenoble INP (France) and Paris-Saclay University (France)
Upon successful completion of the programme, students are awarded a double diploma from the first and second universities, as well as a certificate delivered by KIC Innonergy.

All of the InnoEnergy masters have 120 ECTS credits.

Besides the aforementioned programs, ETSEIB offers a Master's degree in Industrial Engineering with several specialisations: Automatic Control, Biomedical Engineering, Chemistry, Construction and Structures, Electrical Engineering, Electronic Engineering, Energy, Industrial Scheduling, Materials and Mechanics. Energy issues are dealt with not only within the specialization in Energy: there is a common mandatory course on Energy Technology.

Energy topics are present in courses taught at other Schools of UPC, but not to the extend they are dealt with within the curricula exposed above (except in the Bachelor's degree in Energy Engineering, taught at EEBE, Barcelona East Engineering School).

Regarding SSH contents, there are a few non-technical elective courses offered at ETSEIB in the framework of the Bachelor's degree in Industrial Technologies:

- In the fourth semester: Communicating Technical Information; Debates on Technology and Society; Entrepreneurship; History of Industrial Engineering. The School of Barcelona; History of Invention and Technological Innovation; Human Preparation for Workplace; Technological and Scientific Development in Antiquity. Egypt and Middle East; The Origins of Modern Engineering. All of them of 3 credits.
- In the eighth semester: Culture, Technology and History in China and Japan; Data Analysis for Business and Industry; Decision and Negotiation in Industrial Engineering; Engineering, Industry and Society; Oral Communication in Academic and Professional English; The History of Applied Mathematics in Engineering; Train, Transport and Technology. From Steam to High Speed. All of them of 4.5 credits, except the last two (3 credits).

1.4.2 SSH Topics already present in energy teaching

Master's degree in Energy Engineering.

In this program some courses are in a larger or lesser extent related to SSH:

- **Energy Economy and Comprehensive Energy Planning Models** (elective, 1st Semester, 5 credits): The aim of the course is to bring students to the fundamentals of energy economics, providing them the basic tools needed to understand the current energy problems and their interconnection with other fields. This course is taught by a member of the academic staff of the Department of Electric Engineering.
- **Energy and Environment** (mandatory, 1st Semester, 5 credits): The course aims at assessing the economic, social and environmental impact of the production, use and management of energy, with a holistic view of the life cycle of the different systems, and recognising and valuing the most remarkable developments in the fields of energy efficiency and the rational use of energy. Beyond the Life Cycle Assessment, tools are presented to evaluate the Life Cycle Costing and some reflections are done regarding the Social Life Cycle Assessment.
- **Energy resources** (mandatory, 1st Semester, 5 credits): Upon completion of the course students should be able to:
  - Understand, describe and analyse, in a clear and comprehensive manner, the whole chain of energy conversion from its state as energy source to its use as energy service, including the processing, transportation and end use of energy.
  - Identify, describe and analyse the situation and characteristics of the different energy resources and of the end uses of energy in their economic, social and environmental dimensions, and make value judgments.
  - Manage the acquisition, structuring, analysis and display of data and information on the energy field and critically evaluate the results obtained.

  The course aims at raising students‘ awareness on the strategic and security of supply implications of the different energy alternatives. It aims as well to develop in the students the values of justice, solidarity and equality from the fact of relating conflict and underdevelopment situations with the global energy needs.

  The contents of the course are transversal and aimed to summarize a knowledge which, in most of the cases, is the object of other courses. The course is organized as a series of theoretical sessions (thought as participative conferences) that provide transversal synthesis elements complementing the contents of other subjects, and an overarching vision of the energy system from different standing points. Some of the conferences and lectures are delivered by academic staff, expert in the topic. Other conferences are delivered by external experts, including entrepreneurs (currently 2 sessions of 2h each are taught by people with this profile).

  There are some assisted exercises sessions, where students, working in group, try to solve a set of exercises related to the contents of the course.

  During the semester students have to write an opinion article aimed at the general public. At the same time, organised in teams of 3 or 4 people, students work on a tutored project about a specific energy topic, and write a technical report on that topic, that will defend before their supervisor.

  This is one of the courses where more ethic and social aspects are included.
- **Energy Markets** (mandatory, 2nd Semester, 5 credits): upon the completion of the course, students should be able to understand, describe and analyse, in a clear and comprehensive way, the functioning of energy markets and carry out the optimum procurement of energy supplies. Students should be able to undertake projects related to energy management in production and service sectors, recognise and value advances and developments in the field and contribute innovative ideas. This course is taught by a member of the academic staff of the Department of Electric Engineering.
- **Technological Entrepreneurship. Business Plan Development** (elective, 2nd Semester, 3 credits): The course deals with market aspects when analysing a technological business

opportunity. The course addresses as well other aspects that are to be taken into account in the business plan by means of developing a course small project. The project consists on the analysis of a technological business opportunity. Regulatory and social aspects are sometimes present -in addition to technical, environmental and economic. This course is delivered by a member of the academic staff of the Department of Management with a management profile and a PhD in Business Administration from the UPC.

- **Oral and Written Communication** (elective, 2nd Semester, 3 credits): Technical communication is envisaged as a form of cooperation that can have different purposes. The course focuses on the informative and the persuasive purposes and tackles written and spoken genres common in engineering from a rhetorical point of view, which implies that audience and communicative purpose are taken into consideration in order to determine the appropriate language (i.e. degree of formality and type of tone). At the same time, in order to prepare our students for a global, international market, intercultural communicative competence is also catered for. This course is taught by a member of the academic staff at UPC with a singular profile: a PhD in English Philology and Master in Management and Business Administration.

RENE

RENE provides students with a holistic understanding of the renewable energy sector. Throughout the programme, strong emphasis is placed on developing students' research, innovation, entrepreneurship and leadership skills, in addition to their technical knowledge and understanding of the business environment in which renewable energies are deployed.

During the first year, courses followed by students at UPC are coincident in part with those of the Master's degree in Energy Engineering. More precisely, students take the courses on:

- Energy and Environment
- Energy resources
- Technological Entrepreneurship.
- Oral and Written Communication

Students also take a course on:

- **Microeconomics and Energy Markets** (mandatory 5 credits): The course aims at students understanding and being able to apply the tools of microeconomics (elasticity, cost concepts, market structures, externalities and policies to internalize externalities, etc.) to energy markets.

  Upon the completion of the course the student should:

  - Understand the role of energy management in global and regional contexts, and its economic, social and environmental impacts.
  - Be able to analyse and to interpret events and policy proposals in the energy markets with the help of the economic tools (microeconomic concepts and models) provided.
  - Be able to find and to use the information provided on energy markets.
  - Be able to write and to debate on socio-economic issues related to energy markets.

  This course is taught by an Economist member of the academic staff of the Department of Management.

In the first year, students also undertake an intensive 'Entrepreneur in a week' course at the Catolica Lisbon School of Business and Economics and participate in an Innovation Seminar at UPC, with industrial and business partners.

In addition, first-year students participate in a one-week 'Winter School' at the ESADE Business School in Barcelona, where they undertake courses on the fundamentals of entrepreneurship and innovation, including:

- Creative thinking
- Innovation and strategy
- Entrepreneurial finances
- Marketing for start-ups
- Intellectual property (IP) protection

At the end of the first year, students return to ESADE for a four-week summer school that covers business and management topics in greater depth, including:

- Personal and professional skills
- New venture creation
- New product development and service innovation
- Managing high-performance teams
- Operations management
- HR management
- Corporate entrepreneurship

In the second year students choose an area of specialization, and undertake the Master's thesis (30 ECTS credits) as part of an internship at one of RENE's industrial or start-up partners, or at a research centre.

SELECT

During the first year students choose to be either at KTH or a UPC. All students attend exactly the same courses throughout the year by means of remote online classes. Courses followed by students are coincident in part with those of the Master's degree in Energy Engineering and RENE. More precisely, students take the courses on:

- Energy and Environment
- Energy resources
- Technological Entrepreneurship.
- Oral and Written Communication
- Microeconomics and Energy Markets

During your first year, SELECT students joint the RENE students in the courses at the ESADE Business School in Barcelona.

During the second year, students will deepen their knowledge in a chosen area of specialisation, in addition to their final master's thesis (30 ECTS credits). The thesis is undertaken in collaboration with the Master's industrial, research or NGO partners. It should include both the technological aspects of your chosen topic as well as a solid business analysis. Sometimes, it also includes social aspects.

The programme is characterised by the so-called *Grand Challenge Projects*, in which students work in teams to apply their knowledge and skills to real-life projects. The projects give them unique insights into the challenges and solutions for future energy markets and systems. The projects are commissioned by one of the programme industrial partners, and teams compete to have their solution taken forward. All challenges have a strong societal focus, with a clear commercial interest and

benefit, and often involve inter-continental collaboration. Students complete one project in their first year and another one in the second year.

SENSE

The programme helps students develop the skills in electrical power engineering, innovation processes and entrepreneurship in the emerging field of Smart Grids. This master program gives students the ability to combine engineering and entrepreneurship and develop their ability to analyse possibilities and risk from both a technical and business perspective. The program focuses not only on understanding, modelling and analysing the principles behind electric power generation, transmission, distribution and utilisation on a broad scale, but as well on entrepreneurship and creating businesses from innovations.

SSH contents are dealt with, mainly, during the Summer School at ESADE Business School, between first and second year (see the description of the contents above, for MSc RENE).

At the end of the second year students undertake the Master's thesis (30 ECTS credits) as part of an internship at one of SENSE's industrial or research partners.

Energy for Smart Cities

In this programme, technological and engineering studies are combined with knowledge of socio-economic and environmental aspect of smart cities, such as energy efficiency in buildings, electric transportation, energy economics, smart lighting, and other urban services.

Students learn how to construct and employ contemporary energy-conversion technologies and secure energy supply, while taking into account the technical limitations, environmental consequences and economic considerations of new energy technologies and systems. Students consider the impacts of changing energy systems on the end users of the electrical value chain: people, businesses, and the city itself.

First year students combine electrical and mechanical engineering courses with energy-related socio-economic subjects either at KU Leuven or KTH Stockholm. UPC is one of the host universities for 2nd year students of this programme. In the second year, students take general, broadening and option-specific elective courses that enable them to specialise in areas of their interest and undertake a research project for their Master's thesis.

The so-called Innovation Journey is a critical element of the programme, which runs over the two years of study: students work in teams on a real-world challenge set by one of the programme's start-up or industrial partners. The end goal of the innovation journey is to create a feasible prototype that can be developed for market. There are three milestones on the innovation journey, each consisting of a one-week course in a different European city:

- **Smart cities week.** 9-day workshop done in Barcelona combined with the Smart City Congress World Expo. This Workshop allows the students to learn about Innovation: Systematic Innovation Thinking and Innovation methodologies, and how to apply them in smart cities projects. Also some sessions about team work, coaching and elevator pitch were done.
- **Biz Boot Camp. The Challenge Edition.** Workshop done in Leuven, Belgium, with the main objective to give students the opportunities to gain knowledge related to business models and economics. This was implemented through a real case with some Start-ups.

- **Entrepreneurship School.** After the first year exams, MSc Energy for Smart Cities organizes a one-week summer school to sharpen participants' entrepreneurial skills in the energy sector. This summer school includes soft skills such as team-building, networking, leadership, entrepreneurship and intercultural communication. The Summer School is held in Amsterdam.

One further activity with SSH contents, is the:

- **Cost-Benefit Analysis Workshop:** One-day session of 4 hours (2 hours about theory and concept related to cost benefit-analysis, and 2 hours about a practical case).

Master's degree in Nuclear Engineering (MNE)

In the MNE there exist no specific courses addressing SSH topics, but these contents are present in a lesser or a greater extent in several of the courses of this programme.

Students can access the master from technical or scientific bachelors. When the curriculum of the students does not include any course on Economics, they are forced to take an extra course on *Economics and Enterprise*.

The courses of the master proper having some SSH contents are:

- **Regulations and Safety (R&S)**. Mandatory course of 5 ECTS credits.
  Among other Learning Outcomes, at the end of the course the student must be able to: describe the structure Spanish regulations related to nuclear safety and radiation protection; identify and manage radiation protection regulations applicable to operation and management of radioactive waste; and analyse the relation between the Spanish nuclear legislation and international references. Regulatory structure including Nuclear Energy regulation basics and International Organizations are thus introduced in this course.
  At the introduction of R&S subject social and philosophy aspects of safety and accident management are presented stressing the human dimension of general goals and strategies devoted to avoid accidents. All of it takes about 4 hours and is taught by a member of the UPCs teaching staff, F.R., who is a PhD Engineer and holds a degree in Philosophy, and who has been long time working for a NPP operator.
  Another example appears in one of the assignments: a case study having different aspects clearly connected with the practice and the improvement of SSH related skills. A controversy between a regulatory body and a utility is introduced at the very beginning of the semester at the end of a lecture related to Regulatory Structure and International Organizations. The groups of students have to develop the solution of the controversy after meeting several times and playing the role of one of the involved organizations. Such meetings come after specific lectures in which some related information is given. Many SSH contents appear with interesting results. The kick-off session is conducted by an instructor belonging to the Nuclear Regulatory Body's staff, at a time engineer and lawyer.
- **Management of Nuclear Power Plants**. Mandatory course of 8.5 ECTS credits.
  The concept of Safety Culture is developed in detail mainly by and engineer having been formerly Technical Manager of a utility. Many of his own experiences are introduced.
  Many SSH aspects appear also in the subject of "Siting" developed by a senior engineer, E.V., having had the experience of advising on behalf of IAEA, governments of countries willing to make the decision of building their first nuclear power plant. The course also includes a module on communication (4h) taught by the same engineer (formerly speaker of a NPP operator and now speaker of the Spanish Nuclear Society).

One section so-called "Management Tools" involves also interesting characteristics of organizations having an important human load (human performance, operating experience, communication…). The staff of a utility company (ANAV-Endesa) takes care of this module.

- **Project 2**. Mandatory course of 3 ECTS credits.
  Meetings and debates are an important tool used in developing this project. In a debate students are asked to play a role. Such role is sometimes rather technical but it is also related to managing a group, conducting a meeting, criticizing an argument, or compromising economy, safety and performance. The course is delivered by two of the persons mentioned above.

European Master in Nuclear Energy (EMINE)

UPC's students enrolled in EMINE take, during their first year, the same courses as MNE students. After the completion of the first year at UPC they move to Grenoble for the Summer School at GEM. There, students have the opportunity to develop transversal skills and acquire competences that are generally not delivered by standard engineering master programmes and that will help them in their professional life: ranging from Energy Economics topics to facets of the Emotional Intelligence a leader must have, and including issues like Strategy and Innovation in the Energy sector and Intellectual Property.

In general

It is worthwhile to state that, although it is mandatory to include competences related to SSH in the UPC's engineering degrees, and even when care is taken to address these competences within the program, it is not clear that these competences be fully developed by the students, since no specific and objective assessment tools are designed for that purpose.

For instance, one of the seven transversal competences defined by UPC for master's level degrees states: *"SUSTAINABILITY AND SOCIAL COMMITMENT: Being aware of and understanding the complexity of the economic and social phenomena typical of a welfare society, and being able to relate social welfare to globalisation and sustainability and to use technique, technology, economics and sustainability in a balanced and compatible manner"*. Even when the courses addressing this topic have some assessment mechanisms like the defence of a project before the teacher or other students, it is unclear that the fulfilment of the competence be objectively measured (there is no rubric for this issue, for instance).

1.4.3 Methods of linking SSH with energy teaching within the institution

The SSH contents are delivered in several ways, that range from specific courses (like the ones organized by ESADE or GEM regarding Entrepreneurship and Innovation), to addressing some aspects during one lecture.

Reader is referred to the previous section.

1.4.4 Profile of those who teaches SSH issues

Teachers of SSH issues are engineers or scientists, either from the university or from industry, except when these contents are directly supplied by an external institution (eg. GEM or ESADE). But some of the lecturers delivering these contents have a previous experience or a qualification in the field (e.g. and engineer with a degree in philosophy or an engineer who is also a lawyer).

A special case is the course in *Oral and Written Communication,* which is taught by a person holding a Master and PhD in English Philology from University of Barcelona, and Master in Management and Business Administration from ESADE (Universitat Ramon Llull, Barcelona). She is a member of the

academic staff at UPC but with a singular profile: her research interests include internationalisation and multilingualism in higher education, and she has recently published and researched on intercultural communicative competence.

1.4.5 Expectations in SSH issues

Students interviewed fall into two groups. The ones taking the local programmes and the ones enrolled in the international programmes.

The former normally perceive SSH as related to economy and law, topics they find interesting, generally speaking, and necessary for their professional activity. As regarding sociological and communication competencies, they perceive they can be quite useful in the job market, but the students thinking is at times quite conventional in this regard: *companies are interested in sociology because of marketing purposes*; *if you are good at interpersonal skills it will be easier to convince the person of Human Resources office to hire you.* Students realize the importance of social skills in order to express oneself and to influence others; but as well in order to place oneself in the place of the *other people* with whom we may confront and understand their position, but it doesn't seem to be a requirement of the job market. One student pointed out the importance of having contents of history (of science and technology) to be able to learn from past errors (again, with no connection with a real valuation of this skills by the job market). Interculturality is perceived as an important asset, to be valued in the job market: being able to work with people with diverse backgrounds and from distinct cultures. Some of the students, nevertheless, place themselves in a post-conventional plane: sociology and ethics are important to form people who will not only be technically prepared, but who will have a purpose in their work (beyond the self-interest and the interest of economy), and who will be able to question themselves (Are my decisions the most convenient ones for the society?).

The students in the latter group place themselves usually in the post-conventional level. (It is worthwhile mentioning that these students have been selected for the interviews not only on their academic records but also on their entrepreneurship and game-changing potential.) They agree that technological solutions must consider the social aspects of the problems and realize that *"Technical knowledge is not enough to let engineers be able to work in a complex social environment. […] if not related to people, problems' solutions do not have a real impact"* (Interviewed student). As regards to the importance of these aspects in the job market, most of the students agree that companies value the skills: *"The industry sees these broader skills as critical for dealing with real life situations."* (One of the students, nevertheless, is sceptical at this point, while recognises the importance of these aspects for the person). Social aspect is critical then in real life situations and to the workforce. Some of the students even go further: *"engineers such as ourselves will fill some of the most influential and leading roles in the future. Thus, in order to properly influence and direct society towards the improved direction we must move, these broader social aspects are absolutely necessary skills."*

The same group of students expressed their thoughts on the way SSH contents are, should be and could be developed in the academic curricula. "*In engineering courses we are confronted with technical problems, however these issues are fundamentally founded within a social setting. Therefore, without having a good grasp of broader social concepts, we lose touch of the real world relevance of these problems." "In terms of sustainability, the two aspects of economics & environment are quite tangible and discretely assessed, while the third social aspect is sometimes left beside due to the difficulty of quantification." "Being educated in social aspect of technical world should be considered necessary at higher education levels […]. In the energy field, it might be easier to find links between technical know-how and social science than in other even more specific ones."* The feeling is that students of technical programmes related to energy are more aware of the importance of SSH aspects than students of other technical disciplines.

1.4.6 Table: Courses providing SSH content at UPC

Name of Study		Courses	Duration	Didactic elements	Profile of the teachers
Energy Engineering (MA)		Energy Economy and Comprehensive Energy Planning Models			member of the academic staff of the Department of Electric Engineering
		Energy and Environment			
		Energy resources	2 sessions of 2h each		Internal and external experts (including entrepreneurs)
		Energy Markets			academic staff of the Department of Electric Engineering
		Technological Entrepreneurship. Business Plan Development			academic staff of the Department of Management with a management profile and a PhD in Business Administration from the UPC.
		Oral and Written Communication			the academic staff at UPC with a singular profile: a PhD in English Philology and Master in Management and Business Administration.
Nuclear Engineering (MA)		Regulations and Safety (R&S)		Group Work, Roleplay	member of the UPCs teaching staff, F.R., who is a PhD Engineer and holds a degree in Philosophy, and who has been long time working for a NPP operator.
		Management of Nuclear Power Plants		Debate, Roleplay,	staff of a utility company (ANAV-Endesa)
		Project 2			member of the UPCs teaching staff, F.R., who is a PhD Engineer and holds a degree in Philosophy, and who has been long time working for a NPP operator.
EIT InnoEnergy education project (EIT: European Institute of Innovation and technology)	Environomical Pathways for Sustainable Energy Systems (SELECT) (MA)	Energy and Environment		Group work	member of the UPCs teaching staff
		Energy resources			
		Technological Entrepreneurship			
		Oral and Written Communication			
		Microeconomics and Energy Markets			Economist member of the academic staff of the Department of Management

	Renewable Energy (RENE) (MA)	Energy and Environment			member of the UPCs teaching staff
		Energy resources			
		Technological Entrepreneurship			
		Oral and Written Communication			
		Microeconomics and Energy Markets			Economist member of the academic staff of the Department of Management.
		Entrepreneur in a week	1 week		
		'Winter School'	1 week		Business school of Barcelona
		'Summer School'	4 weeks		Business school of Barcelona
	Smart Electrical Networks and Systems (SENSE) (MA)	'Summer School'	4 weeks		Business school of Barcelona
	Nuclear Energy (EMINE) (MA)	'Summer School'	2 weeks		Grenoble School of Management
	Energy for Smart Cities (MA)	Smart cities week	9 days	Team, coaching and elevator pitch	In cooperation with industrial partners
		Biz Boot Camp. The Challenge Edition	1 week	Role play	In cooperation with industrial partners
		Cost-Benefit Analysis Workshop	4 hours		In cooperation with industrial partners

1.5 Helmholtz Zentrum für Umweltforschung (UFZ)

1.5.1 Short characterization of analyzed curricula

The Helmholtz Centre for Environmental Research is an interdisciplinary research centre with a focus on natural sciences, thus it itself encompasses both social and technical research and education. Research related to energy issues, notably geothermal energy is a small part of research at UFZ. Curricula of the Helmholtz Interdisciplinary graduate School for Environmental Research (HIGRADE) has been analyzed. HIGRADE is a collaborative venture between the Helmholtz Centre for Environmental Research (UFZ) and six German universities: Universität Leipzig, Martin-Luther-Universität Halle-Wittenberg, Technische Universität Dresden, Technische Universität Bergakademie Freiberg, Friedrich-Schiller-Universität Jena, and Universität Kassel. The curriculum accompanies the education of doctoral researchers at the UFZ. It consists of courses that are recurring, e.g. on time per year, and courses that are nonrecurring. Many of the courses are taught by researchers from UFZ departments. Some courses are given by lecturers from other institutions.

HIGRADE curriculum provides courses that can be chosen by the PhD students voluntarily, except of the courses: Good Scientific Practice. Often the leader of the department, the dissertation supervisor or the institution that funds the scholarship recommend courses that PhD students should visit. Most important criteria for course selection is a content-related proximity to the own research topic. Furthermore, most courses, also those on SSH issues, require some prior knowledge, so that the selection of topics outside the own research becomes less attractive.

All PhD-students doing research on natural scientific issues related to geothermal energy were interviewed about their personal HIGRADE curricula and regarding their expectations on SSH issues.

1.5.2 SSH Topics already present in energy teaching

Since 2015 in HIGRADE eight courses were given in which SSH issues in the broadest sense were addressed. In four of the courses SSH issues were taught exclusively, in 4 courses SSH issues were only one topic among others. These courses provide insights in theoretical aspects within the SSH sub disciplines economics, sociology, law, politics but also introduce theory and methods of transdisciplinary research in order to prepare PhD students for transdisciplinary research at the UFZ.

Courses that address SSH issues exclusively:

Introduction into social sciences

This course addresses PhD students from the natural sciences to learn about social sciences and PhD students from social sciences learn about other social sciences. Basic theoretical approaches and methods of economics, law, geography, sociology and environmental politics are introduced. The aim is that students understand basic approaches and methods of social sciences, their application in practice, and the role of social sciences within UFZ research. For illustrative purposes, teachers use examples from their current research. Thus, in 2015 various case studies related to renewable energy issues were presented in the course. The studies primarily focused on conflicts with local citizens' initiatives.

Renewable Energy and Participation (renamed from: Aspects on Geoenergy & Participation)

The course was organized one time in 2016. Issues taught by social scientists covered self-organization of renewable energy, local energy autonomy concepts, renewable energy grass roots initiatives in EU and Germany, factors of acceptance and citizen initiatives, political aspects such as

feed-in-policy in Germany and EU. The course aimed on familiarizing students with key concepts of self-organization of the energy transition toward renewable energies as well as on discussing and comparing case studies across the EU in the context of EU energy policy.

Introduction to Solution-oriented Environmental Research

The course introduces the major fields of research of the UFZ and the approach of problem-oriented environmental research. Approaches of transdisciplinary research, concepts of citizen science and integrative environmental research are introduced to the students. The difference of disciplinary, multidisciplinary, interdisciplinary, and transdisciplinary research approaches are discussed. On a conceptual level, different epistemologies and methods in natural and social science are dealt with. The course aims on familiarizing PhD students with the UFZ mission, research areas, and research approach. This is done in order to enable students to see the broader picture in which their PhD is part of and to sensitize them for the challenge of bringing different disciplines together in environmental research.

Introduction to Risk Assessment and Management (with an emphasis on flood risks)

This course focusses on the specific issue of flood risk management and related research in social sciences. The overall aim is an introduction to social and economic perspectives on risk assessment and management. Two perspectives are taken: first, the role of economic assessments of flood risk (and drought) for management approaches. Key methods and required data for the estimation of different types of flood damages are explained. Second, social scientific contributions to ideas of (flood) risk management (risk perception and vulnerability). Some empirical examples are used to illustrate insights on how flood risks are socially constructed and what this possibly implies for future challenges for research and policy-making.

Courses that address SSH issues beneath others:

Good scientific practice

This course aims on familiarizing PhD students with good scientific practice, data management, publication practice and authorship, responsible mentoring, cooperation in science and conflicts of interest, scientific misconduct, managing conflicts. Rules of good scientific practice are taught in order to raise awareness of the different areas in the scientific process in which questionable scientific practice and misconduct can appear. Students shall learn about appropriate solutions for difficult situations in the work process of scientists so that they are able to decide and act appropriately.

Bioeconomy – An Introduction

This course provides an introduction into key concepts in bioeconomy (including bioenergy), their meaning and their use in public discussions. Besides an introductory lecture on Bioeconomy the course provided a field trip to leading institutions that work in the field of bioeconomy in Central Germany. Thus the practical side of the implementation of the German bioeconomy strategy was exemplified.

Young Biodiversity Research Training Group (yDiv)/HIGRADE course: Working at the Science-Policy Interface

This course offers an overview on major biodiversity policy issues, as well as the opportunities and challenges for researchers working at the science-policy interface. Students carry out a basic training in participatory knowledge exchange and science communication. The advantages and challenges of the approach of citizen science as tool for research and innovation are discussed. Another focus is on

techniques of knowledge exchange facilitation and interdisciplinary teamwork. Based on the content of this course students shall be enabled to identify the relevance of their own research, to carry out interdisciplinary research projects, and to increase the impact of their research results on policy.

Competences and Skills in Interdisciplinary Cooperation

Success of interdisciplinary research and cooperation basically depends on individual scientists skills to perform goal oriented and effective in an interdisciplinary team. The seminar offers the opportunity to reflect on personal experiences with interdisciplinary work and to enlarge the personal repertoire of skills and tools to work successfully in interdisciplinary contexts. The seminar provides insights and answers to the following questions: What are the specifics of my discipline? What are the dynamics of an interdisciplinary team/group? How can I communicate effectively in an interdisciplinary team? What do I need to integrate different perspectives in an interdisciplinary context? Which methods can be applied to formulate and achieve a common goal/research question? What are difficulties in interdisciplinary work and how can I contribute to solve them?Within the course students acquire skills, tools and methods to integrate different perspectives to achieve a common goal in interdisciplinary cooperation.

Beyond HIGRADE

Beyond HIGRADE, there are other possibilities for students to get in touch with SSH issues. It is possible to participate in lectures from scientists e.g. of the Department of Urban and Environmental Sociology. Lectures on specific research issues are frequently organized at UFZ covering the scope of research areas from natural and social sciences. However, while some of these lectures are announced to all UFZ researchers, information about others are usually distributed only within the department-email-lists. Therefore it is difficult for students and scientists to be aware about open lectures from other departments.

Conferences, especially those organized at UFZ, by the interviewed students are also seen as a good opportunity to get in touch with SSH issues (e.g. IMWA 2016 Annual Conference 2016 “The Annual Conference of the International Mine Water Association” or “UFZ Energy Days”). Furthermore, informal networks of UFZ PhD-students as well as HIGRADE events are opportunities to get in contact with SSH issues (e.g. UFZ-Doc-Days, sport-courses, the doctoral student’s representation called: do-it, carrier-mailing-list, DOCALL-mailing-list, department- regulars' tables or the international café of the UFZ).

1.5.3 Methods of linking SSH with energy teaching within the institution

Except from the two courses “Introduction into social sciences” and “Renewable Energy and Participation” SSH issues are not specifically linked with energy issues.

Generally the most dominant method of teaching SSH issues is lectures. However, this format in most courses is combined with manifold methods such as field-trips, discussions, role-plays, and practical exercises.

The duration of the courses is between 1 and 3 full days (see table, annex).

1.5.4 Profile of those who teaches SSH issues

Courses with exclusively SSH issues are taught by lecturers trained in social sciences in a broader sense: geography, sociology, economics, law, political science. Courses that provide SSH issues beneath others are taught by lecturers without SSH background; they are trained in biology, or chemical engineering.

1.5.5 Expectations in SSH issues

The interviewed PhD students expect that skills in SSH issues can be relevant for future employment. In that case the issues should be linked to the political, administrative and legal background and context of the topic of their doctoral thesis (e.g. nature conservation and groundwater modeling in the context of geothermal energy). An issue of specific relevance is the challenge to understand and deal with citizen's initiatives in the context of renewable energies, especially geothermal energy.
It is expected the higher future occupational position, notably leading positions (outside science), the more likely is the chance to be confronted with SSH issues additionally to the own profession. SSH issues are helpful to understand how the personal (natural scientific) research links to societal problems. PhD students have great interest in understanding how different social groups perceive energy related issues (for example how social groups perceive the energy transformation in Germany).

Although the HIGRADE curricula offer SSH issues, some shortcomings are identified by those interviewed. Students who write their PhD on natural scientific aspects of energy related issues expect that courses on SSH issues are linked to topics and issues they deal within their PhD. This is not always the case (only 2 courses that explicitly deal with energy issues). Such topics could be for example water shortage, risks for nature and society which arise from energy use, impact of emissions on climate change, how energy issues are perceived in society and more generally how energy and society are related. Courses on SSH issues attended by the interviews were often taught in long monologues. Interactions between the lecturer and the students would have increased the attractiveness of SSH issues for the PhD students.

1.5.6 Table: Courses providing SSH content at UFZ

Titel of the course	Duration	Didactic elements	Profile of the teachers
Introduction into social sciences	2 days	exercises, discussions, role-play	Teachers from: • Department of Environmental Politics / UFZ (academic education: studies in Political Science, Sociology, Economics, Public Law) • Department of Economics / UFZ (academic education: studies in Political Science and Economics) • Department of Urban and Environmental Sociology / UFZ (academic education: studies in European Studies/ International Relations and Development Policy)
Renewable Energy and Participation (renamed from: Aspects on Geoenergy & Participation)	1 day	Lecture and additional seminar	Teacher from: • Department of Urban and Environmental Sociology / UFZ (academic education: studies in sociology and history)
Introduction to Solution-oriented Environmental Research	1 day	Presentations, group discussions, interactive elements	Teachers from • Department of Analytical Environmental Chemistry / UFZ (academic education: studies in Environmental Sciences and Environmental Chemistry) • Department of Environmental and Planning Law / UFZ (academic education: studies in law, environmental law) • Department of Ecological Modelling / UFZ (academic education: studies in mathematics, Mathematical Physics, Applied System Sciences) • Department of Environmental Politics / UFZ (academic education: studies in geography) • Department of Bioanalytical Ecotoxicology / UFZ (academic education: studies in biology) • Department of Aquatic Ecosystem Analysis (academic education: studies in Chemistry?)
Introduction to Risk Assessment and Management (with an emphasis on flood risks)	1 day	brief exercise (flood damage evaluation example), questionnaire, group discussions. Role play	Teachers from: • Department of Economics / UFZ (academic education: studies in Economic Geography) • Department of Urban and Environmental Sociology / UFZ (academic education: studies in Sociology and Geology/Human Geography)
Good scientific practice	2 days	lectures, exercises, discussions, role-play	Teacher from: • Institute of Systemic Medicine and Organizational Ethics / Berlin UFZ (academic education: studies in human biologist with focus on

			bioethics, trained systemic coach and process consultant)
Bioeconomy – an Introduction	2 days	Teaching and learning methods: Excursion, workshops, lecture	Teacher from: • Department of Bioenergy / UFZ (academic education: studies in Chemical Engineering)
Young Biodiversity Research Training Group (yDiv)/HIGRADE course: Working at the Science-Policy Interface	3 days	Role play, world cafe and other facilitation techniques/ Interactive discussions with science-policy experts, field trip /Lecture elements / Brief student oral presentations on science-policy aspects	Teachers from: • German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig (academic education: studies in in biology) • Federal Agency for Nature Conservation (academic education: studies in biology)
Competences and Skills in Interdisciplinary Cooperation	1 day	Theoretical input, discussion, practical exercises, role play, reflection and exchange, work in small groups	Teacher from: • Center of Biodiversity and Sustainable / University of Gottingen (academic education: studies in Forestry and Social and Cultural Anthropology)

2. Situation on further technical institutions in Czech Republic, Poland, Spain and Germany

2.1 Method

The analysis of the situation in the partner countries aimed on getting a broader picture of SSH issues in specific energy teaching (energy teaching issues represented by TEACHENER partner institutions – nuclear, geothermal etc.) and to prove and/or broaden the results from the partner institutions. For this reason in each country relevant institutions and curricula (and teachers) have been identified that were questioned about their experience and expectations linking SSH issues to energy teaching. The analysis was based on a standardized questionnaire (see annex). This questionnaire was prepared with the *google forms* tool and sent out by the project partners to universities and research institutions, offering curricula in energy issues. The addressees of the questionnaire were selected by the TEACHENER partners and most of them were already known by the partners (established working relationships) and belong to their field of competence and research. Project partners were free to send the questionnaire in their national language or in English.

2.2 Czech Republic

2.2.1 Short characterization of investigated institutions (and curricula)

In the Czech Republic there are 9 universities with dedicated undergraduate and doctoral curricula in the energy and power production fields. Most of them focus on industrial engineering, and their energy oriented curricula typically include lectures which - to some extent - cover all potential power sources (classical, nuclear, and renewable). All the corresponding university departments or centers were approached. Ten of them eventually participated in our investigation: three from the Czech Technical University in Prague (nuclear engineering, mechanical engineering and electrical engineering), two from Brno University of Technology (mechanical engineering and electrical engineering), one from Czech University of Life Sciences Prague, University of Chemistry and Technology in Prague, Technical University of Ostrava, University of West Bohemia and Technical University of Liberec. Altogether the questionnaires provided reports from 21 different university courses focused on energy engineering and power production.

2.2.2 Topics already present in energy teaching

In the questionnaire, the lecturers mentioned that the following SSH topics have been already present in their energy related courses (in order from the most to the least frequent): economy, history, law, policy, environmental aspects, role of the EU, ethics. Almost two thirds of the courses with some SSH contents make a compulsory part of the curricula, the rest are optional courses; with one exception all of them are run once per every academic year (one course is run in every semester). The relative weight of the SSH topics within the course vary from more than three hours in 50% of the courses to less than an hour in 20% of the courses.

2.2.3 Methods of linking SSH with energy teaching within the institution

SSH are mainly taught in formal lectures (60%), to a lesser degree (30%) in the form of seminars or discussions. Group work is rare, “other forms” are reported more often (e.g. visit tours, working experience)

2.2.4 Profile of those who teaches SSH issues

40% of the lecturers declared to have some formal background or training in the SSH issues. The rest are trained exclusively in engineering or natural sciences.

2.2.5 Expectations in SSH issues

From the proposed options, most of the participants (approx. 70%) would expect the project to contribute to the issues of Energy and the public. Technology assessment, Energy consumption patterns and Energy awareness also ranked high. On the other hand, there was rather low interest in the conflict management and the energy prosumption. Importantly, not a single university declared interest in proposing new regular courses given by highly qualified SSH experts and several even reacted to this in the comments by pointing out that the main challenge for the quality of technical education presently relies in insufficient engineering training, e.g. in the project management. Also in this respect, the participants recommended that the SSH topics should be dealt within regular courses managed by the university. However, the majority also agreed that SSH experts should be occasionally invited to teach single lectures. One of the comment explicitly proposed that students should be taught more on the relation of material and human values with respect to the conflict between growth and sustainability

2.3 Poland

2.3.1 Short characterization of investigated institutions (and curricula)

In Poland, at 18 technical universities, the energy related issues are carried out primarily at the bachelor level of studies. The curricula of these studies depend on whether they are typical Energy or Electrical Engineering studies or energy related issues appear only as a supplement or an extra knowledge. In this case, these energy related issues are treated as a subtopics and their total number of hours is small in relation to the other courses.

Specialized master studies (or graduate studies) on Energy or Electrical Engineering are offered by Warsaw University of Technology (Warsaw), Wrocław University of Science and Technology (Wrocław), Silesian University of Technology (Śląsk) and AGH University of Science and Technology (Kraków). Doctoral studies, in fields on Energy or Electrical Engineering, are carried out on all of these universities. The curricula were investigated on Energy or Electrical Engineering on the following faculties:

- Warsaw University of Technology– Faculty of Electrical Engineering; Faculty of Power and Aeronautical Engineering
- Wrocław University of Science and Technology – Faculty of Electrical Engineering; Faculty of Mechanical and Power Engineering
- Silesian University of Technology Politechniki Śląskiej – Faculty of Electrical Engineering; Faculty of Energy and Environmental Engineering
- AGH University of Science and Technology Akademii Górniczo-Technicznej – Faculty of Energy and Fuels; Faculty of Electrical Engineering, Automatics, Computer Science and Biomedical Engineering.

The questionnaire was sent to the deans of eight departments listed above. Questionnaires were then forward to the teachers in order to verification the implementation of SSH issues in their subjects. It was also forward to the staff responsible for the study programs.

We received a response to the sent questionnaires from five faculties of the eight listed above but only one response contain the analysis of curriculum at doctoral studies.

2.3.2 Topics already present in energy teaching

All of the questionnaire responders indicated that SSH issues are the part of the teaching in the curricula. They mark the following SSH issues, that are already present in energy teaching: the basis of economy and philosophy, different ways of communication, methods of increasing the efficiency of intellectual work, effective learning techniques, the social impact of the development of new technologies and the role of technical innovations in modern culture, project management, human resources management; energy law.

SSH issues, in the vast majority of surveyed courses, are implemented in the scope of more than 3 hours per term. Only two subjects contain from 1 to 3 hours of teaching about SSH issues per term. It also noted that the SSH issues in energy subjects are compulsory and they are conducted regularly. In that case, students can choose one of the three proposed subjects. On doctoral studies, subjects related to SSH issues are irregular.

2.3.3 Methods of linking SSH with energy teaching within the institution

All questionnaires clearly showed that SSH issues are mainly taught in lectures. In two cases teamwork and project classes are in addition to the lecture.

2.3.4 Profile of those who teaches SSH issues

SSH issues are the vast majority taught by teachers with SSH education. Only one subject -Legal aspects of energy is carried out by a teacher with no SSH education.

2.3.5 Expectations in SSH issues

Out of all the questionnaires responders, indicated: energy and the public; technology assessment; 'Smart grids'; energy awareness; energy prosumption as the most important issues that should be expanded in teaching. One respondent concluded that there is no need to add more SSH issues in energy teaching. All of the questionnaire responders indicated that SSH issues in teaching on energy issues should be integrated by staff of the own institute. One respondent marks the option of hiring high qualified SSH expert to conduct one-time lectures.

2.4 Spain

2.4.1 Short characterization of investigated institutions (and curricula)

12 universities (10 of them public) have been identified that offer technical masters programmes (20 in total) related to energy, mostly energy engineering. The masters' titles include concepts such as: energy engineering, thermal energy systems, environmental engineering and energy sustainability, electric power industry, renewable energy and energy efficiency, nuclear technology and science, electrical energy, smart energy systems or energy technology. We approached the responsible person in charge of the master (director or coordinator) for the 20 masters identified. They either replied themselves or send the survey to the lecturers responsible for some of the courses. We gathered eleven replies to the survey:

- Integration of Renewable Energy in the Power Systems (University Carlos III, Madrid, UC3M)
- Master on Energy Technology for Sustainable Development (Technical University of Valencia, UPV)
- Master in the Electric Power Industry (Universidad Pontificia Comillas, Madrid)
- Master on Energy Conversion and Energy Efficiency (Universidad Complutense Madrid, UCM)

- Master in Renewable Energies and Energy Efficiency (University of Zaragoza, UNIZAR)
- Master in Energy Engineering (University of Oviedo, UNIOVI)
- Master in Smart Electrical Grids and Distributed Generation (University of the Basque Country, UPV/EHU)
- Master in Thermal Engineering (University of the Basque Country, UPV/EHU)
- Master in Energy Engineering (Technical University of Madrid, UPM)
- Master in Thermal Energy Systems (University of Seville, US)
- Master in Intelligent Systems in Energy and Transportation (University of Seville, US)

2.4.2 Topics already present in energy teaching

The SSH issues mentioned as being already present in energy engineering teaching include: regulation and economics of the electricity sector, ethics, ethics on research, ethics on energy technology, sustainability, politics, economics, microeconomy within the electricity sector, law and legislation, social impacts, integration, entrepreneurship, leadership, group psychology and history and sociology within the environmental framework. In most cases (fifteen out of seventeen) the courses are obligatory and are always offered on a regular basis. The amount of hours on SSH issues is different – reaching from less than one hour to more than three hours.

2.4.3 Methods of linking SSH with energy teaching within the institution

SSH issues are taught in different formats, in some cases as lectures, in others as discussion and in others as seminars, sometimes combined with discussions or group work.

2.4.4 Profile of those who teaches SSH issues

SSH issues are mostly taught by teachers who do not have a SSH background. Only in five courses out of seventeen the lecturers are trained in SSH.

2.4.5 Expectations in SSH issues

According to the majority of respondents, the relevant topics to be taught within the existing curricula would be energy technology and the wider public (8 out of 11) and ethics and philosophy of energy development (6 out of 11). Energy awareness, Technology assessment and Smart grids are relevant for 4 out of 10 respondents. The other topics suggested in the questionnaire, like energy consumption patterns, prosumption or conflict management are mentioned by two or three respondents. Other topics: regulation and economics of power sector, economic efficiency and sustainability of the system, are considered relevant by 1 respondent. There are different opinions regarding who could teach these topics: the staff of the university, experts occasionally invited to teach single courses or highly qualified experts offering new regular courses. In some cases, the respondents opt for a combination of two or all three options.

When asked about recommendations for TEACHENER project, one professor suggests that there is a need for lecturers to keep up to date with changes taking place in the industry sector and to be aware of the main policy goals. According to another respondent, it would be useful to provide examples on how to apply SSH concepts to technical subjects in a systematic way. In the same line, a third respondent proposed to focus on how energy policies are driven in practice, i.e. whether they are driven by technology, short-term macro-economy, long-security of supply or environmental concerns makes a large difference in the characteristics of the energy sector of a country.

2.5 Germany

2.5.1 Short characterization of investigated institutions (and curricula)

In Germany, at about 30 universities and institutes single introductory courses on geothermal energy are included in teaching and courses on hydrology, engineering hydrology, applied geosciences, management of georesources, energy systems, civil engineering or geophysics. The issue of geothermal energy at these universities is rather a subtopic that has only few space and time (only some hours) in teaching.

Full curricula on geothermal energy are provided at four universities in Germany: at the University of Applied Science Bochum/ International Geothermal Centre (Bochum), the Institute of Earth and Environmental Sciences (Freiburg), the Institute for Applied Geosciences (Darmstadt), and the Center for Geosciences at the Technical University of Munich.

Three of the four institutions offer a specialization on geothermal energy within the master program.

- In Bochum a specialization on "Geothermal Energy Systems" is possible within the master program "Civil Engineering".
- Within the master program "Applied Geosciences" in Freiburg the combination of the elective course "Geothermal Energy" with the elective courses "Hydrology" or "Hydrochemistry" is possible.
- At the Technical University of Munich geothermal energy issues are integrated in the master program "Engineering- and Hydrogeology"

Only the institute for Applied Geoscience at the Technical University Darmstadt provides master programs exclusively focused on geothermal energy: "Applied Geoscience" and "Energy Science and Engineering". The institute furthermore offers the B.Sc. "Applied Geoscience" that also has a focus on geothermal energy.

Thus teaching on geothermal energy in Germany is rather an issue of master level teaching.

Questionnaires have been sent out to teachers responsible for the master programs at these four universities and to teachers at four institutes that provide introductory courses on geothermal energy in order to grasp the picture on SSH issues in geothermal energy teaching. Six of them filled out and sent back the questionnaire.

2.5.2 Topics already present in energy teaching

In the questionnaire, the teachers mentioned the following SSH issues, that are already present in energy teaching: social acceptance of energy technology, dealing with risks, communication, social aspects of environmental impacts and the general legal and economic framework relevant for geothermal energy technology. Within the courses, the amount of hours on SSH issues is different – reaching from less than one hour (per course) to more than three hours (per course). Furthermore, all courses, with one exception, are obligatory and are taught yearly.

2.5.3 Methods of linking SSH with energy teaching within the institution

SSH issues are mainly taught in lectures. Further methods applied are discussions and group work.

2.5.4 Profile of those who teaches SSH issues

SSH Issues are exclusively taught by teachers who do not have a SSH background and are trained in natural sciences.

2.5.5 Expectations in SSH issues

According to the respondents, topics such as energy technology and the wider public (5), technology assessment (5), conflict management and energy prosumption (4) would be of relevance within the existing curricula. To a lesser extent the topics of energy awareness and energy consumption patterns (2), Ethics and philosophy of energy development (2), Smart grids (1) and energy system and its environmental impact (1) are mentioned. Those topics could be integrated into teaching about energy, whether by staff of the own institute, by inviting occasionally experts to teach single courses or by establishing new (regular) courses given by qualified SSH experts. However, establishing a course exclusively on SSH issues is considered as being too extensive. SSH issues should be integrated directly to the curriculum of the respective master program.

3. Summary

Within the following the common ground of the analyses and overarching issues revealed by the analyses will be summarized.

3.1 Current Situation of implementing SSH issues in teaching energy issues

First and foremost it can be concluded: SSH issues in all partner HEI‘s are already part of energy teaching. This is also true for most of the energy curricula captured within the online questionnaire. However, the extent to which SSH issues are taught in technical and natural scientific energy related curricula is generally small. SSH issues that are already integrated in energy teaching correlate either with the general research focus of the institution, the main focus of the curricula, or with theme and focus that PhD students have in their work.

In all four technical partner HEIs economy and management and to a lesser degree legal and political questions are already integrated in technical and natural scientific curricula (always related to the specific energy issue – e.g. legal and political situation for nuclear energy). Additionally soft skills and transdisciplinary training in the analyses are counted as SSH issues. These are already integrated in energy teaching and are seen as highly relevant by students and teachers. On contrary, to date SSH issues such as history, sociology, psychology, or ethics are only in single partner institutions taken up in energy teaching (e.g. Gdansk).

At *CTU in Prague* within curricula on nuclear energy historical, legal and economic aspects of energy generation are most present. SSH issues are presented in optional courses or seminars that can be chosen by students on voluntary basis. Above this “transferable skills” and “soft skills” are important in teaching. At *the Gdańsk University of Technology* (GUT) societal questions on energy grids complete the technical focus. Most central are economic, psychological, and ethical aspects (issues) in the SSH part of teaching. Focal themes are communication, basic knowledge on human behavior as well as methods of solution oriented research. SSH issues integrated in teaching energy engineering at the *UPC in Barcelona* focus economic and societal dimensions of production, use, and management of energy. Legal, economic, historical, sociological, and ethical aspects in the context of global energy demand, renewable energies and energy efficient cities are important issues in the curricula. Furthermore, social and philosophical aspects of safety and disaster management are taught. However, economic and management issues seem to be dominant over ethical and sociological aspects. At *UFZ in Leipzig* teaching is strongly influenced by the transdisciplinary orientation of this research center. SSH issues are strongly connected with the solution oriented research on natural hazards and risk, renewable energies and methods of transdisciplinary research.

At all partner HEIs SSH issues are taught in form of lectures or seminaries. Didactic elements such as group work, discussions and student projects are used. Moreover role playing games and excursions are partly used in order to bring SSH issues from an abstract theoretical level to a more comprehensible practical level. It seems that SSH issues are taught by teachers without SSH background when these issues are part of more technical or natural scientific courses and have a small share there. However, at all partner HEIs special courses that focus exclusively on SSH issues are provided. Such courses are taught by teachers with SSH background.

The situation at other universities in partner countries is in most cases similar to the situation at the partner HEIs but varies across the countries. The results can be summarized as follows.

In the *Czech Republic*, situation in the energy programmes at universities with respect to SSH is similar to that of CTU. In the curricula dedicated to education and training in the energy engineering, a significant attention in some of the courses is focused on economy, history and law. A few universities also foster lecturing on ethical issues. Most of the SSH relevant education is integrated directly into the energy courses and about 2/3 of this education is obligatory. An important, although a minor, part of the lecturers (about 40%) declared to have some formal training in SSH.

The situation at other universities in *Poland* is similar to the situation at the University of Gdansk. The focus of SSH issues currently taught is on economy and management as well as soft skills (e.g. communication, learning techniques). However more specific issues, such as social impact of the development of new technologies or the social science aspects of innovation are dealt with in some curricula. Courses on SSH issues in energy subjects are compulsory, are conducted regularly and have a scope of more than 3 hours per term. SSH issues are mainly taught in the form of lectures. In Poland the vast majority of SSH issues are taught by teachers with SSH education, this is different from the other three countries.

A wide range of SSH issues is currently taken up within energy teaching in *Spain*. Nearly all social scientific disciplines from economy and law, over history and sociology up to ethics find its way into the curricula of different courses of study. Teaching is completed by specific issues such as social impacts or energy technology ethics. SSH issues are taught in form of lectures, discussion, seminars, and group work. SSH issues are mostly taught by teachers who do not have a SSH background. Only in few cases lecturers are trained in SSH.

In *Germany* SSH aspects are tailored to the content of the course of study. Thus most important issues from the field of SSH are social acceptance of energy technology, dealing with risks, communication, social aspects of environmental impacts and the general legal and economic framework relevant for geothermal energy technology. The amount of SSH issues has a wide variety - reaching from less than one hour (per course) to more than three hours (per course). Different than at UFZ at HEI's in Germany SSH courses are obligatory. Lectures, discussions, and group work are most common formats used to teach SSH issues. The issues are exclusively taught by teachers who do not have a SSH background and are trained in natural sciences.

3.2 Issues from SSH needed/wished in energy related curricula

The identification of SSH issues required in energy related curricula, is based on surveying two groups of people: students at the partner HEIs and teachers at other HEIs in partner countries.

The idea of interviewed students about the relevance of SSH issues for their future working life is different. While in Spain and Germany the students expect that future employers recognize competences, skills and knowledge on social aspects, in Czech Republic these competences are seen as an individual quality that enables responsibility in research but will not be important for employers. In all four countries students express the wish to become certain in public debates and preparing information campaigns and to be able to influence actors and societal developments. Thus, students wish to learn about communication and improve their abilities in this area in the frame of SSH teaching. Thus, students tend to reduce social scientific disciplines such as sociology on marketing, human resources management or soft-skills. This gives hints on existing lacks in SSH knowledge.
However, as regards the individual social responsibility of a researcher they see the relevance of SSH issues. Knowledge in SSH issues can become relevant if they are closely linked with the issue of the master or PhD thesis, e.g. political or legal issues. Students wish to get in contact with SSH issues but those should be close to their own research area or curricula thus, close to their interests. Such issues could be for example: risk research, questions of social acceptance of energy technologies, and, more general the relation of energy and society.

Students estimate the existing time available as too low to integrate more SSH issues. Only some of them could imagine an extension of the course offer in order to get more insight in SSH issues. Furthermore, students note, that courses about SSH issues should be freely selectable and not obligatory.

Questioning of teachers at other HEIs revealed a clear tendency and priority over all four countries for two of the SSH issues (that have been suggested in the questionnaire as choice question): *Energy and the public* and *Energy awareness.* In Poland, Czech Republic and Germany furthermore questions of *technology assessment* are considered being relevant in teaching. All other issues have a different relevance in the partner countries. In Spain for example the topic of *ethics and philosophy of energy development* is seen as highly relevant.

Teachers also were questioned on how SSH issues might be integrated in existing curricula. In all four countries it was made clear that there is no extra time available in either undergraduate or postgraduate programs for new SSH courses due to rather high and increasing requirements in the technology courses. Thus it has been stated that SSH issues have to be integrated in the current teaching portfolio. A less clear picture shows the answers to the question of how and by whom SSH issues should be integrated either by staff of the institute or by external teachers. However, it is clearly stated that teachers teaching SSH issues should extend their SSH knowledge and the need to be updated with the industrial reality and be aware of the policies and of what are the drivers for those policies (technology, macro-economy, security of supply, environmental concerns, etc.).

3.3 Conclusions for the TEACHENER Project

Engineering education in energy issues provided at partner HEIs and other HEI within the partner countries that have been taken into account within this analysis cover a broad range of issues and aspects related to energy in society. Reaching from basic principles of energy

generation (thermal as well as electric energy) based on different technologies (e.g. nuclear energy, geothermal energy, renewable energies), to technical aspects of energy infrastructures (e.g. energy grids) and questions of energy-management relevant for the distribution of energy, up to issues such as efficient cities that relates to the question of energy consumption. Thus, as the analyses show, the current situation of SSH issues integrated in curricula but especially needs on SSH issues are to large extend specific not only to the country but also to the HEI and even each specific curricula. This overall finding has to be considered in the developing of teaching modules. Modules and content developed by TEACHENER should be closely related to the topics of the respective energy studies. As these topics are very wide and differ between the partner countries and HEI's (nuclear energy, geothermal energy, etc.) but also between courses of energy **studies** ***teaching modules need to be tailored to each curricula and course of study***. Two key SSH topics that need up to date education in all countries are: relation between the public and the energy production and energy awareness.

An overarching issue seems to be the understanding of what SSH issues are (or could be) and what their relevance in the specific energy context is. While teachers in energy education point to the relevance of SSH issues in natural scientific and engineering energy teaching, students are less aware. Many of them (but not all) tend to reduce social scientific disciplines on marketing, human resources, management or soft skills such as communication. Thus, modules developed by TEACHENER should ***clearly highlight what are SSH issues and in how far they are relevant for technology development and research in energy issues*** and make clear in how far this differ from soft skill education. Most challenging seems to show relevance of SSH knowledge for carriers outside of science.

Another issue that has been raised in all countries are temporal restrictions. Existing courses and curricula are already dense and time is lacking to teach important engineering issues. Thus modules developed by TEACHENER should not be additional and should not extend present programs but should be ***integrated in existing courses*** (technical or SSH focused, depending on the curricula) and improve the quality of the existing SSH contents of the energy curricula.

Modules developed by the TEACHENER project should not strongly focus on students, but rather on ***teachers and their lifelong education***, aiming at improving their knowledge on relevant SSH issues. This result is mainly based on the current situation in Germany, Czech Republic and Spain where SSH issues are for the overall part taught by teachers without SSH background. The situation in Poland is different in this regard– SSH issues in energy teaching are currently taught by teachers that have a background in SSH.

Annex

TEACHENER Project – Questionnaire

The transdisciplinary TEACHENER project (www.teachener.eu), funded within the Erasmus+ scheme, aims on integrating social sciences and humanities (SSH) into teaching about energy on Master and PhD level. SSH issues thereby include for example politics, history, sociology, law, philosophy, ethics or economics. TEACHENER aims to fill the gap between social sciences and

humanities and energy teaching at universities in Europe, by transposing social sciences and humanities knowledge to the domain of higher technical education.

Within a first step we analyze the current situation in energy teaching. Therefore we would like to ask you to answer the following questions.

1. Are SSH issues (such as politics, history, sociology, law, philosophy, ethics or economics) part of the teaching in your discipline/curricula?

   If so, please enter the title of the course (As it is crucial for us to get the full picture about your curricula, please try to think of all courses that possibly include SSH issues and fill in the information about all of them. Further courses can be filled in at the End of this questionnaire).

   Your discipline/curricula:

   _____
   _____
   _____

   Title of the course:

   _____
   _____
   _____

   SSH issues:

   _____
   _____
   _____

   for students this course is:
   - o obligatory
   - o optional

   The offer of this course is:
   - o regular
   - o irregular: yearly
   - o regular: less than yearly

   Social sciences content within this course has a scope of:
   - o less than 1 hour
   - o 1-3 hours
   - o more than 3 hour

   The course is offered by teachers who are:
   - o trained in SSH
   - o not trained in SSH

   SSH issues are presented in the form of: *(multiple answers possible)*
   - o seminar
   - o lecture

- o group work
- o discussion
- o Other:

2. On which SSH issues do students need more knowledge? Which of the following topics are important from your point of view in the course of studies: *(multiple answers possible)*

   - o Energy and the public
   - o Technology assessment
   - o Ethics and philosophy of energy development
   - o Energy consumption patterns (e.g. heating behavior)
   - o Conflict management
   - o 'Smart grids' (e.g. data security, privacy of data)
   - o Energy awareness
   - o Energy prosumption (users producing their own energy)
   - o Other:

3. How SSH issues should be integrated in teaching on energy issues? *(multiple answers possible)*

   - o By the staff of our institute
   - o By inviting occasionally experts to teach single courses
   - o By establishing new (regular) courses given by highly qualified SSH experts
   - o Other:

4. Do you have specific suggestions, recommendations for the TEACHENER Project? Please share these thoughts with us.

….. *space to introduce information for further courses*

5. At the End of this questionnaire, for statistical reasons, we would like to ask you to let us know which position you hold on your institution:

   Institution:

   _____

   _____

   Position:

   _____

   _____

6. Thank you for participating