THE GREEN ENERGY TRANSITION - A CASE FOR LIFELONG LEARNING

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ABSTRACT

The EU has launched a series of ambitious plans to accelerate the energy transition, notable the 'Fit for 55' package that was presented by the Commission in July 2021. The target of the package is to reduce greenhouse gas emissions by 55% by the year 2030. Climate change mitigation through phasing out fossil fuels and becoming energy independent are central targets for the EU. The universities are supposed to be forerunners when it comes to research and education for providing the skills and competencies for enabling environmentally and economically sustainable development of society. However, when it comes to the energy transition, is the technology driven by the companies, with the universities just trying to keep up with the technical development? Are the skills acquired from traditional engineering education enough to support the green transition? In this paper, a qualitative study on how the current curricula support the green transition from the viewpoint of university-level engineering schools in Finland is presented. Based on this study, an analysis on potential changes beneficial for empowering the students to be able to rapidly contribute to the energy transition is performed. In addition, it is discussed how the current offerings could be used for lifelong learning to contribute to the green transition.

KEYWORDS

Green transition, Energy technology, Sustainability, Continuous education, Lifelong learning
CDIO Standards: 2, 3, 4, 5, 12

INTRODUCTION

Over the past few years, we have seen a series of initiatives by the EU to accelerate the energy transition, for example, the Battery directive(European Commission, 2020a) and the EU strategy on offshore renewable energy (European Commission, 2020b). To further accelerate the transition, the EU Commission presented its 'Fit for 55' package in July 2021 (European Council, 2021). The proposals included in the package aimed at providing a coherent and balanced framework for reaching the EU's climate objectives. The goal is to reduce greenhouse gas emissions by 55% by the year 2030 and to make the EU climate neutral by 2050. The Russia-Ukraina conflict starting in 2022 made all of Europe aware of our dependency on fossil fuels.

The need for a rapid transition to sustainable and fossil-free energy systems was suddenly not only policy-driven but driven by a pan-European energy crisis. This gave rise to the RePower EU plan (European Commission, 2022), which aims to make Europe independent from Russian fossil fuels well before 2030.

The universities are supposed to be forerunners when it comes to research and education for providing the skills and competencies for enabling environmentally and economically sustainable development of society (United Nations, 2015; UNESCO, 2021). Also, the CDIO Standards have been updated to include these themes (Malmqvist et al., 2020). Sustainability was one of the development targets already in the previous major revision of the CDIO Syllabus (Crawley et al., 2011). Furthermore, the crucial role of engineers in sustainable development was taken as one of the main motivations also for the recent update of the syllabus (Malmqvist et al., 2022).

However, when it comes to the energy transition, is the technology yet driven by the companies, with the universities just trying to keep up with the technical development? Are the skills acquired during university studies enough to support the green transition that is needed in the energy sector, the industry and society in general? In this paper, we present a qualitative study from the viewpoint of the universities in Finland on how the current engineering curricula support the green transition. Based on this study, we perform an analysis of which changes would be beneficial for empowering the students to be able to rapidly contribute to the energy transition. In addition, we analyse how the current offerings could be used for lifelong learning, providing knowledge and thinking models for professionals in the industry, to contribute to the transition and the conclusions of what actions the universities should take.

The research questions that were addressed in this work are the following:

1. How well does the current curriculum support the energy transition?
2. What action (curriculum changes) should be taken to better support the energy transition?
3. What is the role of lifelong learning for the energy transition?

The research questions are addressed by a literature review, interviews of representatives of the seven universities offering engineering education in Finland, and by an analysis of the results achieved.

ROLE OF HIGHER EDUCATION IN THE ENERGY TRANSITION

On June 16, 2022, the European Council adopted a recommendation (European Council, 2022) for member states to support policies and programmes about learning for the green transition and sustainable development. Members states are recommended to step up efforts to support education and training for green transition for learners of all ages. University engineering education has a special role, as technology for green transition needs to be available to enable this transition.

In a study by Biancardi et al., 2023, the authors have conducted a study on student perception of sustainability and energy issues. Earlier studies on how students and professionals can be prepared for the energy transition emphasize the integration between different disciplines (Huijben et al., 2022) and the importance of bringing students closer to real contexts (Colmenares-Quintero et al., 2023). Others bring up potential pitfalls with focusing on the topic too narrowly as there are discrepancies between what is technically feasible and socially desirable (Sakellariou and Mulvaney, 2013). Indeed, the energy transition ought to be addressed from a broader sustainability transition perspective, for example, in the context of the UN's Sustainable Development Goals (Dziubaniuk et al., 2022).

Many previous authors have addressed the need for a change in curriculum for supporting sustainability goals. It is often mentioned that education needs to be multidisciplinary, including both technical and social aspects of sustainability in education (Krupnik et al., 2022). Lozano et al., 2022 mention the role of a holistic approach to teaching for sustainability. There are however not many research papers that directly address the analysis of the technical content of education required for green transition and sustainability.

A recent Finnish report has analysed the effects of the green transition on educational requirements in engineering. The report looks at the skills needed in three related sectors: the process industry (a big off-taker for green energy), the energy industry (production) itself, and the construction industry (building and installing the new energy system) (Wikman et al., 2022). The report furthermore distinguishes between three types of skills needed for the transition in these sectors: core technical, system-level, and complementary skills (Wikman et al., 2022). With complementary skills, the authors refer to safety, digital solutions and modelling, but also more recent knowledge such as circular economy and environmental impact assessment.

Another analysis report published by the Association of Nordic Engineers (DAMVAD Analytics, 2022) provides a more detailed list of competencies needed for a sustainable future. The main areas of technologies are listed as Power-to-X, wind power, battery, hydrogen, biomass, geothermal and carbon capture technology. It is mentioned that engineers are indispensable for reaching Nordic net-zero emission targets. Overall themes that need to be addressed are the electrification of society, systems thinking, knowledge sharing and big picture thinking, the increasing role of data and digitalisation, and the demand for engineers with soft skills. The report also mentioned the need for collaboration between universities, and also between countries, to ensure that knowledge from one country can be reused in another. One such example of collaboration is the BotH2nia hydrogen cluster (both2nia.com), where the partners have a common set of events and education on wind power and the hydrogen economy.

Lifelong learning and green transition

Different opportunities for continuous and lifelong learning have been discussed widely in different arenas. The ageing population in several countries, including Finland, together with rapid technological development has raised concerns about the universities' ability to contribute to the needs of future society. Sustainability and energy transition are typical examples of topics that require multidisciplinary competence development of professionals working in the field. Learners of all ages and backgrounds should be able to access high-quality, equitable and inclusive education and training on sustainability, climate change, environmental protection and biodiversity (European Council, 2022).

The Government of Finland published a new National Higher Education Strategy for Lifelong Learning recently (Ministry of Education and Culture Finland, 2022). One of the goals of the strategy is to strengthen and clarify the role of higher education institutions as providers of different types of courses and other research-based activities contributing to the lifelong learning of individuals as well as the development of organizations. These learning opportunities should be easily accessible and available. For example, different open education solutions (e.g. MOOCs), and course designs based on called micro-credentials (European University Association, 2020) are expected to facilitate learning. Furthermore, closer connections between lifelong learning and RDI activities are expected to increase the societal impact of the universities.

What does the landscape look like in practice at the moment? The challenge to create such high-quality educational offerings that are able to meet individual, industrial and societal expectations is not trivial. Creating timely, learner-centred and economically efficient learning solutions that are easily available on digital platforms is not enough. Also, both individuals and organizations shall actively and continuously seek new knowledge and utilize these opportunities for growth. According to Eurostat (2022), adults in the Nordic countries participate in different education and training very actively compared to the EU average. However, participation in open university courses is strongly field-connected. For example, professionals in the field of Education and Humanities participate actively in these courses whereas Engineering and Science professionals are clearly underrepresented. That is, there should be room for the development and co-creation of new learning innovations.

METHODOLOGY: INTERVIEW OF FINNISH ENGINEERING UNIVERSITIES

Research approach

We established a qualitative research design covering all universities offering engineering education in Finland. A qualitative approach was chosen as the topic is new and we wanted to form a deeper understanding of all the nuances of how engineering schools are addressing the energy transition or of the underlying motives and personal reflections of faculty at these schools. The national focus is justified by the wish to account and control for various differences in national educational systems and the debate around that.

Selection of interviewees

Following our qualitative approach, we looked for professors and lecturers in the field of energy engineering (or closely related to it) at seven universities offering engineering education in Finland, that is: Aalto University (Aalto), Lappeenranta-Lahti University of Technology (LUT), Tampere University (TUNI), University of Oulu (OY), University of Turku (UTU), University of Vaasa (UWA), and Åbo Akademi University (ÅAU). We managed to cover at least one interviewee from each university. While it is impossible for one person to oversee all courses and degree programs in their institute, these contacted interviewees were very helpful to explore and set a research agenda. In total, we made ten interviews (meaning we interviewed two persons at three universities and one representative from the rest).

Data collection and analysis

For the interviews, we developed an interview protocol (see Appendix 1), which was derived from our perception of important topics underlying the overall research question. The interviews were semi-structured following the interview protocol in an open-ended way, meaning that the interviewees were free to elaborate on the topics beyond the immediate answer itself. The interviews lasted 30-60 minutes and were performed in December 2022 by one of the authors of this article. Structured notes were taken during the interviews. We used thematic content analysis to extract findings of interest for our study. This essentially meant that we organized the results in groups following the structure of the interview protocol (see the results section).

RESULTS

Interview results were arranged based on the questions and conversations during the discussions. The responses from different teachers belonging to the same university were counted to create transparency. The case concerns different experiences and practices associated with belonging to a geographical area and department. Our aim is to provide a guideline for a green energy transition in the context of lifelong learning for engineering universities in Finland. This would increase knowledge-base in general and enhance the curricula in accordance with the needs of society.

Courses supporting the new energy technology

The interview starts with a general question to the interviewee meant to analyse at a larger level whether there are courses on specific domains that were communicated with the interview question. This topic brought up a discussion on what it truly means *"New"*. The reality is that sometimes "new" simply means improvements to the present technologies. Many of the interviewees responded that the universities where they work are moving towards renewable energy teaching and all courses are oriented towards this.

Figure 1 unveils that hydrogen, photo-voltaic, bio-fuels, heat recovery and energy storage, are the most mentioned topics, part of the energy transition covered within the universities curriculum. Other technologies like wind and battery had a lower response rate pointing towards being moderately thought to students. Fuel cells and new fuels are novel research topics on energy transition at the beginning of the research, and therefore not many technical universities are putting effort into this. One respondent noted that mechanical parts are a great addition that could better support the knowledge given to students. Other respondents remarked that environmental engineering is a unique subject studied within the university.

Figure 2 emphasises energy transition as the highest encounter within the course examples given by the interviewees. Some mentioned that energy transition is only a chapter or part of the course curriculum. Others mentioned having specially employed professors on energy

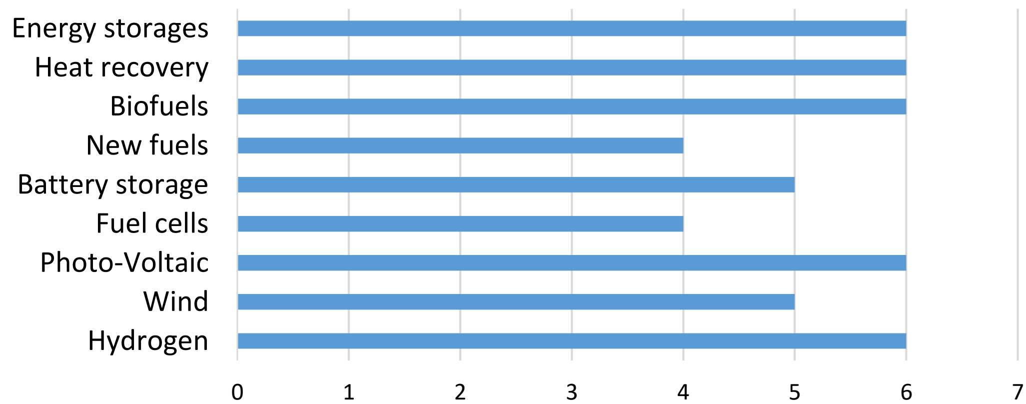

Figure 1. Number of universities adopting topics in new energy technologies courses in their curriculum

transition that could cover both technical and socio-economical aspects.

Changes compared to five years ago into energy transition

There seem to be clear differences in the educational strategies of the different universities. Some choose to have stable five-year curricula while others change their plans annually or bi-annually. Yet, many interviewees stated that their curriculum is updated continuously according to the industries' needs and the advancements in technology and society. An interviewee noted that the university's strategy has been changed towards topics in energy and carbon-neutral technologies.

Students seem to have more trust in the universities' curricula after topics in statistics and process engineering have been incorporated into courses. It is justified by the numerical values incorporated within courses that give more value to the students. Moreover, applications and practical examples (or hands-on experiences) are considered very crucial for students to understand the motivation behind each course. The hybridization and electrification of the power trains are as well novel addition. A minor in sustainability and a master's programme in environmental engineering are very close subjects to the energy transition. Energy scenarios and power to Ex (energy) technology-connected courses were mentioned, too. On the other hand, one respondent noted that there have been no drastic changes made in the curriculum compared to five years ago.

Improvements in supporting the new energy technology

The most common answer to this question was the lack of highly-skilled personnel trained for teaching courses connected to the energy transition. However, international cooperation and resources are bringing new opportunities and improving the ways of teaching at Finnish universities and, therefore, help keep the country stay at the same technological level as others.

Interviewees noted the need for intensified research on heat systems, energy storage, bio-gas

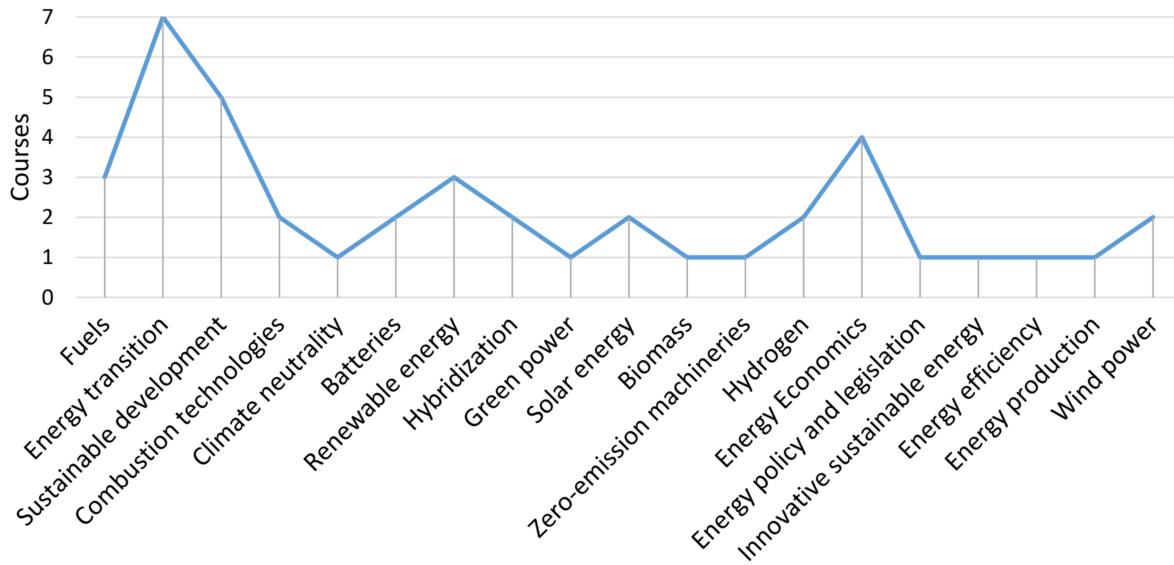

Figure 2. Courses that support the new energy technology

cleaning techniques, system flow detection, and small modular reactors. Studies on how technical and financial energy transition fits into the social sector's needs to proceed simultaneously. Also, new initiatives to reduce the cost of new technologies (e.g., hydrogen production) are needed. Energy systems designed to produce biomass are an addition that would facilitate the existing processes because the current price for biomass fuel is many times higher than that of fossil fuels. One interviewee raised that, at a university, one needs to have the ability to be self-sufficient. Given this, the values of the university connected to energy transition are sufficient motivators to continue the activity within the unit.

Cross-disciplinary courses or learning experiences

The previous topic raised responses where some noted that their departments don't currently have cross-disciplinary courses or external cooperation. Yet, some units are utilizing courses on different topics such as strategy and vision making, governance, policies and laws on energy transition given by other universities. Others have policies and legislation deeply incorporated into their own curriculum. Other examples of cross-disciplinary courses include topics in hydrogen, electrical energy storage systems, materials sustainability, energy policies, fuels, power plants, and life-cycle analysis.

The sustainable urban energy course is an example where students incorporate sustainable development and model energy at a city level. The *climATE* programme of Aalto University is a research and art exhibition on climate change and food systems (Aalto University, 2019). One interviewee noted that sustainable values transmit to people through their habits. Therefore, there is a lack of social science to be added to curricula. The mentioned topics and courses are listed within the educational program of the interviewed universities.

Courses that support the business modelling of the new energy markets

Several interviewees mentioned there is neither space in the curriculum education nor availability of courses in business modelling of the new energy markets. Yet, a major challenge when modelling the new energy systems is whether they are economically competitive or not.

This topic is present in the following courses that are part of the interviewed universities' curricula: Sustainable energy, Feasibility, Electrical energy storage systems, Fuel and Off-grid value chains, Business models and Entrepreneurial journey, Energy market systems, Turning circular economy technologies into business - commercialization and business model development.

An example is a course called *Sustainable Energy Project*, where students need to analyze the feasibility of an energy production and management design assignment. Another interesting course is called *Power Exchange Game for Electricity Markets*, where students trade electricity using actual data and see how their decisions result in profit or loss.

Lifelong learning

Few interviewees mentioned that their universities do not currently target lifelong learning students due to a lack of motivation, time or other projects. Occasionally, companies want to improve the employers' competencies and send their employees to attend university courses. Some courses are good bridges between universities and companies. An example is the *FiTech* (Vasankari et al., 2021) platform where many of the universities are sharing their courses. In addition, some universities provide special courses designed for lifelong learners.

Lifelong learners are both a challenge and an opportunity for universities. Opportunity comes from the valuable feedback that specialists with substantial years of field experience could be able to provide. One of the practical challenges of lifelong-learning-oriented courses is that students are often losing their interest during the course (or feel the time pressure from their ordinary work making the unable to commit to typical university courses) and, consequently, the courses need to be split into micro-credit modules. Business thematic courses have previously solved the need for lifelong learning. Furthermore, there are Massive Open Online Courses (MOOCs) designed, for example, for climate actions in the transport sector and achieving climate neutrality. Such an example is the *UNITE* (Hetemäki et al., 2022) project that is responsible for developing new solutions for meaningful and sustainable interaction between people, forests and technology.

Statistics related to energy-related students/year, courses and teachers

Statistics related to energy students, courses and teachers from these seven Finnish universities were collected. The question aimed to provide an understanding of a numerical approximation based on the interviews compared to the data available in the national educational statistics database *Vipunen* (Table 1). In this graph, we see that the interview results give a much larger estimate of students in the area compared to the numbers in the *Vipunen* database for LUT. This also reflects the overall feeling of the culture of future energy relevance for the university that was perceived in the interview.

LUT has the highest number of energy-related courses; approximately 250 courses in total. Next are Aalto and TUNI with 100 and 70 energy-related courses respectively. The other respondent universities have between 2 to 20 courses in this category. In addition, the number of teachers related to energy was discussed, too. The findings were similar to the question concerning the number of courses. LUT has approximately 200 teachers in energy Aalto and TUNI have

Table 1. Number of students studying energy-related topics annually - interview results compared to statistics in the Vipunen database

University	Total Vipunen	Total interview
University of Vaasa	453	10
University of Turku	192	26
University of Tampere	1506	700
University of Oulu	1098	50
Lapeenranta-Lahti University	2142	4000
Åbo Akademi University	176	35
Aalto University	3880	150

roughly 70 teachers each, and the rest less than 15.

Energy saving actions of the university

We also wanted to understand to what extent universities live as they teach, that is, how well the energy transition is integrated into the universities' operational activities. The energy crisis has brought new guidelines and rules for different organizations, including universities and student dormitories. The University of Turku made a strategic objective and commitment to being carbon neutral by the end of 2025 (Kola, 2020). As a general rule, the overall indoor temperature at the universities has been lowered, and many have reduced their real estate area moving different departments in the same building, or into a new structural and energy-efficient facility. The changes include replacing laboratory equipment with less carbon-intensive, adjusting the duration of fume cupboards, and optimising the period and power of air conditioning. Other suggestions for energy reduction are ride-sharing, commuting using bikes, and ongoing recommendations related to the working practices of personnel (the footprint of own daily work). Some energy-saving actions (e.g., temperature droppings) brought negative feedback due to the uncomfortable environment for developing the activity within office areas.

DISCUSSION AND CONCLUSIONS

The aim of this paper was to analyse how well the curriculum of engineering education universities in Finland supports the rapid need for an energy transition that we have globally, in Europe, and locally in Finland. We also analysed how the curriculum is changing and the role of lifelong learning in the transformation. In order to achieve the results, an interview-based qualitative study was performed with representatives from all seven universities providing engineering education in Finland. Previous research did not give much information on the actual implementation of green energy transformation curriculum changes. Several research articles stressed the need for such modifications, especially the need for a multidisciplinary curriculum, especially including social sciences and technology. However, very few actual examples of how that should be done were mentioned. That does not imply that such activities have been implemented, only that there is very little research on the volume and effect of such implementations. The best source of information on practical curriculum changes needed was actually provided by engineering association publications, and not by academia.

The interviews performed in this research however gave substantial insight into the activities in Finland. The seven universities providing engineering education have all taken considerable steps to change the curriculum to support energy transformation. All universities have introduced courses on new energy, and many existing courses have been adopted to support the new energy. However, strong multidisciplinary efforts are not yet visible, supporting the society-wide aspects of the energy transformation. Many of the changes are also more incremental than radical changes in the way education is performed and built up.

There is clearly a need for nationwide collaboration when it comes to lifelong learning. Emerging energy technology does not yet have a standardized learning material, generated teaching material should be reused between sites and made available for persons already in the working life. This way of working is not well established and needs a cultural change in the organization. Digitalization of educational resources gives a good platform for future collaboration.

FINANCIAL SUPPORT ACKNOWLEDGEMENTS

The author(s) received no financial support for this work.

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APPENDIX

Questions used for the interviews are the following:

1. How well do you think your curriculum supports the new energy technology? e.g., hydrogen, wind, photo-voltaic, fuel cells, battery storage, new fuels (hydrogen, ammonia, methanol), biofuels, new forms of waste heat recovery (data centres, marine systems, wastewater), energy storage systems
2. Examples of courses that support the energy transition?
3. What has changed in your curriculum during the last 5 years supporting energy transition?
4. What do you think your university should do to better support the new energy technology?
5. Do you have cross-disciplinary courses/learning experiences? (e.g., psychology, social policy-making, legislation)
6. What courses support business modelling of the new energy market?
7. Lifelong learning: Do you target lifan elong learning students (professionals out there) –> what kind of offerings (MOOC, on-site intensive courses, micro-credentials)
8. Number of energy-related students (total/annual)
9. Number of energy-related courses em Number of teachers related to energy technology
10. Did your university implement any energy-saving actions?