New Teaching Environments Near Real-World-Like Laboratories for Power Engineering

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NEW TEACHING ENVIRONMENTS NEAR REAL-WORLD-LIKE LABORATORIES FOR POWER ENGINEERING

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The Technical University of Denmark offers educations within power engineering at all levels: bachelor, master and PhD. Relevant bachelor programs use the CDIO educational framework, which allows the students to learn engineering fundaments in a context of conceiving, designing, implementing, and operating real-world systems [1].

The tool to be presented here is mainly establishment of teaching facilities at the Technical University of Denmark adjacent to the research facilities and where nearness to the ‘real world’ is essential and implemented by clearly visible research activities and by close cooperation with the power industry.

THE CONCEPT

In order to establish nearness between teaching and the real power engineering world, it is important to create a study environment close to the experimental platform and the research group. For that purpose, a new educational center ‘world of education’ is under development, closely linked to the research platform PowerLabDK and the center. Suitable building design contributes to an optimized logistic and minimization of the physical distance from classroom to hands-on learning environments with a clear view to the outside world in industry and utilities.

Traditionally, undergraduate power engineering education will in the early semesters consist of basic disciplines, the distance of which to the real power system appears quite large as seen from the student’s point of view.

This is illustrated in Figure 1, emphasizing how the initial teaching in large classrooms often takes place in separate lecture halls with no relation to other activities at the university. Later in the study, when the students are getting involved in more specialized courses, they might get a first indication of the research environment. Even laboratory exercises often take place at separate locations and first in connection with individual student projects, the door is opened to ‘other side’ of university business and maybe even the external relations to power industry and utilities.

The basic principle behind the new concept is shown in Figure 2. A major change as compared to the traditional structure is the introduction of considerable amounts of student working spaces adjacent to the research environment. By limiting the number of very specialized student laboratories for exercises, resources can be focused on higher utilized, flexible working areas forming a dynamic and motivating study environment with a very broad interface to the professional world.

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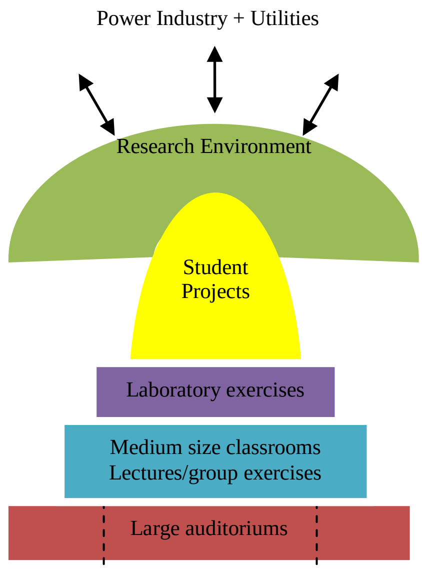

Figure 1. Traditional path from initial teaching in large classes to application oriented student projects with research relation. The time frame for M.Sc.- educations is 5 years, for the CDIO based B.Eng.-education it is 3½ year.

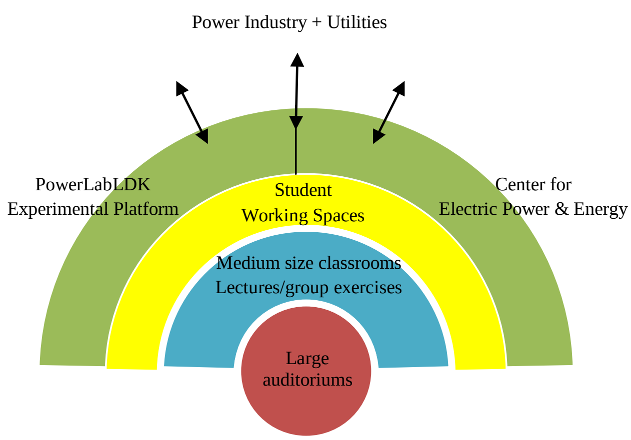

Figure 2. New concept based on minimized distances between power teaching and the research environment plus external relations to industry and utilities. Note the student working spaces with broad interfaces to 'the real world'.

The most direct impact of such a concept is a teaching environment, supporting the relevance of courses and projects, the topics of which are directly concerned with or at least obviously useful for power engineers. This mutual benefit is naturally increased by means of the broader interface seen in Figure 2. Another tool is adaption of the course portfolio to future needs as part of the university – industry/utility synergy.

Another effect is the better visibility of the research environment generates a clear perspective for the students, initially just by seeing 'what is going on' and later by their direct involvement.

This nearness to state-of-art research and the related external partners implements a function as eye-opener also for students, initially not intending to specialize within power engineering: If the research environment is designed to communicate the wide range of research areas and at the time the theoretical/experimental challenges related to this areas, a considerable percentage of all students with ambitions within electrical engineering should be able to find the personal niche and career. If research activities are visible from an early stage in the study life, the students will be able to realize the broad range of choices they have regarding specialization, hereby again minimizing the risk of early disappointment and doubts if their dream study can fulfill their expectations.

Based on this, we might emphasize three kinds of impacts, the concept will have on the students: motivation – challenges – perspective.

A 4th aspect, to be mentioned is acknowledgement, pretty often overlooked, in particular in the early years of the study. If we can involve the students earlier, and communicate some positive feedback, this kind of acknowledgement most likely will increase the motivation as well.

IMPLEMENTATION AND CURRENT STATUS

At the Technical University of Denmark, the first phase of a unique research platform, PowerLabDK, with total investment costs 18M€, has recently being finalized and offers a state-of-the-art environment composed by flexible fundamental research laboratories integrated with large-scale experimental facilities and a complete full-scale power distribution system (27,000 customers; 33% wind power penetration) which can be accessed directly from within the lab [2]. The vision of PowerLabDK is to be a driving force for groundbreaking new knowledge and innovative technologies within electric power and energy created in a dynamic and open environment of collaborating researchers, professionals and students from companies and universities. The initiative is supported by industry and utilities and the second phase of the project, involving the teaching environment is ongoing.

Figure 3 shows the physical location, the laboratories, visible on the northern part are newly established or updated.

It can be seen that the coming teaching facilities have a broad interface to the research area and one laboratory for students, the StudentLab is located even inside the laboratory area. Clearly visible on the right side of the StudentLab is the ControlLab which forms the heart of PowerLabDK. Figure 4 shows a view from inside this laboratory.

A Scada system gives the possibility to monitor and to control the major functions of the laboratory. The Island of Bornholm is part of the laboratory and allows experiments to be performed with direct connection to a power system in operation.

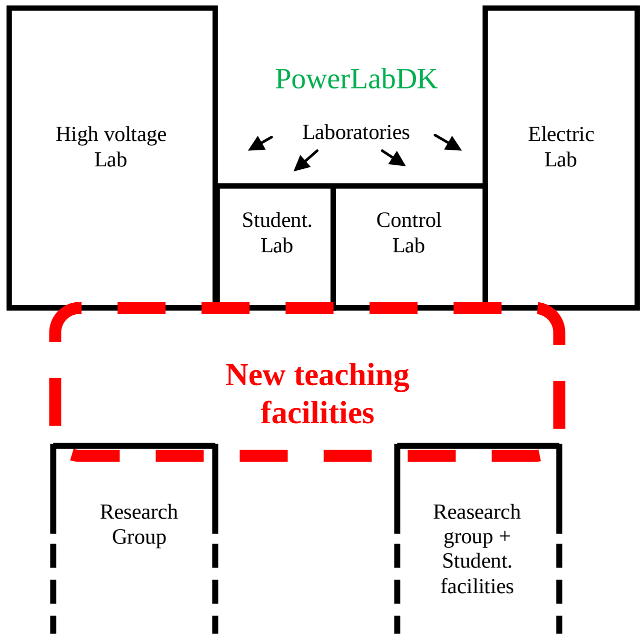

Figure 3. Physical location of the new teaching facilities adjacent to different laboratories under PowerLabDK at DTU (slightly simplified). Note the broad interface between teaching facilities and the laboratories.

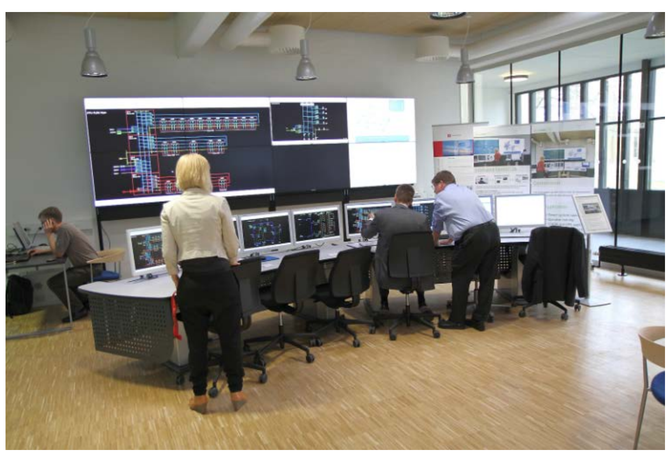

Figure 4. ControlLab + Scada system for education and research. The Scada system allows for monitoring and control of the main laboratory facilities including monitoring of the electrical power system on the island of Bornholm.

THE CONCEPET IN REALTION TO CDIO - STANDARD 1, 6 AND 7

The CDIO-principle has been successfully implemented in the B.Eng.-educations at DTU. The principle ensure that engineering students are able to perform essential functions like 'conceive-design-implement-operate complex value-added engineering systems in a modern team-based environment.' [1].

You can also say, engineers do not just work with the product, but are also involved in the whole process from the first ideas to operating, within the frames of the organization. For the educational programme, the real life as a professional engineer is a starting point and 'application-oriented elements are continuously incorporated in the teaching and where the individual courses are linked to multidisciplinary projects, ensuring a cohesive programme' [3].

With PowerLabDK and the nearby teaching facilities another aspect is added to this, supporting the CDIO principle: A study environment with an open window to the real world and involvement of this world in the education should ensure that the transfer to real life already starts at the very first study years. Our concept is supposed to contribute to this through the whole power engineering education.

The nearness concept supports directly CDIO standard 1 'The context'. The conceiving and designing process usually will take place in the new teaching environments. By early utilization of the nearby laboratories, the implementation phase can be optimized. Since the laboratories are designed in close relation to the real power world, operation can be tested in the laboratories, hereby finalizing the learning and product deployment process.

The research and student laboratories in the 'world of education' form a close to optimum background for fulfilling CDIO standard 6 on engineering workspaces and laboratories to encourage hands-on learning. The close to the real power system gives the opportunity to learn that 'hands-on' is not limited to a product development process in the laboratory, but improves the system building skills in the most direct way.

The research laboratories, PowerLabDK, at DTU are run in close cooperation with the customers, typically utilities and power industry. Student projects run in these environments often will be conducted in cooperation with the customers, which means that students get involved in the whole process. In such a way, not only the disciplinary knowledge is trained, but as well are the personal and interpersonal skills as described by CDIO standard 7 on integrated learning experiences.

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BIOGRAPHICAL INFORMATION

Joachim Holbøll is associated professor and deputy head of Center for Electric Power and Energy at DTU, Department of Electrical Engineering and senior member of IEEE. His main field of research is high voltage components, their properties, condition and broad band performance, including insulation systems performance under AC, DC and transients. Focus is also on wind turbine and future power grid applications and power engineering education.

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