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An industry-based project for teaching electrical power systems

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ABSTRACT: Industry expects engineering graduates to be work-ready, with both theoretical and practical backgrounds to be able to solve real-world problems with or without little on-the-job training. In this article, a project developed by the University of South Australia (UniSA) jointly with an industry partner PSD Energy, is described. The project is sponsored by the Australian Government and is preoccupied with teaching electrical power systems using industry standard software, hardware and real industrial power system setup. The project is industry-inspired and, in part industry-based and, as such, gives the students an immediate advantage of being job ready. The project development, its structure, implementation details, expected outcomes and authors' experiences in teaching the course are outlined and discussed in this article.

INTRODUCTION

Employment of work-ready engineering graduates increases the productivity of companies and improves their competiveness on the market. In the past, graduate employment programmes were a common scenario, especially, in larger companies, where graduates were trained on the job, moving between different sections of the company for several months and acquiring overall experience with a company function and specific hands-on skills. Due to financial pressures this approach was abandoned for some time in many companies but in recent years, the practice has been reinstated, something, which is especially visible in the electrical power industry. An ageing and retiring workforce has left many power companies without suitably qualified employees and facilitated the reintroduction of invigorated employment schemes.

Alternative to graduate employment programmes is the involvement of companies in the development of industry-relevant courses in the undergraduate engineering curriculum. The benefits of the industry and academia involvement and the disadvantages when it does not happen, have been highlighted in the literature [1-11]. Industry engagement has additional weight in improving the relevance of the power systems teaching. At many universities, the reduction of university funding has led to universities having obsolete laboratory equipment that is expensive to maintain or replace. This, in turn, has shifted emphasis in teaching to theory that is not enough motivational for university students.

The Australian Government established a fund for Enhancing Industry Engagement in Engineering Degrees that has helped to develop the project, improving students' learning outcomes and industry relevance. This has been done in association with an industry partner company PSD Energy, for students in the 3rd year Power Systems Analysis course. The project details and outcomes are described below.

INDUSTRY BASED PROJECT

Students enrolled in the Power System Analysis course complete a semester project that after initial familiarisation with the software and hardware leads them to the PSD Energy Company's Power Factory based development. The company agreed to make available all specifications and data of the project, which is probably the most valuable part of the student projects. It places the students in the commercial, technical and economic real-world from the outset.

The company project selected for the educational application applies to a 33kV power supply extension in South Australia to cover the hematite mining expansion. It adds about 2,780 MVA of new load to the existing 1,070 MVA. The extension is substantial and requires careful checking of the existing installation, power flow, fault calculations and a proposal of installation of a new voltage regulation auto-transformer to remedy the voltage drops. The industrial input gives the whole exercise a dimension of reality as students work on a real industry project using real data, modelling a real system and using industry standard software and hardware.

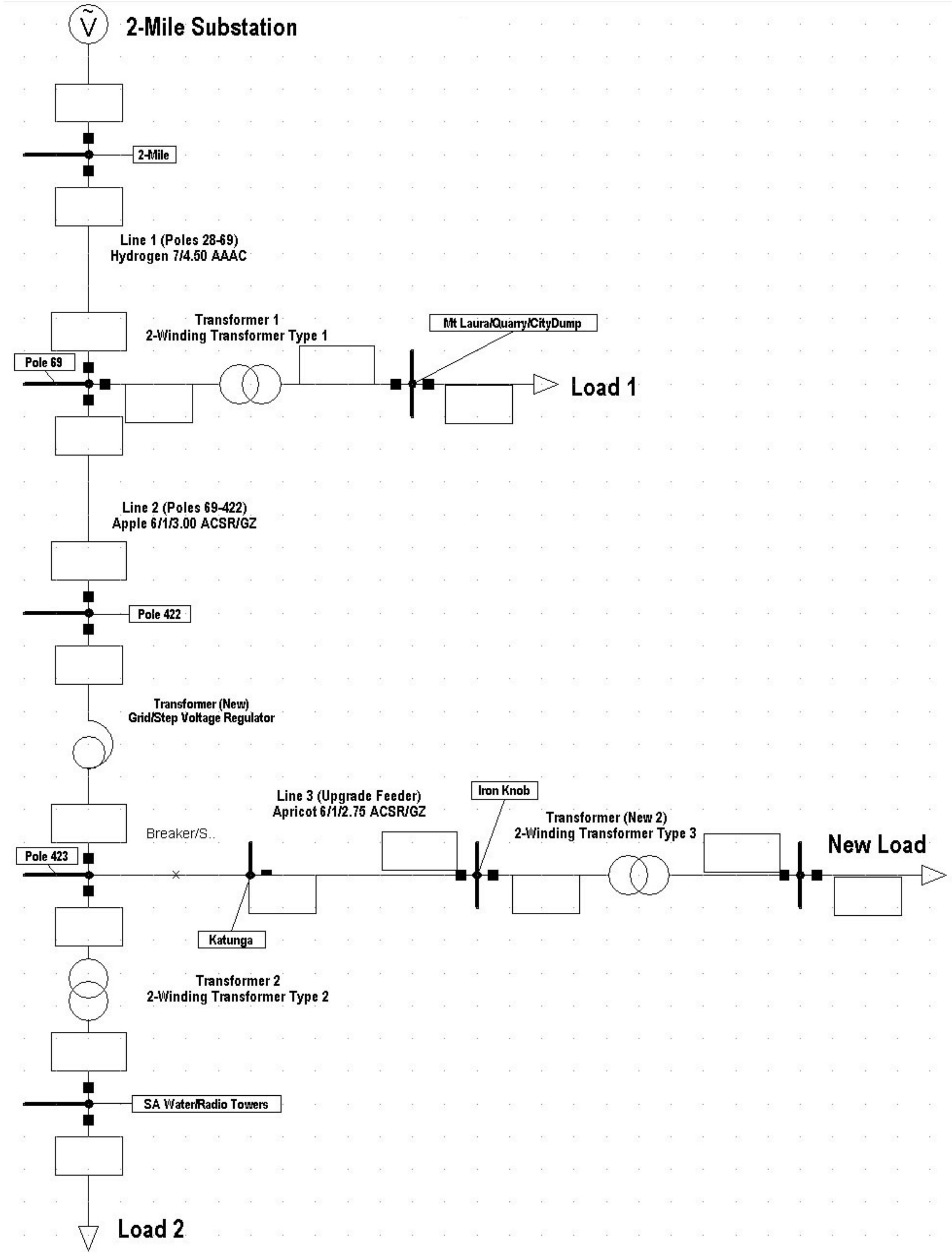

Figure 1: Power factory diagram of the power system project.

There are several stages to guide students to a design of a power system of a reasonable size. These include:

1. System modelling;
2. Power flow simulation;
3. Fault analysis;
4. Protection design;

5. Tuning real hardware (distance relay) for protection;
6. Testing the distance relay using testing facility of the industry partner company.

In Stages 1-4, students use professional, industry standard software. In Stage 5, students learn to use and set up industry standard hardware. In Stage 6, students participate in the testing procedure of the protection relay in the company. The power factory diagram used in the more advanced stage of the student project is shown in Figure 1, and demonstrates the relative complexity of the system, to be expected in real-world applications.

SOFTWARE

The industry partner recommended that DIgSILENT Power Factory version 15 software to be purchased specifically for this project [12]. The educational version of the software was available at a reasonable cost.

The software has a user friendly Graphical User Interface (GUI) shown in Figure 2, with a range of symbols for power systems components on the right-hand side pane. Drawing a single-line diagram of an electrical power system is easy, and can be effected by dragging the required components into the configuration space, connecting them and, then, specifying their parameters for required types of modelling and calculation.

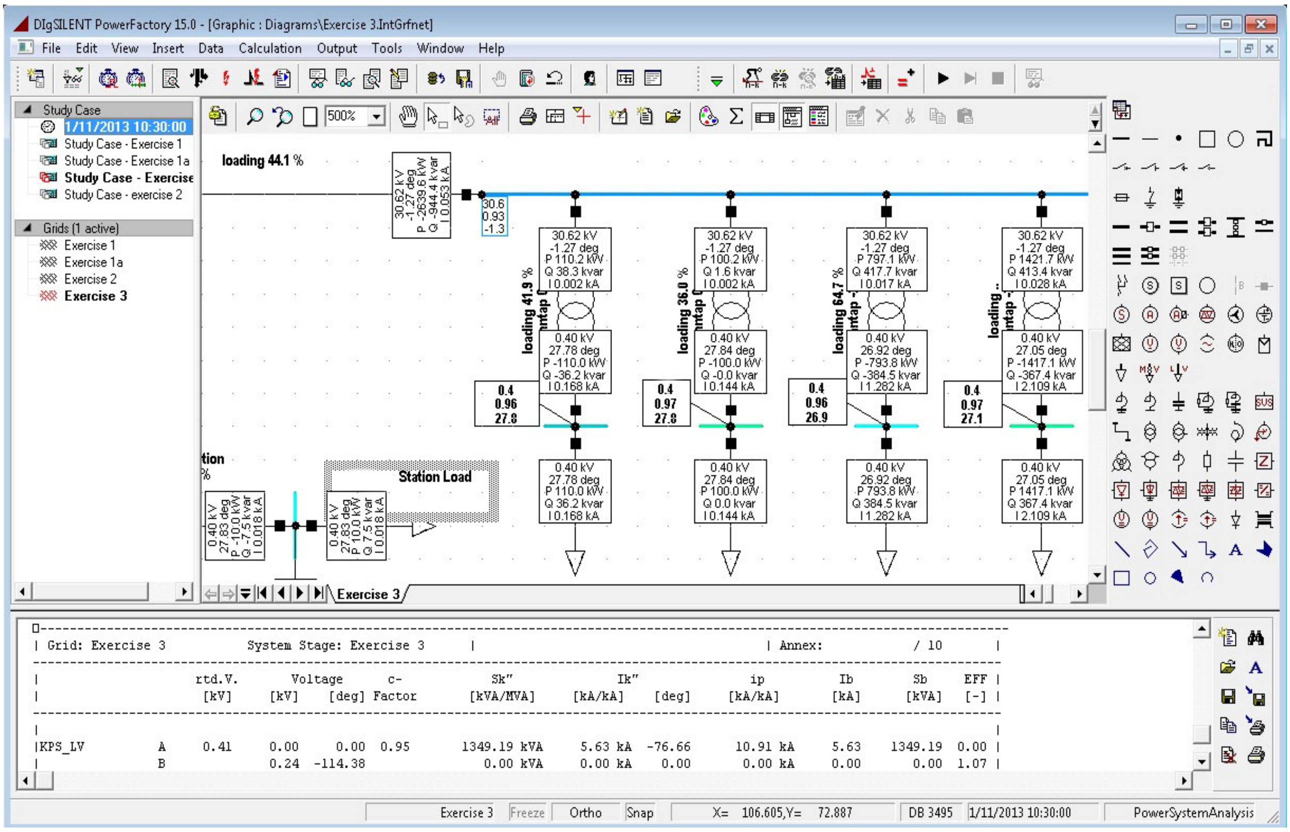

Figure 2: DigSILENT power factory GUI showing application example of a LV AC system [12].

The software is quite comprehensive and can be used for system analysis and design, power flow analysis, fault analysis, contingency analysis, power quality, protection system design plus more. The software also supports modelling and the simulation of modern power systems that include distributed generation, wind and PV sources, micro turbines, battery storage and other components of smart grids, as well as various power electronic devices. In total, Power Factory software supports 500 different objects that can be used for modelling power systems.

One example of the software comprehensiveness is the variable selection during the short-circuit analysis, shown in Figure 3. Since the power components have been modelled with *1, 2-sequence* resistance models, parameters as zero-sequence, positive sequence or negative sequence currents and fault magnitudes can be easily monitored.

The software guides the user through the system configuration and, unlike other software used in teaching of electrical power systems courses [13], does not require any programming skills. By using the software, students reinforce the theory learned in the course and also see the relevance of the theory to practical applications. Examples of templates for two system elements are shown in Figure 4 and Figure 5.

It can be seen that a range of parameters need to be entered; thus, inspiring students to learn the new concepts required if they intend to work in the power industry. The software can also encourage them to learn more as browsing through power system configuration templates allows them to find a lot of terms and definitions that are usually beyond the scope of university courses. The increased student motivation helps in improving the teaching effectiveness.

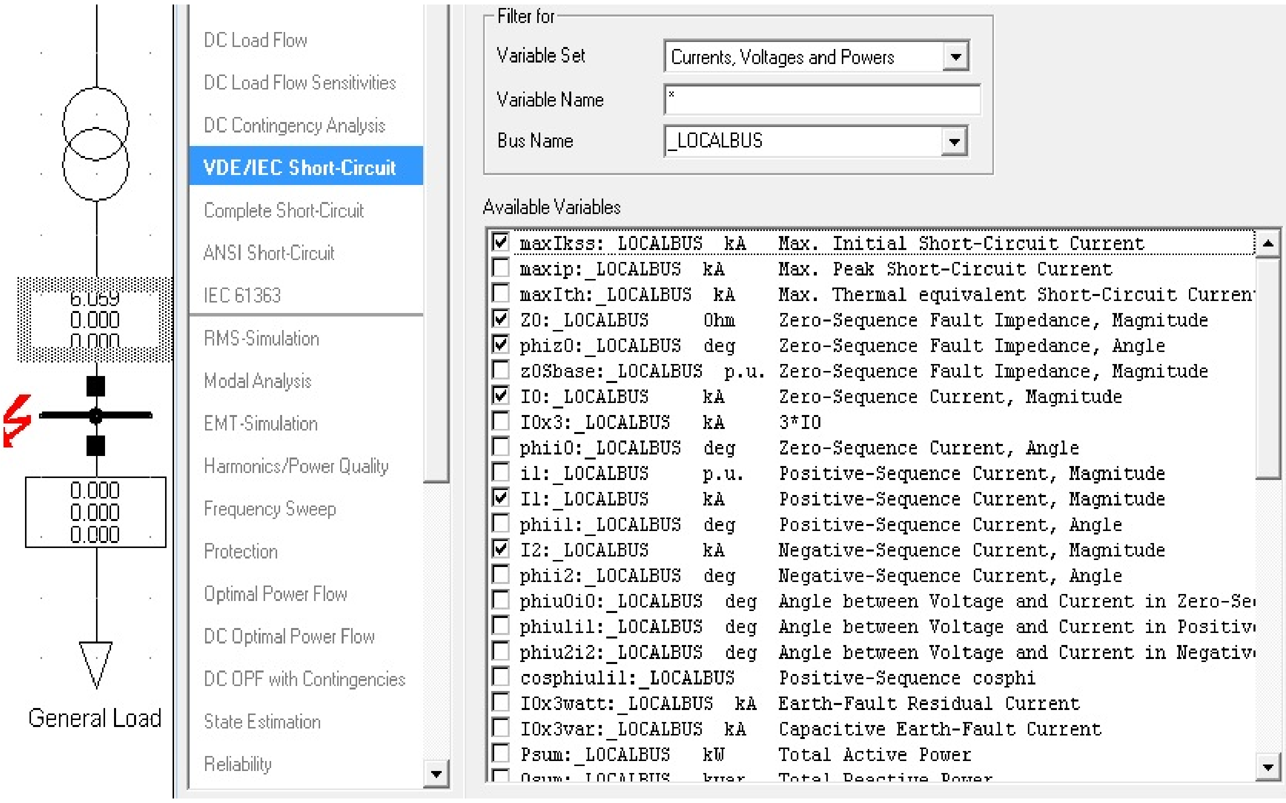

Figure 3: DigSILENT power factory variable selection during the process of short-circuit analysis.

The software has the capacity to exchange data with other professional software for power systems analysis, including Power System Simulator for Engineers (PSS/E) [14], and Supervisory Control and Data Acquisition (SCADA) systems.

In undergraduate courses, only a fraction of the software capabilities are typically used. However, it can be a very useful tool in designing the curricula of these courses. The courses can be structured around exercises using the software, rather than trying to fit the software exercises around the power engineering theory covered by a conventional curriculum.

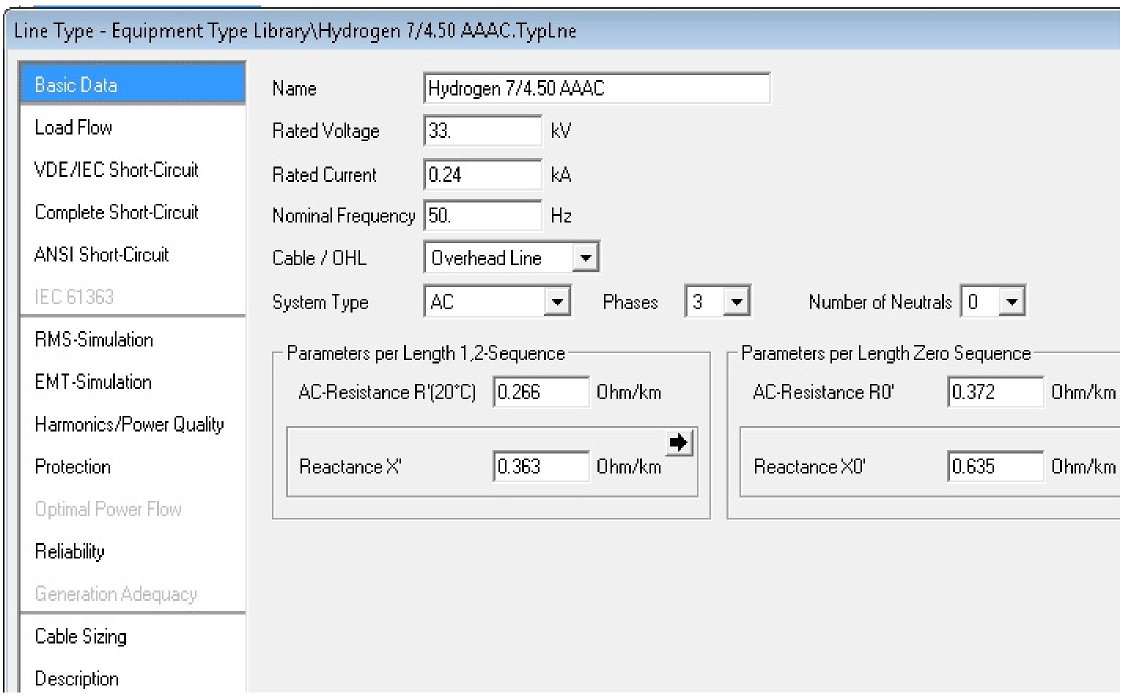

Figure 4: DigSILENT power factory template for transmission line 1 - basic data parameters.

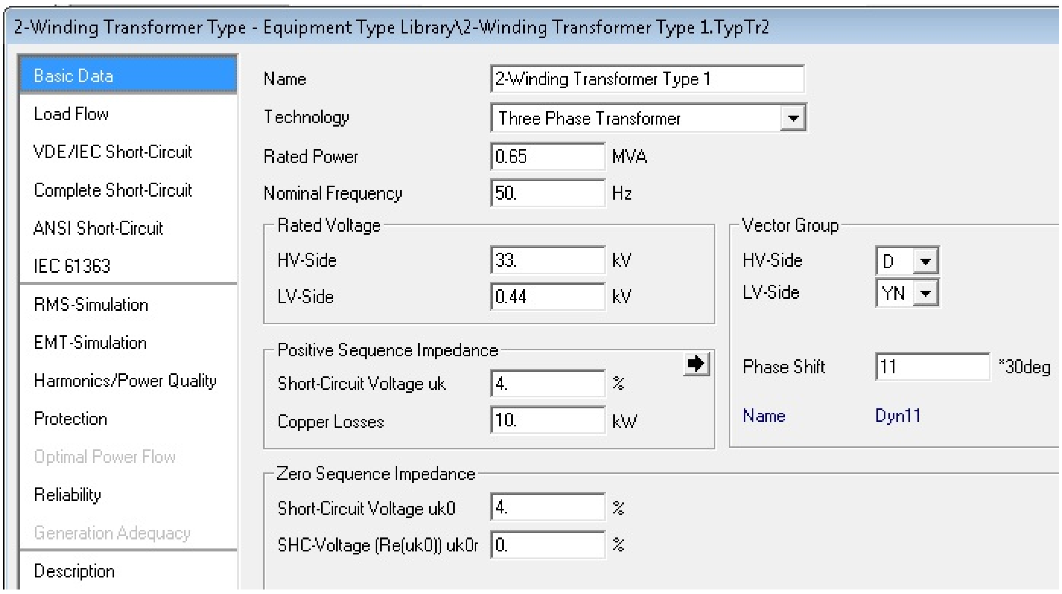

Figure 5: DigSILENT power factory template - transformer 1 - basic data parameters.

HARDWARE

Hardware was also selected on the recommendation of the industry partner company. For the purpose of the project, the transmission protection system SEL-311C [15], shown in Figure 6, was purchased. The hardware is a relay for protection, reclosing, monitoring, and control of transmission lines. It is a modern electronic device that includes software to control its configuration and provides an option for on-line setup. It also includes various data communication options suitable for interfacing with a SCADA system.

Figure 6: SEL-311C transmission protection system [15].

PROJECT IMPLEMENTATION

The project is still in its developmental stage and is planned to be fully implemented in 2014. Stages 1-3 have been already available during 2013. This allowed students to grasp the fundamentals of industry standard software and take the full benefit of using it. Two engineers from the partner company have been invited to give seminar presentations on the project, as well as sharing their graduate engineer experiences in the electrical power industry.

CONCLUSIONS

The students responded well to the introduction of the project and appreciated learning the professional software. They also highly appreciated interaction with young engineers from the partner company. The formal evaluation of the project will follow in 2014.

Although all stakeholders agree that the collaboration between industry and universities is important and beneficial to students, industry and universities, there is still no evidence of a permanent framework that successfully supports this alliance. Governmental support and the willingness of the industry partner to be engaged in the educational process may indicate a most welcome change in the climate of industry/university partnerships.

In this article, a project has been presented that is based on a course practical component developed in collaboration between the University of South Australia and an industry partner, PSD Energy. The project aimed to enrich students' learning experience by engaging them in an industry relevant and industry-based project in the area of electrical power systems. The project has demonstrated increased motivation of the participating students leading to better learning outcomes.

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