CALIFORNIA STATE UNIVERSITY, BAKERSFIELD

Sustainable Electricity Grid: A Course Design

Campus as a Living Lab Grant Program

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A. Renewable Energy

The United States' needs for electric power are filled predominantly by fossil fuels and nuclear power, resulting in a system that lacks diversity and security, contaminates the environment, threatens public health, jeopardizes the stability of Earth's climate, and discourages energy independence. Fortunately, renewable energy resources such as wind, solar, bioenergy, and geothermal can fulfill a significant proportion of America's energy needs, which can help to reduce the impact of many of these problems while providing other important benefits. However, sustainable integration of these resources into the grid requires further studies and research.

In spite of constant increase in the demand for electrical power over the years, the necessary investments were not allocated for the transmission grid. The result is that some parts of the grid become overloaded or congested due to the lack of upgrades and new transmission lines. Renewable energy resources are helpful in addressing the electrical power needs in the congested areas. But in order to use their energy in power systems, renewable energy generation units should be able to supply the grid (grid-connected). Grid-connected generation units contribute to the reduction of fossil fuel usage and consequently the overall carbon footprint. But, the stochastic nature of renewable energies is problematic for the stable operation of power systems. And so their high level of penetration endangers the sustainability of existing power systems and puts the entire grid at risk.

B. Renewable Energy in California

For low levels of integration (< 5%), the intermittency of renewable resources does not cause a significant impact due to the large existing reserve margins. But, for a higher percentage of renewable energy penetration, the fluctuations in energy can exceed the available local reserve capacities and put the sustainability of the grid at risk. The average renewable integration in the US is around 15-20% and the percentage is increasing in many states. California in particular, has a long history of support for renewable energy. In 2009, the integration of renewables was 11.6% while another 9.2% was generated from hydro plants. As this percentage increases, California's power systems must be enhanced against possible hazards that endanger the sustainability of the system.

As a leading state in technology and innovation, California can be a model in the development, design and implementation of sustainable grids. In particular, the teaching of future generations of engineers plays a key role in this process. Besides, the California legislature approved a target of 33% renewables by 2020, which opens abundant career opportunities in the state. Nowadays, Californian engineers working in power industry face many challenges with regards to the implementation of renewable energies. Learning about these challenges can greatly prepare power engineering students for their future careers.

C. Local Concerns

Besides all the national motivations for renewables, San Joaquin Valley (Valley) is highly interested in renewable energies due to their reductive effect on air pollution. The Valley's air quality challenges are

unmatched by any other region in the State. Despite major reductions in emissions and corresponding improvements in air quality, the Valley's topography, climate, and geography, combined with the presence of two major transportation corridors connecting northern and southern California, contribute to the region's difficulty in meeting federal health-based standards for particulate matter and ozone. The Valley's extreme non-attainment designation for ozone reflects the significance of these challenges and highlights the needs for renewables.

In fact, overcoming the barriers that prevent either the use of zero-emission renewable energy sources or the reduction of emissions from renewable energy systems to make them cleaner than comparable non-renewable alternatives is a major goal for the local community. The students at CSUB can benefit from topics related to renewable energies and their integration in power systems.

D. Course Description

The Department of Computer and Electrical Engineering and Computer Science (CEE/CS) at California State University Bakersfield (CSUB) recently started a new program in ***electrical engineering***. Due to the national and local needs, an emphasis is given to the areas related to power generation, transmission, and distribution. An introductory course on electric power systems is included as a required core course in the program. This course is offered in winter 2014 quarter for the first time where the funds are used to enhance the course and quality of education for CSUB students. The course will be offered every winter quarter thereafter. The course traditionally covers basic elements of power systems, three-phase circuit analysis, transformers, transmission line configuration, the per unit system and power flow. However, due to the importance of recent changes in the grid, new discussions related to the sustainable operation of electric power grid were included in the course. Students showed interest in these discussions and it's the belief of the instructor that a preliminary knowledge of sustainable electric grids enhances students' understanding and will be useful in their future career.

E. Sustainability Integrated in the Course

To enhance the course on power systems with discussions on sustainable grids, various topics were added to the course. New topics include electric grid sustainability and include power systems operation with renewable energy, smart grid technologies, and the impact of vehicle-to-grid technologies on load management. Since the course is an introductory course in power systems, the depth of these discussions kept at a limited level. However, the students learned about basic concerns on the sustainability of electric grid and the technical constraints around it. With the revision in the course, the students are now familiar with many important issues that otherwise could not be included.

In addition to incorporation of sustainability topics in the course, term projects were defined in which the students worked in teams. In these research projects, the electric power system on campus is used as a micro-grid to study and practice sustainability topics covered in class.

The students in each group were responsible for research on the project and proposing practical solutions. The students prepared technical reports and presented their findings by the end of the quarter.

F. Outcomes

We strongly believe that the current project successfully implemented in the course. The project integrated sustainability topics with educational instruction in the classroom. The students showed great

interest in these additional topics and questioned the instructor with great questions. In fact, the interconnection of classical topics and recent trends in power systems proved to be a significant area for developing innovative ideas. The students enjoyed this aspect of the recent changes and proposed many good ideas. The development of the course greatly enhanced with topics of sustainability and the changes will have an impact on students and local community in many years to come.

G. Budget

The budget report is given in the following table.

Expenses	**Funds**
Salaries/ Benefits (Faculty)	6075.41
Stipend (Student Assistant)	4336.50
Equipment/ Supplies & Services	1538.09
TOTAL	$11950