PIMS Workshop on Mathematics and Clean Energy Applications

May 22, 2019: Lunch and Learn:

Narratives in Mathematics and Clean Energy

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How I got involved in renewable energy

I did not get into clean energy by a specific choice, but I have been involved in several industrial collaborations which have had a clean energy component, first working on models of hydrogen fuel cells and now on Lithium-ion batteries. It began with a decade-long project (1998-2008) in collaboration with scientists at Ballard Power Systems, a Vancouver company that was a world leader in the development of hydrogen fuel cells. It was a group project, with several other faculty members participating, notably Keith Promislow, who became a close personal friend. We still work together, he recently interested me in a project involving the computational modelling of sea ice. Working in a large, interdisciplinary group on an applied project appeals to me.

The project began under the umbrella of MITACS, a Canadian network that supported industrial mathematics activity from 1999 to a few years ago. Keith and I had funding from MITACS and Ballard, and formed a group to develop models and computational simulation tools for hydrogen fuel cells. Much of what we did was modeling, that is writing equations that described processes within a fuel cell and then thinking of ways to compute approximations to these models efficiently. These models were what is known as “multi-scale,” since details of processes from channel to channel (about 1mm) affected performance along the length of the cell (up to 1m long) and a number of cells (up to 100) are combined in a fuel cell stack to make appreciable power. Much of what we did is summarized in the review article, "PEM Fuel Cells: A Mathematical Overview" if you want to see the technical details. As mathematicians, we really brought something to this project and this industry. Standard engineering computational tools such as computational fluid dynamics packages are not a good fit to models from this industry due to their multi-scale nature, the stiff electrochemical reaction rates and the capillary dominated two phase flow in the electrodes.

While some of the work really required mathematical skills at the PhD level, much of it did not. As mentioned by several of the speakers at the conference, much of the mathematics for clean energy models is taught in undergraduate mathematics service courses, which many students learn. Thus, we can question whether there is a gap in our departmental pedagogy that needs to be filled. Another gap to fill is in the attitudes of most academic mathematicians. Concentrating on research in a single, technical, abstract area is seen as the best path to professional success. In some departments (not my own but not uncommon) most of the applied work I have done would not count towards professional advancement (tenure and promotion), since it was not mathematics research but rather the use of “known” mathematics in a new application (known to us but not to the application scientists). I am not advocating that all mathematicians should work on such projects: it was the high-level mathematical training I received in a mathematics-focused environment that gave me the skills to contribute to the applied projects. However, I believe such outreach should be encouraged and rewarded in Math departments more than it is currently.