

WIP: French Experience for U.S. Students in Renewables-Based Power Systems Research

Ali Mehrizi-Sani, Chen-Ching Liu
Bradley Department of Electrical and Computer Engineering
Virginia Tech, Blacksburg, VA 24061
e-mails: {mehrizi,ccliu}@vt.edu

Jean-Luc Schanen, Nouredine Hadjsaid
G2Elab, Grenoble Institute of Technology, France
e-mails: {jean-luc.schanen,
nouredine.hadjsaid}@g2elab.grenoble-inp.fr

Abstract—This work-in-progress paper shares our experience and student feedback based on the first two years of our international research internship program at Grenoble Institute of Technology in France made available by Virginia Tech and supported through an NSF IRES grant. This program, IRES: Track I: U.S.- France Program for INverter-based And Cybersecure Control and Communication for eLEctric power system (PINNACLE), trains and sends about 18 U.S. students (6 each year) for 8 weeks to Grenoble to engage in research and extracurricular activities, including language instruction, several industry visits, and integration with an existing international internship program, in its G2Elab. The overarching theme of students' research projects is to enable a massively inverter-based electric power system while addressing control, communication, and cybersecurity requirements and challenges. Students' exposure to these problems, especially in a European context, is expected to help them think of innovative solutions to the U.S.'s similar challenges. Additionally, G2Elab has active collaborations with several industry partners, which facilitates industry tours and field trips. This program is mutually beneficial and strengthens our existing collaboration by providing a framework for conducting research projects of common interest. We recruit nationally for this program. The program alumni are a cohort of individuals with highly desired skills for industry and graduate programs.

I. INTRODUCTION

This work-in-progress paper provides an account of our experience in an International Research Experience for Students (IRES; funded by the U.S. National Science Foundation) program. This program, IRES: Track I: U.S.- France Program for INverter-based And Cybersecure Control and Communication for eLEctric power system (PINNACLE), builds on the decade-long history of collaboration between Virginia Tech and Grenoble Institute of Technology (Grenoble INP). Grenoble INP's electrical engineering program ranks first in France [1]. PINNACLE trains and sends 18 U.S. students (6 each year for) 8 weeks to Grenoble to engage in research and extracurricular activities, e.g., language instructions, industry visits, and integration with the existing Giant International Internship Programme (GIIP), in G2Elab (Grenoble Génie Electrique: Grenoble Electrical Engineering). We recruit students nationally. For non-Virginia Tech (VT) students, this program provides exposure to VT, one of the oldest power

programs in the nation. For VT students, PINNACLE increases the appeal of the power track. Ultimately, our alumni will have highly desired skills for industry and graduate programs.

II. RESEARCH THEME AND WORKFORCE FOCUS

The overarching theme of student's research projects is to enable a massively inverter-based electric power system while addressing its control, communication, and cybersecurity requirements and challenges. The power system is the largest man-made machine. As it transitions to include a larger share of renewables and inverter-based generation, it challenges conventional stability and control concepts. In such a system, the interaction between inverter-based generation and the mix of motor- and electronics-based loads merits new investigative studies. Simultaneously, as a cyber-physical system, the modern power system produces large volumes of data by phasor measurement units (PMU), smart inverters utilized for renewables, and a network of about 65 million meters. Availability of data and communication offers significant flexibility for the system operation, planning, and remote control; however, the electric power grid's growing dependency on information and communication technology (ICT) significantly increases its vulnerability to network unavailability and security issues. Therefore, ensuring timely and secure delivery of data is central to guaranteeing performance of control, optimization, and supervisory systems, see Fig. 1. Under Grenoble mentorship, the U.S. students work on these research challenges [2]–[9]. Students' exposure to these research problems, especially in a European context, is expected to help them think of innovative solutions to the U.S.'s similar challenges.

In addition to the research challenge discussed above, domestic workforce and graduate student shortage is a hurdle in grid modernization efforts. A pillar of a more modern grid is application of inverters, modern controls, and 5G communication for the integration of renewables. Our goal is to prepare U.S. power engineering students for the workforce, motivated by the following observations:

- About 30% of engineering jobs remain unfilled due to lack of qualified candidates [10], [11];
- About 62% of current power engineering employees are eligible to retire over the next decade [12];
- Only 19% of full-time graduate students in electrical engineering programs are domestic [4], [13].

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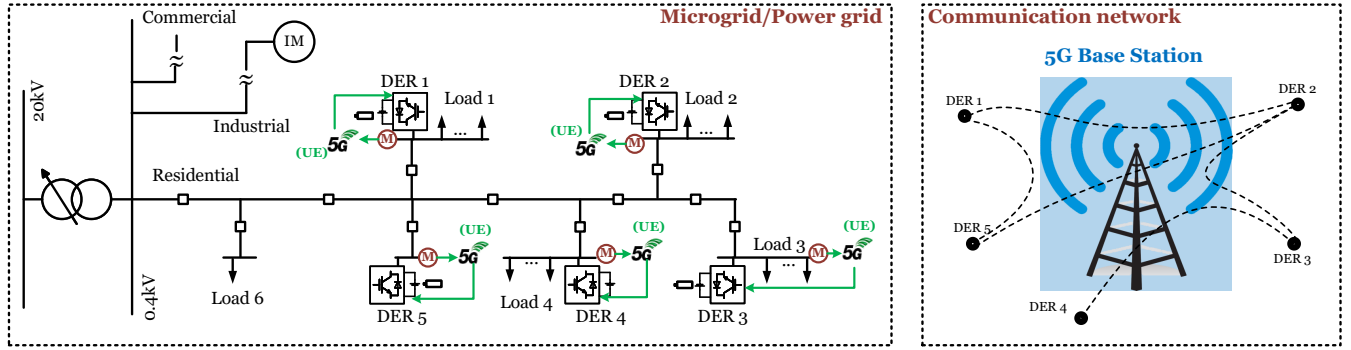


Fig. 1. Example microgrid system with 5 distributed energy resources (DER) together with a communication network. Each DER has its own sensor/meter (shown as **(M)**) and 5G antenna (UE: user equipment). The communication links are independent of the electrical connections between DERs.

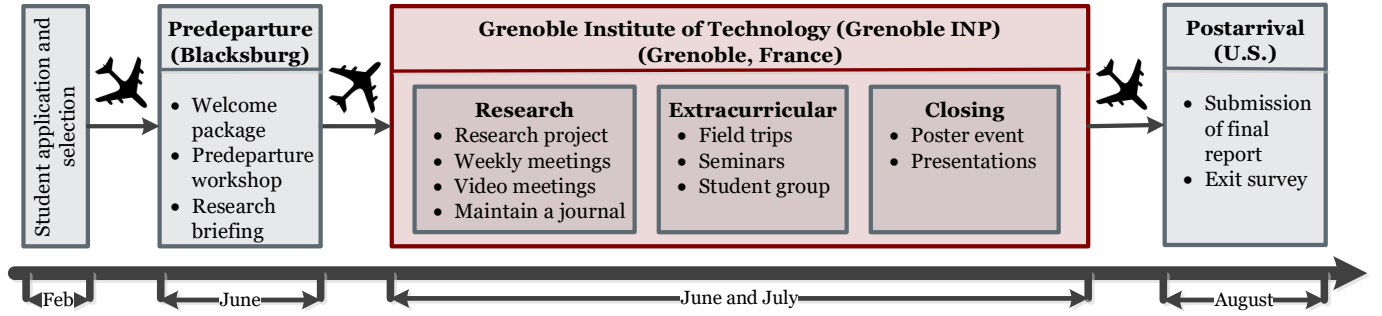


Fig. 2. Summary of our integrated research, extracurricular, and cultural activities.

III. PROGRAM STRUCTURE

We have designed several activities for students to foster a “community of scholars” for long-lasting relationships beyond conclusion of this program. Fig. 2 shows the overall program activities.

The local organization in Grenoble is built on two main and unique pillars: (i) immersion into a research activity, (ii) and discovering the university ecosystem and French culture. For discovering research in G2ELab, students are assigned a mentor, who takes care of explaining the global organization of the department and the global scientific vision to which the student’s project contribute. The day to day supervision is provided by a PhD student, who also contributes to providing a complementary vision of research and facilitate the integration in the department. In addition to this main activity at G2ELab, the students are integrated in the existing Excellence Program GIIP. This program was created mainly for international PhD visitors, but has been extended to Master’s and Bachelor’s visitors so that it can include the PINNACLE students. The aim is to facilitate all practical aspects of the day to day life in Grenoble (e.g., housing, public transportation, and bank account), introduce the students to all strength of Grenoble ecosystem, and learn a bit of the French Culture. The following is the nonexhaustive list of activities that have been organized for the students: visit of European Synchrotron Radiation Facility (ESRF), Schneider Electric research center

“Technopole,” French courses for beginners, and even an initiation to French cooking! In 2023, the consul of the United States of America in Lyon visited Grenoble and had a moment of discussion with the PINNACLE students. During the third week of July, all students of the GIIP have a common seminar to present their work in presence of their mentors. This allows having a nice overview of the variety of scientific topics addressed in Grenoble in addition to present their own work.

IV. PROGRAM LOGISTICS

In support of this program, we put together several logistics provisions as described below. The program timeline is shown in Fig. 3.

a) *Travel Contingency Plan:* If travel is restricted in a certain year, e.g., due to health concerns such as COVID-19, we plan to make the following adjustments so our students still benefit from the salients features of this program: (i) Our events, e.g., welcome/closing workshops and weekly meetings, will be made virtual; (ii) We will arrange for virtual tours, including those available on Google and native websites of facilities, to the extent possible to increase exposure of the students to the “host” country; (iii) Considering savings in travel costs, we will increase the cohort size to provide the PINNACLE experience to a larger set of students.

b) *Travel, Airfare, and Insurance:* Ticket purchases are handled by ECE/PEC staff. Students travel from their home

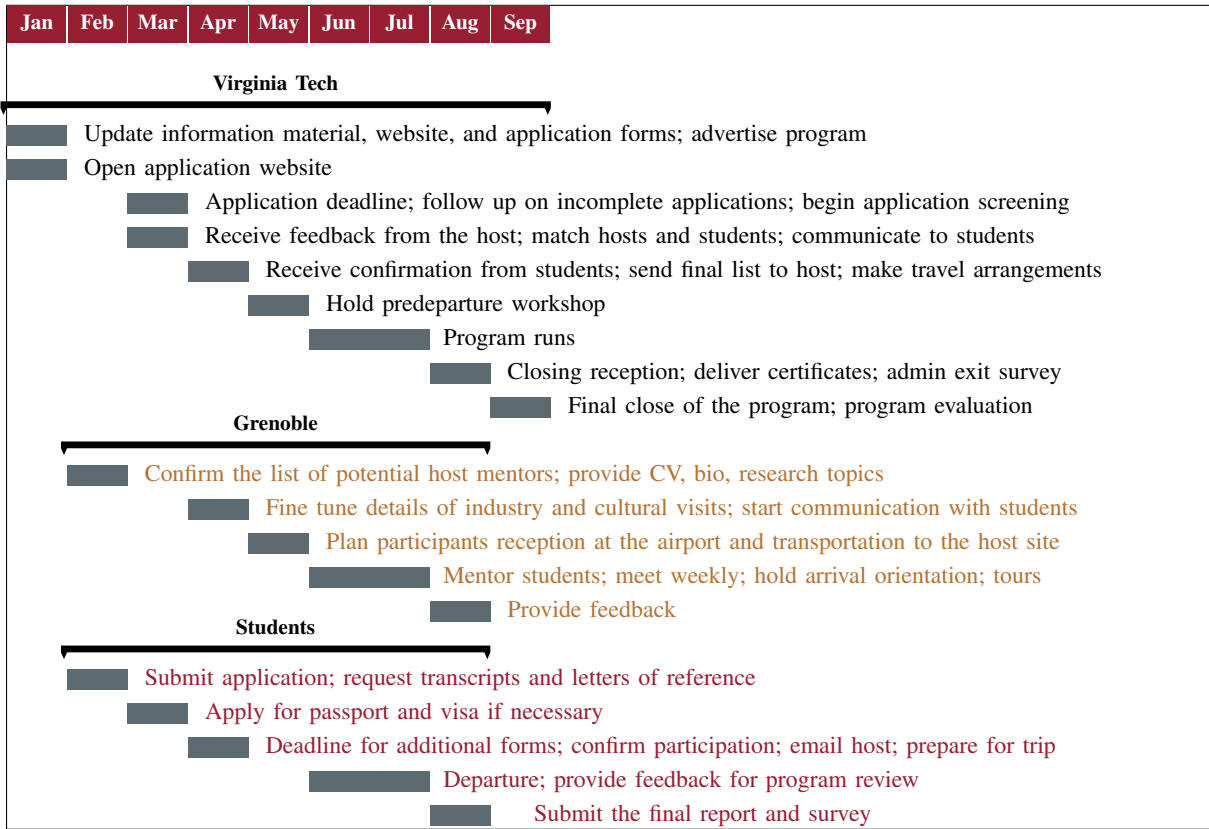


Fig. 3. Tentative timeline and schedule of events.

airport to Lyon (LYS; nearest major airport) the day after. At the conclusion of the program, students fly back to their home airports. Students must have a passport, and depending on nationality, a valid visa. (U.S. citizens currently do not need a visa for short-term research at a French university.) We provide international health insurance for students as arranged by VT.

c) Arrival at the Foreign Site: We make arrangements with Grenoble (LCMobility Relocation Service) to greet the students at the airport and take them to their accommodation. This helps students not worry about the foreign country arrangements, especially if this is their first international trip. The greeting person has a roster of the students, signage, and flight information. To facilitate border crossing for the students, we provide them a letter confirming that (i) the students is a participant in this NSF-funded program, (ii) duration of the program and date of departure, (iii) purpose of trip (research and not enrolling in courses), (iv) financial support, and (v) local contact information.

d) Arrangements for Housing: In coordination with Giant International Internship Program (GIIP) at Grenoble, we reserve a block of rooms at Grenoble Student Housing located close to G2Elab at GIIP's negotiated rate. Having students in a single site helps with building a "community of scholars." While the actual residence location may change from year to year, this arrangement remains the same and students are

housed together.

e) Safety and Security: We coordinate the trip with the U.S. consulate (Lyon, 1.5-hour drive) by providing a roster of participants and contact information of the U.S. and Grenoble program directors. The consulate's contact information is provided to the students as part of their welcome package.

f) Program Website: We will maintain a comprehensive website with the following sections:

- Program Information. Online application forms, eligibility criteria, activities, projects in progress;
- Resources. Passport/visa information, Grenoble tourist bureau, weather and time, writing guides;
- Current Scholars and Alumni. CVs, bios, project reports, and advice from alumni; and
- Mentors. CVs, bios, pictures, and research interests.

V. EVALUATION AND STUDENT FEEDBACK

We share our results for the first two years of the program and also discuss our plan for its final evaluation.

A. First Two Years of the Program

Below, we share results from first two years (summers of 2022 and 2023) of evaluation of this program. Considering that this paper reports a work-in-progress (WIP) work, we expect our final publication to include more analysis and data.

Some representative results of program evaluation are shown in Table I. Overall, the scholars were satisfied with

TABLE I
PRELIMINARY EVALUATION RESULTS

Question	Score (out of 5)
Travel and accommodation	3.30
Meetings with mentors	4.42
Nonresearch activities	4.00
Project presentation	4.00

the program and felt their time was well spent. We also had a number of open-ended questions whose answers are summarized below.

a) *Are you considering graduate school after this program?*: 100% of scholars answered yes to this question citing its role. This is significant as many students initially did not have research experience.

b) *How did the program contribute to your international experience?*: All students appreciated the international experience; for most, it was their first time living in a foreign country for an extended time (more than two weeks). This is indeed reflected in the lower score for travel and accommodation in Table I as many students were not familiar with the intricacies of international flights and/or available dorms. For examples, students mentioned lack of direct flights as a reason for a lower score—something that is determined by the economies of the airlines.

c) *Knowing what you know now, would you participate in this program again?*: All of scholars answered yes, citing “hands-on research experience,” “learning about the European culture,” and “Yes I absolutely would. It was the perfect combination of cultural immersion and all of the challenges that come with that as well as forcing me to branch out academically while simultaneously being a great application of my prior experience. I had new experiences every day and honestly couldn’t believe what I was doing daily. It was the most wonderful time.” as the highlights of the program. Most students mentioned they had hoped the program could be longer.

B. Plan for Final Evaluation of the Program

The evaluation plan for assessment tools to be reported for the full paper are summarized in Table II. This plan includes formative and summative assessment tools. Formative evaluation provides feedback on the ongoing operation of the project. Summative evaluation provides feedback on the extent to which project outcomes are met. Our evaluation goes beyond each year’s cohort, as we will follow up with our alumni to track their performance (GPA, publications, and research experience) and their professional development and career after graduation (job, graduate school, or internships). Because the typical measures of research success occur in months and years following the conclusion of the actual work, we will use research presentations to evaluate the technical rigor of the program. Ultimately, we aim to answer the following educational research question:

Educational Research Question	What is the measurable impact of our activities on the graduation rate, academic performance, attrition rate, professional competence, and workforce placement of a cohort of power students?
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TABLE II
EVALUATION PLAN AND ASSESSMENT TOOLS

Entity	Success Criteria	Mechanism
Quantitative Measures		
Project Leaders (PI and foreign host)	Numbers of (i) students successfully completing IRES, (ii), (iii) student papers submitted/accepted, (iv), (v), (vi), (vii) papers/proposals submitted/accepted with Grenoble, (viii) industry site visits, (ix) Grenoble students coming to VT, (x) students going to graduate school, (xi), (xii) participating/returning mentors.	Six months after the end of each cohort through online search engines, an online survey, and comparison with national and ECE averages
Quantitative Measures		
PIs	<ul style="list-style-type: none"> • Appropriateness of student selection criteria and program • Research results and publications • Student persistence in degree and recruitment into STEM careers 	Monthly Meetings and discussions
Mentors	<ul style="list-style-type: none"> • Organizational quality and overall experience • Value of undergraduate student researcher in the lab • Helpfulness of program administrators • Willingness to participate in similar program in future 	Online survey, in-person meeting each year during the orientation session and after the session
Students	<ul style="list-style-type: none"> • Organizational quality and overall experience • Value of scientific research and mentorship; quality of lab facilities • Influence on long/term career planning • Helpfulness of program administrators • Usefulness of pretrip and onsite orientations 	Exit survey onsite prior to departure of participants and questionnaires via email after arrival in U.S.