



MEC 4722 RENEWABLE ENERGY CAPSTONE PROJECT

Spring Semester 2021

Health and Energy Platform of Action (HEPA)

Abstract: In collaboration with the Renewable Nations Institute (RNI), the 2021 MEC 4722 Renewable Energy Capstone Project will provide undergraduate students at Vermont Technical College (VTC) with the opportunity to gain knowledge in off-grid renewable energy systems for healthcare facility electrification in deep-rural communities across the developing world in the context of multi-lateral donor planning for the emerging global *Health and Energy Platform of Action* (HEPA) of the World Health Organization (WHO). The Project will engage students in engineering design, energy modeling and simulation for select deep-rural healthcare facilities in the Republic of Uganda identified by the United Nations Foundation (UNF) in the *Uganda Country Summary Report*. Capstone students will: (i) examine peer-reviewed publications and multi-lateral donor-based literature on healthcare facility electrification in deep-rural communities across the developing world; (ii) assess energy end-use requirements for deep-rural health care services, including energy services for COVID-19 patient care; (iii) conduct energy needs assessments for healthcare facility electrification, including energy storage, utilizing standardized audit tools, (iv) analyze 24-hour electric power load profiles disaggregated by priority health care services; and (v) prepare renewable energy systems specifications for construction bid documentation. Capstone Project outcomes will provide critical data to assess the efficacy of a proposed student internship program at the VTC in collaboration with the RNI to provide accurate, timely and scalable energy efficiency and renewable energy (EERE) project development services for deep-rural healthcare facility electrification under the HEPA program for developing countries on the World Bank Group (WBG) *COVID-19 Emergency Response Commitment Projects List*.

Background Information:

The World Health Organization (WHO) estimates that over 1 billion people (12.8% of the world's population) in deep-rural communities throughout Sub-Saharan Africa, East Asia and the Pacific, Europe and Central Asia, Latin America, the Caribbean, the Middle East and North Africa are served by healthcare facilities that lack access to electricity. The WHO further estimates that \$2.7 trillion is required through 2030 to provide access to electricity—primarily off-grid solar technologies with energy storage—for tens of thousands of deep-rural healthcare facilities in over 100 developing countries, including 51 least-developed countries (LDCs).

The WHO, the United Nations Development Programme (UNDP) and the World Bank Group (WBG), in collaboration with the International Renewable Energy Agency (IRENA), the Sustainable Energy for All (SEforALL) Initiative, and the United Nations Foundation (UNF), are currently building mechanisms—the global *Health and Energy Platform of Action* (HEPA) and the *COVID-19 Emergency Response Commitment*—to promote enhanced cooperation among health and energy actors with the goal to accelerate universal healthcare facility electrification to address deep-rural health care needs related to the COVID-19 pandemic. The HEPA program collaborators are in urgent need for cost-effective, accurate, timely and scalable energy efficiency and renewable energy (EERE) planning services for deep-rural healthcare facility electrification.

Capstone Project Objectives:

The 2021 MEC 4722 Capstone Project is designed with three objectives, as follows:

- (1.1) Provide Capstone Project students with the opportunity to gain knowledge in off-grid renewable energy systems design for healthcare facility electrification in deep-rural communities across the developing world in the context of national-scale, multi-lateral donor planning;
- (1.2) Provide guidance to the VTC and the RNI for establishing a financially viable, multi-sector, multi-institutional Work-College Consortium program model on the VTC Randolph Center campus to provide direct technical assistance under the HEPA program for deep-rural healthcare facility electrification to developing countries on the *WBG COVID-19 Emergency Response Commitment Projects List*.
- (1.3) Provide the multi-lateral donor community and multi-sector stakeholders in developing countries with critical data as to the efficacy of a Work-College Consortium internship program to provide cost-effective, accurate, timely and scalable EERE project development and decision support services for deep-rural healthcare facility electrification.

Expected Outcomes:

- (1.4) Capstone student activities include the following:
 - (1.4.1) Examine peer-reviewed publications and multi-lateral donor-based literature on healthcare facility electrification in deep-rural communities across the developing world;
 - (1.4.2) Assess energy end-use requirements for deep-rural health care services, including energy services for COVID-19 patient care;
 - (1.4.3) Conduct energy needs assessments for healthcare facility electrification, including energy storage, utilizing standardized audit tools;
 - (1.4.4) Analyze 24-hour electric power load profiles disaggregated by priority health care services; and
 - (1.4.5) Prepare renewable energy systems specifications for construction bid documentation.

Technical Specifications for Healthcare Facility Electrification:

The Capstone Project will adhere to project technical specifications for healthcare facility electrification as published in the *WBG ESMAP COVID-19 Emergency Power Supply Response* and the *SEforALL Powering Health Facilities—Approach*. The RNI management team, WHO and WBG country project managers, and/or collaborating higher education institutions (HEIs) will provide detailed general equipment specifications, including medical equipment specifications, as may be required, sourced from peer-reviewed research, current case studies for deep-rural healthcare facility electrification, and field data based upon site inspections, as feasible.

Capstone Student Deliverables:

VTC student Capstone Project deliverables for selected deep-rural healthcare facilities in the Republic of Uganda (as identified from healthcare facilities listed in the UNF *Uganda Country Summary Report*) may include, but may not be limited to, the following:

- (2.1) **Facility Specifications:** Detailed floor plan of healthcare facility with associated construction wiring diagrams and end-use equipment list, including but not limited to, the following: interior and exterior lighting and security equipment; interior and exterior plug loads for specified end-use equipment; cold-chain equipment for medications and vaccines; communication equipment, including telephony, internet and office equipment; potable water pumping and storage equipment, including systems equipment for water purification, pressurization and thermal needs; medical equipment, including surgical equipment, specialized COVID-19 medical equipment for sterilization and medical waste incineration, etc.
- (2.2) **Load Profile Analysis:** Electrical (and/or thermal) load profile (demand and consumption) for a 24-hour period, including required power generation and storage capacity for existing facilities in aggregate and by categorization or classification of healthcare facilities based upon types of health services that are offered at different levels of care, including priority and/or emergency COVID-19 health care services.
- (2.3) **Scope-of-Work:** Capstone Project students will conduct an energy needs assessment and load profile analysis for a minimum of two (2) prototypical deep-rural healthcare facilities sourced from the United Nations Foundation (UNF) *Uganda Country Summary Report*.
- (2.4) **Productivity Assessment:** Detailed documentation, including narrative statements, process notes, datasheets and calculations, charts and graphs of individual productivity (self-assessment) and group productivity (peer-to-peer and group task assessment) for the performance of each step for the deliverables referenced in items 2.1 and 2.2, above.

Tentative Capstone Project Schedule: 02 Jan – 14 May

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| (3.1) 06-29 Jan: Pre-Capstone Planning
Multi-sector Stakeholder Engagement
Curriculum Review / Approval | (3.2) 01-19 Feb: Specifications
Introduction / Facility Assignments / End Use
Building Infrastructure / Medical Equipment
Energy Systems (Sankey Analysis) / Operations |
| (3.3) 22 Feb – Mar 12: Energy Analysis
Load Profile: Aggregated / Disaggregated
Simulation Models: Production/ Use / Storage | (3.4) 15 Mar – 02 Apr: Productivity Analysis
Facility Assignments – Productivity Assessment
Case Study – Baseline Comparison
COVID-19 / HEPA Systems Enhancement |
| (3.5) 05-30 Apr: Capstone Thesis
Thesis Requirements / Publication Standards
Individual Thesis / Due Date: 30 April 2020 | (3.6) 03-14 May: Capstone Presentations
Campus Presentations (03-07 May)
Public Presentations (10-14 May) |

MEC 4722 Renewable Energy Capstone Project Coordinators:

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Student Roster:

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