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# Designing Renewable-Energy Capacity in Burundi's Higher Education: An Integrated Framework for Curriculum, Labs, ICT, Industry Linkages, and Policy

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**Abstract**
This paper presents a full study plan for a multi-year initiative that integrates engineering-education capacity building with the technical deployment of renewable-energy (RE) education in Burundi. Anchored in a national needs analysis—limited electricity access, weak digital learning infrastructure, and low female participation in STEM—the project proposes a coordinated higher-education response spanning curriculum, laboratories, ICT backbone, industry engagement, and policy support.

The project will build on previous work [1] on co-designing new RE curricula with Burundian stakeholders but will also be extended to include ICT curricular co-design as well as pedagogical improvements to enhance the quality of the education delivered.

In this paper, we provide details of the research plan and how it will be executed over the next four years. Anticipated contributions to the engineering education community include a transferable implementation and assessment framework for RE-focused capacity building in low-resource contexts; lessons on aligning pedagogy, infrastructure, and policy; and guidance on partnering with industry to close skill gaps while advancing national sustainability goals.

**Keywords: International engineering education; capacity building; renewable-energy laboratories; curriculum co-design; ICT-enabled learning; industry–university collaboration; gender inclusivity; policy frameworks.**

## Introduction

As of 2024, about 737 million people do not have access to electricity [2] with a large majority of this population located in sub-Saharan Africa. In the case of Burundi, located in East Africa, the electrification rate is only about 13% with most of the population with access to electricity located in the capital city of Bujumbura. The rural populations have almost no access to electricity. In addition to lack of electricity access, connectivity to the Internet is also very limited. The Burundian universities generally have very limited resources and the opportunity for faculty development is also very limited.

Burundi's low electrification rate, limited availability of renewable-energy (RE) programs, a constrained digital learning infrastructure, and persistent gender gaps in STEM collectively limit the country's capacity to educate engineers able to design, deploy, operate, and sustain RE systems at scale [1].

While short-term trainings can address immediate skill deficits, they often fail to create enduring institutional capability. Instead, an integrated, higher-education-based capacity-building approach is needed that treats curriculum, laboratories, ICT infrastructure, industry partnerships, and policy alignment as mutually reinforcing components of a single intervention.

In response to a solicitation from the European Union for the Erasmus Plus program, a team of researchers submitted a proposal in February 2024 for funding to improve the educational programs in Burundi in both the areas of renewable energy (RE) and ICT. The team comprised faculty with expertise in renewable energy and quality education pedagogy and a Burundian expatriate who is based in Stockholm, Sweden and has expertise in ICT training and education. The project was not funded on the initial submission, but although the review was very positive and the final score being close to the threshold for grant award, the project was not funded. Nevertheless, encouraged by the positive review, the team revised the proposal based on the reviewers' comments and resubmitted it in February 2025. A grant was awarded in August 2025. A detailed description of the four-year work plan for this project is presented here.

**Project Overview**

The Burundi Renewable Innovation Growth and Higher Education for Renewable energy systems (BRIGHTER) project (48-month work plan) is a consortium-based capacity-building project targeting Burundian higher education. Five Burundian universities will participate in the project. These universities are the University of Burundi, Ecole Normal Superieur (ENS), the Polytechnic University of Gitega (UPG), the Grand Lacs university (GL) and Institut Universitaire la Centrale d'Afrique (IUNICA). Additionally, the Burundian Ministry of Education will be playing the important role of policy development and curricular harmonization across the Burundian universities. The European Universities leading the effort are Polytechnic University of Lisbon (IPL) and the Slovak University of Technology Bratislava (STUBA).

The initiative is organized into four work packages across 48 months and is structured around four strategic objectives: (1) faculty development and course creation in renewable-energy (RE) systems design and implementation; (2) creation of RE teaching laboratories and ICT upgrades to enable hands-on and blended learning; (3) capacity building for RE business development and entrepreneurship; and (4) co-development of a national renewable-energy education policy framework to support scaling and institutionalization.

Table 1. Baseline and Target Elements of the Project Design

| OBJECTIVE | BASELINE | TARGET BY PROJECT END |
|---|---|---|
| Professors + Courses | 5 professors with RE system design/build skills | 25 professors per institution trained; 4 solar-energy courses developed (design, lab, finance/economics, entrepreneurship) |
| Labs + ICT | No RE teaching laboratories | 5 RE teaching laboratories established; each lab with 10 student stations; ICT and digital learning platforms upgraded |
| RE business capacity | No professors trained in RE business creation | 5 professors trained in RE business development with gender-inclusive entrepreneurship focus |

| | | |
|---|---|---|
| Policy Framework | No nationwide RE education policy framework | Renewable energy education policy framework co-developed with national stakeholders for scaling |

The first steps will be to engage the stakeholders in co-design workshops. In parallel to the curricular content development, RE laboratories will be designed and staged installation and commissioning performed for each of the universities. The laboratory design will be contextualized for the Burundian environment. A good example of an exemplar renewable energy teaching and research laboratory is the one located at Strathmore University in Nairobi, Kenya [3]. This laboratory will serve as a model for the planned laboratories at the Burundian universities. In March 2026, three participants of the project, Chris Clement Igiraneza and his colleague Ferdinand from Kit Hub as well as Dr. Singh from Villanova University, visited the lab at Strathmore University to better understand their teaching arrangements and training equipment. Also, during this trip they visited a company, Davis and Shirtliff, [4] who are a distributor of tier 1 solar equipment. This company, headquartered in Nairobi, Kenya has over 20 years of experience in solar energy projects and opened an office in Bujumbura, Burundi in late 2024. They are willing to serve as an industry partner to the present project.

As indicated earlier in the paper, connectivity in the universities is generally very limited. Starlink antennas will be installed to provide better connectivity at the universities. More generally, ICT system upgrades will be performed at the universities to enhance accessibility, particularly for underserved populations. Faculty institutes, industry-linked experiential learning, and policy working groups will also be used to support this educational initiative.

The integrated framework is informed by engineering education research on active and problem/project-based learning in resource-constrained contexts [5-6], the pedagogical value of hands-on and remote laboratories for RE learning [7-8], and the necessity of aligned digital infrastructure for blended delivery. It also draws on literature on university–industry partnerships to ensure labor-market relevance [9-11], and on evidence that gender-responsive programme design must be embedded across recruitment, participation, learning experiences, and career pathways. Operationally, the framework is implemented through coordinated workstreams (curriculum, labs, ICT, industry, policy) governed by a quality-assurance loop that uses evaluation evidence to iteratively refine design and implementation of the program.

**Study design and methods**

This work-in-progress study plan is guided by three research questions: (RQ1) To what extent does the integrated intervention increase institutional capacity to deliver RE engineering education (curriculum adoption, trained faculty, sustained lab utilization)? (RQ2) What changes are observed in student learning and practice-oriented competencies when RE curricula are paired with commissioned laboratories and ICT-enabled blended learning? (RQ3) How do structured industry linkages and entrepreneurship training influence employability-oriented outcomes, and how are these outcomes moderated by gender-inclusive participation measures?

A mixed-methods, longitudinal design will be used across the project phases. Baseline mapping will document existing curricula, instructional practices, ICT capacity, and laboratory availability, alongside stakeholder needs from universities, industry, and ministries. Co-design workshops will then translate needs into intended learning outcomes, course structures, laboratory exercises, and assessment plans. Implementation will proceed in staged cycles: (i) faculty development institutes (pedagogy + RE technical upskilling), (ii) development and approval of new or revised courses, (iii) procurement/installation/commissioning of five RE teaching laboratories (ten stations per lab), (iv) ICT upgrades and platform deployment to support blended/remote access, and (v) industry-linked experiential learning through internships, mentoring, and co-developed tasks. A policy workstream will run in parallel through working groups with national stakeholders to draft and validate a renewable energy education framework that supports nationwide adoption.

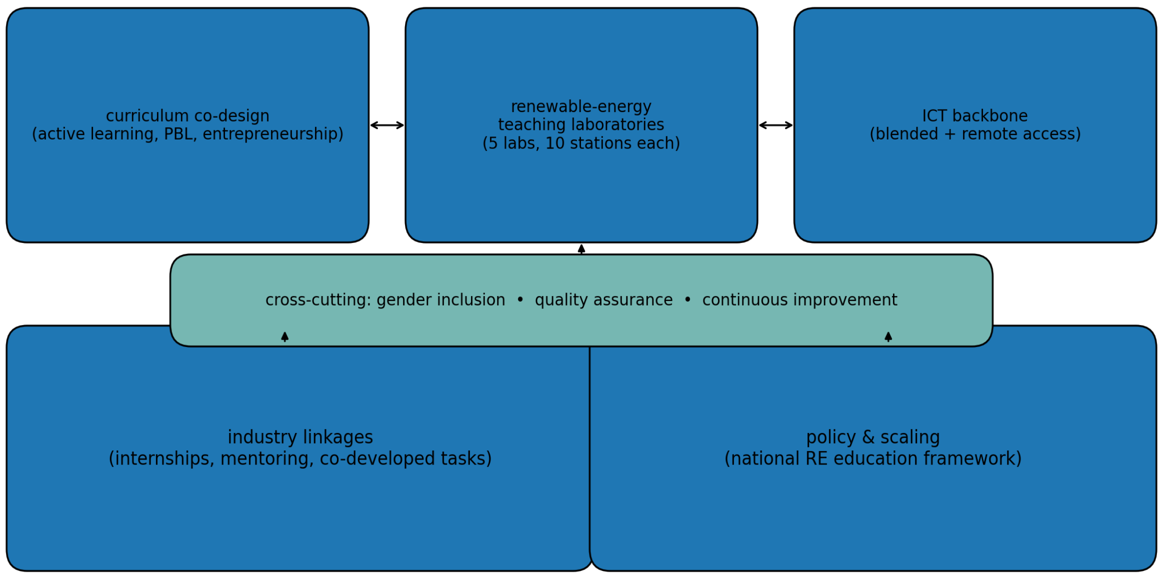


Figure 1. Integrated framework linking curriculum, laboratories, ICT, industry linkages, and policy (with cross-cutting inclusion and QA).

Table 2. Work package structure and its contribution to the integrated framework.

| WORK PACKAGE | FOCUS | CONTRIBUTION TO FRAMEWORK |
|---|---|---|
| WP1 | Management & Quality Assurance | Governance, reporting, risk management, and evidence-based continuous improvement |
| WP2 | Curriculum Development & Integration | Course design, learning outcomes, lab-linked learning activities, and adoption within programmes |
| WP3 | Governance & Human Development | Faculty development, partnership mechanisms, and |

| | | |
|---|---|---|
| | | capability building for sustainability |
| WP4 | Dissemination, sustainability & scaling | Stakeholder communication, community of practice, gender-focused dissemination, and scaling pathways |

**Evaluation plan**

Evaluation will combine quantitative and qualitative indicators aligned to engineering-education outcomes (curricular adoption, lab utilization and competency gains, instructor development), access and equity (participation of women), and innovation/employability (industry engagement and entrepreneurial activity). The study will report baseline conditions, data-collection instruments, analytic approaches, and continuous-improvement loops across the project's phases.

Evaluation will align indicators with the project's stated baselines and targets and with established engineering-education assessment approaches. Quantitative measures will include counts of trained faculty; number of courses developed and adopted; lab commissioning milestones; lab utilisation rates; and participation metrics including women's participation. Learning outcomes will be assessed via course-embedded assessments (e.g., design reports, laboratory performance tasks, rubrics for project-based artefacts) and pre/post concept or skills checks where feasible. Qualitative measures will include classroom and lab observations, instructor reflective logs, student focus groups, industry mentor interviews, and document analysis of course materials and policy outputs. Evaluation findings will be reviewed at regular quality meetings to support continuous improvement and to document how implementation decisions were made.

Table 3. Evaluation questions, evidence sources, and timing.

| EVALUATION FOCUS | EVIDENCE SOURCES | TIMING |
|---|---|---|
| Institutional capacity (RQ1) | Faculty training records; curriculum approvals; course syllabi; lab commissioning logs; usage statistics | Baseline; each implementation cycle; annual review |
| Learning and competencies (RQ2) | Rubric-scored projects; lab performance tasks; pre/post checks; learning analytics; student focus groups | Per course offering; end-of-semester synthesis |
| Industry and employability (RQ3) | Internship/mentoring participation; employer feedback; co-developed task artefacts; graduate destination tracking (where feasible) | During placements; end-of-year review |
| Equity and inclusion | Gender-disaggregated participation and retention; qualitative feedback on | Baseline; every cycle; final synthesis |

| | | |
|---|---|---|
| | barriers/supports; inclusion actions implemented | |
| Policy outputs | Working group minutes; draft framework iterations; validation workshops; adoption commitments | Throughout; final validation |

**Anticipated contributions and limitations**

The anticipated contribution is a transferable implementation-and-assessment blueprint for RE-focused capacity building in low-resource contexts. The framework explicitly links (i) pedagogical design (active learning and contextualised PBL), (ii) enabling infrastructure (labs and ICT), (iii) labour-market alignment (industry partnership structures), and (iv) scale mechanisms (policy integration). The study will also contribute practice-based lessons on how to sequence investments (faculty development, lab commissioning, platform readiness) to reduce adoption risks and improve sustainability.

As a work-in-progress study plan, this paper does not yet report outcome data. Implementation will face practical constraints typical of low-resource contexts (procurement lead times, infrastructure reliability, and staff workload), and attribution may be challenged because multiple components change concurrently. To mitigate these risks, the evaluation design emphasises documentation of implementation fidelity, triangulation of data sources, and use of baseline and intermediate measures to support plausible contribution claims.

**Conclusion**

Building sustainable renewable-energy capacity through higher education requires more than isolated curriculum updates or ad hoc trainings. This study plan proposes an integrated framework that combines co-designed curricula, commissioned teaching laboratories, ICT-enabled blended learning, structured industry engagement, and policy alignment. By pairing these components with an explicit evaluation and continuous-improvement loop, the initiative is positioned to generate both practical capacity gains and evidence on how to design RE engineering education interventions that are scalable, inclusive, and context-responsive.

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