Undergraduate Research on Optimization to Learn the Minimization of Transmission Power Losses on DC Microgrids

Juliana I. Castrodad-Garcia
Dept. of Mathematics
Univ. of Puerto Rico-Mayaguez
Mayaguez, Puerto Rico, 00681
Email: juliana.castrodad@upr.edu

Eduardo I. Ortiz-Rivera
Dept. of Electrical and Computer Eng.
Univ. of Puerto Rico-Mayaguez
Mayaguez, Puerto Rico, 00681
Email: eduardo.ortiz@ece.uprm.edu

Guillermo Lopez-Cardalda
Dept. of Electrical and Computer Eng.
Univ. of Puerto Rico-Mayaguez
Mayaguez, Puerto Rico, 00681
Email: guillermo.lopez@upr.edu

Abstract— This research-to-practice full paper describes an educational approach for non-engineers about the use of optimization in DC microgrids. This interdisciplinary project can help different students and academics in STEM to provide simplified and optimal solutions in DC microgrids. The application of optimization on the topic of DC microgrids will be a handy tool in the educative process for the awareness of the environmental effect of energy systems. The proposed educational methodology in this paper leverages numerical optimization techniques, explicitly employing MATLAB to minimize transmission power losses with photovoltaic modules under Maximum Power Point Tracking (MPPT) conditions. Previous knowledge of basic programming, computer software, and derivation of functions, including partial derivatives, is needed to understand the basis for the optimization process. It is critical to know how to derive a function and how to find the Hessian matrix to find the minimal value, which will be the optimal value of a function. Additionally, knowledge of electrical engineering will allow further analysis of optimal solutions. The student will gain a deeper understanding of the subject and develop vital and technical skills that will empower them to use computer software as a valuable tool for optimizing a function subject to constraints. This expedited approach facilitates the acquisition of optimal solutions for approximate values. This paper works on developing a theory to educate students on renewable energy topics using mathematical analysis in real-world problems.

Keywords—DC microgrids, optimization, STEM education.

I. Introduction

At the fundamental level, optimization uses different computational methods to find the best solution to a problem. Using an objective function that will be optimized, as well as variables and constraints, numerical optimization will see the values of the variables that will maximize or minimize the objective function, staying within the boundary conditions. With these minimized values for the variables, the optimal value of a function can be calculated. Additionally, knowledge in basic programming, computer software, and electrical engineering will facilitate the use of computer programming in MATLAB and further analysis of optimal solutions. This mathematical approach to minimization of power losses for DC microgrids is a method that will help optimize renewable energy systems.

Moreover, the student will gain proficiency in MATLAB programming using the *fmincon* tool and theoretical knowledge that will help solve practical problems in electrical engineering and renewable energy. This work is based on undergraduate research experience at the University of Puerto Rico, Mayaguez Campus. Finally, this paper will provide a list of recommended courses for the student to learn about optimization, microgrids, and energy systems.

II. DC Microgrids

In electrical distribution, DC microgrids represent a self-sustaining and versatile solution characterized by simplicity, compatibility, and flexibility. Operating primarily on direct current (DC), these networks offer a streamlined alternative to traditional AC systems. Comprising interconnected DC sources, such as solar panels, batteries, and other renewable energy generators, along with DC loads, DC microgrids facilitate efficient energy distribution within localized areas. Their design enables seamless integration with the existing AC infrastructure while affording independence from the primary power grid when necessary. Moreover, their adaptability allows for incorporating renewable energy sources and energy storage devices, fostering sustainability and resilience. Notably, the cost-effectiveness of DC microgrids further enhances their appeal, making them a compelling option for improving energy efficiency and mitigating environmental impact. Therefore, optimizing the power load systems within DC microgrids is imperative to ensure safe and reliable operation under grid-connected and isolated conditions, underlining the importance of robust control mechanisms and establishing a stable connection through the power lines.

III. Theory of Optimization

Applying mathematical analysis to real-world problems further provides theoretical approaches for solving different problems. The mathematics behind optimization is critical before working with programming and on computer software. Learning the theory will give a more abstract and general definition and an image of how optimizing will choose the best viable option.

In [1], it is understandable that optimization occurs not only in mathematics but also in science and the analysis of physical systems. To use optimization [1], an objective must first be identified, which depends on the problem's evaluation criteria. The variables are the characteristics of the objective that will, in turn, optimize the system. Optimization aims to find variables that optimize (or minimize) our objective. Be it constrained or unconstrained optimization, at least one type of restriction can consistently be implemented.

One of the most important parts of optimization is constructing an appropriate model of the objective, variables, and constraints. This will create an algorithm that will allow us to find a solution that is usually more accessible with the help of a computer program such as MATLAB. Each algorithm is made for a specific function or objective, so creating an appropriate algorithm is imperative before writing the code.

Furthermore, by analyzing the objective and its restrictions, it is possible to choose the best optimization method. If this is not done correctly, the method may not be efficient. Sensitivity analysis plays a crucial role in this, as it helps to check if the solution is optimal. It allows for the evaluation of changes needed in the model or data, ensuring the accuracy and optimality of the optimization process.

IV. Math behind Optimization

There are two types of constrained optimization problems: linear programming and nonlinear programming problems. Nonlinear programming problems are often found in physical sciences or engineering, where some constraints or the objective function are nonlinear. Since global solutions are challenging, these problems tend to find a local optimal solution, which only happens in linear programming problems.

When optimizing a function mathematically, it can sometimes be evaluated and understood more efficiently with a graph since optimization is the minimization or maximization of a function subject to constraints on its variables. A function restriction will help determine a function's minimum value or the optimal value. The first step in optimizing a function is to ensure that the feasible region, the intersection of the restrictions and the objective function, is not an empty subset and has an inferior bound. This region is crucial in function optimization.

The values of the local minimums of a function will become the objective of calculating the first derivative; finding the critical points will be the first step. Evaluating the vector function of the gradient equal to the null vector will provide a subset of critical points. Afterward, evaluating the critical points in the Hessian matrix will give us information on the critical point: a local, global maximum, minimum, or saddle point.

Optimization, though it may seem straightforward, is a process that demands meticulous consideration of every case and the possibility of arriving at an optimal solution for an objective function. Without this careful exploration, we would merely arrive at a solution, not an optimal one. Yet, it is this very meticulousness that makes optimization such an engaging field, offering a detailed insight into how variables can be manipulated to yield the best possible solution to a problem.

Although it is not a typical undergraduate course, it is an essential topic in implementing and applying mathematical analysis to real-world problems. The use of optimization will provide the best solution to a problem. This further implies that, when faced with a problem, mathematical optimization will reduce factors that could damage the possibility of a beneficial solution. It will become a tool that will make favorable conditions to reduce or eliminate a problem and become a direct pathway connecting theoretical mathematical techniques to problem-solving in any topic or subject.

V. Benefits of Basic Programming Skills

Computational knowledge and coding skills will ease difficulties and provide a tool for applying mathematical theory when working with real-world problems. Specifically, optimization, computer programming, and coding are handy tools that facilitate the application of mathematics. Although there is a basic structure for an optimization code, each method has its differences. Because of this, some methods may find an optimal solution while some do not. Sometimes, it updates the last solution, so it takes less time to find the optimal solution. Many factors affect the effectiveness of a method, such as the convergence of the function, the number of iterations it takes to get to the optimal value, the search direction of each iteration, whether a function is convex or concave, as well as the error percentage of the calculations, among others. Optimization is not always easy, but it is essential to understand the mathematics involved in it. Without it, the analysis of an objective function and decision-making regarding the best approximation method will become more laborious than it should be.

Programs such as MATLAB and Simulink are tools that will help optimize functions using equality and/or inequality restrictions. These will help keep the objective function between the boundaries of the available equipment for real-life application. In this paper, a basic explanation of the use of optimization in MATLAB will be provided. Furthermore, using the program Simulink found in MATLAB will create a visual representation of the advancement of the variables. Using basic programming will generate an opportunity for applying mathematical analysis of subjects and topics discussed in undergraduate courses.

VI. MATLAB and Simulink

When working with equations in electrical engineering, one of the best ways to view and analyze a problem is by creating a diagram. The program Simulink in MATLAB will allow a representing block diagram of the objective function that will be minimized.

This block diagram will be connected to the MATLAB code, which will create a link to the code variables in MATLAB so that graph representations can be obtained. These graphs will show the progressively advanced variables. In the same way, this provides a visual representation of the objective function,

[1] From here on out, when referring to optimization, it is specifically referring to constrained optimization.

and the values assigned to each variable. Analyzed mathematically, the graph will show the limit of the objective function (most likely a curve) when it approaches the optimal value.

A. *Using MATLAB*

After understanding the mathematics behind optimization, computer and programming skills can be applied to any type of problem. There are many types of minimization codes for MATLAB. However, when minimizing power losses, the best optimization code is using the *fmincon* tool. This tool will allow the state of the objective function to be implemented and the equality and inequality restrictions in the code. It is one of the most efficient minimization tools since its iteration time is short, and it provides an exact optimal solution, which can be viewed in the graph representations in Simulink.

Before starting to write the code, it is essential to ascertain that the intersection of all constraints is not equal to the empty set. If this happens, the system will never provide an optimal solution since there is no value that satisfies the restriction conditions; therefore, the function will have no solution.

After confirming that the subset of the intersection of all the constraints is not the empty set, the code can begin to be compiled. In MATLAB, two scripts will be opened and used, apart from running the code afterward in the command window.

B. *First Script*

In this first script, the constraints will be elaborated into the code. Both equality and inequality equations will be defined by our variables *ceq* and *c*, respectively. Both will be equal to zero; each constraint must be manipulated so that they both have zero on one side. Regarding the inequality restrictions, the *c(x)* function will be less than or equal to zero. The main function will name both *c* and *ceq*; this will all be assigned the script's name so that these restrictions are considered when running the program in the second code.

It is useful to write the objective function and all of the constraints before starting to compile, where the restrictions can be categorized and rewritten afterwards as equality and inequality equations.

A simple example can be considered: if one considers an area that must be less than or equal to 40, the following equation (1) can be obtained, where x_1 and x_2 represent the sides of the rectangular area. The *c(x)* function (2) will be less than or equal to 0.

$$x_1x_2 \leq 40 \tag{1}$$

$$c = x_1x_2 - 40 \tag{2}$$

C. *Second Script*

The second script will consist of the restrictions for the unknown values and the boundaries for the objective function. This script will contain six essential parts: the objective function, initial values, equality and inequality matrices, boundaries, the nonlinear optimization function, and the display code.

1) Objective function: This will be the function that will be minimize.

2) Initial values: These values will be based on inference, previous knowledge, or educated guesses of these variables.

3) Equality and inequality matrices: A and *Aeq* will be matrices that are going to be multiplicated by the unknown variable vector, and it will be equal to *b* and *beq*, respectively. Both *b* and *beq* must be assigned constant values, they are not matrices.

4) Boundaries: Lower and upper bounds are specified for our unknown variables.

5) Nonlinear optimization function: Using the *nonlincon* tool, this calls the first script so that the function will be subject to the restrictions of both scripts.

6) Display: Asking the program to display the minimized unknown variables will provide an idea of the values used for the optimized function.

Additional unknown variables that are not the ones being minimized, must be defined in the code in both scripts. Furthermore, the *nonlincon* tool is used inside the *fmincon* function, which calls the variables to minimize in terms of the restrictions stipulated, the initial values, the *A* and *Aeq* matrices, the constant values *b* and *beq*, the lower and upper bounds, and our *nonlincon* tool. Finally, our code will be run in the command window with the second script open, since it is the second script that calls the first one to its constraints.

A final example will be shown, modified from [2], where the function that will be minimized is (3) subject to (4) (5) (6) with initial values (7).

$$min.\ f(x) = x_1x_4(x_1+x_2+x_3) + x_3 \tag{3}$$

$$x_1x_2x_3x_4 \geq 3 \tag{4}$$

$$x_1^2+x_2^2+x_3^2+x_4^2=40 \tag{5}$$

$$1 \leq x_1, x_2, x_3, x_4 \leq 6 \tag{6}$$

$$x_0 = (1, 5, 5, 1) \tag{7}$$

After compiling, the resulting code is presented in Figures 1 and 2. The results obtained in Figure 3 from the command window in MATLAB show that the variables stayed within the bounds in (6). The results also show the final objective, the objective function (3), evaluated with the optimal values. Evaluating the optimal variable values in the equality and inequality restrictions indicates that these variables fit the constraints.

```
function [c,ceq] = example1(x)
c = 36 - x(1)*x(2)*x(3)*x(4);
ceq = x(1)^2 + x(2)^2 + x(3)^2 + x(4) - 40;
```

Fig. 1. First script compilation in MATLAB code.

```
objective = @(x) x(1)*x(4)*(x(1) + x(2) + x(3)) + x(3);

x0 = [1, 5, 5, 1];
lb = 1.0* ones(4);
ub = 5.0* ones(4);

A = [];
b = [];
Aeq = [];
beq = [];
nonlcon = @example1;

x = fmincon(objective,x0,A,b,Aeq,beq,lb,ub,nonlcon);

disp(x);
disp(['Final Objective: ' num2str(objective(x))]);
[c,ce] = example1(x);
```

Fig. 2. Second script compilation in MATLAB code.

```
Local minimum found that satisfies the constraints.

Optimization completed because the objective function is non-decreasing in
feasible directions, to within the value of the optimality tolerance,
and constraints are satisfied to within the value of the constraint tolerance.

<stopping criteria details>
    1.0000    4.6164    3.9652    1.9667

Final Objective: 22.8093
```

Fig. 3. Final results for optimization example.

VII. Minimizing Power Losses

It is important to note that minimizing power losses will help maintain a reliable electrical system by reducing dangerous risks and finding less expensive materials. In DC power lines, power losses can occur due to resistance, especially over long distances. The lines create resistance, which converts electrical power into heat, heating the line. Therefore, it is important to use power lines with a material that will reduce the chances of high resistance. Optimizing the electrical system will provide a framework for the voltage carried by the electrical lines, which will help choose the best material to avoid burning power lines. This way, optimization provides insight into the electrical details of the system as a whole but also gives a range of factors to consider when choosing the best material for the microgrid.

Optimization is a convenient tool for many types of systems. In DC microgrids, optimizing power losses in transmission lines is based on minimizing voltage values through various lines. After understanding how to minimize a simple function subject to constraints in the previous section, the code provided can be used to compile the code for a problem of power losses.

Before viewing the macro, one must understand the micro. This paper provides insight into minimizing power losses in three transmission lines, with fixed values for the other variables in these equations. This analysis, however, can be extended to the minimization of various transmission lines.

By leveraging Kirkoff Laws, we can construct the following linear PV model for three transmission lines. This technical approach is instrumental in our understanding of power systems optimization.:

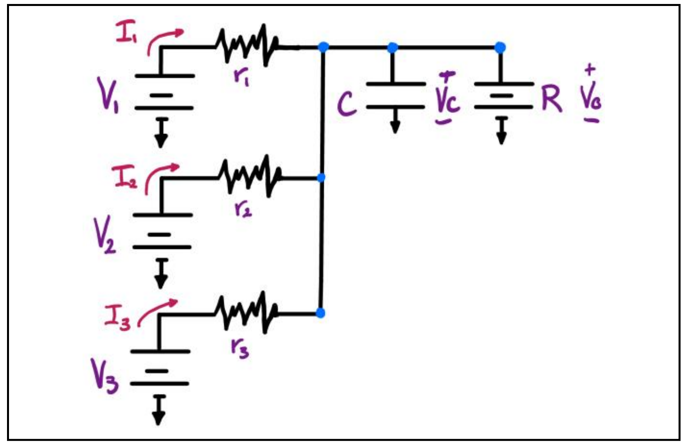

Fig. 4. DC microgrid model with photovoltaic modules.

Using the DC microgrid representation from Figure 4, we find the following equations, primarily the function of power losses that will be minimized (8):

$$P_o = \sum_{k=1}^{n} \frac{(V_k - V_c)^2}{r_k} \tag{8}$$

$$\sum_{k=1}^{n} \frac{V_k(V_k - V_c)}{r_k} - \frac{V_c^2}{R} = \sum_{k=1}^{n} \frac{(V_k - V_c)^2}{r_k} \tag{9}$$

$$\left(\frac{1}{R} + \sum_{k=1}^{n} \frac{1}{r_k}\right) V_c = \sum_{k=1}^{n} \frac{V_k}{r_k} \tag{10}$$

$$V_c - V_k < 0 \quad \forall\, k \in \mathbb{N} \tag{11}$$

The equality restrictions (9) (10) are manipulated to fit properly in the code, considering that this analysis is for power losses in three transmission lines. This means that in the equations (8) (9) (10), n will be equal to 3. Similarly, the inequality variable restrictions (11) are also rearranged to accommodate them in the inequality matrix.

After writing everything in the MATLAB scripts, as observed in Figures 5 and 6, results are obtained in the command window, as shown in Figure 7.

```
function [c, ceq] = minimizefunction1(x)
Vo=120.;
r1=0.001;
r2=1;
r3=1/0.001;
Ro=0.1;

c=(x(1)/r1)+(x(2)/r2)+(x(3)/r3)-Vo*((1/r1)+(1/r2)+(1/r3)+(1/Ro));
ceq=(x(1)*(x(1)-Vo))/r1+(x(2)*(x(2)-Vo))/r2+(x(3)*(x(3)-Vo))/r3-(Vo^2)/Ro-
    ((x(1)-Vo)^2)/r1-((x(2)-Vo)^2)/r2-((x(3)-Vo)^2)/r3;
end
```

Fig. 5. First script compilation of equality and inequality restrictions.

```
r1=0.001;
r2=1;
r3=1/0.001;
Vo=120.;
Ro=0.1;

objective = @(x) ((x(1)-Vo)^2/r1 + (x(2)-Vo)^2/r2 + (x(3)-Vo)^2/r3)
x0= [12.6544, 12.6545, 12.6551];

A = [-1, -1, -1];
b = -Vo;
Aeq = [];
beq = [];
lb = 0.;
ub = +Inf;
nonlincon = @minimizefunction1;

x = fmincon(objective,x0,A,b,Aeq,beq,lb,ub,nonlincon);

disp(x)

disp(['Final objective: ' num2str(objective(x))]);
[c,ceq] = minimizefunction1(x);
```

Fig. 6. Second script compilation with variable restrictions.

```
Local minimum found that satisfies the constraints.

Optimization completed because the objective function is non-decreasing in
feasible directions, to within the value of the optimality tolerance,
and constraints are satisfied to within the value of the constraint tolerance.

<stopping criteria details>
  121.1988  121.1987  121.2131

Final objective: 1438.56
```

Fig. 7. Final results for optimization of power losses.

With these results obtained from the code, it can be concluded that the optimal voltage value would be approximately 121 volts, resulting in a value for power losses of 1,438.56 watts. This means that for three microgrids installed, it is suggested to offer a current of 120 volts for a minimized value of power loss of 1,438.5 watts, based on the restrictions in (9), (10), and (11).

Furthermore, observations in the message from the code found in Figure 6 show that the program stops compiling when it finds values that satisfy the constraint tolerance and the objective function for a non-decreasing value within optimality tolerance. This gives way to any possible optimization problem where the *fmincon* tool provides a minimum optimal value based on the constraint and optimality tolerance for more preferrable or recommended results and fewer error percentage.

Additional unknown variables can be found in the function and its restrictions, to which they are assigned the following values for voltage (Vo) and resistances (r1, r2, r3, Ro): Vo = 120, r1 = 0.001, r2 = 1, r3 = 1000, Ro = 0.1.

In Figure 8, with the help of the Simulink tool, a graph is obtained of the progress of the power loss approximating the optimal value of the objective function. Using this optimal value, the materials based on the assigned values of the unknown can be found and the microgrid could be constructed. If this is not the case, the additional unknown variables can be altered and manipulated to obtain the optimal solution within the ranges of the materials available.

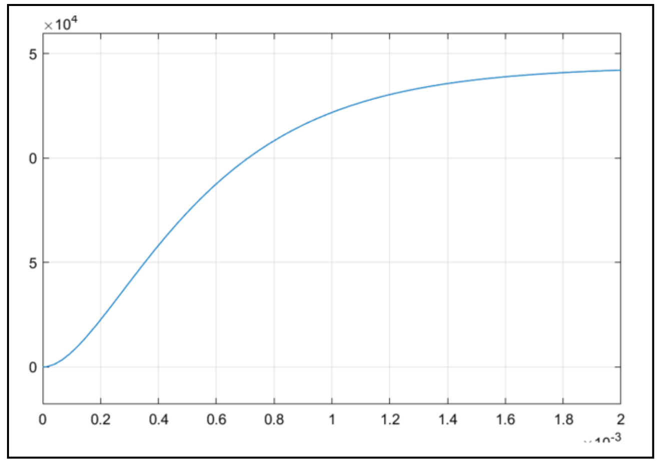

Fig. 8. Power loss graph obtained with optimal voltage values.

Additionally, in the Simulink code, an additional graph was created, shown in Figure 9, so that the progress of the optimal voltage values could be observed while approximating the optimal value for the power loss.

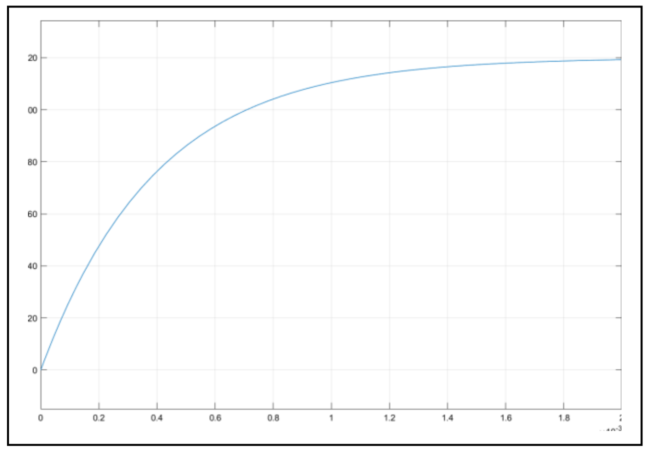

Fig. 9. Optimal voltage values approximating 120V.

The analysis suggests that optimization has proven to be a vital tool in electrical engineering. Using optimization for DC microgrids incorporates adaptability, reliability, and stability. These ensure that the energy flows in the correct direction and reduce the impact of fluctuations in energy generation or demand. Optimization also gives way to the system's ability to adapt to operating conditions or configuration changes. This allows the system to become more suitable for different environments and ensures that the system continues operating efficiently and effectively.

Optimization has shown that previous knowledge obtained from suggested courses is crucial. This knowledge will provide insight into mathematical analysis and facilitate the mechanical calculation process in optimization.

VIII. EDUCATIONAL INVOLVEMENT IN THIS WORK

A. *Accreditation Board for Engineering and Technologies*

As part of an engineering program accredited by ABET, this work aligns with the following student outcomes [3]:

- An ability to identify, formulate, and solve complex engineering projects by applying engineering, science, and mathematics principles: The student identified the challenge of increasing renewable energy usage to mitigate pollution from fossil fuels. Subsequently, the student researched optimizing DC Microgrids, including developing an algorithm to minimize power losses in DC transmission.
- An ability to apply engineering design to produce solutions that meet specified needs with considerations of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors. Throughout this project, following procedural steps akin to engineering design processes, the student has explored potential solutions to address the impacts of global warming, such as promoting the utilization of DC renewable energy sources like solar panels, thermoelectric generators, and batteries.
- Ability to communicate effectively with a range of audiences: In this research, the student actively engages with engineering and scientific communities by presenting mathematical models and equations.
- An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, considering the impact of engineering solutions in global, economic, environmental, and social contexts.
- An ability to function effectively on a team, establish leadership, create a collaborative and inclusive environment, set goals, plan tasks, and meet objectives: While the student conducted this research independently, the methodology could be extended to a group setting, where tasks could be delegated among team members. For example, some members could focus on external optimization of photovoltaic microgrids using the PV Exponential Model [4]. In contrast, other students could concentrate on optimizing duty ratio and designing, simulating, and constructing DC/DC converters for maximum power point tracking or power curtailment. At the same time, other students could focus on developing algorithms for financial optimization and investment recovery of the DC microgrid [5].
- An ability to develop and conduct appropriate experimentation, analyze, and interpret data, and use engineering judgment to conclude: Following the optimization of DC Microgrids, the student had the opportunity to simulate and analyze DC microgrids using laboratory equipment, thus validating the functionality of their work.
- An ability to acquire and apply new knowledge as needed, utilizing appropriate learning strategies: Upon completing this work, the student has acquired skills and knowledge that could facilitate the design of optimized DC microgrids, thereby contributing to enhanced renewable energy utilization.

B. *Courses Suggested in This Project*

The following courses outlined in Table 1 are recommended for Electrical Engineering students interested in establishing a foundation in power electronics and renewable energy and engaging with this project.

TABLE I. SUGGESTED COURSEWORK

Suggested Course	**Relevant topics, skills, and/or coursework**
MATE 3030. Introduction to Geometry.	Geometry of the triangle and of the circle, foundations of axiomatic geometry, and elements of non-Euclidean geometry.
MATE 3171. Precalculus I. MATE 3172. Precalculus II.	A preparatory course for calculus covering the essentials of relations, functions, complex numbers, linear algebra, trigonometry and analytic geometry.
MATE 3031. Calculus I MATE 3032. Calculus II.	Integration techniques, infinite series, vectors, polar coordinates, vector functions, and quadric surfaces
MATE 3063. Calculus III.	Differential and integral calculus of several variables, and an introduction to differential equations with applications.
MATE 4031. Introduction to Linear Algebra.	Euclidean vector spaces, matrices and linear equations, spectral decomposition of normal operators.
MATE 3020. Introduction to the Foundations of Mathematics.	Topics include the propositional calculus and set algebra, finite and infinite sets, transfinite arithmetic, Peano's axioms, and development of the real number system.
MATE 6026. Numerical Optimization.	Topics include optimization on convex sets, minimization methods of nonlinear problems, nonlinear equations, conjugate methods, and special structure problems.
COMP 3010. Introduction to Computer Programming I	Topics include data types, control structures, functions, arrays, files, and the experience of running, testing, and debugging programs.
INEL 3105. Electrical Systems Analysis I.	Analysis of direct current and alternating current linear electric circuits; laws and concepts that characterize their behavior.
FISI 3171. Physics I FISI 3172. Physics II	Principles of mechanics, waves, and thermodynamics for engineering, physical sciences, principles of electricity, magnetism, optics.
INEL 5417. Power Electronics Applied to Renewable Energy System	Use of algorithms for maximum power point tracking; control of photovoltaic and wind systems, and its applications.

The course codifications specified above are for classes offered at the University of Puerto Rico- Mayaguez Campus [6][7].

C. *Skills Developed by the Student*

The student will develop vital skills in first, second, and partial derivatives and matrix properties. Furthermore, learning to identify minimums, maximums and saddle points will be key for finding the optimal value of a function, as well as the skill of simplifying linear equations. Vital skills in programming and mathematical analysis of results will become crucial to the educational development of the student. These will become handy tools for future applications of Mathematics in real-world problems and research.

IX. Opportunities for Students

A. Undergraduate Research Programs

In addition to the opportunities available within the undergraduate curriculum, students may participate in summer research programs and engage with technical societies associated with power electronics, mathematics, and renewable energy. Examples of such opportunities include:

1. Research Experience for Undergraduates (REU): This program offers research opportunities for students across various universities in the United States. Some universities host research laboratories funded by the U.S. Department of Energy (DOE) and the National Science Foundation (NSF), enabling students to collaborate with faculty and graduate students on mathematics and energy systems projects. For example, the REU Summer Internship program at Villanova [8].
2. DOE National Laboratories: National Laboratories across the United States offer research programs for undergraduate students to engage in the latest developments in renewable energy under the guidance of laboratory staff scientists and engineers. Programs such as the CHRES Summer Internship program, Science Undergraduate Laboratory Internship (SULI), UNIFI National Renewable Energy Laboratory Internships, and Oak Ridge Institute for Science and Education (ORISE) are among those available [9]-[11].

B. Professional Associations

1. IEEE Power and Energy Society (PES): Also known as IEEE PES, this society is the premier platform for sharing the latest technological advancements in the global electrical power industry. Membership provides access to numerous benefits, including webinars, technical reports, tutorials, and videos [12]. IEEE PES also boasts numerous student chapters worldwide, offering opportunities for students to develop leadership skills and participate in community projects related to renewable energy.
2. IEEE Power Electronics Society: As a sister society of the PES, has facilitated and guided innovation in power electronics technology such as the effective use of electronic components, the application of circuit theory and design techniques, and the development of analytical tools toward efficient conversion, control and condition of electric power. It has local chapters, that offers members in local areas network with colleagues, develop activities for professional development, and share expertise through technical exchange [13].
3. American Mathematical Society: The American Mathematical Society is an association of professional mathematicians dedicated to the interests of mathematical research and scholarship. It serves the national and international community through its publications, meetings, advocacy, and other programs [14].

X. Conclusions

Renewable energy systems are currently a big topic of conversation due to their environmental effects on our need for reliable power sources. Optimization has proven to be a powerful tool for solving new problems in the field of electrical engineering associated with energy losses. Minimizing power losses on photovoltaic systems with maximum power point trackers for a DC microgrid has become an application to electrical engineering where long-lasting renewable energy systems are possible. The use of optimization programs and minimization tools for non-engineers as well as for educational topics such as renewable energy systems and applied mathematics will become handy in the awareness of the environmental effects of traditional energy systems and the advancement of adapting renewable energy sources and devices to improve energy efficiency and mitigation of the environmental impact. Educating students on these topics will provide an educational approach to the applications of mathematical analysis in real-world problems and a new insight into the world of renewable energy systems.

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