# Internship in the decarbonization projects for urban districts and industrial parks

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# ABSTRACT

From march to august 2021, my DAAD scholarship consisted of an internship in a German enterprise, where I had the fortune to take part in one of the largest companies not only in Germany but also worldwide. It was SIEMENS AG. From my expertise, working with Homer Energy Pro, the objective of the internship was to carry out a complete analysis of the software tools used for designing, simulating, and optimizing energy systems.

The methodology was firstly based on a literature research of software tools that simulate and optimize distributed energy systems. The findings were classified in to three main groups and then they were deeply analyzed having interaction either with the tool or with their repositories. In the results section, the most versatile tools were expose and finally, in the section of conclusions, I summarize my work at SIEMENS. Furthermore, I suggest some future projects that might be interesting to develop at ITM.

*Key words*: Energy system design tools, Resilience networks, Optimization tools, IDE, Python.

# ACKNOWLEDGEMENTS

I would like to take this section of my internship report to highlight the great work of my parents Claudio Patricio Restrepo and Eugenia Herrera, who from the first day I start at university, were willing to support me all the time in my academic process. I would also like to thank all the professors who shared their knowledge and experiences with me, especially Bonie Johana Restrepo, Luz Adriana Trejos, Luis Fernando Grisales, Maria Vilma García, Jorge Sierra and Silvana Vásquez for supporting me in my learnings of extracurricular topics and to support me in my academic exchange. Besides, I would like to thank DAAD, Frankfurt University of Applied Sciences and my supervisor Lukas Höttecke at SIEMENS AG to let me have an excellent experience during pandemic times in Germany. Finally, I would like to thank all my family members, friends, and a person I remember with great affection called Andrea Malo who became a source of inspiration to achieve any goal I set in my life.

This report and my degree are dedicated to all these wonderful people and institutions.

“I have not special talents. I am just passionately curios” Albert Einstein

# ACRONYMS

ESD: Energy System Design

HP: Heat Pump

NIS: National Interconnected System

NIZ: Not Interconnected Zones

IDE: Integrated Development Environment

GUI: Graphical User Interface

AWS: Amazon Web Services

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# 1. INTRODUCTION

Urgent action is necessary to accelerate the pace of the energy transformation and decarbonization of the economy (Renewable & Agency, n.d.). Limiting the global average temperature rise to no more than 1.5°C above pre-industrial levels will require the complete decarbonization of all sectors of the economy by early in the second half of this century. That will be very challenging, particularly in some key industry and transport sectors where viable options are currently limited. Renewables, supplemented with other technologies, can play a pivotal role in these sectors, but the potential of renewables has not been fully recognized to date. Actions that deliver only partial emission reductions will not be sufficient, and some may hinder reaching zero. The focus of policy makers and industry investors must unerringly be on a pathway that progressively scales up those few options that are consistent with reaching the zero-emission goal. (Asmelash et al., 2020).

The global energy system must be transformed. Although addressing climate change remains a key driver, the energy transition brings a much wider range of benefits than simply carbon emissions reduction. It can make universal energy access affordable, improve human health, increase energy security and diversify energy supply (Larsson, 2019). On top of that, the transition to industry 4.0 and digitalization requires quick energy process changes to the upcoming times.

Policies enacted to help mitigate climate change can directly or indirectly stimulate renewable energy deployment across all end-use sectors by mandating a reduction or elimination of greenhouse gas emissions, phasing out the use of fossil fuels and/or increasing the costs of energy from fossil fuels relative to renewables. Climate change policies include banning or phasing out fossil fuels, enacting targets to reduce greenhouse gas emissions (including, for example, “net zero” commitments), and development and participation in carbon pricing and emissions trading programs (REN21 Members, 2020). **Error! Reference source not found.** shows countries and states with early 2020 climate change policies.

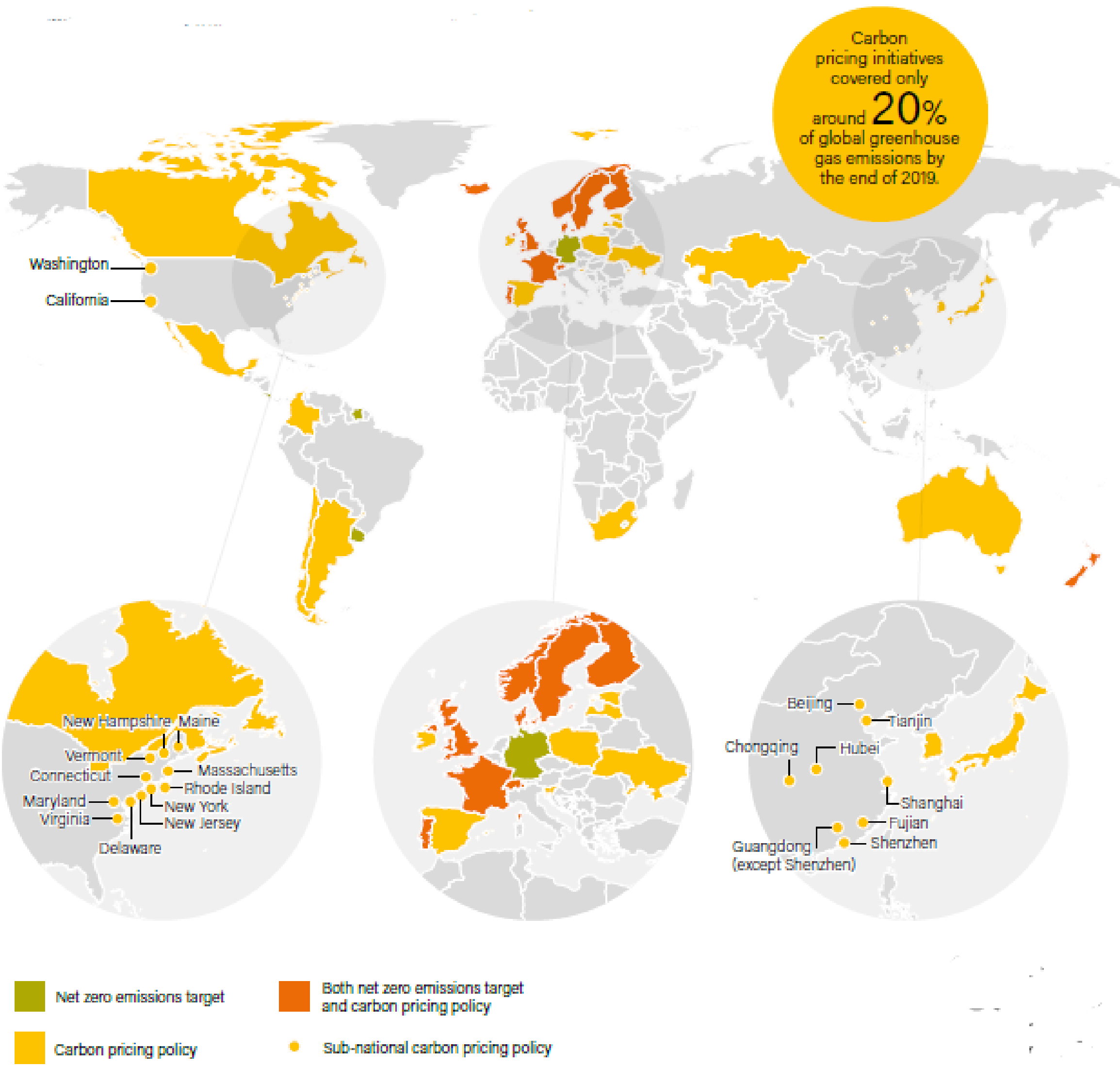


*Figure 1: Countries with Selected Climate Change Policies, Early 2020* (REN21 Members, 2020)

In the NZE, the combined size of the market for wind turbines, solar panels, lithium-ion batteries, electrolyzes and fuel cells represents a cumulative market opportunity to 2050 worth USD 27 trillion. At over 60% of the total, batteries account for the lion's share of the estimated market for clean energy technology equipment in 2050 (**Error! Reference source not found.**). With over 3 billion electric vehicles (EVs) on the road and 3 terawatt-hours (TWh) of battery storage deployed in the NZE in 2050, batteries play a central part in the new energy economy. They also become the single largest source of demand for various critical minerals such as lithium, nickel and cobalt (IEA, 2021).

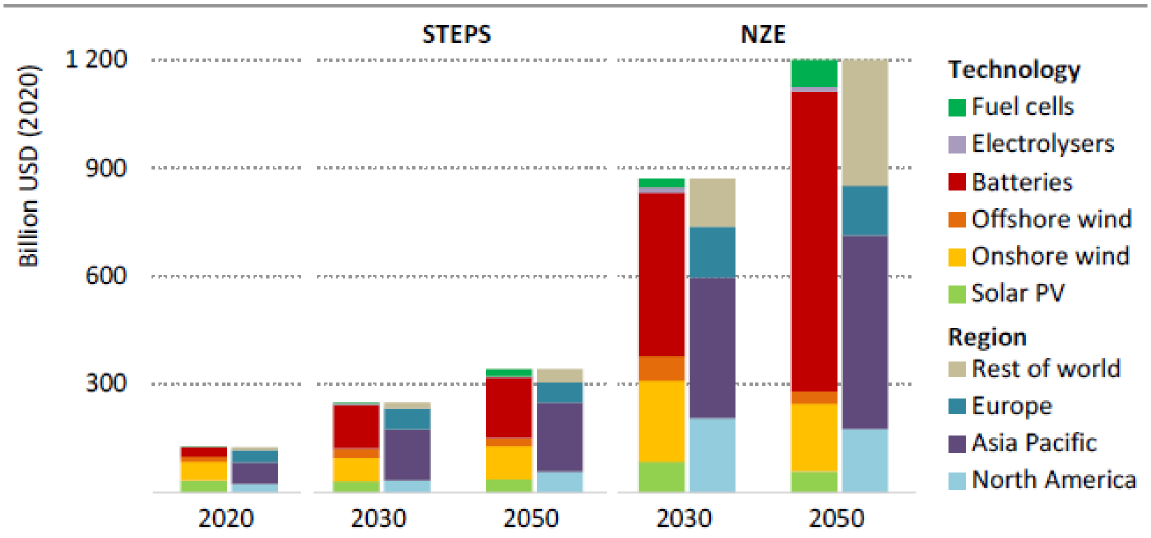


*Figure 2: Estimated market size for selected clean energy technologies* (IEA, 2021)

Tackling environmental issues, the capacity installed of RE increase exponentially worldwide and researchers work hard to achieve the targets set by different countries. Furthermore, currently electricity access has become fundamental for people and decentralized networks ought to be the optimal solution. In Colombia the 52% of the territory still belongs to the NIZ due to the geographical position makes harder to include the country in the NIS and laws las 1715 has been recently established to promote the RE (Superintendencia delegada para energía y gas combustible, 2020).

Worldwide distribution grids are facing the challenges of integrating increasing amounts of distributed and volatile generation and the prospected growth of peak demands through electromobility, HPs and other electrical and thermal components (Schreck et al., 2020). However, those challenges might be forecasted, optimized, and predicted with energy system simulation tools. Those types of software contain a wide variety of features the gives accurate results to full fit most of the costumers needs.

The internship at SIEMENS AG consisted in contributing to the research for the decarbonization of industrial parks and urban districts to meet the ambitious European goals, especially the German ones, of carbon-free cities by 2050 or before. On this project, I was able to build on the mechanical, thermal, and electrical know-how gained during my academic training as an electro-mechanical engineer. In addition, the dimensioning, knowledge, and evaluation of energy systems, acquired in the various workshops in which I participated in the institution (ITM). My work was based on the search for software tools that can design, evaluate, and optimize energy systems, always seeking to generate a positive impact mainly on the environment, not only at a domestic level but also at an industrial level.

**General objective**

Develop a complete analysis of the software tools used for the design and simulation of energy systems.

**Specific objectives**

- Literature review of software tools for the design and simulation of energy systems.
- Classify tools according to their characteristics (academic, OpenSource and commercial).
- Verify the integration of thermal models and electrical models in energy systems using simulation tools.
- Select the most versatile tools according to their functionality.

# 2. THEORETICAL FRAMEWORK

In order to achieve the final report objectives, some relevant terms were clearly defined:

## 2.1 Energy system

The term energy system compress all components related to the production, conversion, delivery, and use of energy (Intergovernmental Panel on Climate Change, 2015). Basically, energy systems contain the main fields of engineering and management to satisfy the consumer needs in the forms of heat, fuels, and electricity.

Industries, commercial areas, large buildings, municipalities, and communities are facing three main challenges: costs, security of supply and $CO_2$ reduction. With the help of local distributed energy solutions, it is possible to turn these challenges into long-term calculable variables across all businesses and industrial sectors. The solutions utilize an optimized mix of distributed energy resources (DER) such as renewable energy, combined heating and power stations, or storage systems, supported by sophisticated energy management (SIEMENS, 2021).

## 2.2 Decarbonization

The process by which countries individuals, or other entities aim to achieve a low-carbon economy, or by which individuals aim to reduce their carbon consumption or achieve zero fossil carbon existence. It typically refers to a reduction of the $CO_2$ emission associated with electricity, industry, and transport (Wimbardana Wimbadi & Djalante, 2020) .

In 2013, the Deep Decarbonization Pathways Project was launched which is a global collaboration of the 16 countries responsible for 75% of greenhouse gas emissions. The multidisciplinary team of energy researchers proposes three pillars of decarbonization: efficiency, decarbonization, electrification (Haley et al., 2015). According to a literature review of 40 scientific articles related to decarbonization processes in the electric power sector conducted by Jenkins (Jenkins et al., 2018), it can be established that the studies collectively model and evaluate two general paths to decarbonize electricity; the first path is based primarily (or even entirely) on the incorporation of renewable energy sources (with storage devices such as batteries, among others) and a second path is based on a wider range of low-carbon resources as biomass (Mora, 2019).

## 2.3 Resilience networks

Ability of a network to defend against risks and maintain an acceptable level of service in the presence of such challenge like man made attacks or unexpected weather conditions. Those issues are faced today more than ever before, as a major requirement for energy system designers. The procedure to satisfy the resilience need are explain in a resilience control loop, where firstly, a resilience target is defined. Secondly, challenges analysis and defensive measurements are considered like redundant and diverse infrastructure with self-protective services, detective systems, remediation, and recovery subsystems. Thirdly, resilience estimators are estimated to determine if targets are correctly met and finally, resilience management to control resilience mechanisms, are settled down with policy and protocols to provide an effective service (Smith et al., 2011). Nowadays this resilience project has been mainly installed in developed countries such as USA, China, and Germany to avoid black outs in different cities, districts, or critical loads. However, the negative side of this security measurement is that it increases dramatically CAPEX and OPEX of the projects.

## 2.4 ESD tools features

### 2.4.1 Software development

Despite the success of the web as an application platform, the vast majority of software is developed using a desktop based integrated development environments (Aho et al., 2011). They do provide many nice code intelligence features like auto-completion or quickly pulling up the documentation associated with functions and classes (Fallis, 2013). However, an IDE inside a browser offers several benefits. The developer does not need to worry about installing, configuring, or updating the environment as the latest version available on the cloud is automatically used. Along with an IDE, there can be additional developing tools such as a development server or a test harness. Since the developers are connected to the cloud, the created projects can easily be stored in the cloud (Aho et al., 2011).

After some changes, all the data or code is managed with a repository.  Which is a shared database of information about engineered artifacts produced or used by an enterprise. Examples of such artifacts include software, documents, maps, information systems, and discrete manufactured components and system. Over the lifecycle of engineered artifacts, many objects of many different types are defined, created, manipulated, and managed by a variety of tools that need to share data. For example, software engineers use design tools, language editors, compilers, builders, and debuggers to create and test programs (Bernstein & Dayal, 1994).

The most used repository used worldwide is GitHub which is basically a code hosting platform for collaboration and version control. GitHub lets developers to work together on projects where they can either store a development project or simply make commitments from different branches (Munaiah et al., 2017).

After all the development process some big enterprises store their own products on the web safely. Therefore, AWS offers a broad set of global cloud-based products including compute, storage, databases, analytics, networking, mobile, developer tools, management tools, IoT, security, and enterprise applications: on-demand, available in seconds, with pay-as-you-go pricing. Cloud computing provides a simple way to access servers, storage, databases, and a broad set of application services over the Internet (Varia & Mathew, 2014).

### 2.4.2 Optimization tools

An optimization software provides better design and development of optimization solutions for real-life problems. Although the tool generates different solutions under different constraints, only one optimization solver is unable to solve all types of real-life problems. The general framework of optimization solver consists of five main procedures. These are problem formulation, model creation, model configuration, optimization, solution generation. The objective functions and constraints are defined in problem formulation. In model generation, all the functions and constraints identified are modeled using modeling language. The decision variables are integrated in the defined model. The model is configured according to the constraints and objective functions. The objective functions are optimized using the designed model. Thereafter, the optimized solutions are produced (Anand et al., 2017).

The optimization problems are classified into eight categories such as Integer Programming (IP), Linear Programming (LP), Mixed Integer Programming (MIP), Mixed Integer Linear Programming (MILP), Mixed Integer Quadratic Programming (MIQP), Non-Linear Programming (NLP), Constraint Programming (CP), Mixed Integer Second order cone Programming (MISOCP) (Anand et al., 2017).

### 2.4.3 Tools

Conventional methodology of Energy Generation is manly centralized or produced in remoted places far away from consumers. This process is expensive because huge power stations must be used, transitions lines and environmental damage increase dramatically the price of a project. Nevertheless, in a transition epoch after the pandemic, the industry 4.0 called urgently the need of digitalization. In the last years some ESD tools were developed with the before mentioned features to meet targets set by different governments.

Nowadays decentralized energy generation or renewable energy hybrid system is one of the most promising, economical, and reliable options for electrification. Hybrid energy systems are being utilized for minimizing usage of fossil fuels to reduce environmental effects. But analysis of hybrid system is quite complex; therefore, it requires software tools for design, analyze, and optimization of software (Freitas et al., 2020).

Different type of tools available will be analyzed and explain based on their scope and limitations to finally classify them into the most flexible ones. Considerations like component such as RE technologies, thermal, storage components and electromobility will be some relevant facts to select the tools.

# 3. METHODOLOGY

The aim of this report and the internship was classifying and selecting the most versatile ESD tools available on the market. Under strict copyright regulations and results publications, SIEMENS AG allows to share the research carried out focused on energy system simulation tools currently available worldwide.

Firstly, necessary topics were defined not only for develop a ESD tool but also to deeply understand how it works. Besides as a difference from Latin America, the integration of thermal components is widely used in Germany, and they have a relevant impact in decarbonization process. Therefore, an analysis of these components was carried out.

After that, literature review and research were made to have an overview of the different tools available on the market. These were divided into three main groups. Academic tools, which belong to universities, and they are still in developing progress, or they are not user friendly. OpenSource tools commonly used in the web, and they have normally free access. At the end the commercial tools, which were developed or bought by companies or laboratories, and they use this tool as product for energy stakeholders.

Finally, a deep analysis was carried out to some relevant tools of each group, were the source, scope, components, and limitations were the key factors to determine the most flexible tools.

# 4. RESULTS AND DISCUSSION

Starting from the basic knowledge gained in different research and independent work, the initial functions of the internship encompassed the learning of the programming environment Visual Studio which is an IDE in which web applications or software are developed in programming languages such as Python, C++, and C#. In Germany the programming language C# has become very popular lately as it is easy and fast to use due to its efficient command prediction, which makes object-oriented programming much faster. Within this framework, the concepts of Object-Oriented Programming, Methods, classes, functions, touples and the integration of other programs or libraries such as. Json for the integration of graphics in the codes worked on in C#.

After having worked with basic programming tools, a research and interaction with some repositories was carried out. Concluding that developers or web designers code autonomously or work simultaneously adding their own updates with functions such as Pull, Push and Merge to the local Branch (local code) or to the Master Branch (mother code). This type of data is stored in local or cloud metadata programs such in GitHub or TortoiseGit and finally stored in the cloud with AWS.

After understanding how the development of these tools works, several energy analysis cases were discussed to be decarbonized and optimized in different energy system simulation tools. Noticed was the critical and fundamental usage of thermal components in domestic and industrial electrical installations in Europe and in several parts of the world due to their geographical position and climate conditions. Therefore, it was necessary to analyze the integration of HPs, compression and absorption chillers, gas engines, gas turbines, thermal storage, and heat losses in the energy systems in Germany. In addition to these components, it was extremely important to consider today's energy system simulations, integrating cooling towers for large-scale industrial designs, boilers, hydrogen sources, electrolyzes, electrical and thermal storage systems and of course charging stations that promote electromobility.

Continuously, the search for bibliographic material which analyze simulation tools that integrate electrical and thermal components described above as a basis was carried out. For that reason, tools were analyzed in detail to determine the software flexibility, the precision, the consideration of input data, output data, accessibility to the repository, integrated graphical or optimization tools, tool costs, GUI, and additional functions.

The findings were divided into three groups: Academic, OpenSource tools and Commercial. Some of the software were developed by different German universities which had worked hard to improve these products and they are sold to companies, which finally acquire and continue with the development of these tools. The universities that have developed the most tools are the RWTH in Achen, the TUM in München and the KTH in Stockholm. One of the first tools developed for the analysis of energy systems was DER CAM, acquired by Lawrence Berkeley National Laboratory in 2000 but it had been developed by different researchers, many of whom have taken parts of their code to develop the URBS tools in the TUM and EHDO at RWTH.

The following tools were suggested to analyze: urbs, SWITCH 2.0, EHDO, TEMOA, REopt lite, OSeMOSYS, Homer Pro, Homer Grid, EnergyPro, TopEnergy, PLEXOS, BoFiT and XENDEE.

All of them were classified into different groups and some of them will be briefly described afterwards.

## 4.1 Academic tools

Some factors that were found in common about academic tools is that they are more flexible with the acquisition of input data, however their problem is that they tend to be quite difficult to understand because they do not have a GUI, which it doesn't make it user friendly. Basically, to properly handle this type of tool, users must be part of the team of developers of it or have direct contact with them for a precise analysis and understanding of the product.

For example, the tool “urbs” is a linear programming optimization model for capacity expansion planning and unit commitment for distributed energy systems. It basically optimizes urban energy systems and since it has been adapted to multiple scales, it can simulate projects from neighborhoods to continents dimension. It was also full developed in Python, and it is not user friendly because just the repository and the code are available to work with it (Universität München, 2021).

## 4.2 OpenSource tools

Although academic tools were tedious to analyze, RWTH has developed EDHO, which is not only academic but also Open Source and easy to use for researchers or students who might to work with the tool. Many OpenSource tools are often easier to understand than academic ones. They have a better GUI but contain many other limitations than commercial ones. One of the reasons is that Open Source are limited to money issues and basically the companies that offer more comprehensive energy system analysis software are start-ups or well-established companies in the market. As a result, OpenSource software such SWITCH 2.0, EHDO, TEMOA, REopt lite and OSeMOSYS do not generate revenue, are free and limited.

For example, EHDO determines the optimal technology selection and sizing of all energy conversion units of a supply system while satisfying heat, cold, electricity, and hydrogen demands. Energy demands are provided by the user with an hourly resolution and all technical and economic model parameters can be tailored to specific use cases. The objective functions of the design optimization are total annualized costs, $CO_2$ emissions, or trade-offs between both objectives (multi-objective optimization). The calculation is based on mathematical optimization and uses MILP. The webtool is accessible online for free and the optimization model is open-source (Wirtz et al., 2021). This tool also works together with the optimization tool GUROBI and offers accurate results for an ESD. Figure 3 shows the wide variety of technologies that can be simulated and optimized in the software.

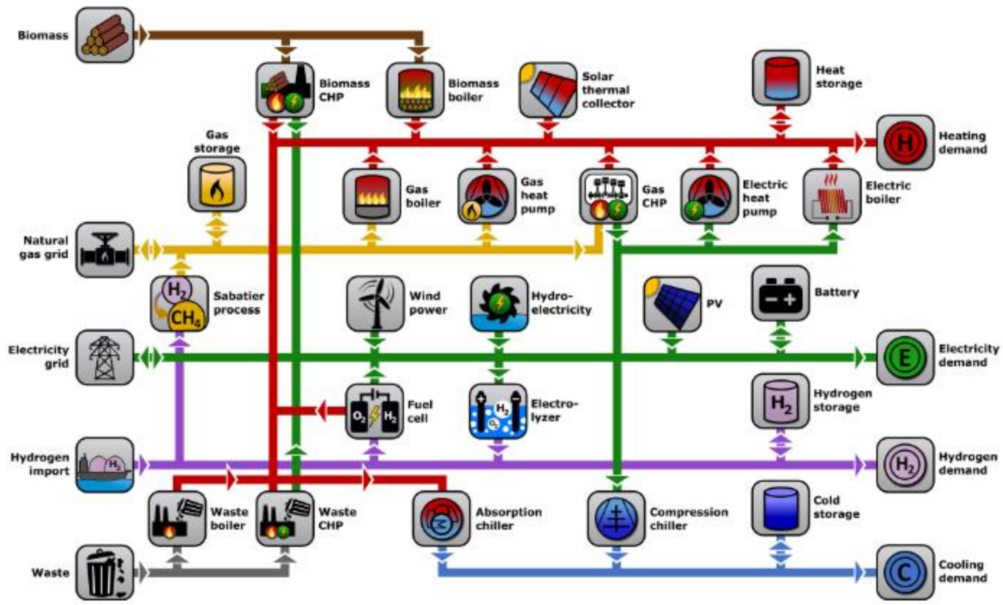


*Figure 3: EHDO facilities to ESD (Wirtz et al., 2021)*

Another example is the tool REopt Lite (Figure 4), which allows users to evaluate the economic viability of distributed PV, wind, battery storage, CHP, thermal energy storage, and geothermal heat pumps (GHP) at an existing site. It also Identify system sizes, dispatch strategies to minimize energy costs and estimate how long a system can sustain critical load during a grid outage (National Laboratory of Renewable Energy, 2021).

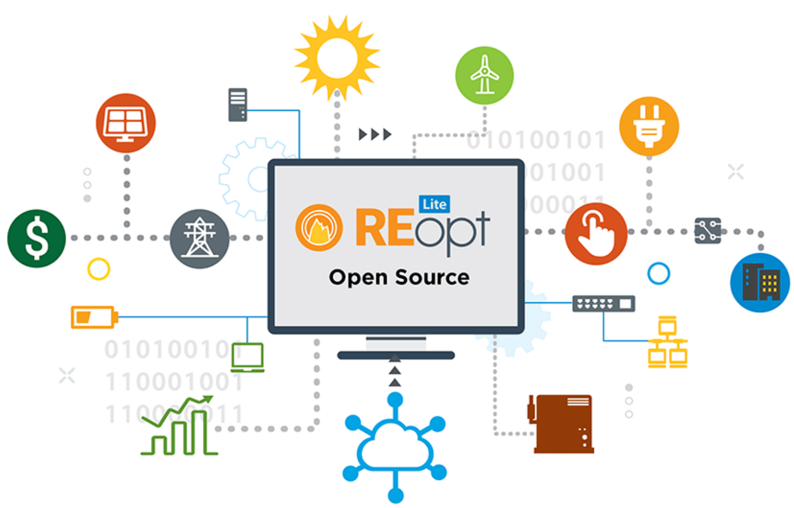


*Figure 4: REopt™ Lite web tool* (National Laboratory of Renewable Energy, 2021)

## 4.3 Commercial tools

Commercial tools are commercialized by different companies which offer free full versions of their tools, advice, and support in the interpretation of results. In the analysis of these tools, the GUI, simulation possibilities and alternatives, as well as the import and export of results were considered.

Despite the accuracy obtained in software such as Homer Pro, Homer Grid, EnergyPro, TopEnergy, BoFiT and PLEXOS, each tool has the limitation that not all of them integrate all the electrical and thermal components described above. While some of these tools have the flexibility to add new technologies, they fall short of accurately analyzing the full performance of the energy design compared to academic tools which are not strictly governed by following the tool's pre-determined parameters.

For example, HOMER Grid and HOMER pro (Figure 5) combine technical and economics ESD features to perform complex calculations, enabling users to compare design outcomes and consider options for minimizing project risk and reducing energy expenditures. With this optimization tool, stakeholders can maximize savings, minimize cost, increase resilience, optimize EV charging stations, reduce carbon emissions, stack values to increase return on investment and explore combined heat and power (Laboratories, 2021).

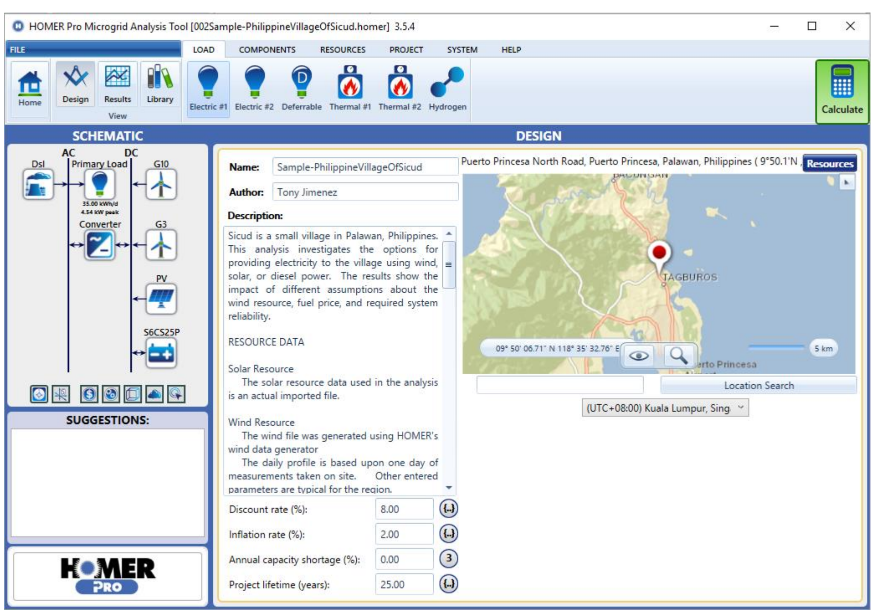


*Figure 5: HOMER pro GUI* (Laboratories, 2021)

Another example is TOP-Energy (Figure 6), which analyzes and evaluates complex energy systems. It simulates, optimizes, and compares different variants enabling the energy systems efficiency increases, revealing savings potential, and supporting investment decisions. The tool supports energy suppliers, engineering offices, power plant operators, and universities in mastering the major challenges of the future, which result from high ecological demands, complex legal requirements, and the premise of reducing ESD costs (TopEnergy, 2021).


*Figure 6: TopEnergy features* (TopEnergy, 2021)

Considering the dimensioning, number of input parameters and output data was found the XENDEE tool shown in Figure 7. It focuses on the development of world-class microgrid decision support that helps designers and investors optimize and certify the fight-through resilience and financial performance of projects with confidence. This software contains most of the electrical and thermal components above described, has an integrated full-scale topological view of the installation site of the energy projects, considers effects such as solar radiation overhangs and angles during the year and is the only tool that considers the size of the cables to be considered in the installation of the energy system. Like other commercial tools, it considers commercial components or technologies, with their reference, price, performance, and efficiency, which makes it much easier to understand the projects compared to academic and OpenSource software. It also has the great advantage that it is a software that does not need to be downloaded but works directly on the web with restricted access by its developers. In addition, it has the support of large entities such as the US Army, the Bavarian Army, and the Rocky Mountain Institute, among others. The disadvantage of this tool is that it is the most expensive on the market and has the shortest demo period.

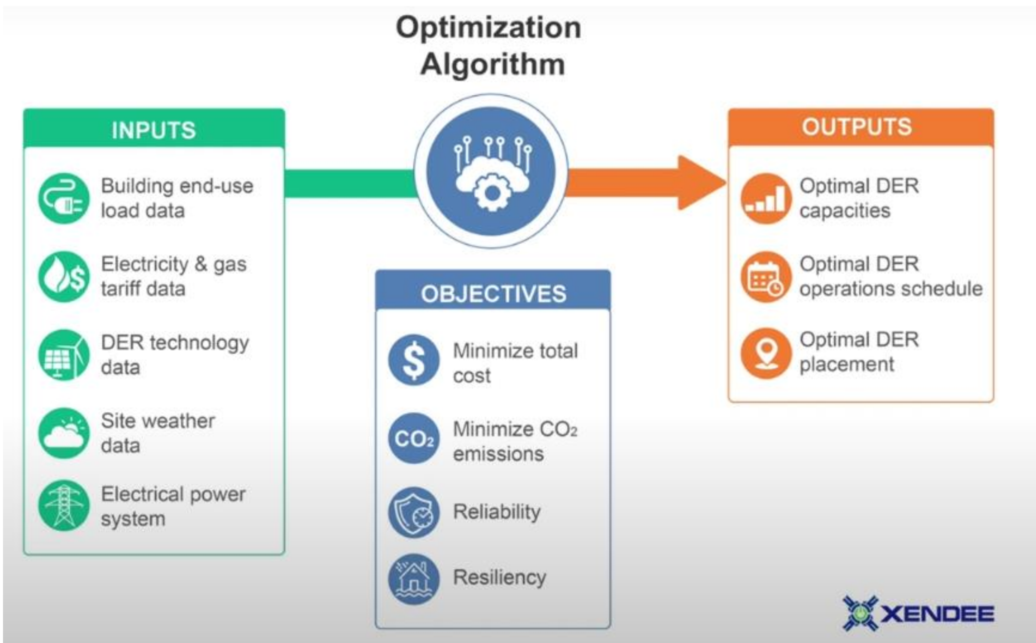


*Figure 7: XENDEE main functions* (XENDEE, 2021)

# 5. CONCLUSIONS, RECOMENDATIONS AND FUTURE WORK

- There are several tools available on the market which can be understood operated by anyone who possess a strong understanding in ESD, distributed energy and energy management.
- Not only Academic but also OpenSource tools are developed in Python. Basically, this programming language has become a must for all engineers and Energy System designers nowadays.
- Even though an IDE might be a great tool to develop or to code a project, currently web repositories and cloud codding take advantage and save time to storage faster and safer the data in the cloud.
- The simulations optimized in each tool had differences due to input and output parameters. Besides, OpenSource and Commercial tools were limited because of the established features developed by the host or company.
- Integrate the knowledge from engineering (mechanic, thermic, electric and among others) with software development is the best combination to full fit the challenges imposed by industry 4.0 and to improve the world sustainability.
- As in German universities, the development of an academic tool for ESD might be a great product for the ITM due to any software have not been yet developed in Latin America.

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FIRMA ESTUDIANTES ____[illegible]____

FIRMA ASESOR Donle J. Restrepo C.

Vo.Bo. versión final informe pasantía como TdG del estudiante: David Restrepo

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FECHA ENTREGA: 18/11/2021

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ACTA NO.______________

FECHA ENTREGA: ______________

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Facultad: ____Ingenierías__________

Programa: _____Electromecánica_______

Nivel: Pregrado __x__ Especialización ______ Maestría ________ Doctorado _________

Modalidad de trabajo de grado: ________Pasantía_______

Título del trabajo de grado: Praktikum im Dekarbonisierung von Stadtviertel und Industrieparks / Practicante en el proyecto de descarbonización de distritos urbanos y parques industriales________

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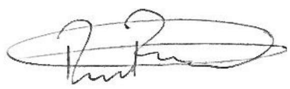

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| | | Fecha | 2015-02-16 |

## 1. INFORMACIÓN GENERAL

**Título**

Praktikum im Dekarbonisierung von Stadtviertel und Industrieparks / Practicante en el proyecto de descarbonización de distritos urbanos y parques industriales

**Objetivo**

Develop a complete analysis of the software tools used for the design and simulation of energy systems.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Plazo:** | **10 de Diciembre de 2021** | **Inicio** | 05 | 04 | 21 | **Fin** | 06 | 08 | 21 |

| | | | | |
|---|---|---|---|---|
| **Intensidad Horaria Semanal** | **8 horas** | | | |
| **Horas Práctica Social** | | | | |
| **En funcionamiento – Negocio Incubado** | SI | | NO | |

## 2. PERSONAL Y EMPRESA

| | |
|---|---|
| **Empresa** | **SIEMENS AG** |
| **Representante** | Sebastian Thiem – Lukas Höttecke |
| **Cargo** | Head of Research group – PhD Student and advisor |
| **Documento** | |
| **Dirección** | Günther-Scharowsky-Straße 1, 91058 Erlangen, Germany |
| **E-mail** | lukas.hoettecke@siemens.com |
| **Teléfono** | +49 173 4204380 |
| **Razón Social** | |
| **Asesor** | Bonie Johana Restrepo |
| **Jurado** | Elkin Edilberto Henao Bravo |

## 3. DESCRIPCIÓN Y ALCANCE

**Descripción**

La pasantía como practicante en SIEMENS AG consiste en participar en la investigación para la descarbonización de parques industriales y distritos urbanos. Buscando cumplir con la ambiciosa meta europea de que las ciudades no emitan carbono como plazo máximo en 2050. Partiendo como base de los conocimientos técnicos en el área mecánica, térmica y eléctrica adquiridos a lo largo de la formación académica como ingeniero electromecánico. Además, de los conocimientos de dimensionamiento y evaluación de sistemas energéticos, adquiridos en los distintos semilleros en los que participé en la institución (ITM). Mi trabajo consiste en la búsqueda de herramientas de software que puedan diseñar, evaluar y optimizar sistemas energéticos buscando siempre generar un impacto positivo principalmente al medio ambiente no solo a nivel doméstico sino también a nivel industrial.

**Alcance**

- Revisión de la literatura con respecto a herramientas de software que permitan el diseño y simulación de sistemas energéticos que evalúen modelos eléctricos y térmicos.

- Clasificación de las herramientas según sus características (académico, libre y comerciales), alcance y limitaciones.
- Partiendo de la información anterior se verificará la forma en que se integran los modelos térmicos y eléctricos en la simulación de sistemas energéticos para cada herramienta.
- Analizar la accesibilidad a los códigos y repositorios de las herramientas de software, herramientas de optimización y tipos de programación (Programación Lineal o Programación Lineal Entera Mixta).
- Selección de herramientas más versátiles según su funcionalidad, flexibilidad y datos de entrada y salida.

## 4. RECURSOS

**Recursos**

Diferentes softwares de desarrollo como Visual Studio, Visual Studio Code, Spyder, C# y Python
Acceso a repositorios y softwares de simulación de sistemas energéticos como GitHub, urbs, Homer Energy, TopEnergy etc.
Softwares de optimización como GAMS, GUROBI y GLPK

## 5. PARTICIPANTES

| **Nombre** | **Cedula** |
|---|---|
| David Restrepo Herrera | 1216726752 |
| **Observación** | |
| | |

## 6. SEGUIMIENTO

**Seguimiento**

- aprobación de la propuesta: 18 de noviembre de 2021
- aprobación del informe final – PASANTÍA: 6 de noviembre de 2021

| | | | | |
|---|---|---|---|---|
| **Deserción** | | | | |
| **Vinculación Laboral** | | | | |
| **Práctica Profesional** | | | | |
| **Trabajo de Grado Terminado** | SI | x | NO | |

| | | | | |
|---|---|---|---|---|
| **Visita Empresarial Realizada** | SI | | NO | |

ABSTRACT

From march to august 2021, my DAAD scholarship consisted of an internship in a German enterprise, where I had the fortune to take part in one of the largest companies not only in Germany but also worldwide. It was SIEMENS AG. From my expertise, working with Homer Energy Pro, the objective of the internship was to carry out a complete analysis of the software tools used for designing, simulating and optimizing energy systems.

The methodology was firstly based on a literature research of software tools that simulate and optimize distributed energy systems. The findings were classified in to three main groups and then they were deeply analyzed having interaction either with the tool or with their repositories. In the results section, the most versatile tools were expose and finally, in the section of conclusions, I summarize my work at SIEMENS. Furthermore, I suggest some future projects that might be interesting to develop at ITM.

*Key words*: Energy system design tools, Resilience networks, Optimization tools, IDE, Python.