

Introduction to Optimization and the XENDEE Platform



Dr. James Nelson

The Polytechnic School, Ira A. Fulton Schools of Engineering

Director of Technology and Innovation, Laboratory for Energy And Power Solutions (LEAPS)

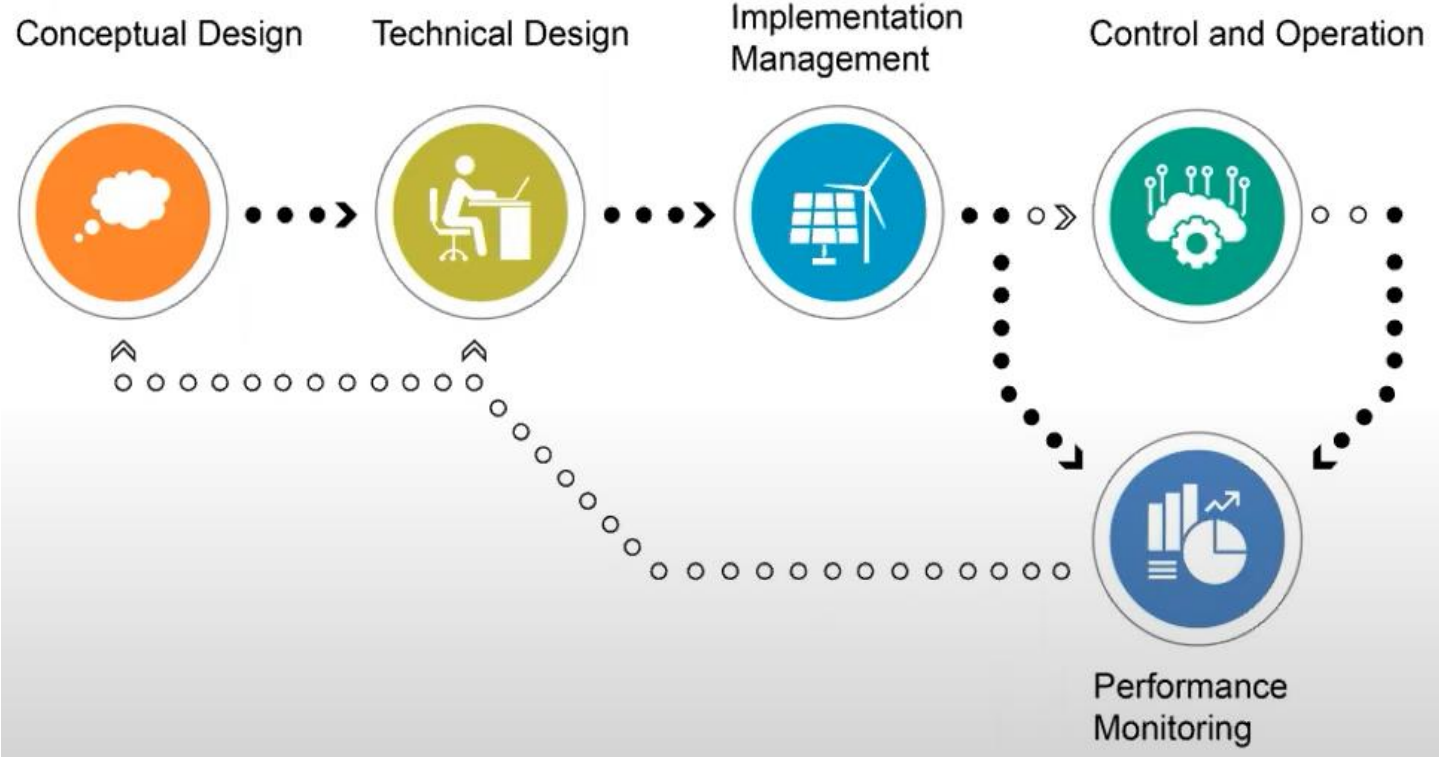
Marlon Acevedo

Workforce Development Lead, Laboratory for Energy And Power Solutions (LEAPS)

XENDEE Platform

XENDEE Platform

Holistic microgrid design platform primarily used for planning, operations, and financial analysis.

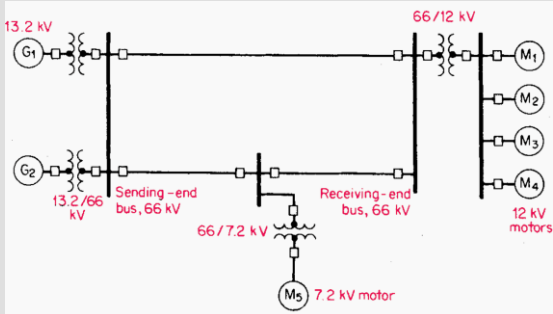
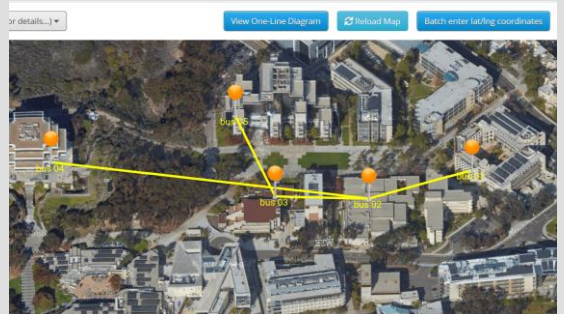
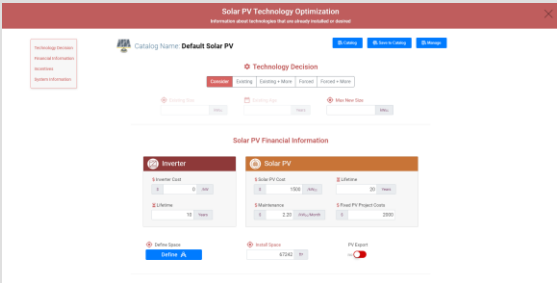
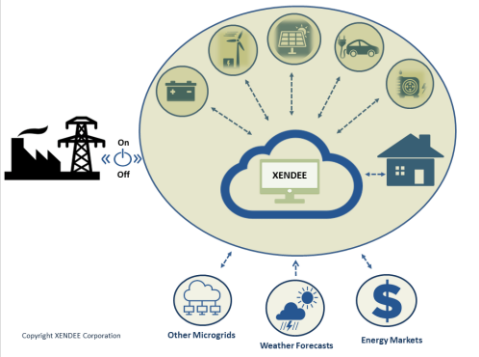


XENDEE Platform

Economic Optimization
(Preliminary Design)

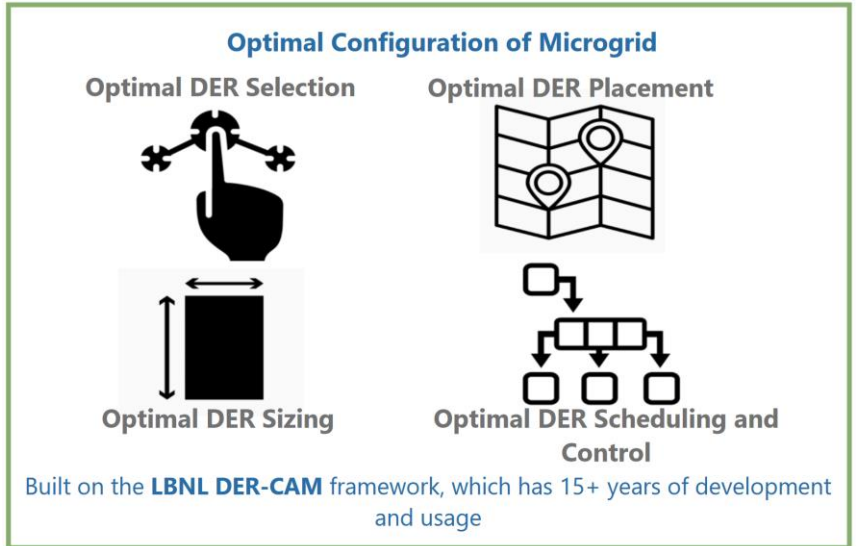
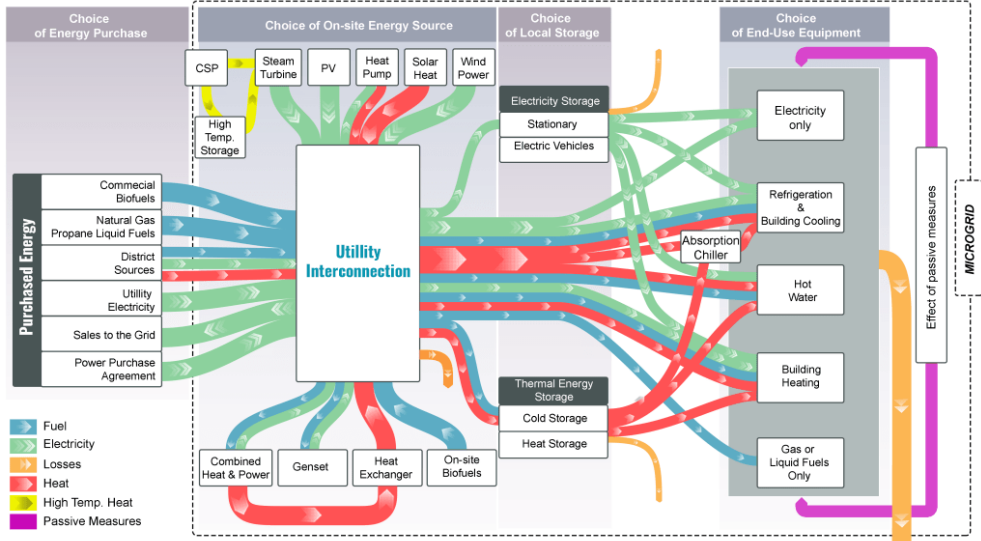
Graphical Information
System (GIS)

Power Engineering



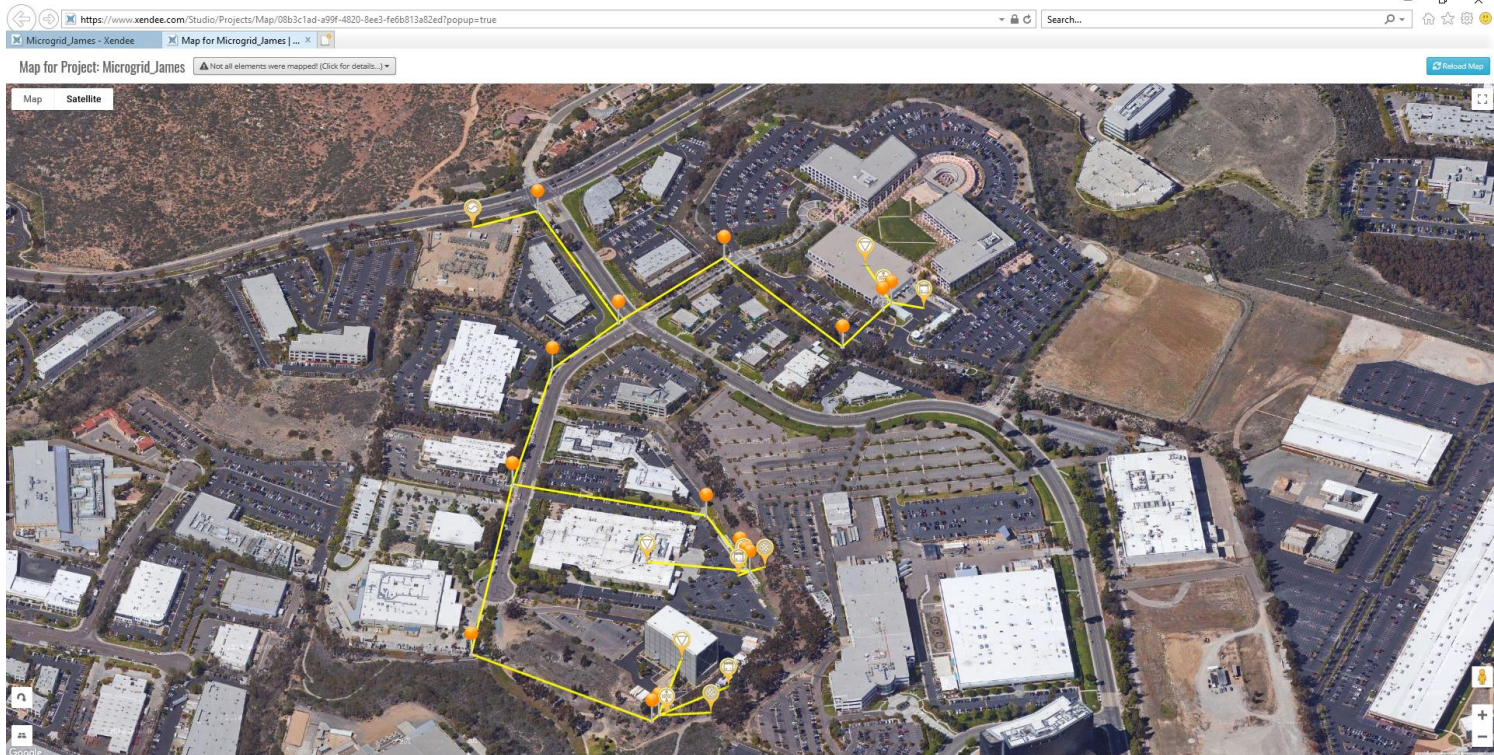
Economic Optimization

The XENDEE economic optimization suite provides users with a design and implementation tool that optimizes selection, sizing, dispatch, and placement of technologies for Microgrid, Mini-grid, and Distributed Energy Resources projects.



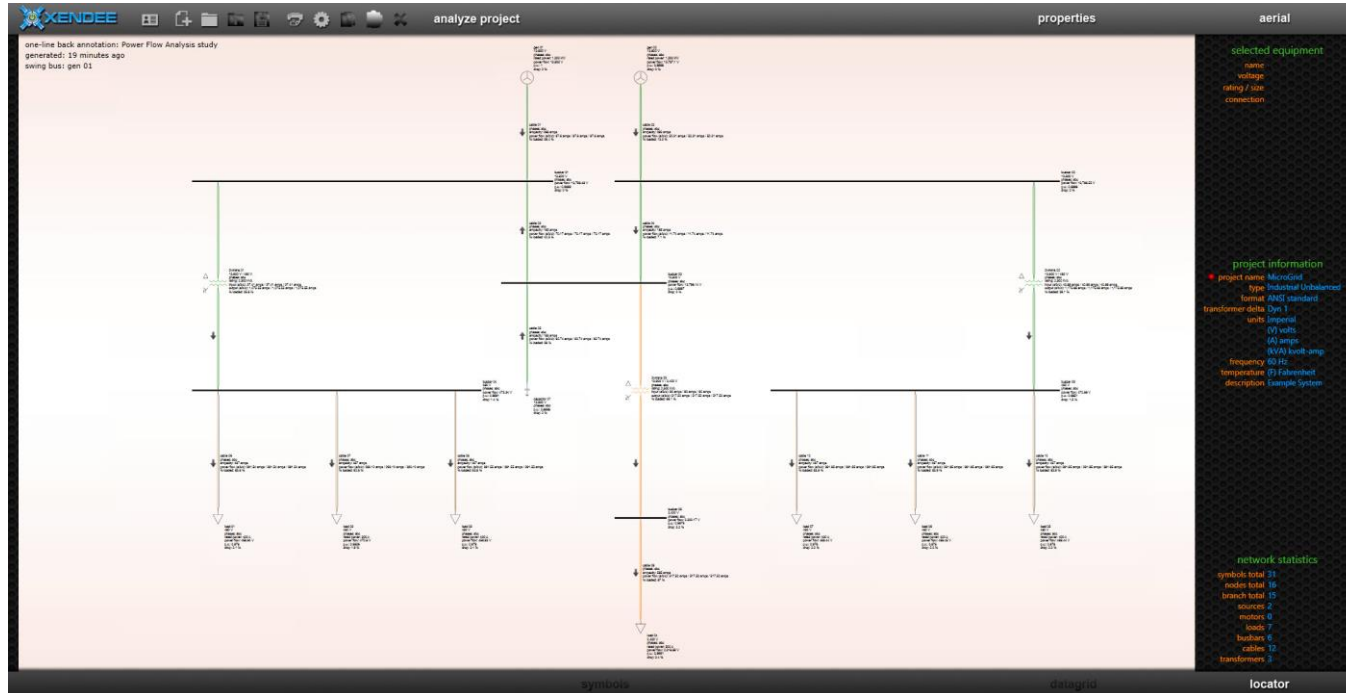
Graphical Information System

The XENDEE graphical information system (GIS) allows users to easily input geographical locations of system assets on a project site for accurate power flow studies and easy visualization.



Power Engineering

XENDEE provides an easy to use graphical user interface (GUI) to create, modify, and analyze power flow studies. The GUI connects to EPRI's OpenDSS tool as a physics engine. OpenDSS is a validated and industry accepted power flow algorithm environment.



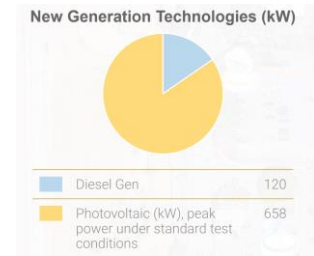
What is Optimization?

Optimization

Optimization: an act, process, or methodology of making something (such as a design, system, or decision) as fully perfect, functional, or effective as possible

Must serve an average 20
kW load

$$0 = P_{dg} + P_{sol} - P_{load}$$



Engineering
Requirements



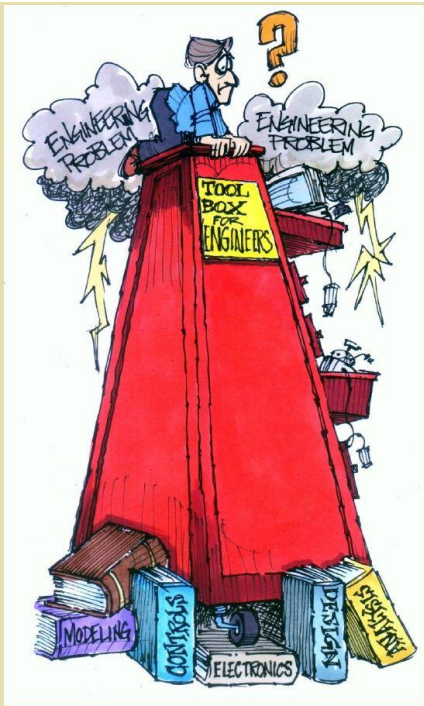
Mathematics



Optimized Solution

Why Optimization

Optimization is a tool in an engineers tool box used to solve problems that can be formulate to either minimize or maximize a function.

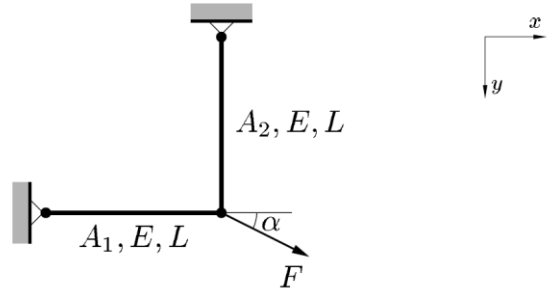


Minimize

Find the cross-sectional areas that minimize weight under stress constraints.

$$f(A_1, A_2) = (A_1 + A_2)\rho L$$

$$\begin{aligned} \min_{A_1, A_2} & A_1 + A_2 \\ \text{s.t.} & \begin{cases} A_1 \geq \frac{F \cos \alpha}{\sigma_0} \\ A_2 \geq \frac{F \sin \alpha}{\sigma_0} \end{cases} \end{aligned}$$



Maximize

Let x be the number of tables of type T1 and y the number of tables of type T2. Profit $P(x, y) = 90x + 110y$

$$\begin{cases} x \geq 0 \\ y \geq 0 \\ 2x + 4y \leq 7000 \\ x + 2.5y \leq 4000 \\ 2x + 1.5y \leq 5500 \end{cases}$$



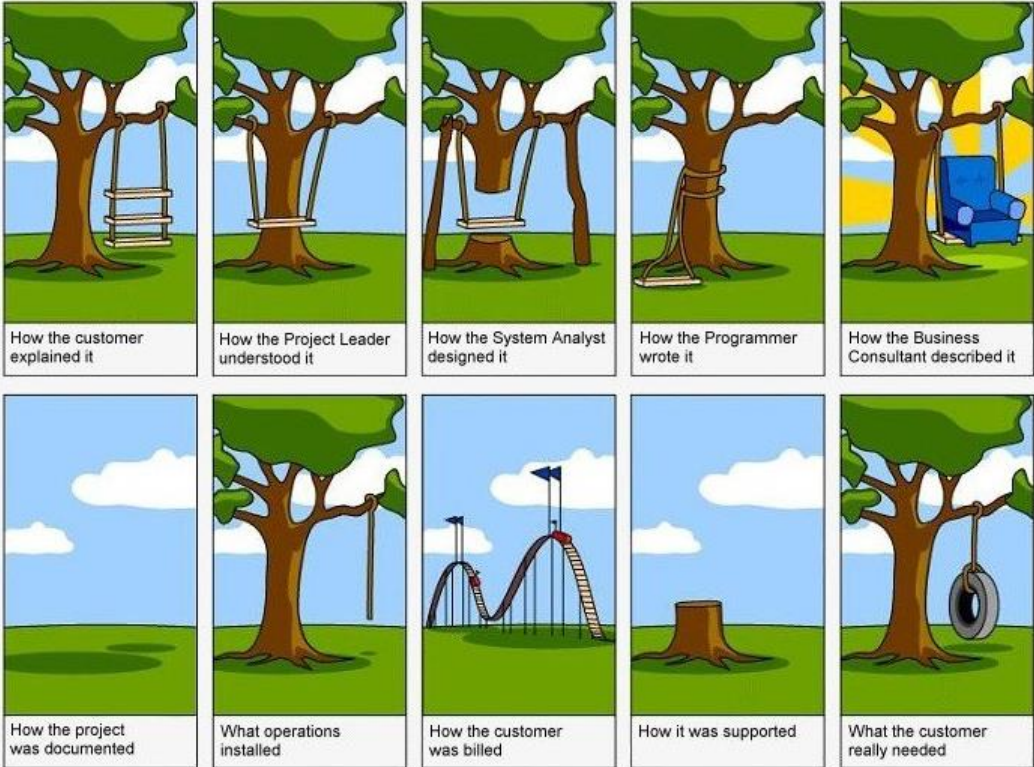
Engineering Requirements

The process of understanding qualitative requirements and creating quantifiable metrics for design and testing.

Light weight -> Weigh less than 50 kg

Inexpensive -> Manufacture cost less than \$100

Small -> Volume less than 2 m³

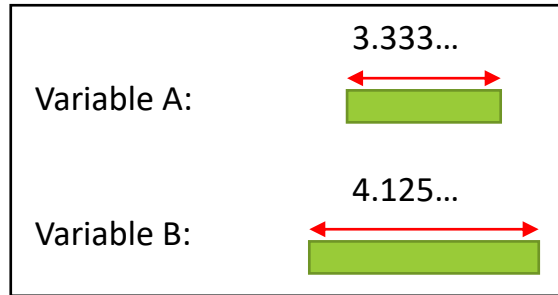


High Level Classifications

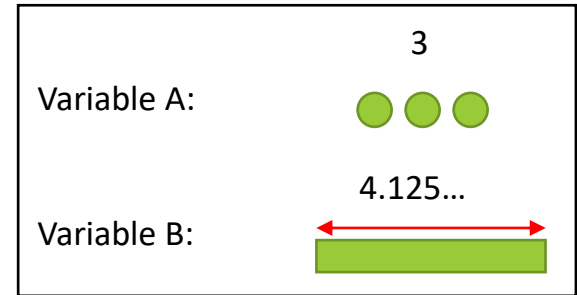
- **Discrete** – Model only contains variables that take on values from a discrete set (often integer or binary)
- **Continuous** – Model contains variables that can take on any real value
 - Tend to be easier to solve because of the smoothness of the functions
- **Mixed Integer** – Model contains both discrete and continuous variables



Discrete



Continuous



Mixed Integer

XENDEE Economic Optimization Assumptions

“All models are wrong, but some are useful.”

Single node – During preliminary design, the distribution network constraints are neglected. All technologies are assumed to be connected to a single infinite bus.

Representative design days – 24-hour profiles, three for each month, represent typical weekdays, typical weekends, and extreme days. Monthly and annual quantities are determined by scaling up the daily variables using the number of days each representative profile occurs within a month.

Linear technology operational characteristic – All operational characteristics of considered technologies must be of a linear form to accommodate the classification of the optimization solver.

“Garbage in, garbage out.”

Technology economic parameters – Best available data is used for estimating the capital and O&M costs of technologies. Once a project is financed capital costs can vary dramatically. O&M costs can vary depending on usage and climate conditions

Electricity providers contractual agreements – XENDEE allows for hourly time-of-use energy and demand charges to be modeled for two seasons of the year. Some complex rate structures may not be able to be directly modeled.

Your First Visit to XENDEE

Making a XENDEE Account

If you have not made a XENDEE account, please follow these steps:

1. Open a web browser and go to <https://asu.xendee.com/JoinNow>
2. Input the requested information
3. Use invite code **PACASU**

Sign Up for Free

Sign up and begin creating the future of electrical power distribution. Power system design and analysis just got a lot easier and accessible. Quickly model and analyze one-line diagrams, build and manage your professional profile, and start changing the future of power.

* First and Last Name

* Email

* Password

* Re-enter Password

* Invite Code

Join Xendee

Making a XENDEE Account

4. Log in with your new XENDEE account: <https://asu.xendee.com/Account/SignIn>

XENDEE ASU Sign In

You are here: Home > Sign In

Email and Password

* Email: sjanko@asu.edu

* Password:

Keep me signed in.

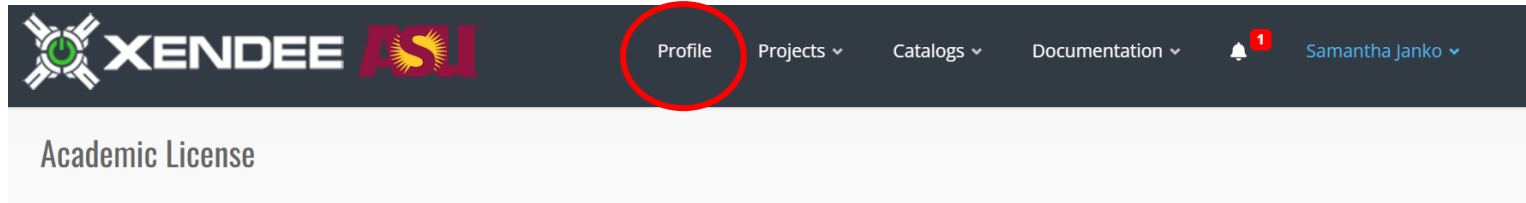
Assistance

[Forgot your password?](#)

[Secure Sign In](#)

Making a XENDEE Account

5. Click “Profile” at the top of the page



Academic License

Academic and Non-Commercial XENDEE SaaS Services Agreement

1. XENDEE SAAS SERVICES AND SUPPORT

1.1 Subject to the terms of this Agreement, XENDEE Inc. (Company) will use reasonable efforts to provide Customer with the Services in accordance with the Service Level Terms defined in Section 9 of this Agreement. As part of the registration process, Customer will identify a user name and password for Customer's account. Company reserves the right to refuse registration of or cancel usernames it deems inappropriate.

1.2 Subject to the terms hereof, Company will provide Customer with reasonable technical support in accordance with Company's standard practice.

2. RESTRICTIONS AND RESPONSIBILITIES

Explore XENDEE

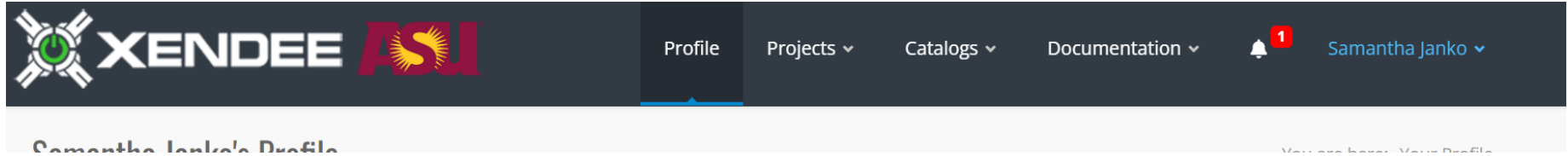
6. Find and identify the following key items on your profile:

- 1 Menu
- 2 Overview
- 3 Recent Projects
- 4 Recent Project Dashboards
- 5 Start a New Microgrid Project
- 6 Economic Optimization
- 7 Deep Circuit Analysis
- 8 Extended Analysis

The screenshot shows the XENDEE user profile page for Samantha Janko. The page is divided into several sections, each highlighted with a red border and a yellow callout box containing a number from 1 to 8. The top navigation bar (1) includes links for Profile, Projects, Catalogs, Documentation, and the user's name. The profile overview (2) shows the user's name, email, and an edit button. The recent project dashboards (4) section indicates that the user has no project dashboards and provides buttons for 'View All' and 'New Dashboard'. The recent projects (3) section displays a table of projects with columns for Name, Type, and Modified. The 'Start a New Microgrid Project' (5) section is divided into three columns: Economic Optimization (6), Deep Circuit Analysis (7), and Extended Analysis (8). Each column contains buttons for various analysis tools.

| Name | Type | Modified |
|--|-------------------------------|----------|
| NAS Pax River (from Mackenzie Wodicker) | Economic Optimization: GIS | April 25 |
| sdf | Economic Optimization: GIS | April 22 |
| project1 | Economic Optimization: GIS | April 22 |
| New Stuyahok Islanded (from Michael Johnson) | Economic Optimization: GIS | March 11 |
| Five_Bus_Microgrid_Task3 | One-Line: Advanced (Explorer) | June 21 |

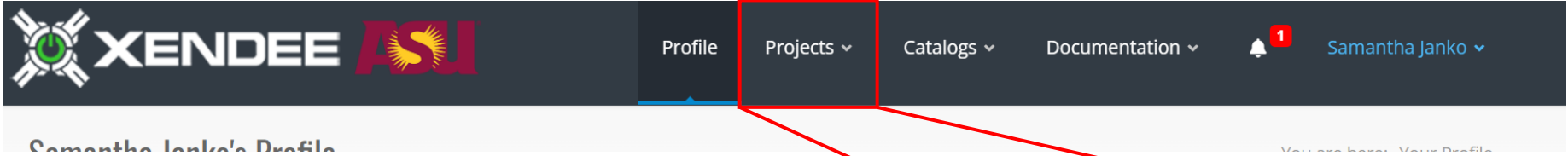
Explore XENDEE



6. Find and identify the following sections of the Menu:

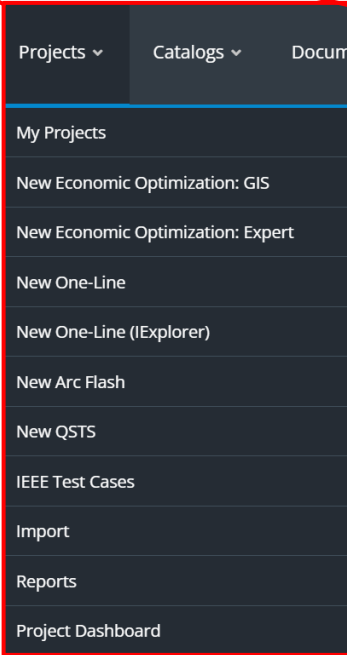
- 1 Projects
- 2 Catalogs
- 3 Documentation
- 4 Notifications

Explore XENDEE

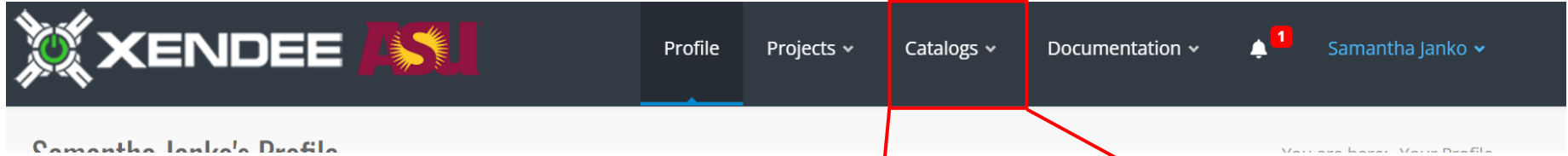


6. Find and identify the following sections of the Menu:

- 1** Projects
- 2** Catalogs
- 3** Documentation
- 4** Notifications

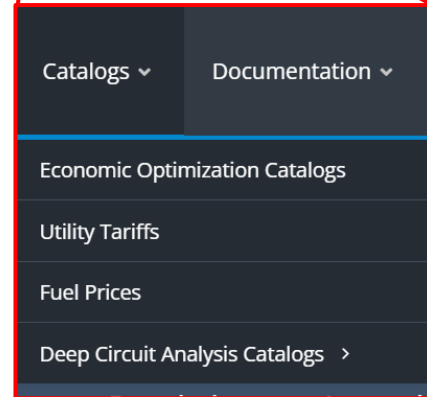


Explore XENDEE

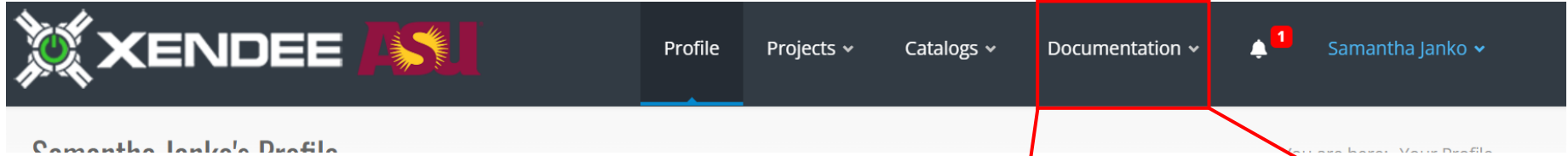


6. Find and identify the following sections of the Menu:

- 1 Projects
- 2 Catalogs
- 3 Documentation
- 4 Notifications

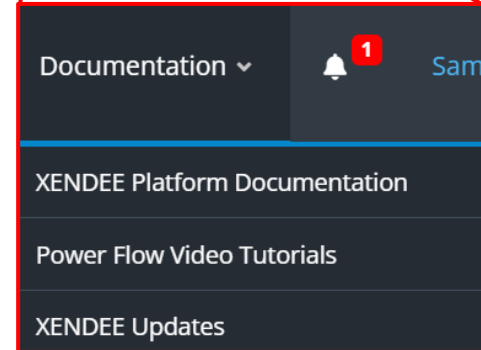


Explore XENDEE

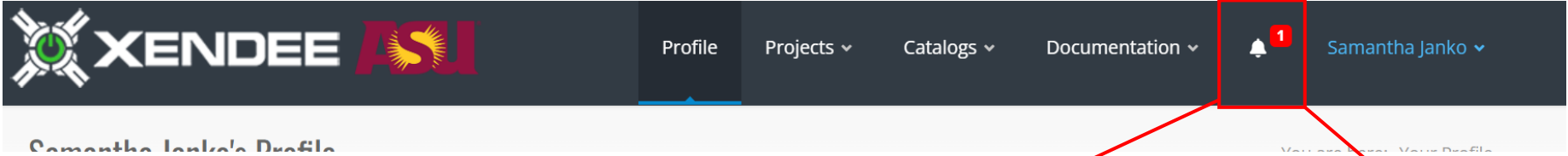


6. Find and identify the following sections of the Menu:

- 1** Projects
- 2** Catalogs
- 3** Documentation
- 4** Notifications

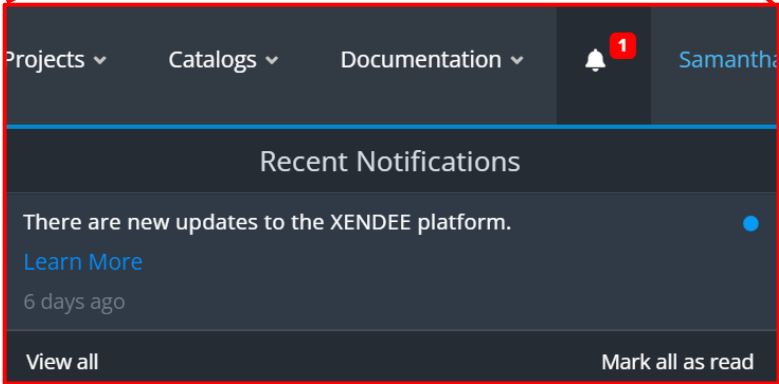


Explore XENDEE



6. Find and identify the following sections of the Menu:

- 1** Projects
- 2** Catalogs
- 3** Documentation
- 4** Notifications



Creating a XENDEE GIS Economic Optimization Project

Starting a Project

Sign in and click on “GIS Configurator” to start a new Economic Optimization Project.

The screenshot shows the XENDEE user interface for James Nelson's profile. The browser address bar shows the URL <https://www.xendee.com/Users/336/James-Nelson>. The page title is "James Nelson's Profile".

Overview

James Nelson's profile card includes an "edit" button and the email address jn1st12@suu.edu.

Statistics

- Membership Plan: [beta user](#)
- Account Details: [Manage my account](#)
- Member Since: [August 11, 2016](#)
- Last Seen: [less than a minute ago](#)
- Profile Views: [2](#)
- [We want to hear from you!](#)
- [Terms Of Use Agreement](#)

Recent Projects

| Name | Type | Format | Modified |
|---------------------------------------|-------------------------------|--------|----------------|
| NIWC Introduction | Microgrid: Optimization | | 10 minutes ago |
| NIWC Pacific Training | Microgrid: Optimization | | 15 minutes ago |
| Microgrid_James | Microgrid: Advanced | ANSI | June 24 |
| PPA | Microgrid: Single Node Expert | ANSI | June 16 |
| Sam | Microgrid: Optimization | | June 14 |

[View All](#) [Import](#)

Start a New Microgrid Project

- Economic Optimization**
 - [GIS Configurator](#) (highlighted with a red box)
 - [Expert Configurator](#)
- Deep Circuit Analysis**
 - [One-Line](#)
 - [IEEE Test Cases](#)
- Extended Analysis**
 - [QSTS](#)
 - [Arc Flash](#)

Smart Energy Project Wizard – Global Settings

- **Project Name** – A name that you can recognize and is relevant to your preliminary design.
- **Project Team** – Allows you to share the project with members of unique teams. *If your account is not associated with multiple teams, you will not see this option.*
- **Project Location** – The address closest to your project location. A map will appear once an address is defined.

The screenshot shows the 'Global Settings' step of a four-step wizard. The steps are: 1. Global Settings (current), 2. Project Options, 3. Technology Options, and 4. Confirm Settings. The 'Global Settings' section contains three main input fields: 'Project Name' (with a red asterisk), 'Project Team' (a dropdown menu), and 'Project Location' (with a red asterisk). Below the 'Project Location' field is a 'Use My Current Location' button. At the bottom right, there are 'Cancel' and 'Project Options >' buttons.

Economic Optimization: GIS – Project Wizard

1 Global Settings
Enter a name and location address for your project

2 Project Options
Choose settings and data options for your project

3 Technology Options
Select distributed energy technologies to include

4 Confirm Settings
Review settings and create the project

Global Settings

Project Name *
Project Name
Enter a unique name for this project.

Project Team
-- Select One --

Project Location *
Project Address
This address is used solely for display purposes in the report. Geospatial data like solar irradiance and wind power performance are determined by the position of the elements on the map.

Use My Current Location

Cancel Project Options >

Smart Energy Project Wizard – Project Options

- **Units** – Define if metric or imperial units will be used in input fields.
- **Currency** – Define the currency for all costs, pricing, and reporting.
- **Project Year** – The year being considered for optimization.
- **Project Type** – Define project type such as grid connected and multi-node.

The screenshot displays the 'Economic Optimization: GIS – Project Wizard' interface. At the top, a progress bar shows four steps: 1. Global Settings (checked), 2. Project Options (current step), 3. Technology Options, and 4. Confirm Settings. Below the progress bar, the 'Project Options' section is highlighted with a green border. It contains three dropdown menus: 'Units' (set to 'Metric'), 'Currency' (set to 'USD (\$)'), and 'Project Year' (set to '2024'). Below these are two toggle switches: 'Multi-Node' (set to 'no') and 'Grid Connected' (set to 'yes'). At the bottom, there are three buttons: 'Cancel', '< Global Settings', and 'Technology Options >'.

Smart Energy Project Wizard – Technology Options

- **Technologies** – Select the technologies to be selected and sized for the optimized microgrid portfolio.

1 ✓ Global Settings
Enter a name and location address for your project

2 ✓ Project Options
Choose settings and data options for your project

3 Technology Options
Select distributed energy technologies to include

4 Confirm Settings
Review settings and create the project

Technology Options

| ELECTRIC TECHNOLOGIES | | HEAT TECHNOLOGIES | |
|--------------------------------|---|----------------------------|---|
| Solar PV | <input checked="" type="checkbox"/> yes | Boiler | <input checked="" type="checkbox"/> yes |
| Battery Energy Storage | <input checked="" type="checkbox"/> yes | Electric Heater | <input type="checkbox"/> no |
| EV Charging | <input checked="" type="checkbox"/> yes | Heat Storage | <input type="checkbox"/> no |
| Wind Turbine | <input type="checkbox"/> no | Solar Thermal | <input type="checkbox"/> no |
| Run-of-the-River Hydro | <input type="checkbox"/> no | | |
| Power Purchase Agreement (PPA) | <input type="checkbox"/> no | | |
| MULTI-ENERGY TECHNOLOGIES | | COOLING TECHNOLOGIES | |
| Generator | <input checked="" type="checkbox"/> yes | Electric Chiller | <input checked="" type="checkbox"/> yes |
| Heat Pump | <input type="checkbox"/> no | Absorption Chiller | <input type="checkbox"/> no |
| Fuel Cell Generator | <input type="checkbox"/> no | Cold Storage | <input type="checkbox"/> no |
| Gas Turbine | <input type="checkbox"/> no | | |
| Small Modular Reactor | <input type="checkbox"/> no | | |
| | | REFRIGERATION TECHNOLOGIES | |
| | | Electric Refrigerator | <input type="checkbox"/> no |
| | | Absorption Refrigerator | <input type="checkbox"/> no |
| | | FUEL TECHNOLOGIES | |
| | | Electrolyzer | <input type="checkbox"/> no |
| | | Hydrogen Storage | <input type="checkbox"/> no |
| | | Methanizer | <input type="checkbox"/> no |

Smart Energy Project Wizard – Confirm Settings

- **Project Information** – Ensure that the correct information and options were inputted. (These can be changed later if necessary)

Confirm Settings

Global Settings

Project Name: Fiji Activities
Project Team: ASU
Project Location: USP ICT Center Building, Suva, Fiji (-18.14838, 178.44364)

Project Options

Currency: USD
Units: Metric
Project Year: 2024

Disclaimer
Xendee assigns default values to cost and performance inputs, and to values in the Xendee catalog entries, which are marked by the Xendee logo. These default values are provided for your convenience and should be reviewed and updated as needed by modelers.

Technology Options

ELECTRIC TECHNOLOGIES

Solar PV yes
Battery Energy Storage yes
EV Charging yes
Wind Turbines no
Run-of-the-River Hydro no
Power Purchase Agreement (PPA) no

HEAT TECHNOLOGIES

Boiler yes
Electric Heater no
Heat Storage no
Solar Thermal no

COOLING TECHNOLOGIES

Electric Chiller yes
Absorption Chiller no
Cold Storage no

REFRIGERATION TECHNOLOGIES

Electric Refrigerator no
Absorption Refrigerator no

FUEL TECHNOLOGIES

Electrolyzer no
Hydrogen Storage no
Methanizer no

MULTI-ENERGY TECHNOLOGIES

Generators yes
Heat Pumps no
Fuel Cell Generator no
Gas Turbine no
Small Modular Reactor no

Cancel < Technology Options Accept & Create New Project >

Create Your First XENDEE GIS Project

Follow the previous process to create a project with the following specifications.

- Project Name – Fiji Activities
- Project Team – Pacific Islands Workshop 2023 (if prompted)
- Project Location – Japan-Pacific ICT Centre, Fiji
- Units – Metric
- Currency – USD (\$)
- Project Year – 2023
- Multi-Node – No
- Grid Connected – Yes
- Technologies Enabled – Solar PV, Battery Energy Storage, and Generator. Ensure all other options are “no”.
- Confirm settings and click “Accept & Create New Project”

