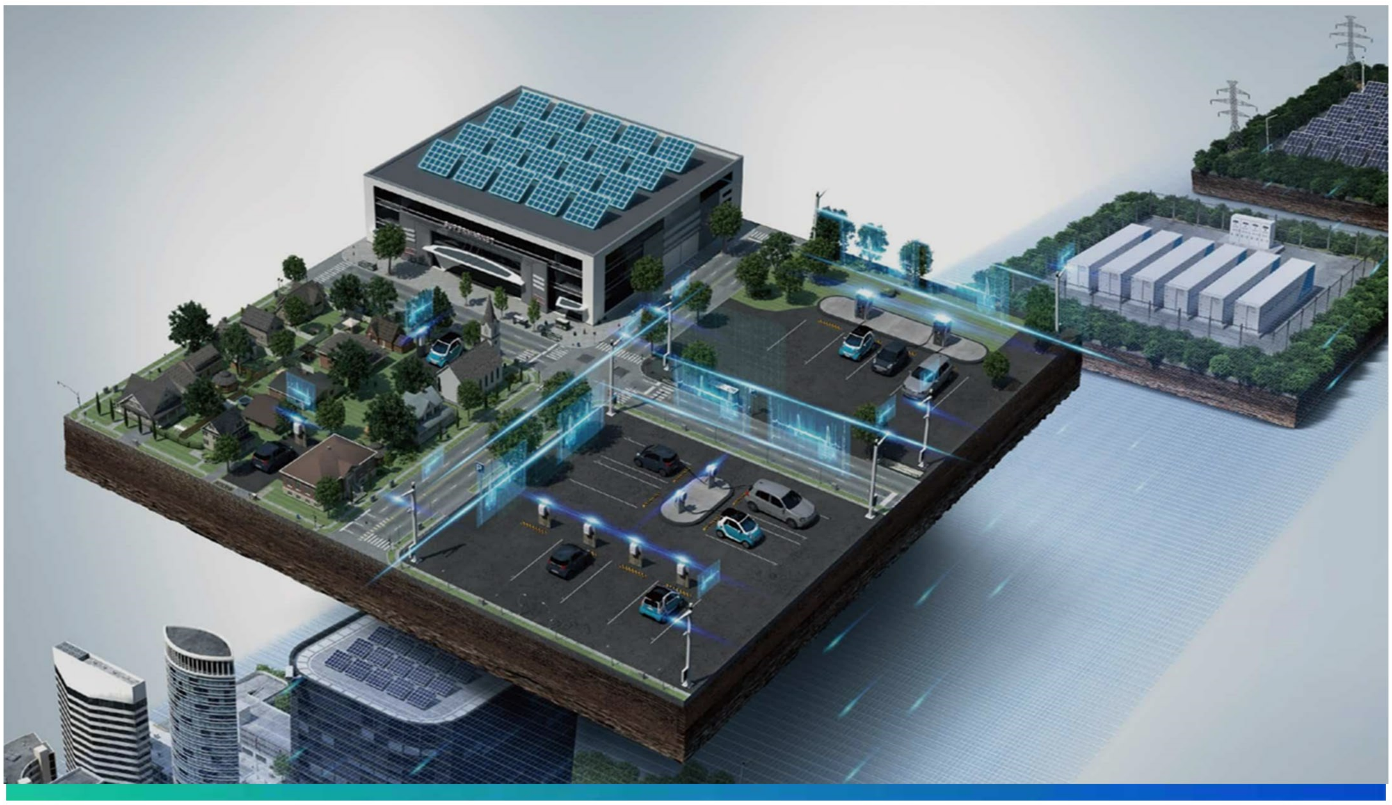
Reducing Costs and Uncertainty in Microgrid Deployment By Employing An Integrated Solution

Part 1 - Sophistication At the Feasibility and Design Analysis Stage is Key



Dr. Michael Stadler
XENDEE | Chief Technology Officer
mstadler@xendee.com

Adib Naslé
XENDEE | Chief Executive Officer
anasle@xendee.com

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MICROGRID KNOWLEDGE

Overview

Microgrids, or Distributed Energy Resources (DER), beyond passive solar energy, are complex systems which must consider a myriad of exogenous factors such as regulation, weather patterns, supply chain driven technology costs, changing technical innovation, and much more to achieve maximum benefits. The detailed technical design and financial decision process to conceptualize these systems requires the consideration of several competing factors (loads, tariffs, expansion plans, etc.) to achieve a predictable outcome (ROI, cost savings, resiliency, carbon reduction, etc.) that makes them an investible asset. This is traditionally a time-consuming process, which requires several steps to carry out. From a project developers' perspective, the first step is to determine high level economic feasibility with sufficient confidence to gain the interest of stakeholders such as the site owner and investment partners. It is essential that this preliminary feasibility phase is quick, accurate, and detailed enough to permit a decision to commit additional development time on this site, amongst a portfolio of many.

Further, the same variables that drive the feasibility decision also drive the following steps of the implementation process including detailed design and build out, ultimately culminating in continuous operation according to the design thesis. Thus, making a financial decision at project initiation using a process that is decoupled from the detailed techno-economic design and eventual control scheme can introduce inaccuracy, uncertainty, and unplanned costs. Therefore, a single platform, which integrates the entire process, is the most reliable approach toward delivering the sophistication, accuracy, and speed needed for financial decision makers to provide project funding and ultimately meet their Internal Rate of Return (IRR) requirements.

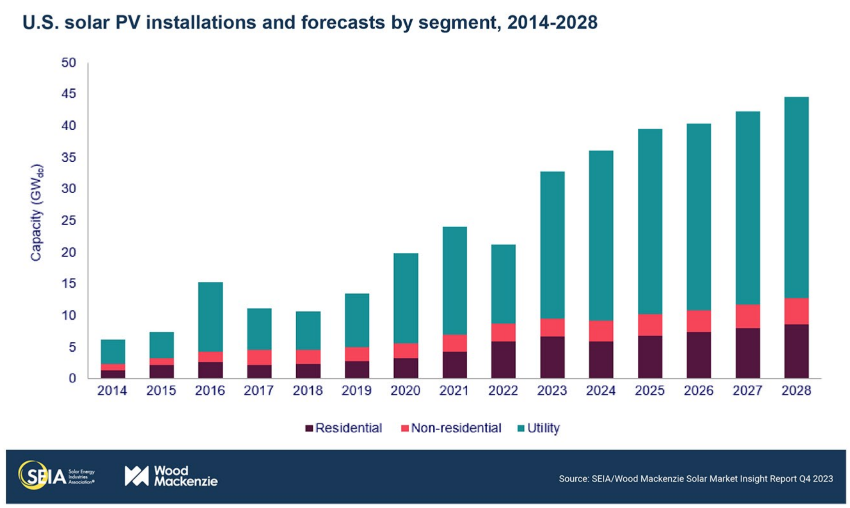

Figure 1: *By 2023, the U.S. solar industry expects to add a record 32 gigawatts (GW) of new capacity, a 52% increase from 2022.*

This paper is the first in a series that discusses the background and lessons learned in designing Microgrids for the private and public sectors, that confirm the value of the integrated design and control process. This whitepaper focuses on the importance of the project proposal phase and shows how an efficient process is carried out leveraging Xendee's new PROPOSE tool.

The Microgrid and DER Market is Large and Growing

The global Microgrid market size was valued at US$ 53.9 billion in 2022 and is expected to reach US$ 245.5 billion by 2032[1], a 70% increase over the next 10 years. This has also been accompanied by a significant increase in Microgrid projects using sustainable technologies with a 47% increase in the market for solar PV and battery storage. By 2023[2], the U.S. solar industry expects to add a record 32 gigawatts (GW) of new capacity, a 52% increase from 2022. The proliferation of Electric Vehicles (EV) due to new support via the Inflation Reduction Act or the National Electric Vehicle Infrastructure (NEVI) requires proper charging infrastructure built quickly. Many of the projects will increasingly include Microgrids in the future to optimize the use and delivery of power and more importantly to avoid delays in utility interconnections that can slow down the EV deployment.

Microgrid Implementation Can Be Long, Complex, and Costly

However, Microgrid and DER projects can be complex, time-consuming, and involve many steps requiring collaboration between many stakeholders and experts (e.g., departments, financiers, utilities, and local regulators). Research performed by Xendee for the US Department of Defense (DoD)[3] analyzed the nine different interlinked steps involved in Microgrid design and implementation. It was found that the time and cost required to perform each additional step of the process increases, driving the need for milestones and stage gates indicating whether the project should continue moving forward.

The blue arrows in Figure 2 show the main work and information flow through the Microgrid design process. At the end of task 3 (Techno-economic assessment), an economic feasibility and rough construction cost estimate has been created and informs the decision to proceed with detailed engineering design in Phase 2. The design process is iterative and involves feedback on the tasks. This is especially true of tasks 5 (System architecture and power subsystem design) and 6 (SCADA subsystem design and system integration), indicated by the double-headed arrow connecting them. At the end of task 6, a detailed design and accurate construction cost estimate enable the decision to proceed to Phase 3 -Construction. The gray horizontal arrows represent additional salient information flows. The data compiled in Task 2 is utilized and supplemented in Task 4 (Data collection for engineering design). Likewise, the designs developed in task 3 are utilized and developed in further detail in tasks 5 and 6. The detailed design that is produced in tasks 5 and 6 includes a complete bill of materials and a list of labor units that enable procurement in task 7.

Sources:

[1] Spherical Insights LLP, https://www.globenewswire.com/en/news-release/2023/05/25/2676117/0/en/Global-Microgrid-Market-Size-To-Grow-USD-245-5-Billion-By-2032-CAGR-of-16-3.html

[2] SEIA & Wood Mackenzie, https://www.seia.org/us-solar-market-insight

[3] US DoD ESTCP EW20-5271, https://serdp-estcp.org/projects/details/32fcde60-980f-4ecd-9978-c0cc97c67ead

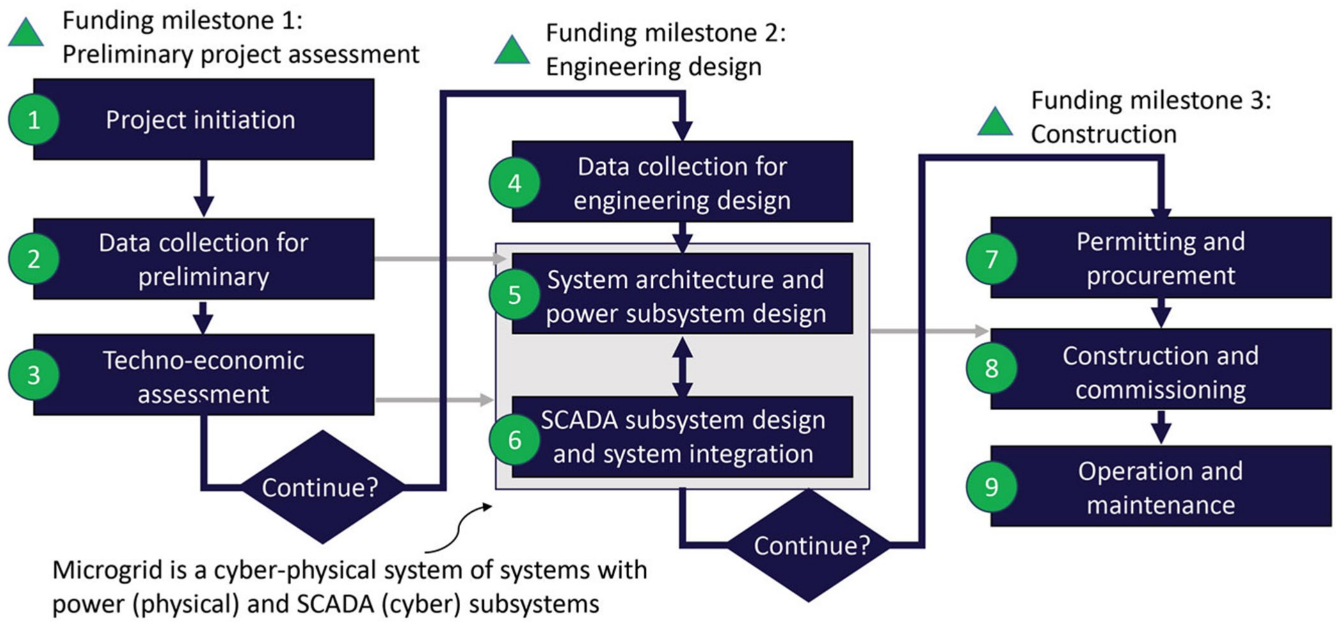

Figure 2: *Nine major steps that are most common to the Microgrid implementation process as found by a DoD ESTCP project[4].*

To understand the magnitude of the costs, Xendee performed research on Microgrid projects. We found that most Microgrids assessments are private contracts between the end user and a development firm. In the DoD space this mostly takes the form of an approved Energy Performance Contractors (EPC) firm or a national laboratory team. We extended the scope to all Microgrid projects nationally, and available reports outside the umbrella of the DoD.

In general, we found a wide range of costs for such projects, all of which were greater than $75k for basic feasibility studies (Task 1 to 3) and as high as $750k for a full design (including engineering design from Figure 2). This is described in Table 1 The wide range of feasibility study costs is consistent with findings from an NREL study, which reports that soft costs[5] exhibit "a high degree of variability, ranging from 1%-75%" of total Microgrid costs[6].

Sources:

[4] DoD Standardized Platform to Guide Rapid and Repeatable Modeling and Design of Secure and Resilient Microgrids (RAPID-Resilient-Microgrid), Michael Stadler, Zack Pecenak, US DoD ESTCP project EW20-B8-5271final report, February 2022.

[5] Soft costs include engineering, construction, commissioning, and regulatory costs, and the cost of a feasibility study would presumably fall under the category of engineering.

[6] Giraldez Miner, J. I., Flores-Espino, F., MacAlpine, S., & Asmus, P. (2018). Phase I microgrid cost study: Data collection and analysis of microgrid costs in the United States (No. NREL/TP-5D00-67821). National Renewable Energy Lab.(NREL), Golden, CO (United States).

Project	Cost [$ USD]	Location/Site Type/ Techs of Interest	Study Type
Massachusetts Clean Energy Center (MassCEC) Community Microgrids Program	Up to $75,000 per project (14 total)	City of Pittsfield / hospital, emergency operations, emergency shelters / gas-fired standby generators, PV, battery	Feasibility Studies funded by MassCEC
NY Prize Community Grid Competition	$100,000 per project (83 total)	Village of Croghan / Rural community facilities / Hydro plant, PV, battery	Feasibility Study
Township of Montclair Microgrid Pilot Study Report	$142,000	Montclair, NJ / City and school buildings, hospital / CHP, PV, battery, EV charging stations	Feasibility Study
Town Center DER Microgrid Feasibility Study	$150,000	Middletown, NJ / US Navy facilities, municipal and city facilities, school / PV, natural gas generators, battery	Feasibility Study
Great Falls Eco-Energy Resiliency Project	$173,000	Paterson, NJ / Municipal, county, & school district buildings / hydroelectric plant, natural gas generators, battery, EV charging stations	Feasibility Study
Aspen Airport-Area Microgrid	$200,000	Aspen, CO / Public facilities near airport / PV, battery, thermal heat transfer	Feasibility Study
Regional and Remote Communities Reliability Fund	$224,000 - $2,359,000 per project (Total funding of $19M AUD for 17 projects)	Yarrabah, Queensland / Indigenous community / PV, Wind, Waste-to-Energy, Biogas and micro-turbines, battery, EV charging stations	Detailed Feasibility Study
Offshore Wind Feasibility Study #2	$300,000	Region off Humboldt Bay / Wind farm PPA / Offshore wind	Feasibility Study
Township's Town Center Distributed Energy Resource (TCDER) Microgrid Program	$679,500	Montclair, NJ / City and school buildings, hospital / natural gas CHP generators, PV, battery, EV charging stations	Full Design (Phase II of Pilot Study)
Blue Lake Rancheria Microgrid	$750,000 (estimated as 15% of total EPIC funding of $5M)	Blue Lake Rancheria / American Red Cross evacuation center / PV, battery, diesel backup generator	Full Design

Table 1: *Survey of publicly available Microgrid feasibility and design cost data*[7]

Sources:

[7] DoD Standardized Platform to Guide Rapid and Repeatable Modeling and Design of Secure and Resilient Microgrids (RAPID-Resilient-Microgrid), Michael Stadler, Zack Pecenak, US DoD ESTCP project EW20-B8-5271, final report, February 2022.

Standardization Saves Significant Time and Money

Xendee's hypothesis was that having a standardized method for performing project feasibility and design can streamline the shown process, thus reducing time, cost, and incorrect go/no-go decision making. Ultimately, this allows developers to move Microgrid projects quickly and efficiently through their funnel increasing their ROI and the overall number of projects built.

To test this, Xendee's team standardized the Microgrid modeling approach for time, cost savings, and projection reliability. The methodology of the DoD study involved:

- A structured data collection system that instructs users as to what data is collected at what step in the process as well as facilitates secure data transfer between project teams.
- Assessment of standard (status quo) practices for the Microgrid design process at three different sites.
- Application and extension of a Mixed Integer Optimization (MILP) approach that allows modeling of investment decisions, operation, and power flow in one tool.
- A training and curriculum program to disseminate the needed Microgrid knowledge for effective modeling with the MILP approach.
- Assessment of time and cost savings with the Xendee platform compared to one-off or standard practices.

We found that compared to the above public data, which shows that typical Microgrid feasibility costs are at least $75k and full system designs can be as high as $750k a standardized modelling approach for the three sites results in less than $55k or 1% of total project costs. The standardized modelling was done in weeks compared to months and years for the three sites.

Specifically, our approach which is underscored by a MILP that considers the complexities unique to each project such as bespoke tariff structures, local incentives, and novel technologies to provide an optimal project architecture for multiple competing objectives (cost and carbon reduction, self-sufficiency, and resilience) was a major cornerstone in moving the project along the different stages of feasibility and design.

Speed and Sophistication at The Proposal Building Stage

These results show the efficacy of a standardized approach on real Microgrid projects. However, this is only effective assuming that the decision to design and implement a Microgrid project has already been made. However, to move forward to these stages, project feasibility needs to be established. In many ways, establishing initial project feasibility requires the same level of sophistication that's required in the detailed design because similar technical variables and financial projections need to be factored in. For this reason, if project feasibility can confidently be established early on, and can be done quickly, development resources can be allocated most efficiently to projects with the greatest likelihood of success.

Project feasibility is critical due to the wide variety of incentive programs, developers, EPC, and others need a quick and simple way to identify if a certain project would be eligible for specific funding programs. One-off assessments will not be successful in dealing with the large number of projects expected in the next few years because of the public and government interest in renewables, EVs, and Microgrids. Technology providers or OEMs for EV charging infrastructure or generation technologies will need a reliable methodology to assess if their technology will be eligible for a certain project or funding scheme.

Thus, to streamline the process the proposal tool needs to deploy even more standardization and databases and third-party API integration than the standardized detailed design tools. Extensive vendor catalogs and full utility rate integration with the load profile database as well as funding programs are also needed. This proposal tool needs to be simple and fast enough to allow in-person evaluations as well as the screening of many opportunities in parallel.

Xendee's PROPOSE is a newly released proposal-building tool that enables significantly reduced proposal writing and project identification times over the already improved detailed design process identified in our work as discussed earlier.

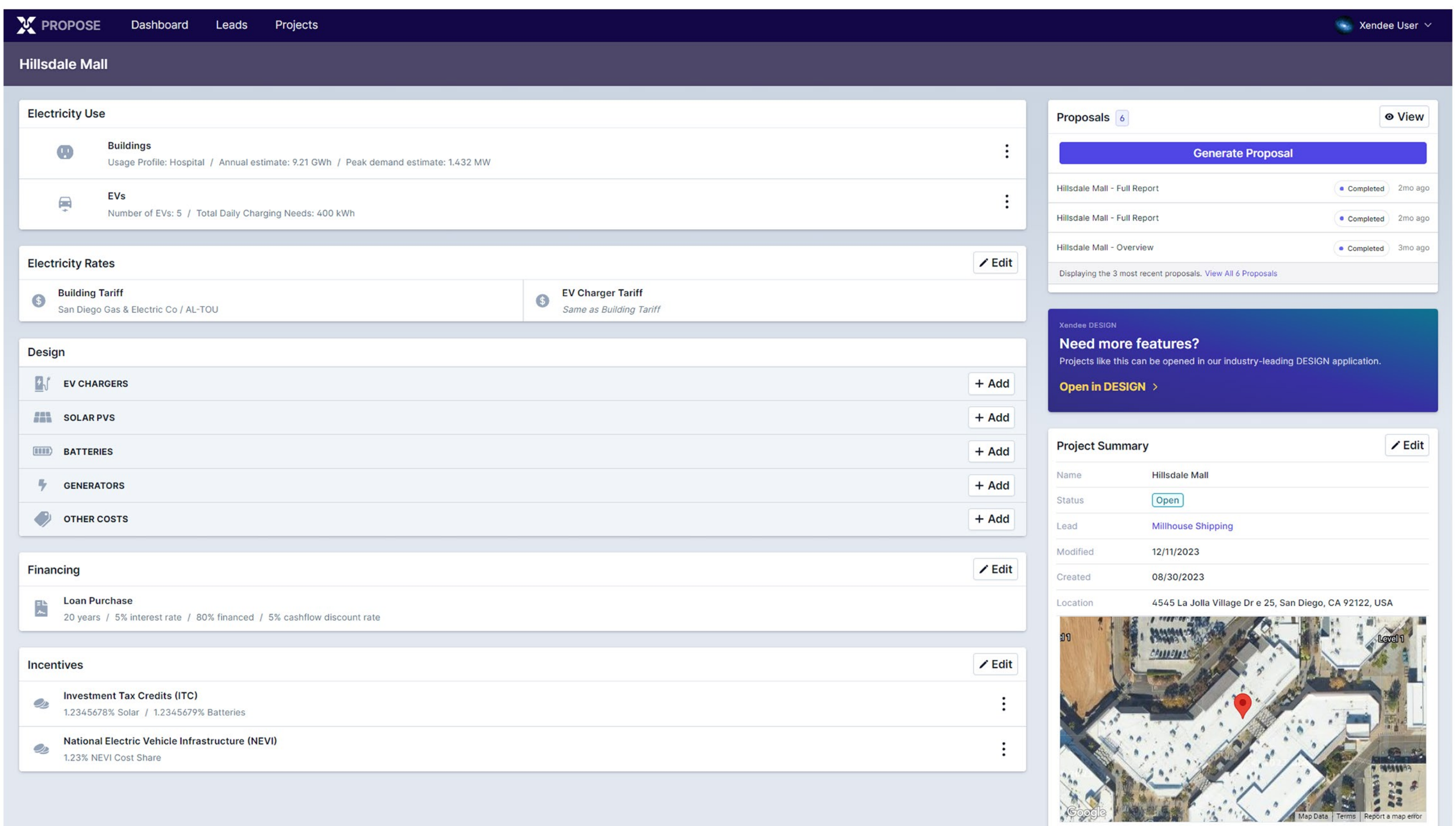

Figure 3: *The main dashboard for a project in PROPOSE. Add technologies like EV chargers, solar PVs, batteries, and generators to the project through a catalog-driven rapid selection process. Financing options, utility tariffs, building loads, and government incentives are also considered. The project is then optimized by the same algorithm as used in Xendee DESIGN (which was tested within the mentioned DoD ESTCP project) to generate an investment strategy and a shareable proposal.*

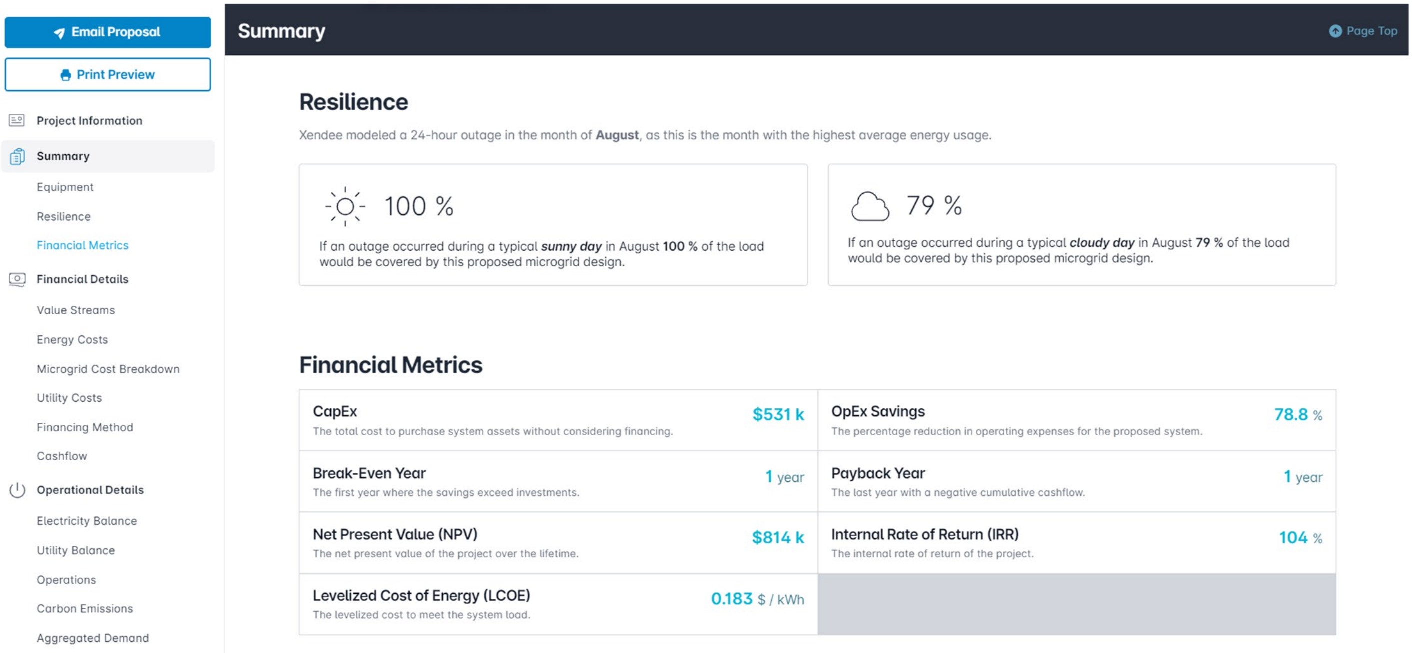

Figure 4: *Proposals can be rapidly generated one after the other to explore the effects of different technologies, budgets, financing methods, and government incentives to find the right investment strategy. Proposals include equipment summaries, resilience models, financial metrics, value streams, energy costs, expense breakdowns, utility costs, financing methods, cash flow, and operational details.*

Figure 5: *Proposals also include a microgrid cost breakdown showcasing the expenses by month for the optimized system. The striped bars in this graph represent the costs of the base case (existing technologies and utility purchases only) versus the optimized results which can also new utilize onsite DER technologies like generators and batteries.*

As a result of our research and work, a successful Microgrid and DER implementation process needs to involve an effective way to integrate the proposal and discover phase, resulting in our Microgrid design, implementation, and control approach as indicated by Figure 6.

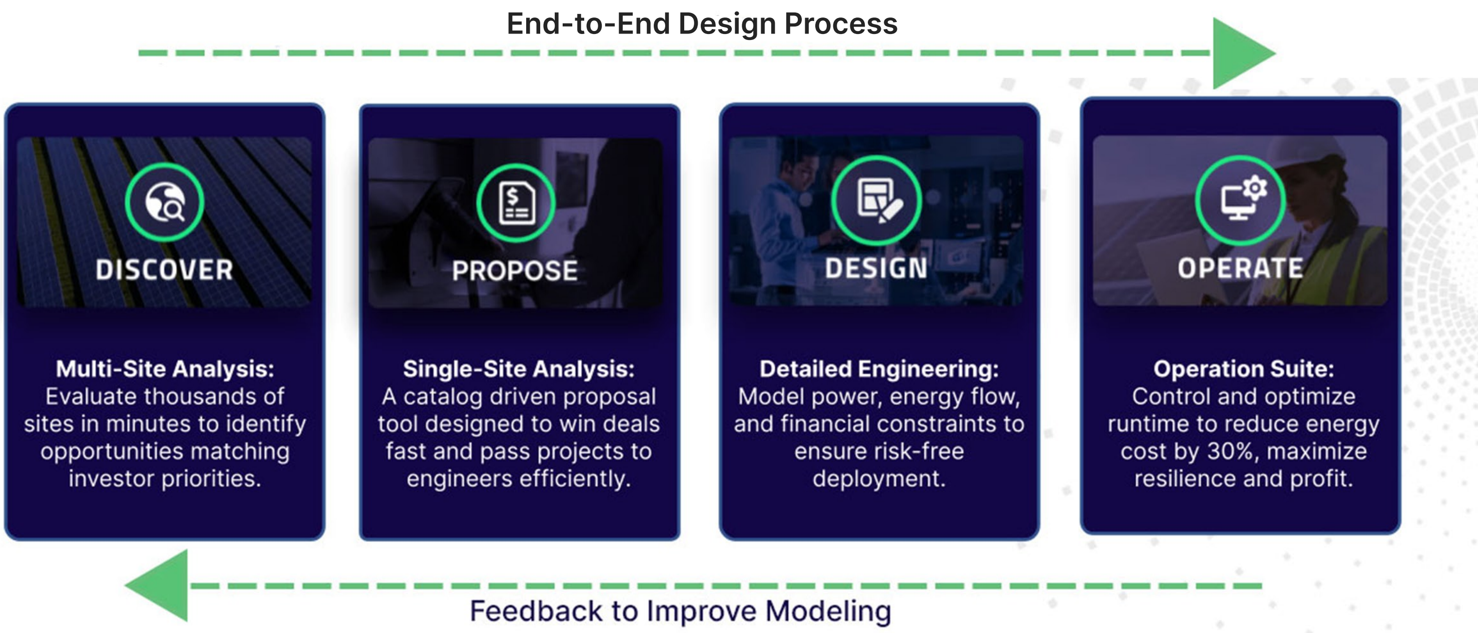

Figure 6: *Xendee's platform provides an integrated approach to Microgrid site selection (single or multi-site), design, and control. This reduces the cost of customer acquisition, reduces pricing errors, and helps get more projects funded that reach or exceed organizational goals.*

All these steps and phases need to be linked to minimize latency and maximize continuity by removing unnecessary steps and facilitating coordination, meaning that the proposals can be seamlessly transferred to Xendee DESIGN for detailed techno-economic and engineering analyses.

Dr. Michael Stadler
Chief Technology Officer

Since July 2018, Dr. Michael Stadler has been the Chief Technology Officer of the San Diego-based XENDEE Corporation, which he co-founded. Before that, Michael Stadler was a Staff Scientist at Lawrence Berkeley National Laboratory, California, leading the Grid Integration Group. He is a recipient of the 2013 PECASE Award of the White House. The PECASE Award is the highest honor bestowed by the U.S. government on science and engineering professionals in the early stages of their independent research careers. Michael has published 260 papers, journal papers, and reports to date and holds 14 copyrights/patents.

Contact:
mstadler@xendee.com
xendee.com

Adib Naslé
Chief Executive Officer

Adib is the inventor of real-time power analytics for mission critical electrical power distribution networks. Previously, Adib was co-founder, and president at Power Analytics Inc. Adib is a senior IEEE member, co-teaches the Microgrid planning and economic optimization course at UC San Diego (CSE-4t1291), is a member of the Advisory Board at the Center for Energy Research at University of California, San Diego Department of Mechanical & Aerospace Engineering, and the Advisory Board for the Power System Engineering Certificate program at UC San Diego Extensions, and holds 26 U.S. and international patents in the areas of electrical power system design, optimization, and capacity assessment.

Contact:
ansale@xendee.com
xendee.com