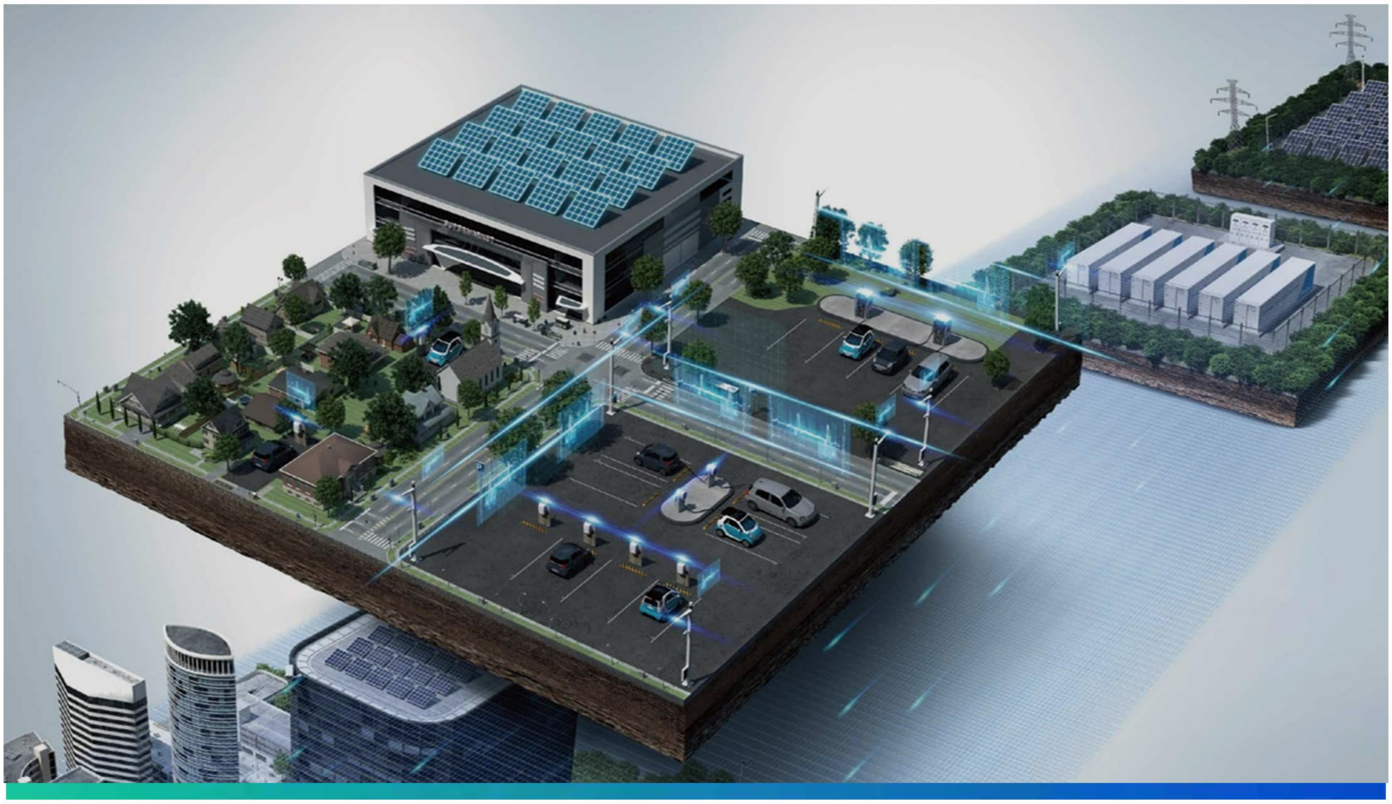
Reducing Costs and Uncertainty in Microgrid Deployment By Employing An Integrated Solution

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



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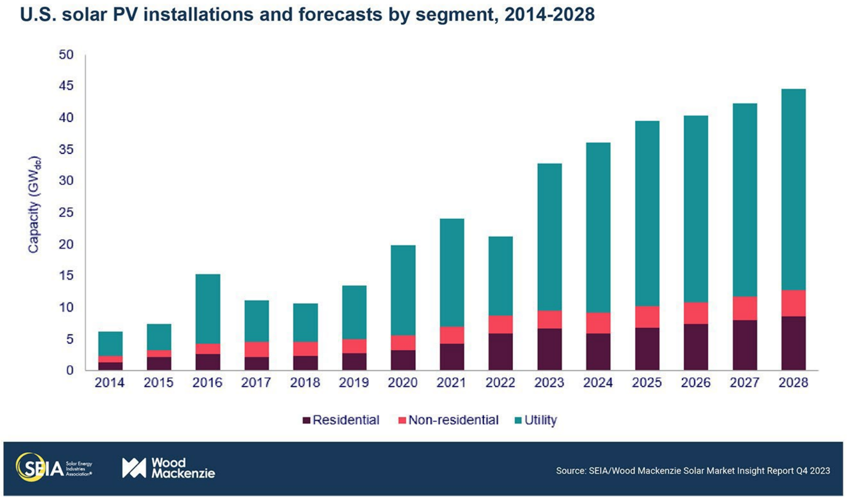
Overview

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.


U.S. solar PV installations and forecasts by segment, 2014-2028

Source: SEIA/Wood Mackenzie Solar Market Insight Report Q4 2023

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

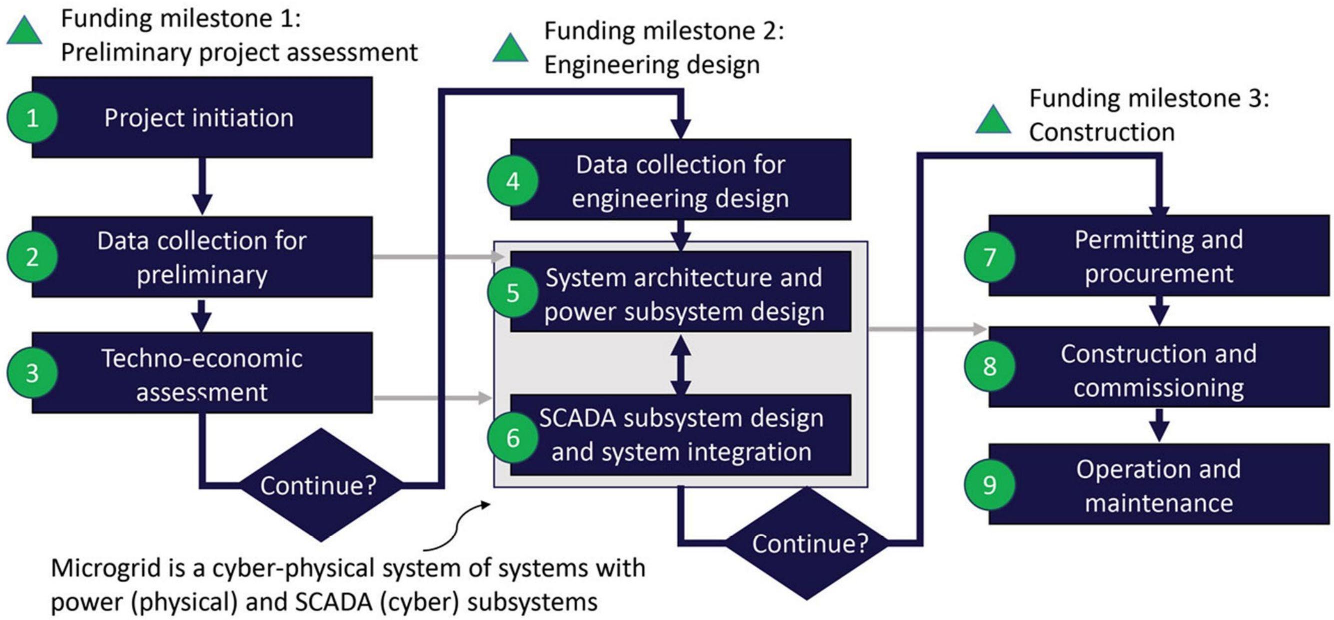


Figure 2: *Nine major steps that are most common to the Microgrid implementation process as found by a DoD ESTCP project*[4].

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.

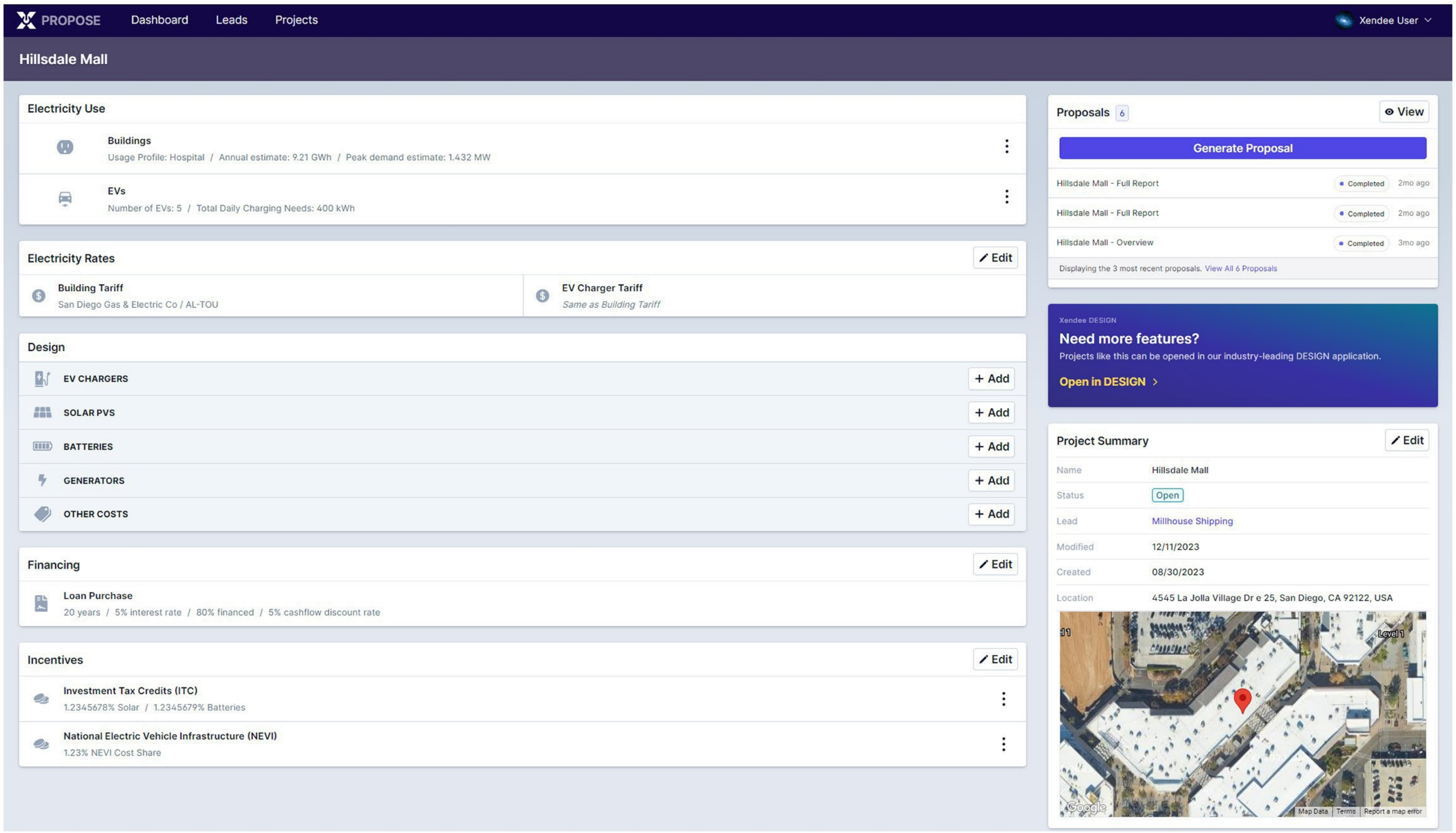
Speed and Sophistication at The Proposal Building Stage

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.



Hillsdale Mall

Electricity Use

Buildings
Usage Profile: Hospital / Annual estimate: 9.21 GWh / Peak demand estimate: 1.432 MW

EVs
Number of EVs: 5 / Total Daily Charging Needs: 400 kWh

Electricity Rates

Building Tariff
San Diego Gas & Electric Co / AL-TOU

EV Charger Tariff
Same as Building Tariff

Design

EV CHARGERS
SOLAR PVS
BATTERIES
GENERATORS
OTHER COSTS

Financing

Loan Purchase
20 years / 5% interest rate / 80% financed / 5% cashflow discount rate

Incentives

Investment Tax Credits (ITC)
1.2345678% Solar / 1.2345679% Batteries

National Electric Vehicle Infrastructure (NEVI)
1.23% NEVI Cost Share

Proposals 6

Hillsdale Mall - Full Report	Completed	2mo ago
Hillsdale Mall - Full Report	Completed	2mo ago
Hillsdale Mall - Overview	Completed	3mo ago

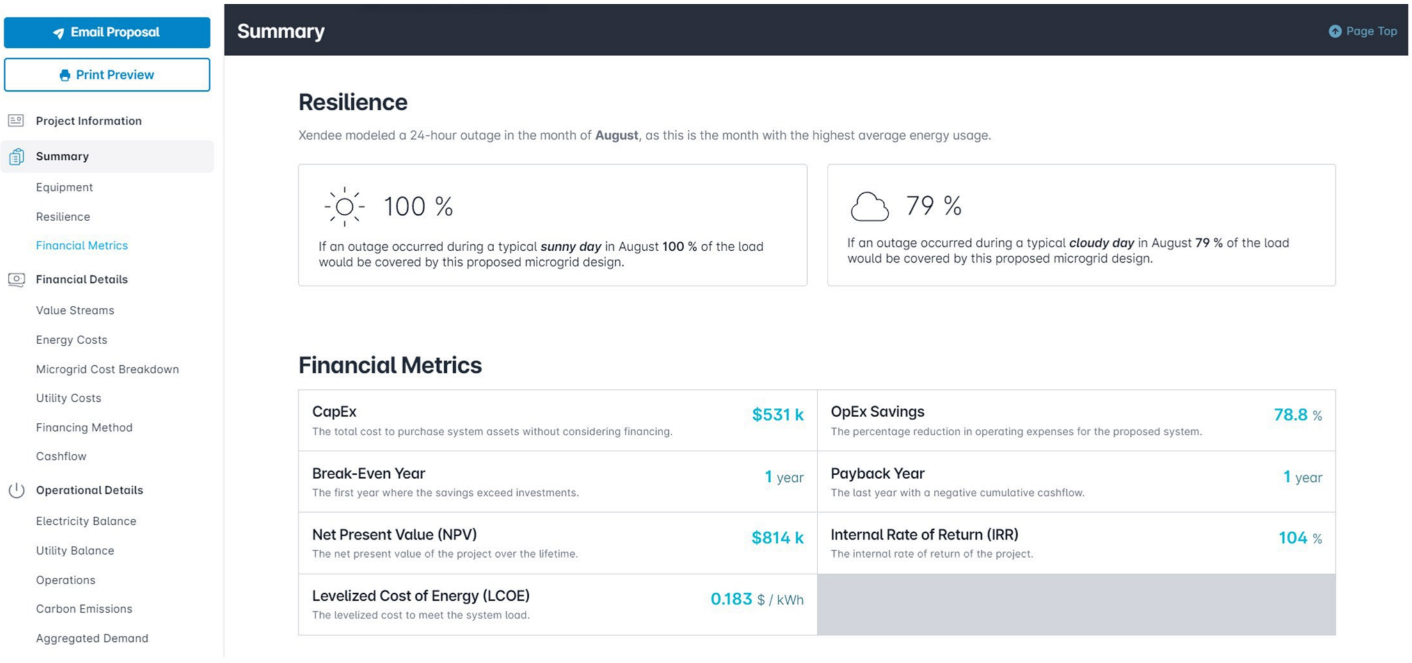
Displaying the 3 most recent proposals. View All 6 Proposals

Xendee DESIGN
Need more features?
Projects like this can be opened in our industry-leading DESIGN application.

Project Summary

Name	Hillsdale Mall
Status	Open
Lead	Millhouse Shipping
Modified	12/11/2023
Created	08/30/2023
Location	4545 La Jolla Village Dr e 25, San Diego, CA 92122, USA

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.*



Resilience

Xendee modeled a 24-hour outage in the month of **August**, as this is the month with the highest average energy usage.

100 %

If an outage occurred during a typical ***sunny day*** in August **100 %** of the load would be covered by this proposed microgrid design.

79 %

If an outage occurred during a typical ***cloudy day*** in August **79 %** of the load would be covered by this proposed microgrid design.

Financial Metrics

CapEx The total cost to purchase system assets without considering financing.	$531 k	OpEx Savings The percentage reduction in operating expenses for the proposed system.	78.8 %
Break-Even Year The first year where the savings exceed investments.	1 year	Payback Year The last year with a negative cumulative cashflow.	1 year
Net Present Value (NPV) The net present value of the project over the lifetime.	$814 k	Internal Rate of Return (IRR) The internal rate of return of the project.	104 %
Levelized Cost of Energy (LCOE) The levelized cost to meet the system load.	0.183 $ / kWh		

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.*

Energy Costs

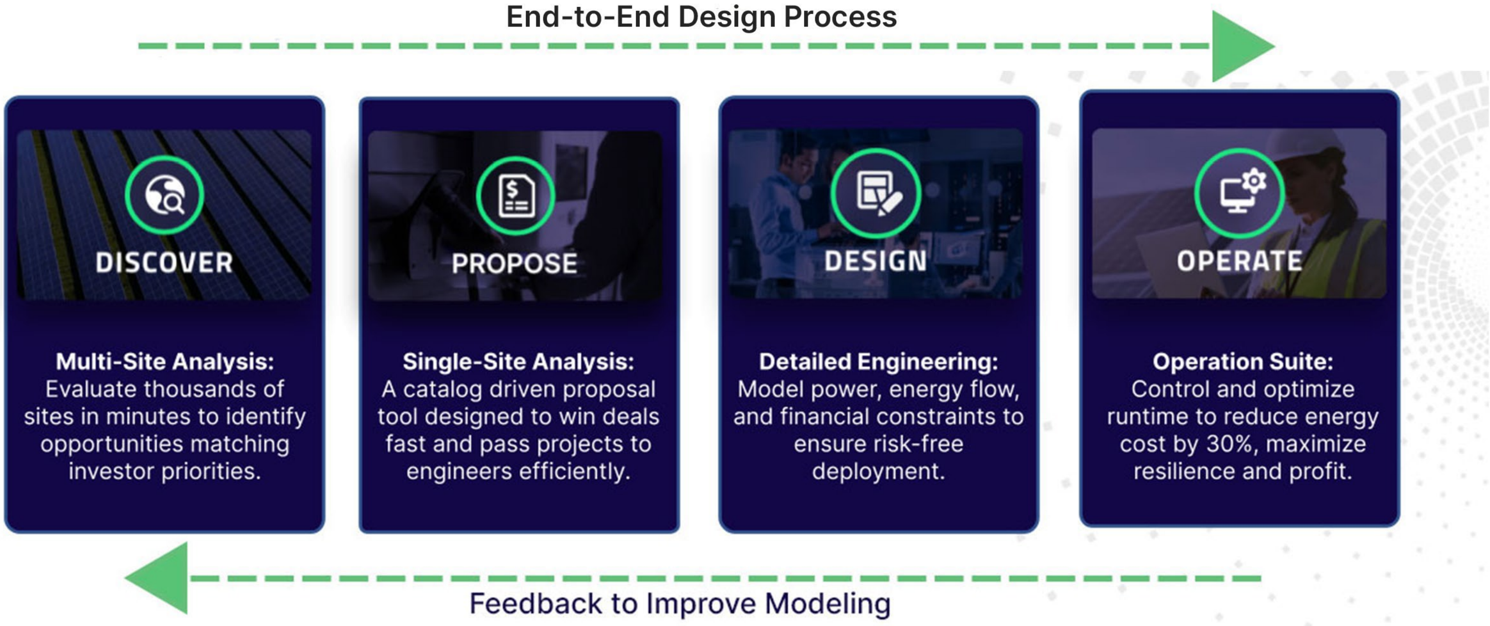
	Annual System Costs	Annual CO_2 Emissions
Current System The estimated annual costs for operating the system today. This estimate includes existing energy and operational expenses.	$144 k	174 MT
Proposed System The total annual cost of operating the proposed system with the technologies outlined in this proposal. Values include capital costs and all energy and operational expenses.	$79 k	19 MT

Microgrid Cost Breakdown

The breakdown of expenses by month for the optimized system. All costs are in thousands of dollars.

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.



Multi-Site Analysis: Evaluate thousands of sites in minutes to identify opportunities matching investor priorities.

Single-Site Analysis: A catalog driven proposal tool designed to win deals fast and pass projects to engineers efficiently.

Detailed Engineering: Model power, energy flow, and financial constraints to ensure risk-free deployment.

Operation Suite: Control and optimize runtime to reduce energy cost by 30%, maximize resilience and profit.

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.

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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.

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

Part Two: The Benefits of a Forward looking Integrated Microgrid Control System

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Overview

This white paper–the second in a series– explores the Model Predictive Controller (MPC) approach to Microgrid and EV infrastructure operation. This is an integrated mathematical and physical model, following the same methodology as in the project planning phase. The main difference from the planning stage, as discussed in "Part 1: Sophistication at the Feasibility and Design Analysis Stage is Key" is that during operation, the Microgrid model is supplied with real-time information (e.g., actual state of the battery or weather forecast). Instead of producing planning and investment results for multiple years into the future, the MPC creates reliable technology dispatch and operational levels for multiple days into the future, and with its forward-looking capabilities, it can mitigate uncertainty.

At the heart of today's sustainable energy revolution is the strategic deployment of Microgrids and Distributed Energy Resources (DER). With the world's increasing focus on moving to renewable energy sources, the need for groundbreaking, efficient, and scalable solutions has become paramount. This white paper and the previous one delve into the challenges inherent in traditional Microgrid and DER design and deployment. In this part 2, we examine the transition from designing to operating Microgrids, a step where an integrated approach that links planning and operation improves operational efficiency, reliability, and cost-effectiveness.

The transition from designing Microgrids and DERs to real-world operation requires consistency between theoretical planning and practical deployment. Most Microgrids are designed with several assumptions in mind–including loads, tariffs, battery operation, and expansion plans–all factors that impact the economic feasibility of a project. However, currently most Microgrid controllers don't follow the assumptions built into the planning phase since planning and control is mostly disconnected and done by siloed tools and approaches.

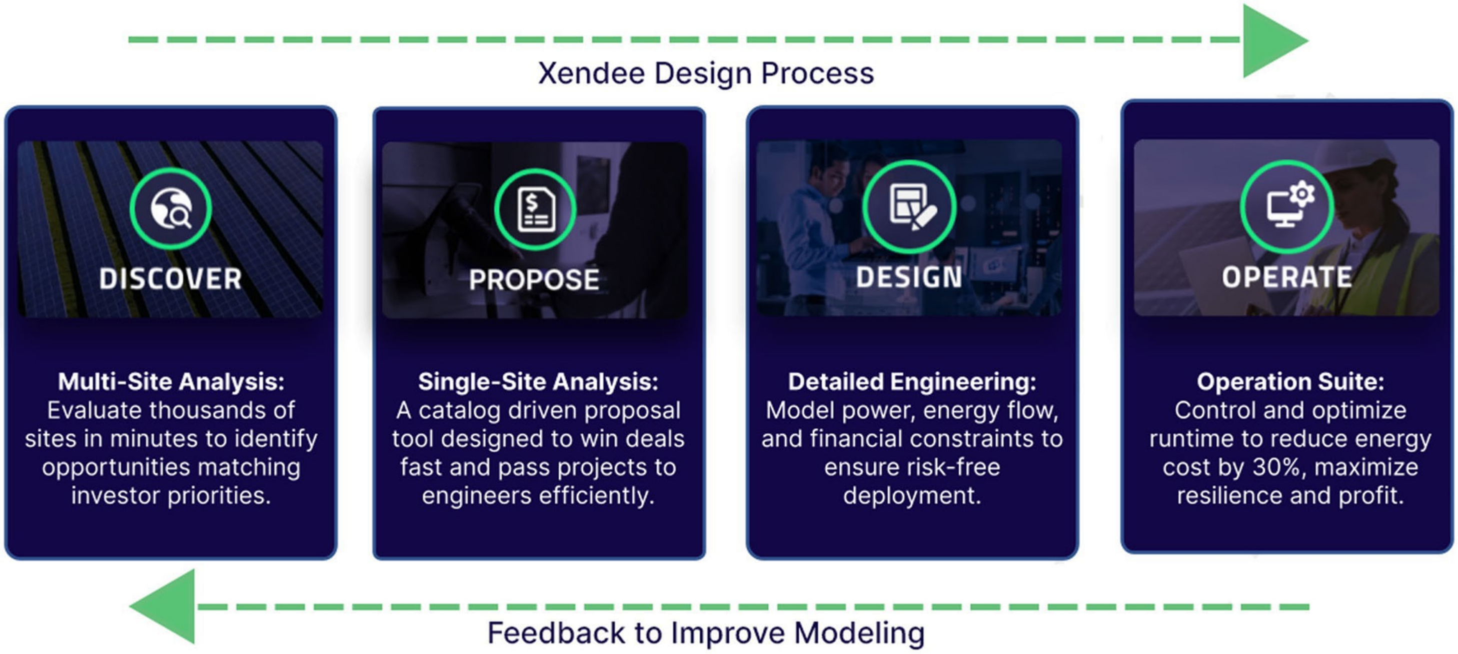
Bridging this gap by integrating initial planning assumptions into the operation phase by using the same methodology, (e.g., models, math and physics) is an important step forward in increasing precision and intended outcomes for the Microgrid owner or operator.

This white paper explains how an MPC works, how it is linked to the planning phase, and what savings are possible. Some installations show more than 60% demand charge (power cost) costs savings and an almost 40% energy cost savings by running an integrated MPC.

Introduction

In the first installment of this whitepaper series, we delved into the complexities and challenges of designing Microgrids for the public and private sectors, emphasizing the importance of a standardized and integrated proposal to design phase. We discovered that compared to typical Microgrid feasibility costs of at least $75,000 and full system designs as high as $750,000, a standardized modeling approach for three sites yielded a cost of less than $55,000 or 1% of total project costs. What's more, this modeling was done in weeks compared to months and years.

In the first white paper, we introduced the integrated modeling and control approach as shown below. A successful Microgrid and DER implementation process needs to involve an effective way to integrate all these phases. Linking these phases will minimize latency and maximize continuity by removing unnecessary steps and facilitating coordination, meaning that the proposals can be seamlessly transferred to the design phase and then to the operational phase.



Multi-Site Analysis: Evaluate thousands of sites in minutes to identify opportunities matching investor priorities.

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Detailed Engineering: Model power, energy flow, and financial constraints to ensure risk-free deployment.

Operation Suite: Control and optimize runtime to reduce energy cost by 30%, maximize resilience and profit.

Figure 1: Xendee's patented platform provides an integrated approach to Microgrid site selection (single or multi-site), design, and control. This reduces time, errors, and costs through a seamless transition from each stage of Microgrid development to the next.

Building on this foundation, this second white paper focuses on the transition from the Microgrid and DER design phase to the operation stage (OPERATE in Figure 1). This phase marks the shift from theoretical models and simulations to the real-world implementation of Microgrids and DERs. Furthermore, we explain the details of Model Predictive Control (MPC) systems which are the core underlying technology of the operational phase in our approach.

The Five Steps of a Microgrid Controller Deployment

The operational phase, as indicated by OPERATE in Figure 1, itself involves 5 major steps. These steps involve significant data acquisition, forecasting model design/calibration, communication integration, and testing procedures which can take years if not done in a proper way.

Figure 2: Needed steps for a successful Microgrid controller deployment.

Step 1: Data Acquisition

First, historic data must be collected or synthetically generated for building loads, Electric Vehicles (EV), and operational data for existing DERs among other data. Later in the process, real-time measurements must also be collected. A Microgrid controller should have some forward-looking capabilities, which can forecast demand or renewable output from Photovoltaics (PV), and that can predict the future load partly based on historic patterns. Thus, very specific data is needed to gain a better understanding of the existing situation and to effectively train forecasting models on load patterns. It is also key to identify missing historical data and to employ similar data or synthetic data from extrapolations.

Here, integration with the planning phase (DESIGN from Figure 1) helps enormously. A Microgrid or DER project modeled in the same platform as the controller allows data transfer to the operational phase. In other words, data and parameters from the planning phase can be seamlessly transferred into step 1 (Data Acquisition) of the OPERATE phase. This significantly reduces time and potential for setup and calibration errors. If linked to the design phase, information about the project - technical specifications and historic demand - are readily available for the controller set-up and calibration.

Step 2: Design and Validation of the Forecasting Models

Every Microgrid use case will have different characteristics and different requirements for the forecasting models. If, for example, an Artificial Intelligence (AI)-based forecasting model exists, it needs to be trained. However, in most cases those models need to be built first. Again, a standardized approach that has multiple forecasting engines at hand that can be automatically tailored to the site's needs will reduce the implementation time. Instead of building new forecasting models, a library of pre-built models should be implemented and calibrated in an automated fashion that reflects the needs of the site.

Step 3: Communication and Technology Integration and Design of Optimization Framework

This step involves two major parts, the core of the controller – the MPC - and the communication integration so that the control signals can be transferred to the DERs. Here, again, standardization helps. If we can use the same math model and principles from the planning phase (PROPOSE, DISCOVER, DESIGN), it will avoid discontinuities between planning goals and operational goals. The second challenge that must be overcome is communication, because the MPC needs to process information from the physical hardware (e.g., inverter). Different technology vendors use different data formats or protocols. If those formats do not use a standardized communication method, the deployment times will increase.

Step 4: Open Loop Testing of the Microgrid Controller

Open loop testing ensures that all forecasting algorithms and the MPC engine are working correctly. The system generates the optimal system setpoints for a rolling time horizon, and calculations are repeated and updated every few mins for multiple days into the future. (See "The Core: The Model Predictive Controller" section below.) However, the setpoints are not implemented in the real physical system and instead used in a simulation environment. In this way, no harm is done to the real system if something is not working as expected. These tests allow for adjusting and calibrating the system's components and ensuring they perform as expected when introduced to real-world conditions. In this step 4 we fine-tune the system, addressing any discrepancies identified during testing. This iterative process of testing and adjusting ensures that once the platform transitions to operation, it performs accurately and efficiently.

Step-5: Closed Loop Testing of DERs at the Microgrid Site

This is the final step which closes the loop and puts the whole system in a fully functional mode where the signals are transferred to the DERs. The Microgrid technologies follow the MPC's optimal instructions to achieve the same goals that the project developers identified in the planning phase.

The Importance of a Seamless Transition and Standardization

Xendee's project deployments indicate that there are huge time savings which can be achieved by a standardized and integrated deployment approach as described in this series of white papers.

The first deployment of such a Microgrid control system took almost two years because of the disconnected approach at that time. Xendee had to build the DESIGN capabilities and link them with OPERATE. Within OPERATE the 5 steps had to be developed and tested. Building the AI-enabled forecasting and communication integration has proven to be one of the biggest challenges. Now with it built, however, a Microgrid control system can be deployed in less than a week, if the communication integration is standardized. Thus, this also makes the case for collaborating with a specific vendor or communication integration partner to reduce the deployment time to less than a day. Only in this way, will large amounts of Microgrid and DER projects be deployed at scale.

Xendee's platform facilitates this transition by integrating the same principles, systems, and advanced algorithms used in the design phase through the stages that lead to operation. This consistency ensures that the operational actions align with the initial design assumptions and objectives. This improves the accuracy and predictability of projects and instills a stronger sense of confidence in project stakeholders, allowing more projects to move forward at lower costs - and with greater speed.

The Core: The Model Predictive Controller

Key to the success of a Microgrid controller are its adaptive and predictive capabilities. The Xendee platform's ability to anticipate and adapt to changing conditions in real time – based on weather forecasts, load forecasting, and other dynamic factors – sets it apart from conventional systems. This forward-looking capability ensures that Microgrids can operate optimally under varying conditions, which is important to maintaining the balance between energy supply and demand, reducing costs, and enhancing overall system resilience. Traditional approaches just balance the system on rudimentary rules, like max utility purchase set-points or charging the battery when there is surplus PV output -without any consideration of actual electricity prices. Additionally, the project developer likely did not use the same basic rules in the planning phase years earlier when projecting performance and financial returns.

On the contrary, Xendee uses the same mathematical optimization models in the planning and operational phase. These optimization models are implemented with Mixed Integer Linearized (MILP) Programming. The MILP automatically designs the Microgrid in the planning phase. Then within the operational phase the MILP, together with the AI-enabled forecasting models, creates the MPC, which automatically determines the best DER dispatch strategy. Essentially, the MPC defines the best control strategy for the Microgrid and implements it.

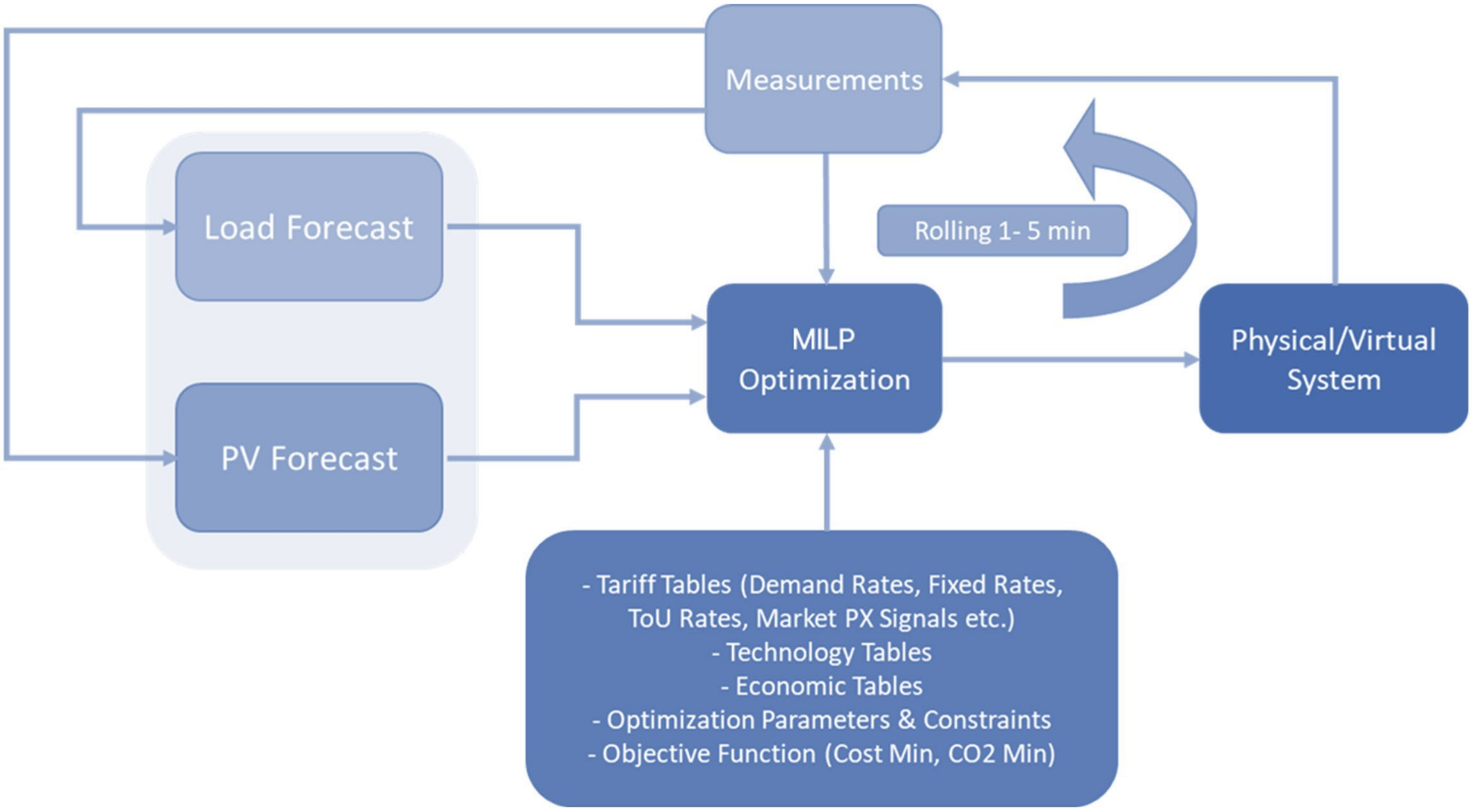

Figure 3: The concept of MPC, following the IEEE 2030.7 standard.

At each time-step (depending on the use case, 1 to 5 mins can be implemented), the system collects real-time data and measurements from the physical Microgrid technologies. For this process, data transfer between the physical technologies and the Xendee forecasting engines as well as the MILP need to be enabled. This can be done by directly installing local gateways or using third-party communication technologies. In any case, standardization on a specific protocol, format, and technology will reduce deployment times.

With the collected data, AI forecasters will predict expected electricity or heating demands or renewable energy generation and provide that information to the MILP, which will combine it with project specific information such as electricity or market rates. In the next step the MILP will calculate the most optimal operational schedule at each time step for the next few days. Then it will instruct the physical DER technologies to follow its instructions to achieve the same goals as in the planning phase. This process repeats every couple of minutes with updated information and, in this way, the MPC naturally adapts itself to future changes. The same approach is used in the planning phase (DISCOVER, PROPSOE, and DESIGN) but utilizes historic information instead of real-time and forecasted information. In other words, the planning phase mimics the real-world controller with accurate foresight.

This link between the planning and operational phase improves the financial savings for Microgrid and DER projects on top of the time savings from a well thought-out and standardized planning process. As the global Microgrid market experiences exponential growth, reaching $245.5 billion by 2032, the significance of streamlining microgrid design and control is critical.

Real-World Applications and Client Benefits

Xendee has demonstrated its MPC impact through various real-world applications.

Notably, in one project, a client with a Microgrid consisting of PV, a battery, and a generator achieved more than a 60% reduction in demand costs and almost a 40% reduction in energy costs compared to a traditional controller. The demand charge reduction is especially important because demand or power charges are mostly assessed on the highest 15 min load peak, either within a month or certain periods within a month. If we assume a demand charge of $45/kW (which can be a real value in California) and a one-time 15-minute utility demand spike of 1,000 kW, the monthly demand charge is $45,000 on top of the energy costs. Thus, the AI-enabled forecasting for utility demand in combination with the optimally planned operation via the MILP is critical as it can drive down the costs for demand charges, as we demonstrated with this client's project. In comparison, if the forecaster modules miss the real spike by just 15 minutes, no savings will be realized.

A second example - with a partner overseas using the MPC approach for a Microgrid with renewable energy and storage technologies - demonstrated a 25% cost reduction over a standard controller.

These different levels of savings indicate that a detailed analysis of the Microgrid via DESIGN is critical before building the Microgrid and deploying the controller. The integrated model for the design and operational phases allows us to estimate the impact of an advanced Microgrid MPC controller before it gets deployed. Thus, the planning phase can already determine the boundaries for the MPC controller benefits.

Conclusion

Through this white paper and the previous one, we have described the complexities of transitioning from theoretical planning to operation in Microgrid and DER deployment. We highlighted the Xendee platform's ability to streamline and standardize this process, cutting costs and saving time. With the Xendee platform, DER and Microgrid developers and operators can move forward with confidence knowing that the real-world operational results of their system will closely reflect the platform's initial design performance and financial projections.

The focus on integrating the same assumptions from design through operation increases return on investment, provides predictability for Microgrid and DER stakeholders, and contributes to a more sustainable energy future.

However, our research journey is still ongoing, and our current engineering focus is on developing communication solutions that facilitate data flow between batteries, EVs, and other loads and DERs in a standardized way.

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. From March 2017 to December 2018, he was the area head of the Microgrid and Smartgrid department at BEST and responsible for the successful establishment of the Smartgrid and Microgrid research area. He also led the design, implementation, and operation of the first Austrian Microgrid testbed. 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.

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