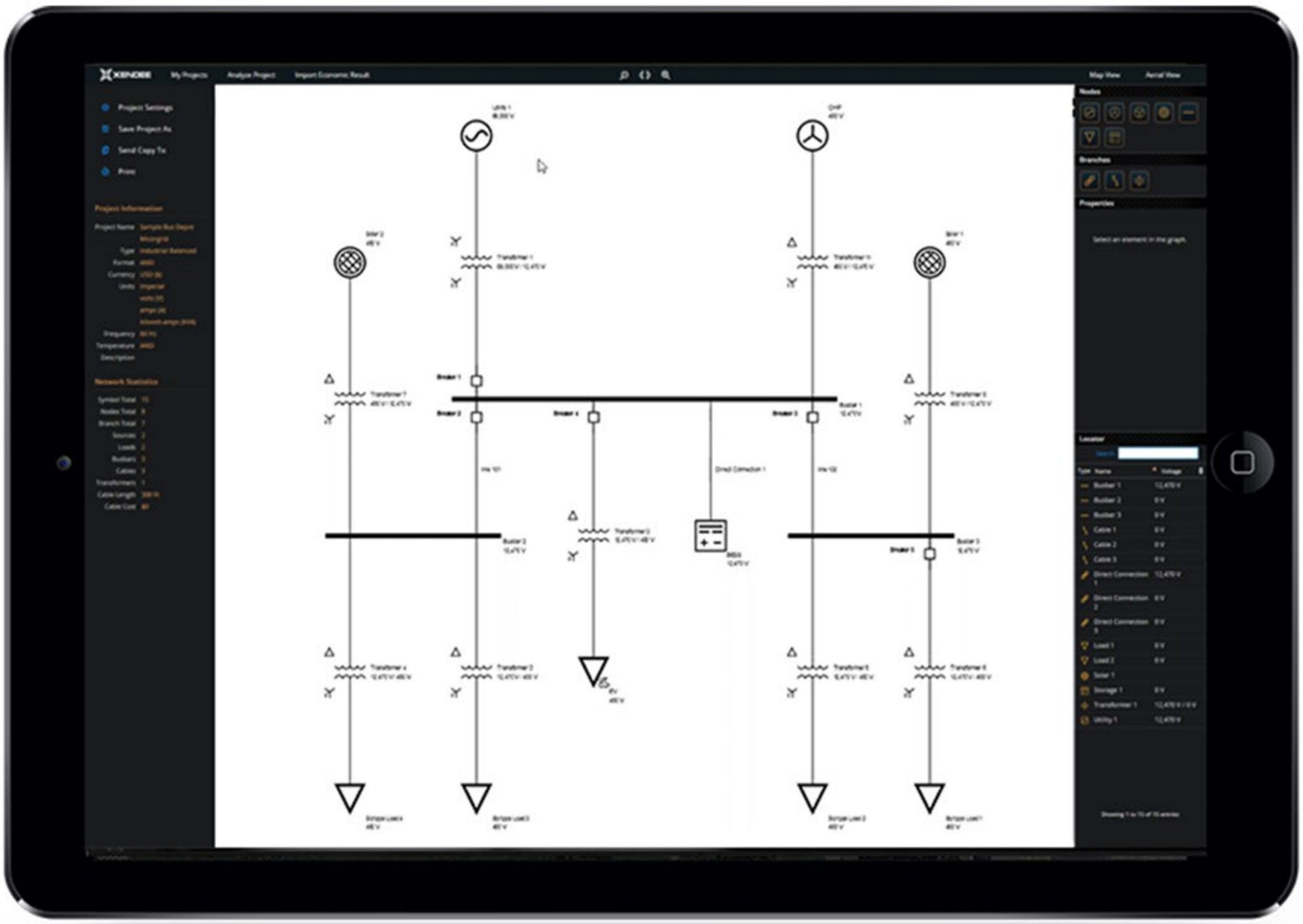
SPECIAL MICROGRID DESIGN REPORT

Designing Microgrid as a Service Agreements Require State of the Art Design Methods



Screenshot of the XENDEE Microgrid Design & Decision Support Platform's detailed electrical designer that models energy systems while also considering optimized dispatch results to capture the most accurate simulations.

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MICROGRID KNOWLEDGE

A Complex System

Microgrids are complex systems by nature. They combine intermittent renewables, Combined Heat and Power (CHP) applications, and power distribution systems to meet controllable loads and capture varied value streams (such as resilience, tax incentives, utility bill reductions, and many more). Further, each Microgrid site is diverse in terms of geography, regulation, and economy. Adding novel business models on top of this, such as a Microgrid as a Service (Maas) business model, can further add complexity while raising the stakes to get it right. MaaS delivers lower cost energy and improved resilience to an end user, usually with a financial guarantee on system performance. In turn, profit to the MaaS provider through a fixed or a variable compensation rate based on delivered energy and installed capacity is provided.

Designing and controlling such systems has moved well beyond simple spreadsheet calculations combined with rules-of-thumb and simulations. Instead, optimal decision-making tools, which can look at the system holistically when making a lifetime plan and determining operation are the only option and are needed to answer the complex Microgrid design and operational problems.

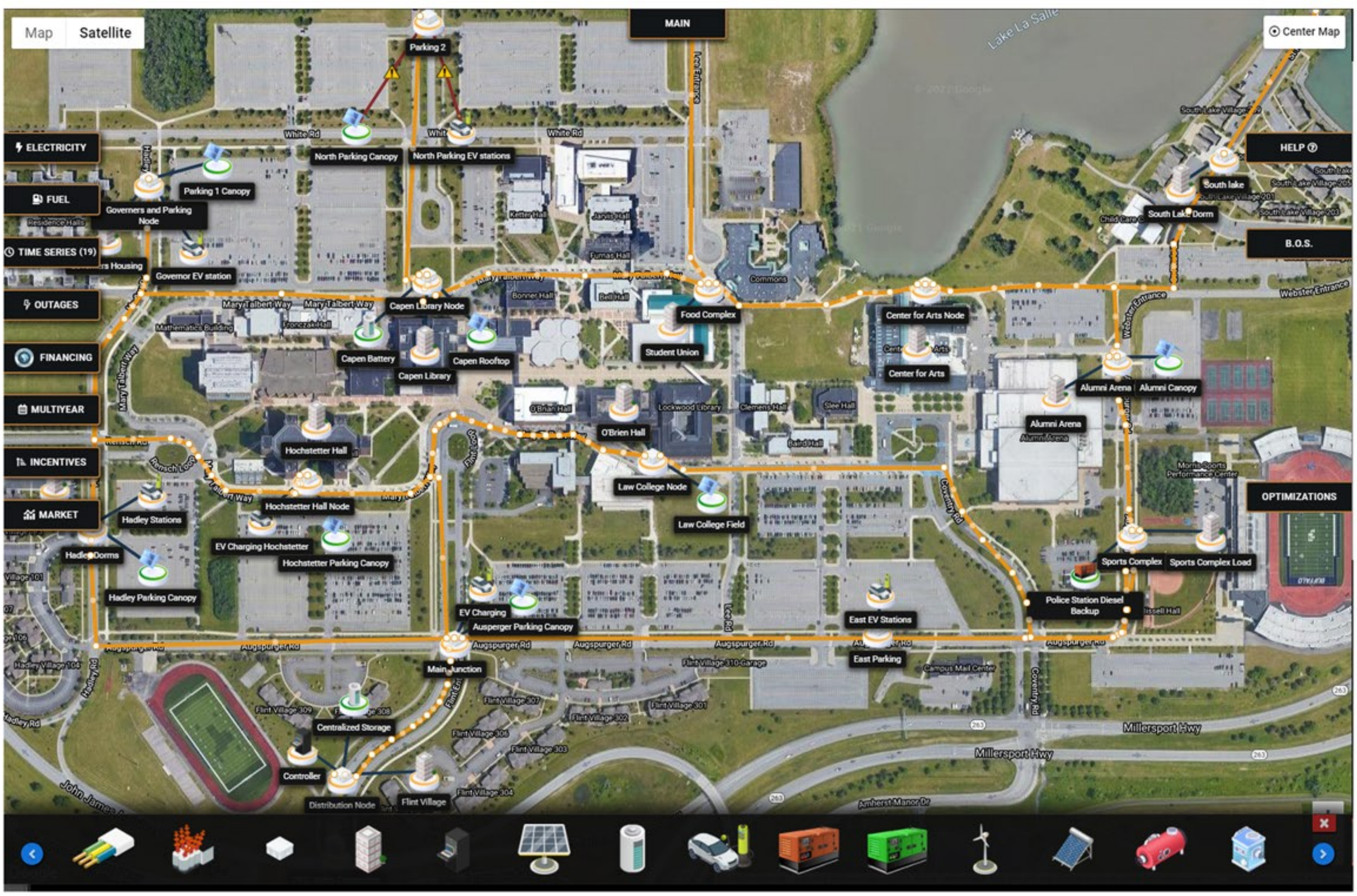


Figure 1: Example of a small campus Microgrid in XENDEE, which needs to determine the optimal infrastructure, distributed energy resources, and operation under a MaaS agreement to provide resilience and lower energy costs.

Such classes of problems can only be solved reliably by comprehensive mathematical optimization techniques which consider all these complications, including distribution system modelling and electrical engineering (as utilized in XENDEE) and solves them for the user in an automated fashion.

These mathematical optimization tools work by weighing the costs (e.g., purchase and operation) and benefits of distributed energy resources (DER) and power system components (underlying infrastructure such as cables and transformers) against the costs to purchase energy externally. Simultaneously the tool considers multiple value streams (also on the heating and cooling side) with different technology configurations and operation to provide an optimal system which drives the best performance at the lowest cost. Further, based on its calculation, the tool can provide accurate financial projections for the project lifetime.

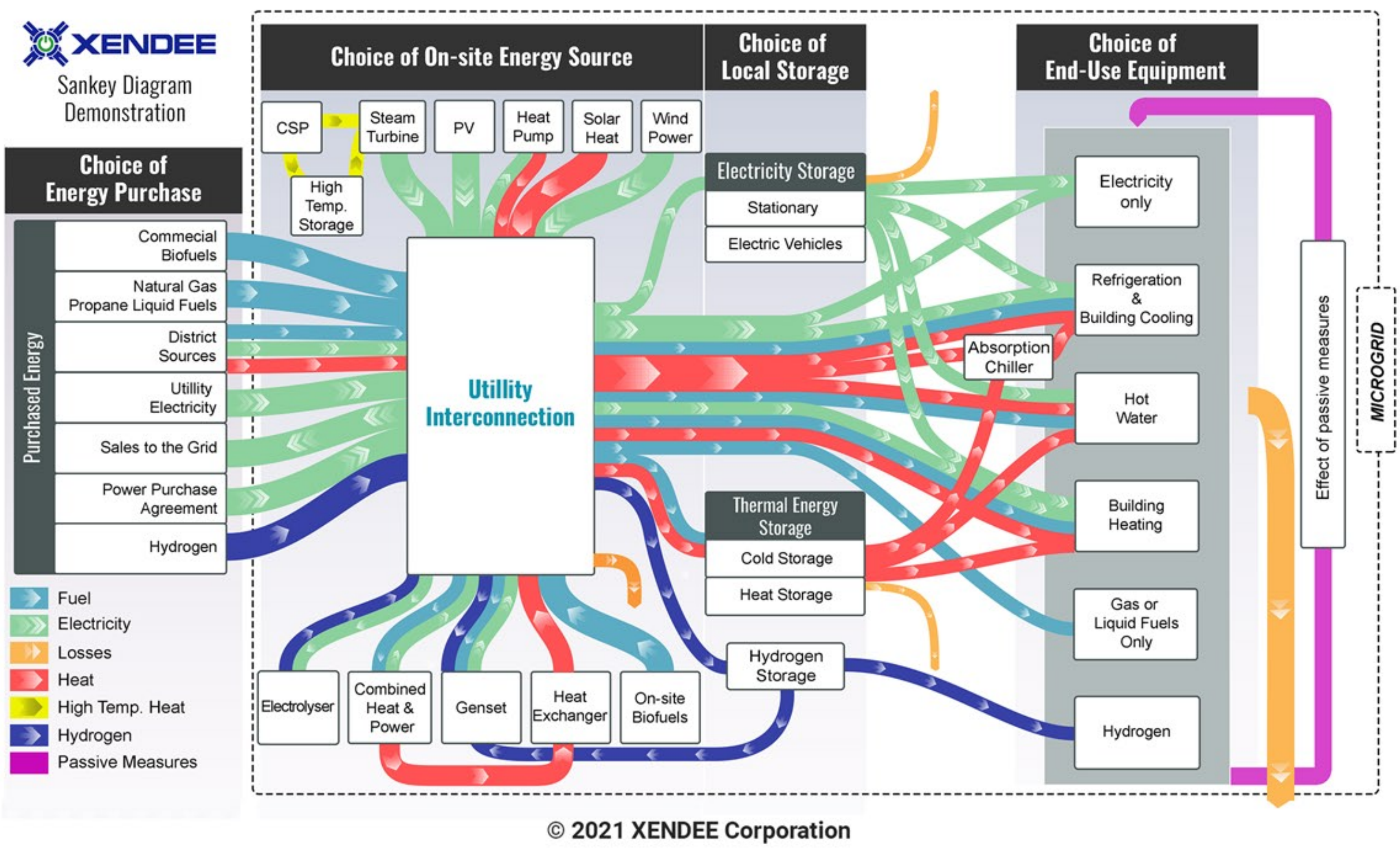


Figure 2: The complexity of interactions between perspective technology and changing energy flows in every time-step (for example because of varying prices, demand, and/or solar insolation), make it impossible for traditional tools to find the best solution and operation of DER technologies. Mathematical Optimization engines like XENDEE can solve for optimal investment capacity, configuration, and operation simultaneously and deliver reliable and bankable system configurations (1st party or MaaS model) easily.

In order to capture the project holistically, it is necessary to use modelling tools which can **plan around future changes in a reliable, fast, and easy way.** For example, ensuring the provided solution will meet an increasing demand against rising energy costs and degrading technologies under the constraints of the performance agreement is crucial to project success. Users also need a multiyear optimization that can provide optimal investment augmentation, operation, and financial projection for a **multiyear horizon** within minutes. Traditional approaches either ignore future changes or can run for weeks despite using crude approximations to bring down the computation time.

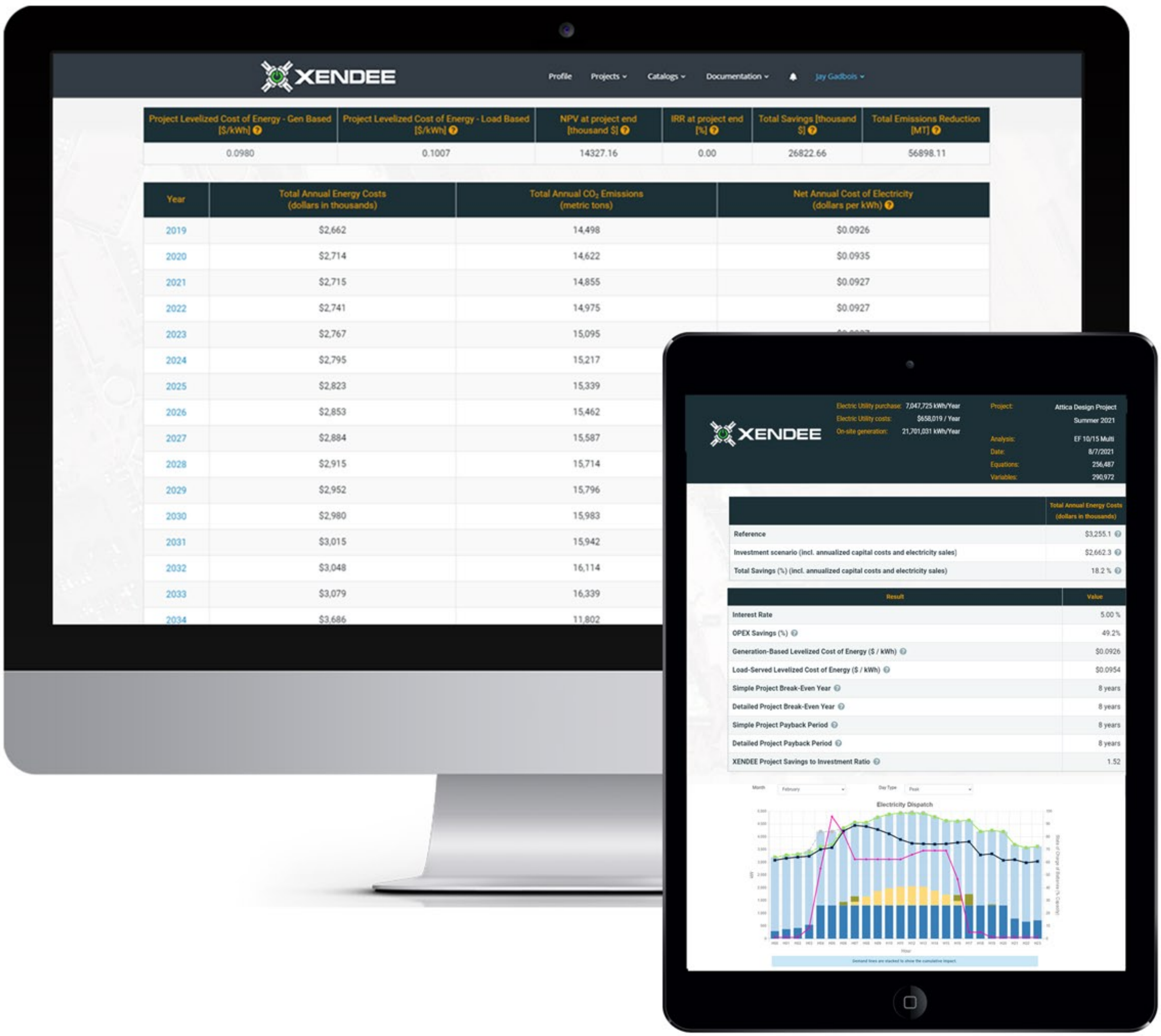
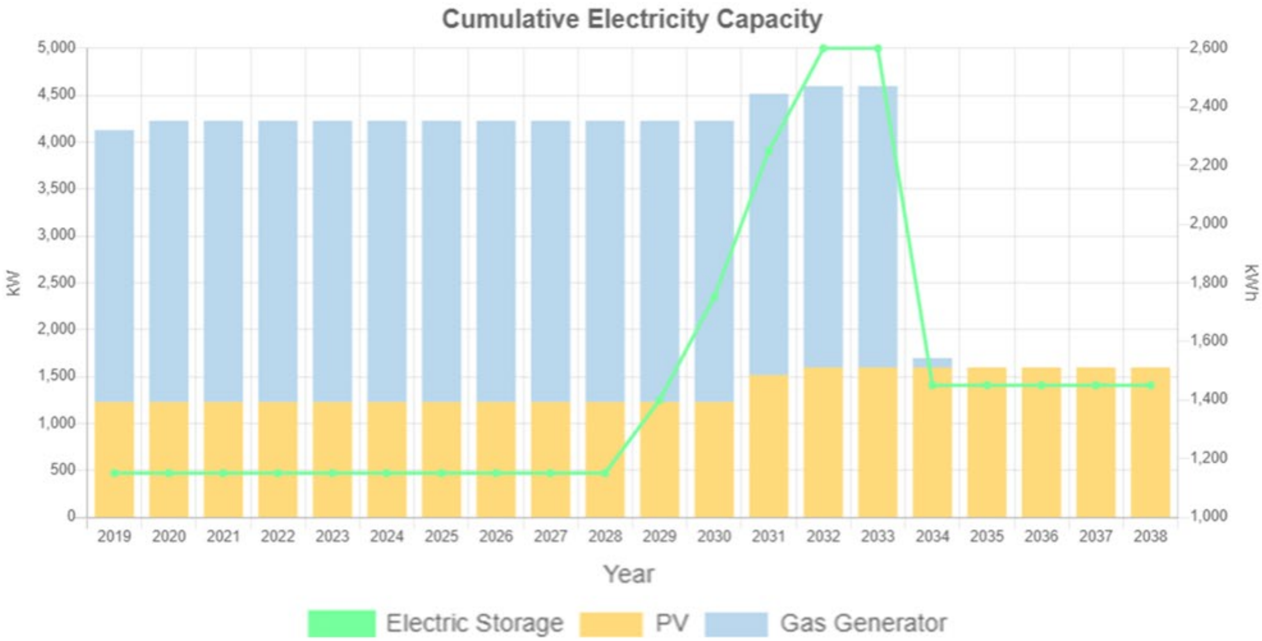


Figure 3: XENDEE multiyear financial projection displaying total energy costs, annual CO_2 emissions and net annual cost of energy over a twenty year period. XENDEE Also breaks each year down and shows the optimized dispatch for each day of every year as seen on the tablet.



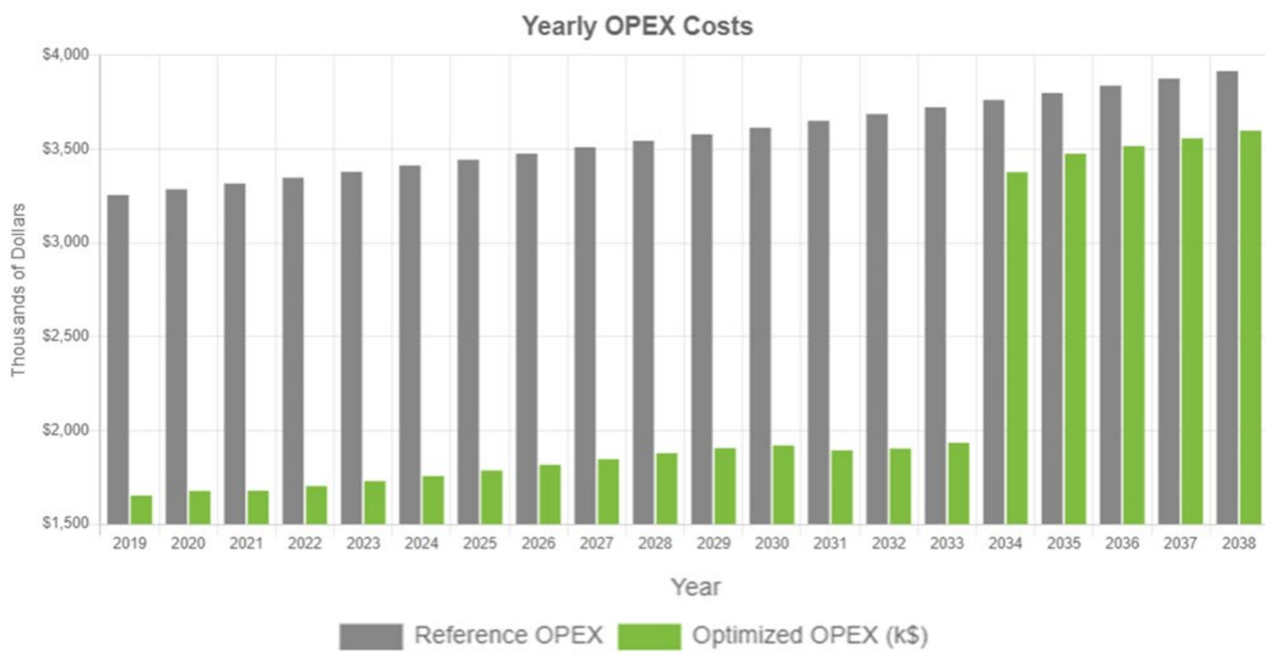


Figure 4. MaaS example that is defined by average annual demand increases of 1.5%, Battery Energy Storage Systems (BESS) degradation of 1.3% per year, PV degradation of 0.5%/year, and 15-year lifetime for the gas engine and BESS system. Because of the changes over time, initial BESS capacity of roughly 1200kWh should be upgraded between 2028 and 2033 to compensate for the aging infrastructure. But, at the end of the lifetime of the gas generator, the most attractive solution is to not reinvest in a generator again. These changes in DER technologies will impact the possible savings and profit generated by the MaaS as indicted by the lower "Cumulative Electricity Capacity" figure. Gray bars represent the business-as-usual case (no MaaS) and green bars the optimized MaaS case. In 2033, because of the end of the lifetime of the gas generator, savings (difference between gray and green bars) are becoming smaller and leave less room for a profit. Alternative scenarios like extended lifetime for the CHP system by a major overhaul could be optimized and assessed. Traditional single year analyses tools cannot reveal these details.

The second challenge that can be observed with current traditional Microgrid design approaches is the limited experience and support for different forms of project financing, which will impact project optimality. For example, concepts of loan obligations, business models, or tax equity (as well as their changes over time) are often completely ignored when determining system configuration. This leads to a disconnected design process where the technical design is iterated alongside a financial spreadsheet to attempt to find a happy medium solution that neither was designed for.

Thus, **incorporating accurate financing into the multi-year optimization alleviates this issue and allows for the most optimal design considering the project financing**, as considered in the XENDEE approach. The loan term financing (LTF) methodology expands the industry standard financing practices, where the optimal solution for the project period is purchased through debt over a given loan term, subject to debt coverage constraints. The amount financed is flexible, and two asset replacement schemas (one that converts replacement to an OPEX term and the other that treats replacement as CAPEX) provide a system with the highest net present value.

Figure 5: Differences between LTF and ETF (ETF at the bottom of the figure). Most importantly the LTF has a concept of project lifetime, which directly influences the design results since DER technology lifetimes should fit into the project horizon. LTF can favor technologies with lower lifetimes if the project lifetime is shorter than the considered DER technology lifetime. Thus, the used financing methodology can directly influence the "optimal" technology portfolio and revenue streams.

However, for the class of Microgrids where such loan terms aren't known, trying to guess these terms can be tedious and lead to a lot of iteration and a large solution space. Also, there is a class of Microgrids which may not require independent financing or don't have a clearly defined project length - 1st party owned and operated Microgrids (since they might just plan to operate forever). For those sites, XENDEE's equipment lifetime financing (ELF) scheme provides a simpler strategy, which is basically an amortized capital cost approach. Under this financing strategy, only the interest rate is needed, as each piece of equipment is amortized over its own lifetime, allowing the optimizer to get an annual equivalent of all considered assets. In this method, a solution which minimizes the annual cost of the system for any unspecified period is provided. This also offers a great feasibility approach, to bring a potential project to a financier to discuss concrete financing terms to drill down with in the LTF model.

Ignoring financing terms, multiyear changes, or accurate system operation will provide a suboptimal system, and leave money on the table. Worse yet, it can lead to projects that violate contractual agreements and produce projects severely in the red. Trying to incorporate such considerations into existing traditional design procedures is not possible, and will lead to convoluted and disjointed design procedures that take months, if not years, due to inefficiencies and iterations between the multiple stages. XENDEE can help here by directly considering all these considerations and providing a fast and reliable solution.