Microgrid Decision Metrics and Cash Flow Models

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GUI Economic Optimization Results

Economic Optimization Results

Project Information – Information about project including name, address, analysis name, date, and optimization equations/variables

Project:	LA Commercial Use Case	Date:	5/8/2020
Address:	Los Angeles, CA, USA	Equations:	269,896
Analysis:	GIS Base Case	Variables:	214,503

HELP

	Total Annual Energy Costs (dollars in thousands)	Total Annual CO_2 Emissions (metric tons)
Reference	$1,057.3	3,477
Investment scenario (incl. annualized capital costs and electricity sales)	$759.4	1,806
Total Savings (%) (incl. annualized capital costs and electricity sales)	28.2 %	48.1 %

Type	Total New Capacity	Technology (New Capacity)
	5.34 MW	PV (5.34 MW)
	714 kWh	ElectricStorage (714 kWh)
	1 MW	Diesel Gen (1 MW)

Result	Value
Interest Rate	5.00 %
OPEX Savings (%)	92.0%
Generation-Based Levelized Cost of Electricity ($ / kWh)	$0.0547
Load-Served Levelized Cost of Electricity ($ / kWh)	$0.0825
Simple Project Break-Even Year	15 years
Detailed Project Break-Even Year	9 years
Simple Project Payback Period	15 years

Economic Optimization Results

Optimal Sizing of Considered Technologies – Considered technologies and optimal new capacity to install.

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High-level Financial Metrics – Important financial metrics used to evaluate project.

- **Total Annual Energy Costs** ($, thousands)
- **Total Annual CO2 Emissions** (metric tons)

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High-level Financial Metrics – Important financial metrics used to evaluate project.

- **Reference** – Values for operating system with no microgrid
- **Investment scenario** – Values for operating system with optimized configuration
- **Total savings** – Comparing the two scenarios

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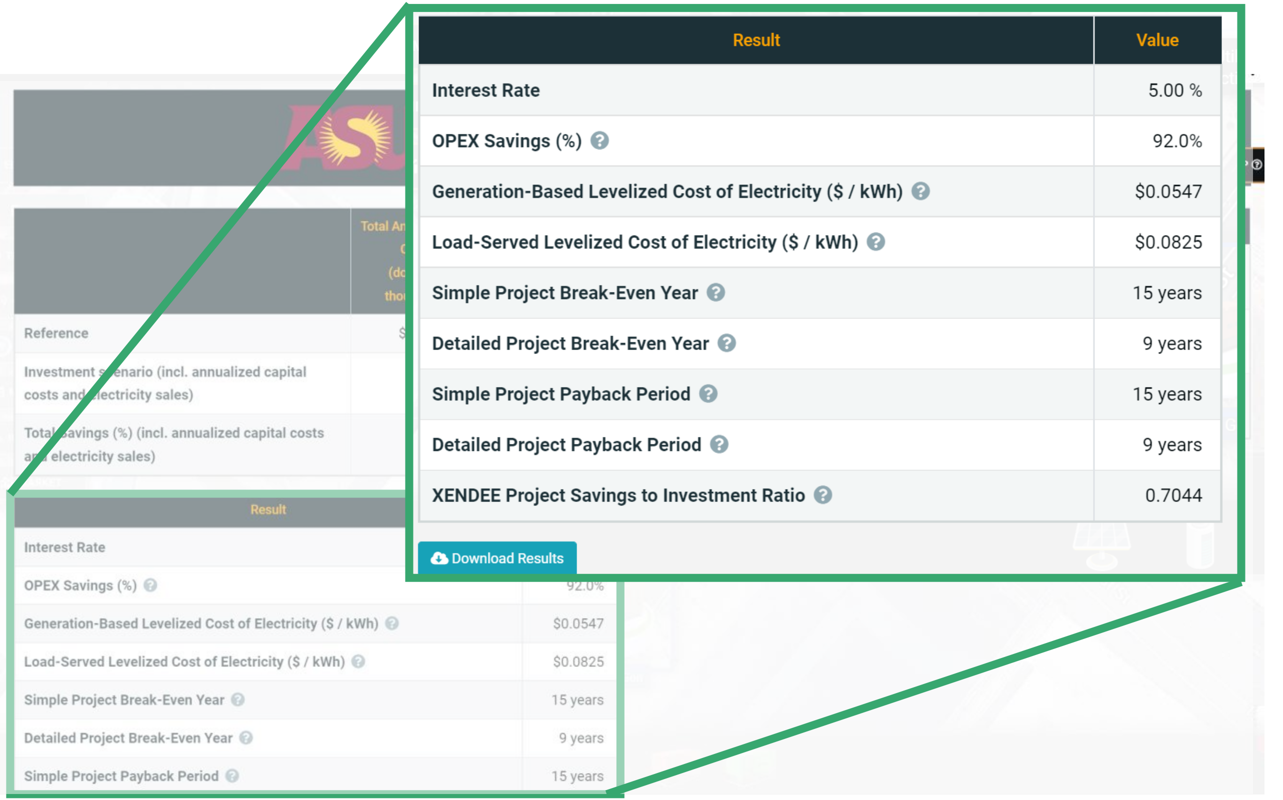
Detailed Financial Metrics – Important financial metrics used to evaluate project.



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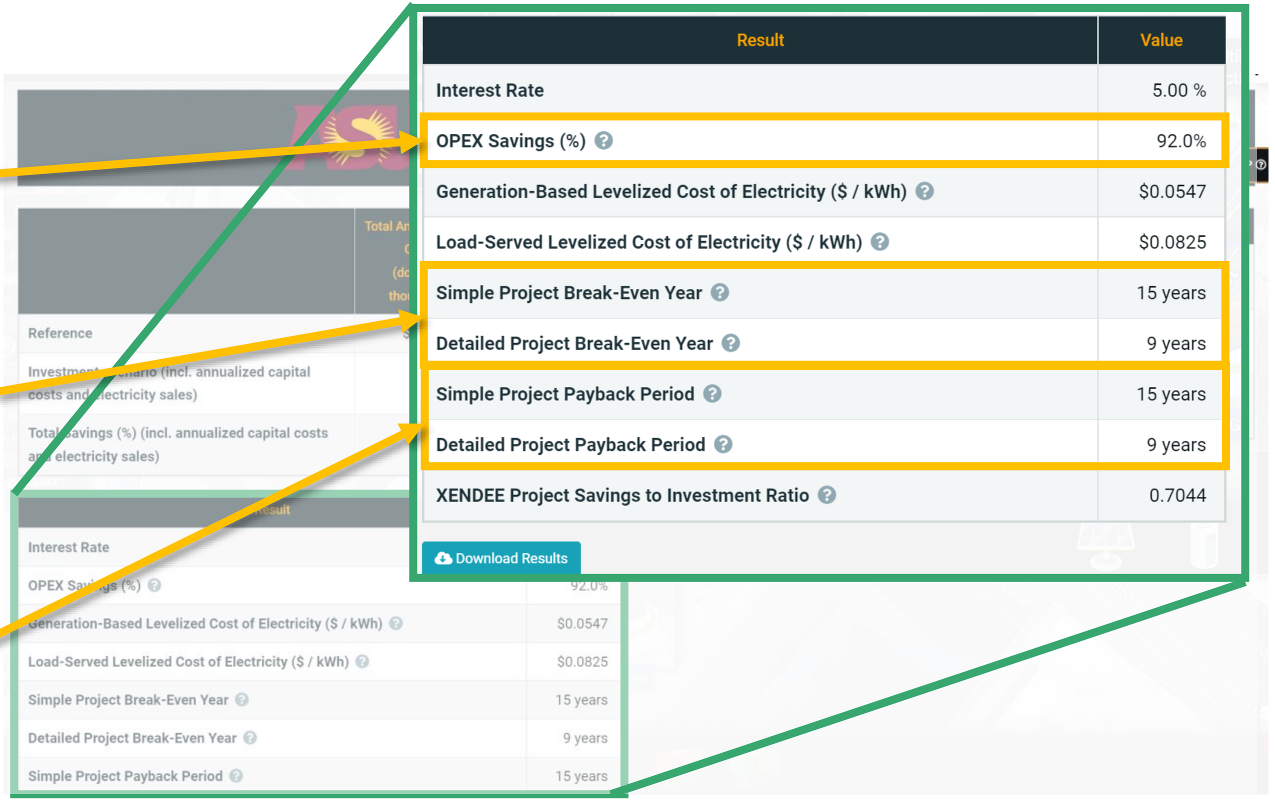
XENDEE Project Savings to Investment Ratio	0.7044

Download Results

Economic Optimization Results

Detailed Financial Metrics – Important financial metrics used to evaluate project.

- **OPEX Savings (%)** – Percentage difference between reference and optimized scenario operational costs
- **Break-Even Years** – The first year in which aggregated savings greater than or equal to all investments
  - Simple: Incentives not included
  - Detailed: Incentives included
- **Project Payback Periods** –
  - Simple: No re-investment costs; no incentives
  - Detailed: Re-investments; incentives included



Economic Optimization Results

Levelized Cost of Energy (LCOE) – The average cost of energy over the system lifetime. Allows comparison of generation technologies with different costs.

Generation-Based LCOE ($/kWh)

$$\frac{Annual\ Cost}{Purchased\ Energy + Generated\ Energy}$$

(from utility) (on-site, from microgrid)

Load-Served LCOE ($/kWh)

$$\frac{Annual\ Cost}{Total\ Electrical\ Load\ Served}$$

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Total savings (%) (incl. annualized capital costs and electricity sales)
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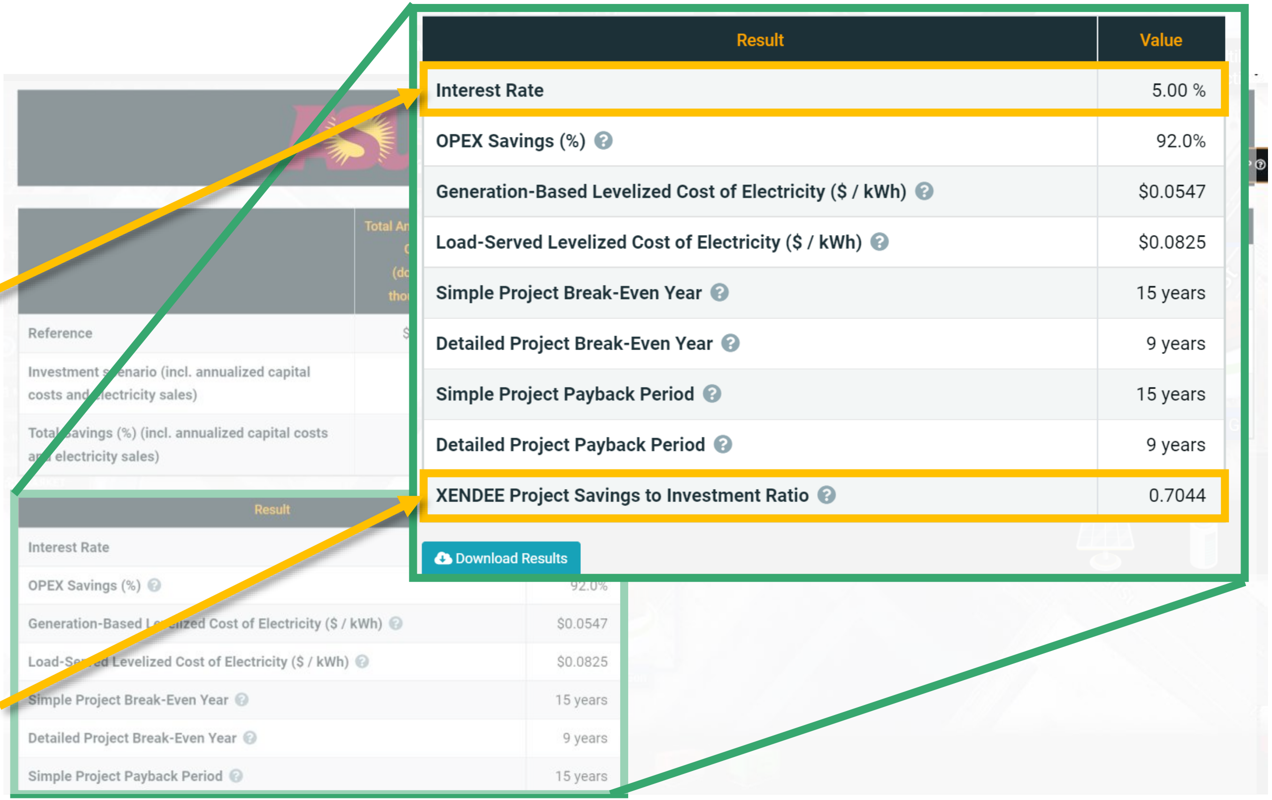
Simple Project Payback Period 15 years

Economic Optimization Results

Detailed Financial Metrics – Important financial metrics used to evaluate project.

- **Interest Rate** – Loan interest rate (user-set in Financing Tab)
- **XENDEE Project Savings to Investment Ratio –** Aggregated investments and average savings up to payback constraint or 20 years



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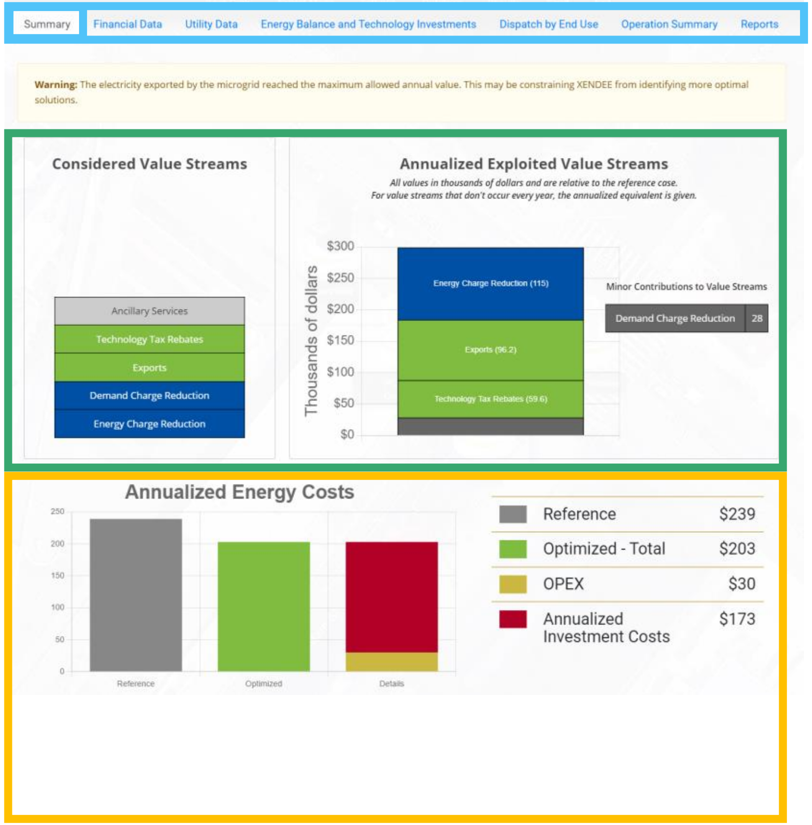
Economic Optimization Results

If we **scroll down** on the Results page, we will find more graphical and tabular data available to us.

- Navigation Tabs – Used to navigate to the financial, investment, and technical results of the report.

Within Summary Tab:

- Value Streams – Breakdown of value streams possible for microgrid with optimized profile.
- Annualized Energy Costs – Average project costs compared to not investing in any technologies over the project duration.

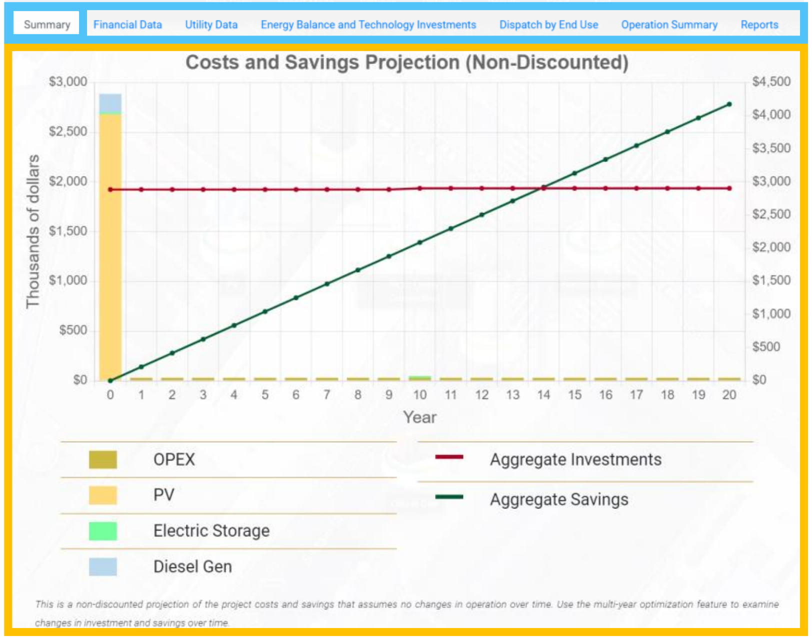


Economic Optimization Results

Within **Summary** Tab:

(scroll down)

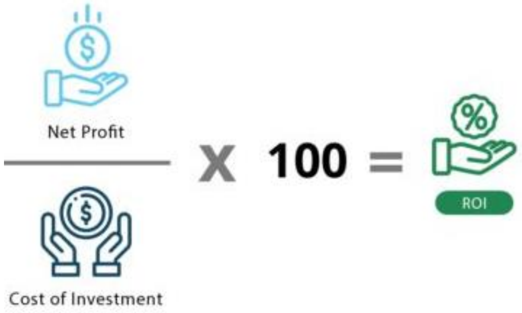
- **Yearly Projections** – Breakdown of the yearly costs and savings over the duration of the project.

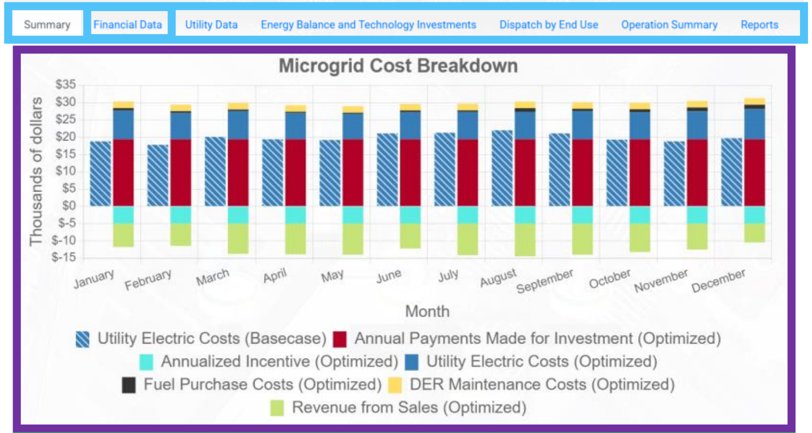


Economic Optimization Results

Within **Financial Data** Tab:

- **Cost Breakdown** – The magnitude and sources of costs of the microgrid project and a comparison to reference case (no microgrid).
- **Return on Investment (ROI)** – The yearly ROI for the optimal microgrid portfolio.





Economic Optimization Results

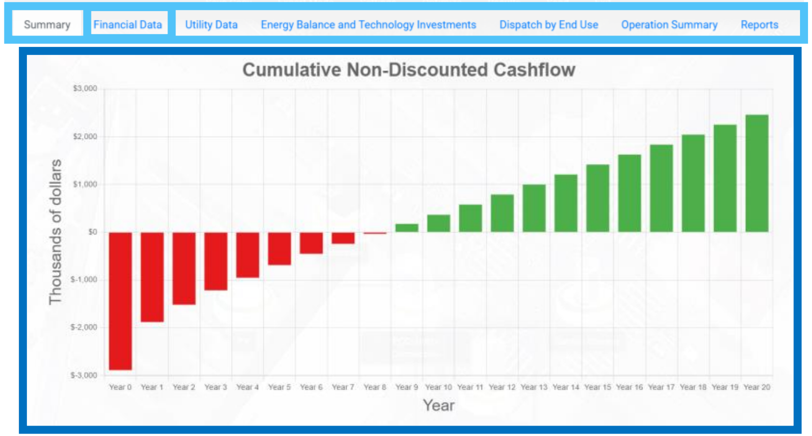
Within **Financial Data** Tab:

(scroll down)

- **Cumulative Non-Discounted Cashflow** – Cashflow without consideration for time value of money.

  Can be projected considering:

  - Upfront Investment
  - Annualized Investment



Economic Optimization Results

Within **Financial Data** Tab:

(scroll down)

Detailed Cash Flow – Expenses and revenue streams for the project duration. This information is also available as downloadable data files.

Detailed Cash Flow

(thousands of dollars)

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Revenue Increase: Electricity Sales	0	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96
Savings: Utility Demand Charges	0	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
Savings: Utility Energy Charges	0	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115
Savings: Fuel Purchase Costs	0	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8
Savings: DER Maintenance Costs	0	-22	-22	-22	-22	-22	-22	-22	-22	-22	-22	-22	-22	-22	-22	-22	-22	-22	-22	-22	-22
Microgrid OPEX Savings	**0**	**209**	**209**	**209**	**209**	**209**	**209**	**209**	**209**	**209**	**209**	**209**	**209**	**209**	**209**	**209**	**209**	**209**	**209**	**209**	**209**
PV	-2,680	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electric Storage	-18	0	0	0	0	0	0	0	0	0	-18	0	0	0	0	0	0	0	0	0	0
Diesel Gen	-188	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total CAPEX	**-2,886**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**-18**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Federal ITC Credit	0	702	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0
Federal MACRS Depreciation	0	96	154	93	56	56	28	0	0	0	0	1	1	1	0	0	0	0	0	0	0
Total Tax Incentives	**0**	**798**	**154**	**93**	**56**	**56**	**28**	**0**	**0**	**0**	**0**	**5**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Net Annual Cash Flow *(Non-discounted)*	**-2,886**	**1,007**	**363**	**301**	**264**	**264**	**236**	**209**	**209**	**209**	**190**	**214**	**210**	**209**	**209**	**209**	**209**	**209**	**209**	**209**	**209**
Cumulative Cash Flow *(Non-discounted)*	**-2,886**	**-1,879**	**-1,517**	**-1,215**	**-951**	**-687**	**-450**	**-242**	**-33**	**176**	**366**	**580**	**790**	**999**	**1,209**	**1,418**	**1,627**	**1,835**	**2,044**	**2,253**	**2,461**

Economic Optimization Results

Within **Utility Data** Tab:

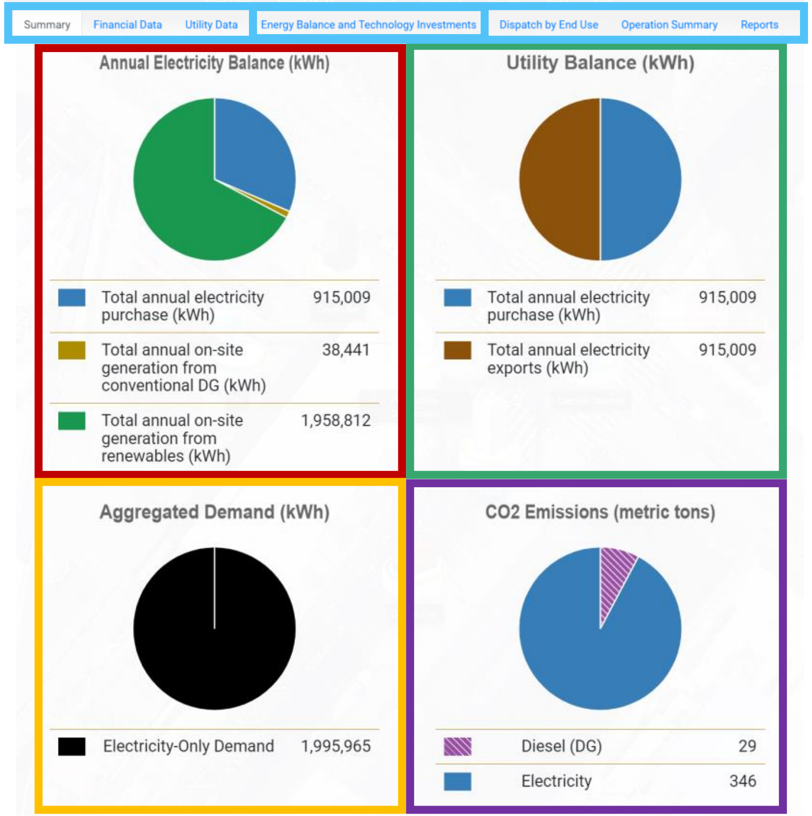
(scroll down)

- **Monthly Breakdown** – The consumer demand, energy consumption, and utility charge per month.
- **Annual Charges** – The energy, demand, and fuel charges.

Economic Optimization Results

Within **Energy Balance and Technology Investments** Tab:

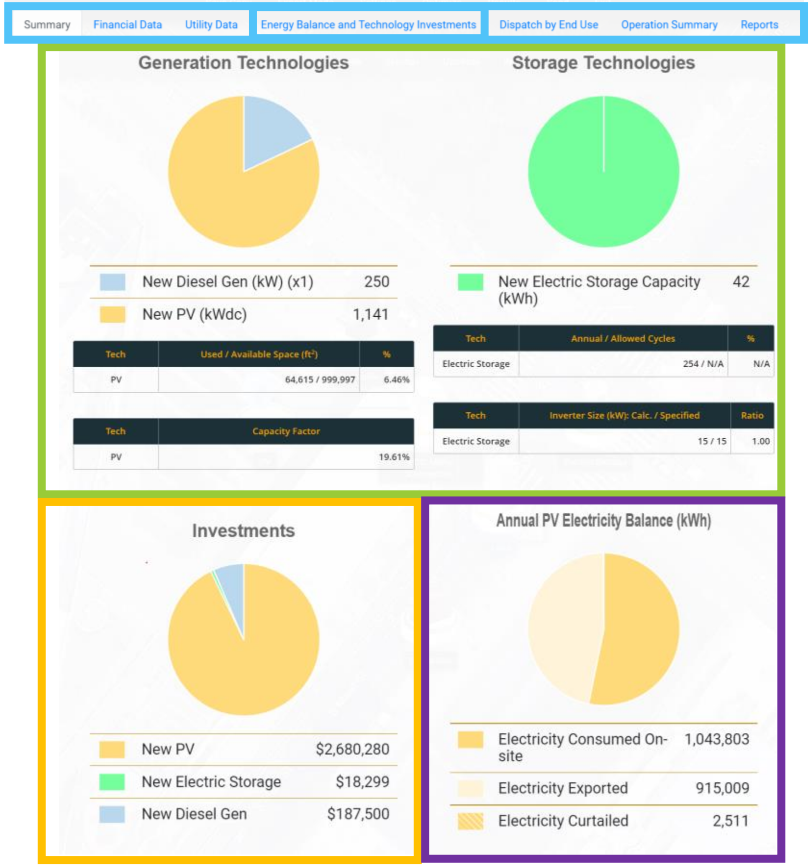
- **Annual Electricity Balance** – The distribution of electrical energy purchased from the utility, sold to the utility, and produced on-site.
- **Utility Balance** – Balance of interactions with the utility.
- **Aggregated Demand** – Aggregated Demand (will have other colors if heating or cooling loads included in model).
- **CO2 Emissions** – Carbon emissions by source.



Economic Optimization Results

Within **Energy Balance and Technology Investments** Tab:

- **Microgrid Portfolio** – The power capacity of the generation technologies and the energy capacity of the battery storage technologies.
- **Investments**– The investment cost of the generation and battery storage technologies.
- **Annual PV Electricity Balance** – Balance of PV and how much was consumed, exported, and curtailed.

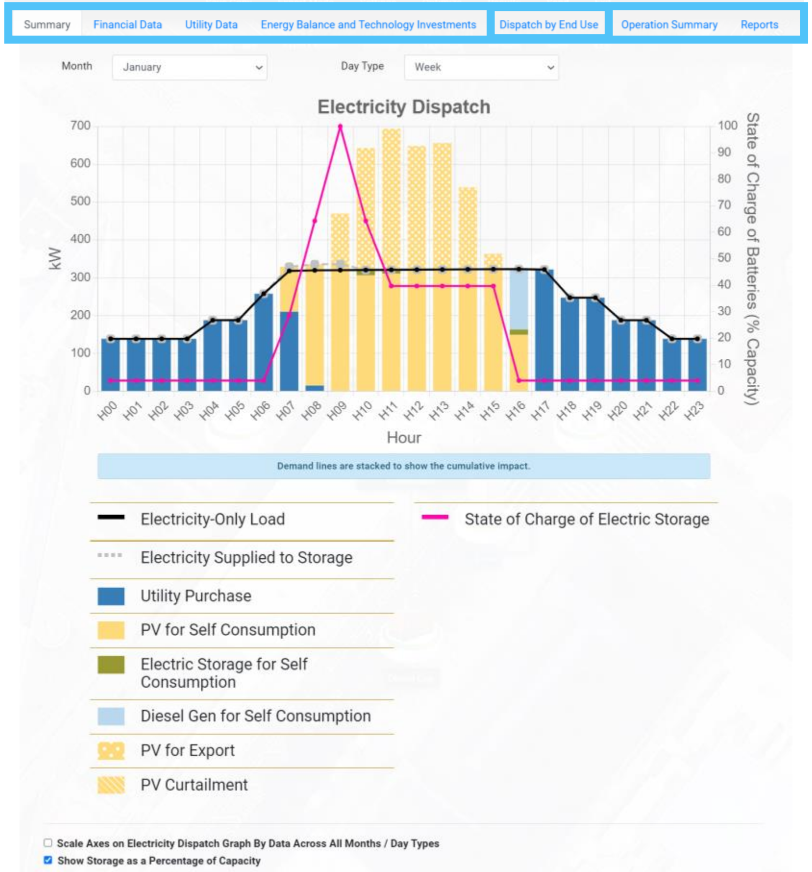


Economic Optimization Results

Within **Dispatch by Energy Use** Tab:

The **optimal electricity dispatch** of all installed technologies to reduce operating expenses and lifetime project costs.
(Heating and cooling dispatch will also show if heating/cooling loads included in model)

Weekdays, **weekends**, and **peak days can be viewed** for each month of the year to understand operational behavior of microgrid with respect to environmental conditions, load profiles, and utility tariffs.



Economic Optimization Results

Within **Operation Summary** Tab:

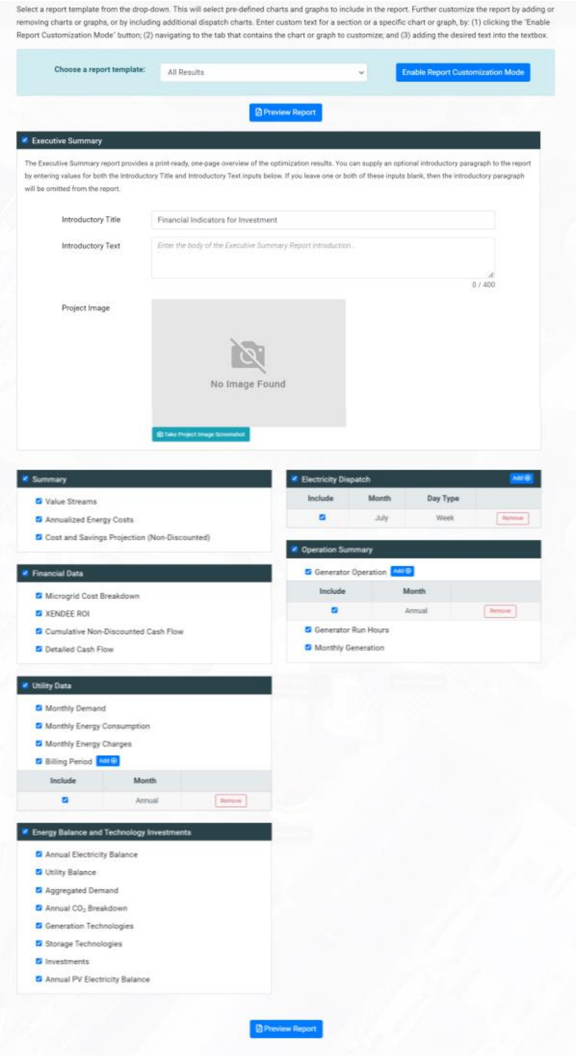
Operation summaries for **each generation type**.

Economic Optimization Results

Within **Reports** Tab:

The **executive report** provides a one-page overview of the optimization results.

The **report data can be customized** to include energy balance and technology investments as well as financial, utility, and operational data.



Cash Flow Models

Summary of Costs

- **Initial Cost** – Capital cost for procurement, installation, and system setup
  - Infrastructure
  - Land
  - Soft cost (e.g. engineering and design)
  - Asset procurement
  - Balance of system
- **Ongoing Cost** – Regular and reoccurring costs of the system including maintenance, labor, fuel, and replacement
  - Operations
  - Maintenance
  - Asset replacement
- **Financing Cost** – The cost, interest, and other charges involved in the borrowing of money to build or purchase assets

Summary of Cost Savings and Revenue

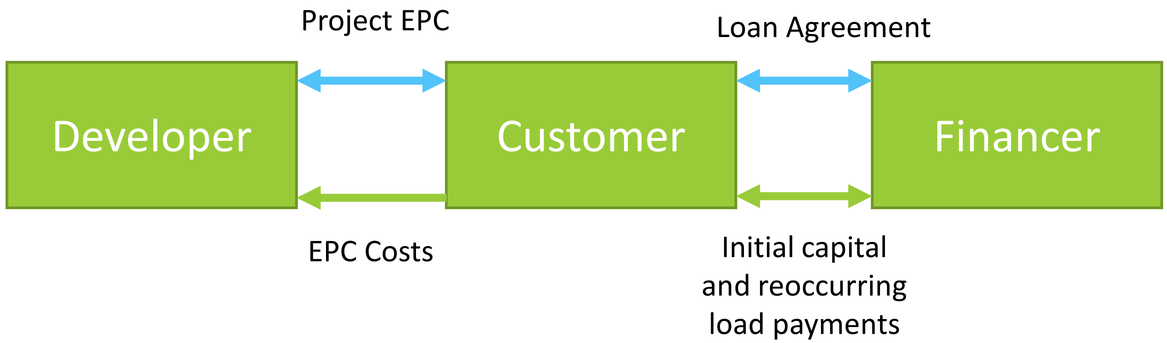
- **Energy Charges** – Utility bill savings related to reduced energy purchases ($/kWh)
- **Demand Charges** – Utility bill savings related to reduced monthly max power demand ($/kW)
- **Avoided Infrastructure Costs** – Reduced distribution network infrastructure needed to serve additional loads and improve resilience resulting from distributed placement of microgrid assets
- **Fuel Costs** – Reduced fuel costs resulting from the addition of renewable generation sources
- **Retail Energy Sale** – Monetary or credit-based revenue obtained through selling energy to utility/energy provider through net metering, feed-in tariff, or similar program
- **Wholesale Market Participation** – Revenue obtained through selling energy, capacity, and/or ancillary services through wholesale markets

Contractual Formats

Purchase or Debt Finance (Loan)

Purchase/Loan Cashflow

Customers can use cash-on-hand or borrow money from financing entities to pay for energy systems/solutions. A developer contracts and commissions the systems, and the customer is responsible for operation and maintenance



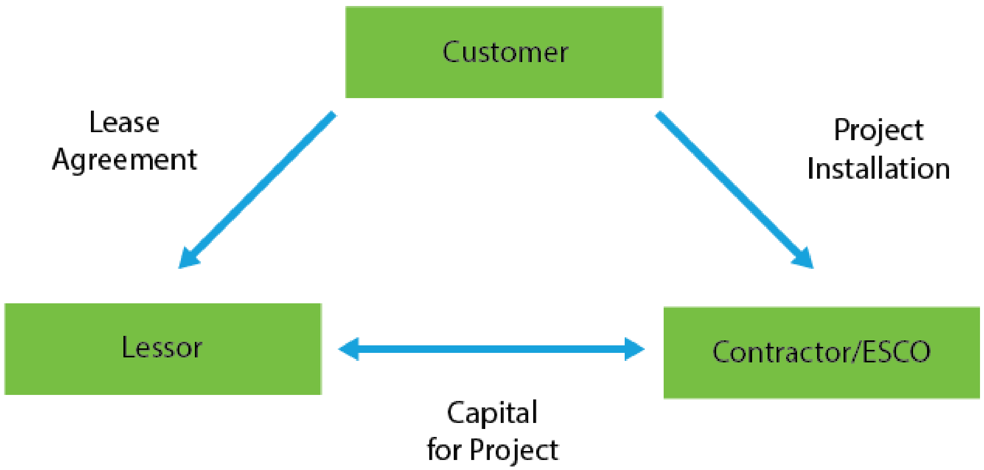
Common Loan Structure

		Commercial Loan	Below-Market Loan
BASIC ATTRIBUTES	Project Types	Energy Efficiency, Renewable Energy, Other Generation	Energy Efficiency, Renewable Energy, Other Generation
	Applicable Sectors	All	Common: Affordable Multifamily, Non-profit, Private Universities/Schools/Hospitals Less common: Government Uncommon: Commercial & Industrial, Multifamily
	Geographic Scope	Nationwide	Nationwide
	Building Ownership	Owned or leased	Owned or leased
	Typical Project Size	Any	Any
CONTRACT STRUCTURE	Contract Complexity	Low	Medium; depends on program requirements
	Parties Involved	Customer, Lender	Customer, Lender
	Payment Type	Typically fixed, but sometimes with flexibility for variable payments	Fixed
	Performance Risk	Borne by customer	Borne by customer
TAX & BALANCE SHEET	Budget Source	Capex	Capex
	Balance Sheet Treatment	On balance sheet	On balance sheet
	Tax Deductions	Depreciation, Interest	Depreciation, Interest
	Equipment Ownership	Internal	Internal
	Collateral Source	Sometimes just equipment (non-recourse loan); sometimes mortgage or other assets in addition to equipment (recourse loan)	Equipment
CONTRACT TERMS	Typical Duration	Often 3-5 years, but flexible	Often 3-5 years, but flexible
	Typical Close Time	Short (1-3 months)	Short (1-3 months)
MARKET ATTRIBUTES	Market Size	Very large	Very large
	Time in Market	Since ~2000 BCE	Since ~2000 BCE

Lease Cashflow

A lease allows a customer to **avoid upfront capital costs** required when purchasing or down payment requirements when financing. Equipment can be customer-owned and operated in capital leases or can have a **third-party owner** and operated in operating leases

Typical Lease Financing Structure



Purchase/Loan Stakeholders and Responsibilities

- **Customer** – Owns equipment and is responsible for operations and maintenance
- **Developer/Integrator** – Engineering, procurement, and construction of energy systems
- **Financing** – Contracting and financing (if needed)
- **Operator** – Ensures proper operation of the system (can be customer responsibility or contracted externally)
- **Technician** – Maintains equipment after installation (can be customer responsibility or contracted externally)
- **Electric Utility** – Approves interconnection of the energy system. Supplies customers with power in the event of energy system failure or inadequate generation to meet local loads. It can also offtake excess local generation and directly compensate customers through net metering or similar mechanisms

Debt Financing Agreements

Loans can be secured if a customer does not have enough cash on hand to fully fund a project. Key terms that can affect the economics of a project include:

- **Loan term** – Duration of time that loan will be fully repaid
- **Interest rate** – Proportion of the amount that the financer charges to borrow capital. Commonly expressed as an annual percentage
- **Down payment** – Initial payment by the customer to the financer. Typically, a larger percentage of the total loan (3-25%) than future reoccurring payments
- **Creditworthiness** – Measure of risk that a customer will default on a loan. Typically depends on credit history and other current debts
- **Secured** – Loan uses physical assets as collateral in the event of customer default

Non-Traditional Loan Programs

Special loan programs are available for customers with specific socioeconomic standings, projects that address societal goals, and/or bad creditworthiness. These programs include:

- **State and Local** – Often available for projects that address energy efficiency and clean energy goals. Can provide lower interest rates and/or lower down payment requirements
- **Community Development Financial Institutions (CDFI)** – Provide loans and financial services to disadvantaged communities
- **Grants** – A direct donation (not considered loan/debt) to a customer by a state, federal, or private entity. Some grants have repayable terms in which a customer must pay back the "donation" but with little to no interest

Purchase/Loan Metrics

For Customers:
LCOE, ROI, IRR

Levelized Cost of Energy (LCOE) – The average cost of useful energy over the system lifetime.

$$LCOE = \frac{\sum_{t=0}^{n} \frac{C_t}{(1+i)^t}}{\sum_{t=0}^{n} \frac{E_t}{(1+i)^t}}$$

$t =$ time, $n =$ lifetime of system
C_t = net cash flow in year t
E_t = useful energy provided in year t
i = discount rate

Return on Investment (ROI) – Measures the gain or loss generated on an investment relative to the amount of money invested.

$$ROI = \sum_{t=0}^{N} \frac{C_t}{I_t} \times 100$$

$t =$ time, $N =$ number of periods
C_t = net cash flow at time t
I_t = total investment at time t

Internal Rate of Return (IRR) – A metric describing the profitability of an investment. Calculated by setting the NPV equal to zero and solving for the discount rate.

$$\sum_{t=0}^{N} \frac{C_t}{(1+IRR)^t} - C_0 = 0$$

t = time, N = number of periods
C_t = net cash flow at time t
IRR = internal rate of return
C_0 = total initial investment costs

How to Compare Loan Options?

- **Annual Percentage Rate (APR)**
  - It means the total cost of interest
- **Fees or additional cost**
  - Banks or financial institutions can charge additional fees
- **Length of the loan (term)**
  - This is the time that it will take to pay the loan
- **Monthly payment**
  - It will be calculated depending on the APR, fees, and the term of the loan

Purchase/Loan Pros and Cons

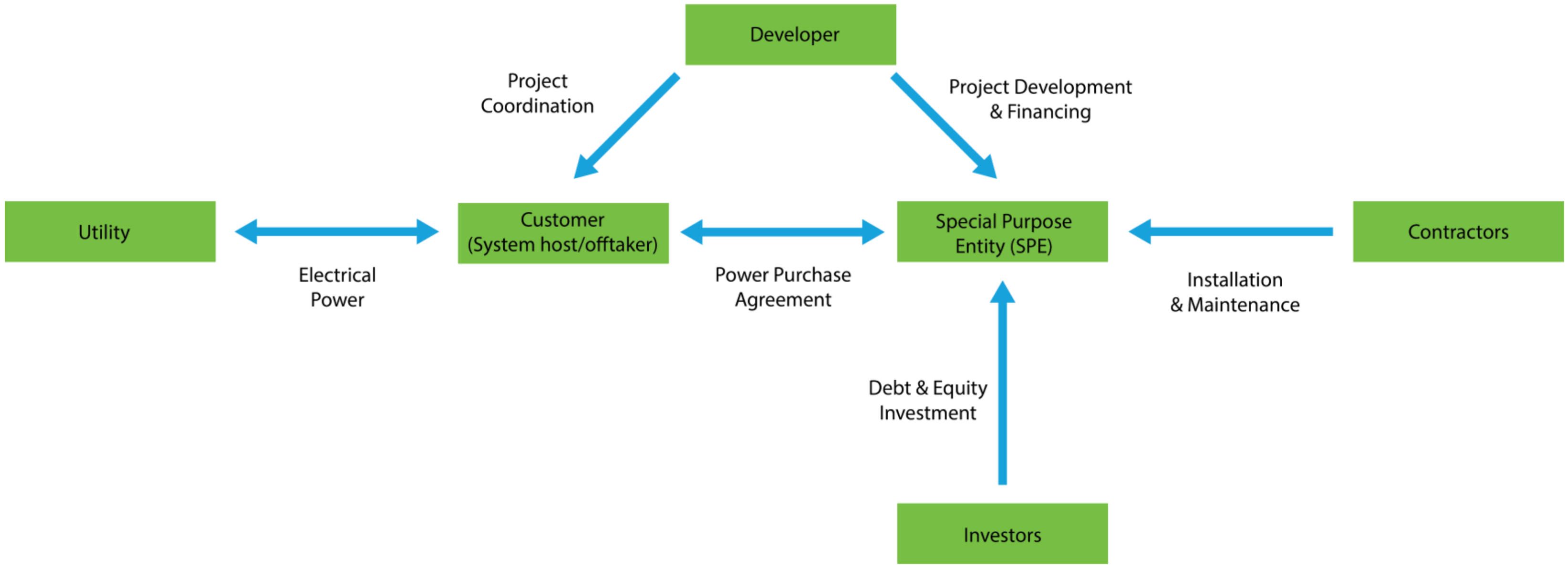
Pros	Cons
✓ Loans are common and relatively simple ✓ Purchase avoids additional financing costs and complex contracts ✓ One loan can finance very large or multiple projects, which reduces overhead	× Bad creditworthiness can result in undesirable loan terms or ineligibility × Large down payment requirements can result in undesirable cashflows × Customer is fully responsible for operating and maintaining the system and has no performance guarantees

Power Purchase Agreement (PPA)

PPA

A **Power Purchase Agreement (PPA)** is an agreement that a third-party developer installs, owns, and operates an energy system and a customer purchases the power produced for a **predetermined $/kWh and time**

Power Purchase Agreement Structure



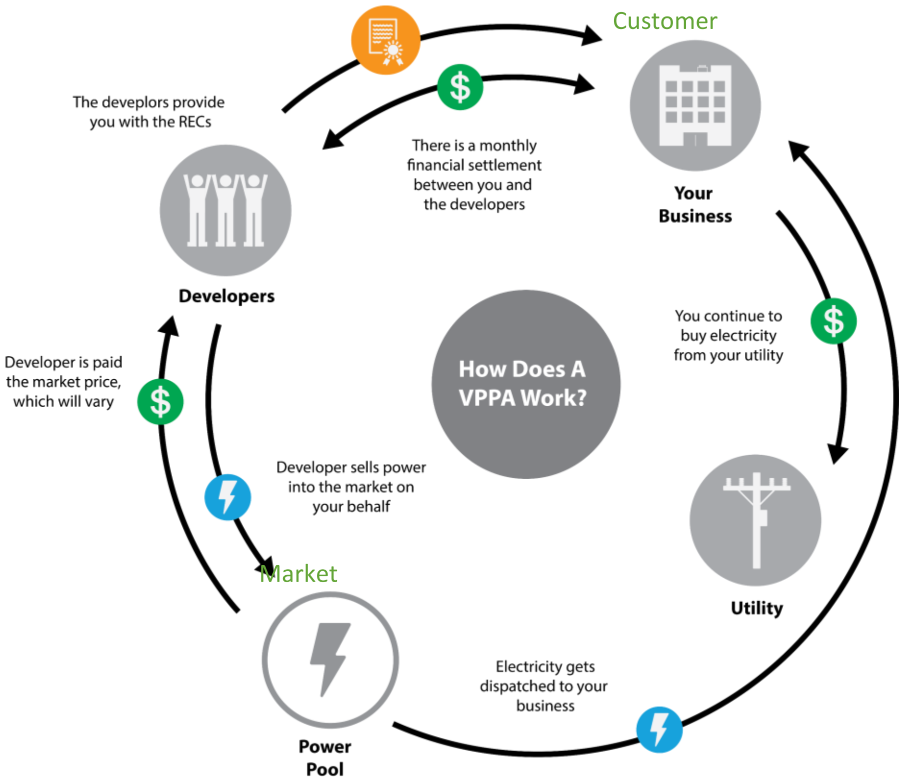
PPA Stakeholders and Responsibilities

- **Customer** – Purchases and offtakes power and renewable energy credits (RECs). It can also be the host of the system if the land is not leased
- **Developer** – Own equipment and often set up a separate entity to reduce risk exposure for the developer and customer
- **Special Purpose Entity (SPE)** – Serves as the legal owner of the energy system and enables outside debt and equity investments
- **Contractors/Integrators** – Procurement and construction of energy system
- **Investors/Financiers** – Debt and equity investments enable joint ownership of SPE to receive a return on investment
- **Electric Utility** – Approves interconnection of energy system. Supplies customers with power in the event of failure of energy system or generation is inadequate to meet local loads. Can also offtake excess local generation and directly compensate customers through net metering or a similar mechanism

Types of PPAs

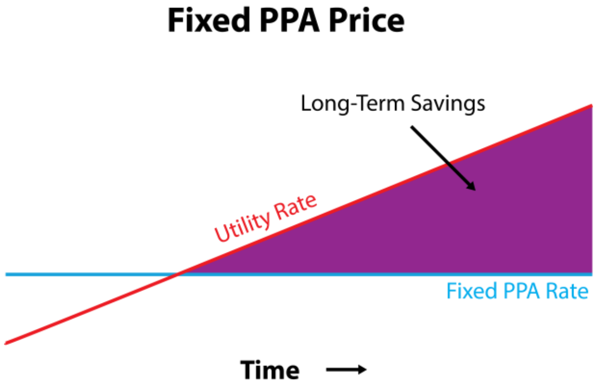
- **Traditional/Onsite** – The energy system is installed at the customer's site or in proximity that allows for direct electrical interconnection

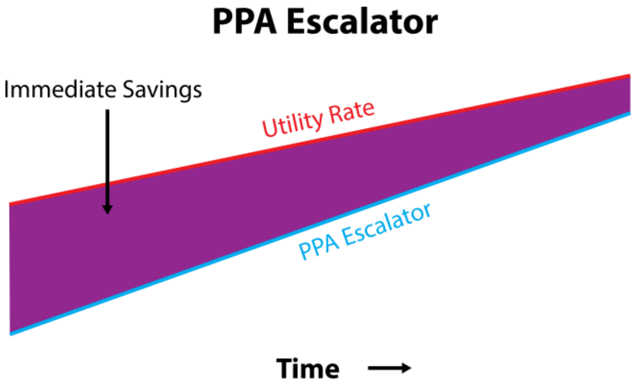
- **Virtual/Offsite** – The energy system is installed offsite, and power production is directly sold to the wholesale market
    - Customer still pays the developer/SPE a fixed $/kWh (strike price) but receives revenue if the wholesale price is greater than the strike price



Escalators

- PPAs enable customers to **de-risk their operational energy expenses** by locking in predefined rates for a predetermined period. This allows for more accurate long-term planning and accounting
- The **first-year rate ($/kWh)** is often less than what the customer pays for power from the utility
- **Yearly escalators** (1-5%) are used to increase the $/kWh that a customer pays
- If utility rates go down or increase at a slower rate than the predefined PPA escalator, **then a customer may end up paying more for power** than directly buying from the utility





Cost Savings and Revenue

- **Customers**
  - Cost savings - **Reduced utility bills** and **lower energy costs** if the PPA rate stays below the utility rate over the term of the PPA
  - Revenue - Can **sell RECs or excess energy produced** by the system

- **Contractors/Integrators**
  - Revenue - **Construction** of the energy system

- **Developers**
  - Revenue - **Selling energy to customers**. This revenue is shared with investors/financers

- **Utilities**
  - Revenue - If the energy system cannot supply 100% of customers' energy needs, **utilities supplement with grid energy**

PPA Metrics

For Customers: LCOE and annual energy expenditure savings	**Levelized Cost of Energy (LCOE)** – The average cost of useful energy over the system lifetime.
For Developers/ Investors: ROI and IRR	**Return on Investment (ROI)** – Measures the gain or loss generated on an investment relative to the amount of money invested. **Internal Rate of Return (IRR)** – A metric describing the profitability of an investment. Calculated by setting the NPV equal to zero and solving for the discount rate.

Levelized Cost of Energy (LCOE) – The average cost of useful energy over the system lifetime.

$$LCOE = \frac{\sum_{t=0}^{n} \frac{C_t}{(1+i)^t}}{\sum_{t=0}^{n} \frac{E_t}{(1+i)^t}}$$

$t =$ time, $n =$ lifetime of system
C_t = net cash flow in year t
E_t = useful energy provided in year t
i = discount rate

Return on Investment (ROI) – Measures the gain or loss generated on an investment relative to the amount of money invested.

$$ROI = \sum_{t=0}^{N} \frac{C_t}{I_t} \times 100$$

$t =$ time, $N =$ number of periods
C_t = net cash flow at time t
I_t= total investment at time t

Internal Rate of Return (IRR) – A metric describing the profitability of an investment. Calculated by setting the NPV equal to zero and solving for the discount rate.

$$\sum_{t=0}^{N} \frac{C_t}{(1+IRR)^t} - C_0 = 0$$

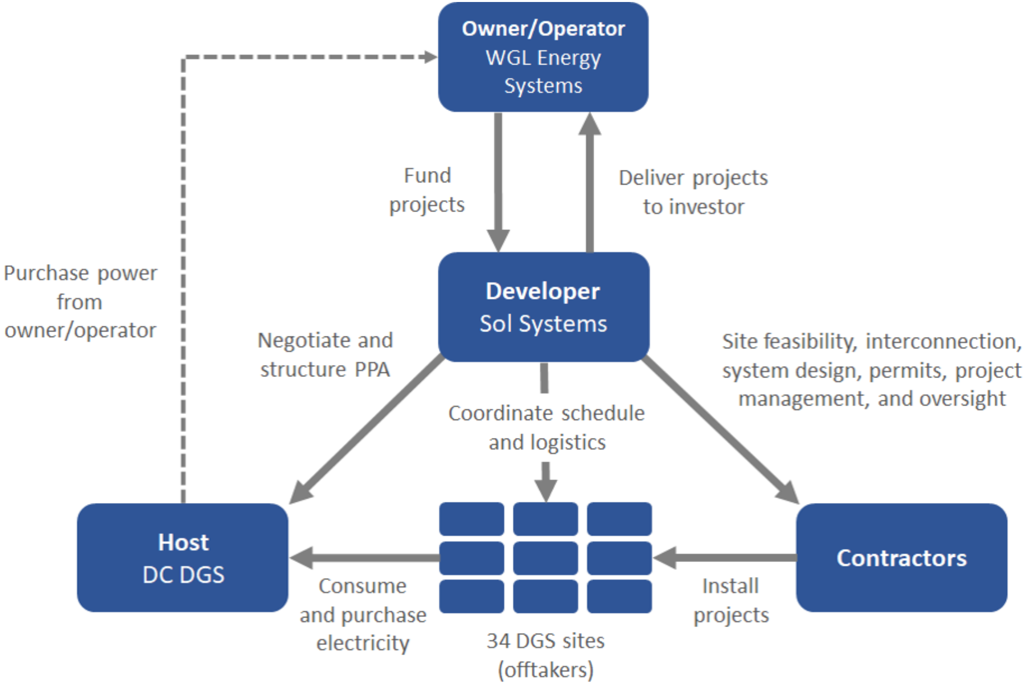
t = time, N= number of periods
C_t = net cash flow at time t
IRR = internal rate of return
C_0 = total initial investment costs

PPA Pros and Cons

Pros	Cons
✓ Positive customer cash flow ✓ Customer avoids construction, operation, and maintenance burden ✓ Structured to be an operating expense for customers ✓ De-risk future energy purchases by locking in $/kWh price for customers	✗ Customer may pay more than utility $/kWh if escalator outpaces market ✗ Higher transaction costs and complicated contracts compared to purchase ✗ Not all site locations allow for PPA or enact stringent barriers

PPA Example

- **District of Columbia Department of General Services (DGS)** implemented a large portfolio of solar projects
- Timeline: 12 months
- DC DGS engaged **Sol Systems as a developer (and finance)**
- Sol Systems engaged **WGL Energy Systems as an equipment owner (investor)**
- DGS purchases power generated at a reduced rate with no upfront cost

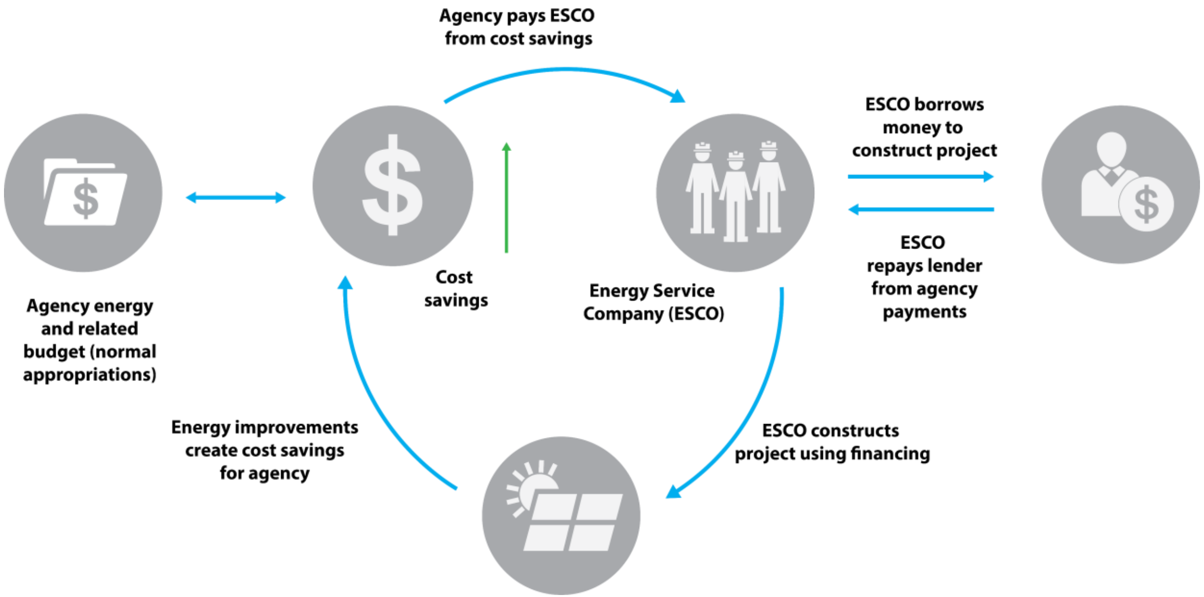


Source: https://betterbuildingssolutioncenter.energy.gov/implementation-models/dc-department-general-services-develops-solar-project-using-a-power-purchase

Energy Service Company (ESCO)

ESCO

An **Energy Service Company (ESCO)** is a company that offers energy services and could act as project developer to integrate design, financing, procurement, installation and O&M, focused on energy savings, retrofitting and energy efficiency



ESPC Stakeholders and Responsibilities

- **Customer** – Equipment is installed on the customer's site. Pays ESCO through realized energy savings

- **ESCO** – Installs and maintains equipment. Revenue generated through cost savings

- **Financers** – Direct financing to customer or ESCO. Repaid at a predetermined rate over the life loan

- **Electric Utility** – Approves interconnection of energy system. Supplies customers with power in the event of failure of energy system or generation is inadequate to meet local loads. Can also offtake excess local generation and directly compensate customers through net metering or a similar mechanism

Types of ESCO

- **Energy Performance Contract (EPC)** – The ESCO builds, owns, and operates the system and sells the energy savings or energy to the customer

- **Energy Service Agreement (ESA)** – The ESCO guarantees a level of energy savings and receives a share or percentage of the savings as a payment

- **Chauffage Contract** – (comfort contracting): The ESCO is responsible for different services like lighting, space heating, and others. This provides a high level of energy management outsourcing

Energy Savings Performance Contract (ESPC) Process

Ideation
Customer identifies and decides to use an ESPC for an energy project.

RFP
Customer develops a Request for Proposals (RFP). ESCO provide proposals that are evaluated and then chosen to move to next step.

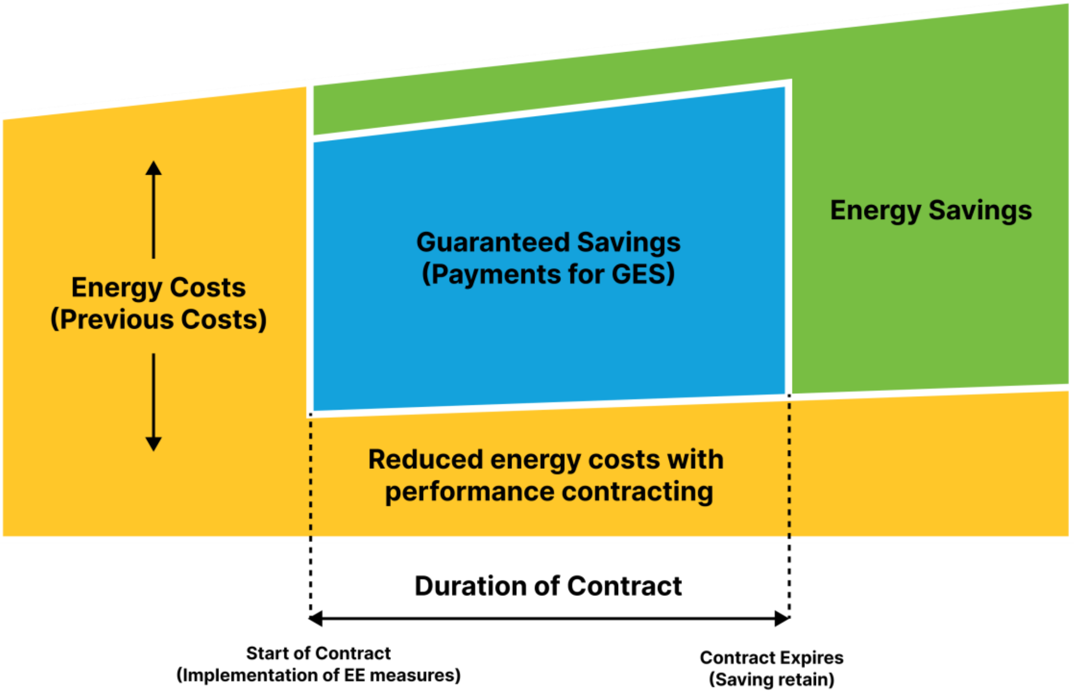
Audit and Contract
Customer issues contract to ESCO to conduct audit and develop a detailed implementation plan/proposal.

Financing
Customer and ESCO finalize contract and arrange for financing

Implementation
Energy system is installed and monitored to quantify energy savings

Shared and Guaranteed Savings

- Yellow region – A customer's direct energy cost
- Blue region – Guaranteed savings that are used to pay the ESCO over the duration of the ESPC
- Green region – Additional savings for the customer during and after the ESPC



Cost Savings and Revenue

- **Customers**
  - Cost savings: **Reduced utility bills**
- **ESCOs**
  - Revenue: **From customers** through their cost savings
- **Financers**
  - Revenue: **From payments** used to finance the capital cost of the installed energy equipment
- **Utilities**
  - Revenue: **Energy purchases** that ESPC is not intended to reduce or remove

ESCO Metrics

For Customers: Annual energy expenditure savings

Annual Energy Savings – Yearly savings attributed to entering the ESPC contract.

$$Savings = EC_b - EC_a$$

EC_b = annual energy costs before ESPC contract and commissioning.
EC_a = annual energy costs after ESPC contract and commissioning.

For Developers/ Investors: ROI and IRR

Return on Investment (ROI) – Measures the gain or loss generated on an investment relative to the amount of money invested.

$$ROI = \sum_{t=0}^{N} \frac{C_t}{I_t} \times 100$$

$t =$ time, $N =$ number of periods
C_t = net cash flow at time t
I_t = total investment at time t

Internal Rate of Return (IRR) – A metric describing the profitability of an investment. Calculated by setting the NPV equal to zero and solving for the discount rate.

$$\sum_{t=0}^{N} \frac{C_t}{(1 + IRR)^t} - C_0 = 0$$

t = time, N = number of periods
C_t = net cash flow at time t
IRR = internal rate of return
C_0 = total initial investment costs

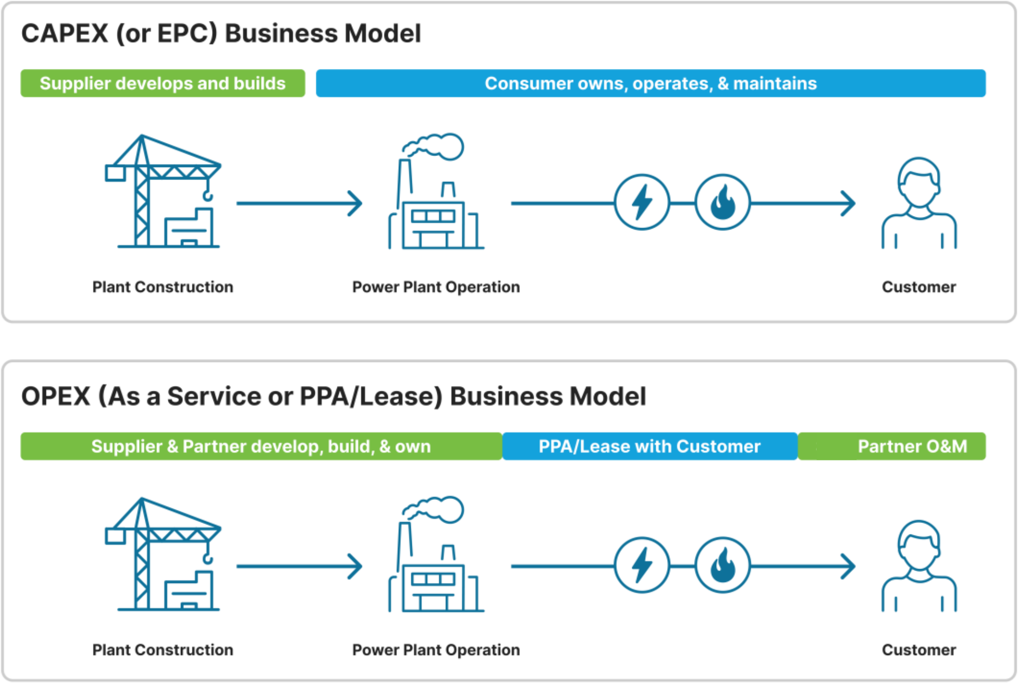
ESCO Pros and Cons

Pros	Cons
✓ Reduced project risk for customer due to performance guarantees ✓ Customer avoids construction, and O&M ✓ ESCOs are widely available in the market and have a standard process ✓ Can pair multiple energy solutions for multiple sites under one contracting mechanism (super ESCOs)	× Contracting and closing is time-intensive and costly × If customer does not own property, contracting and release of ownership of equipment is complicated × Additional overhead cost compared to outright purchase often makes smaller projects inviable

Energy as a Service (EaaS) or Microgrid as a Service (Maas)

EaaS

EaaS **shift the risk of projects** from **customers to developers and owners**. EaaS is a similar model to PPA but instead of buying kWh and receiving RECs, the energy solution is customized to a customer's goals (i.e. resilience, environmental, etc.)



EaaS Stakeholders and Responsibilities

- **Customer** – Hosts energy system and provides reoccurring payments to EaaS entity
- **EaaS Entity** – Owns, operates and maintains system
- **Contractors/Integrators** – Procurement and construction of energy system. Can be the EaaS Entity
- **Investors/Financiers** – Provides financing to EaaS entity and contractors for construction and operation of energy system
- **Electric Utility** – Approves interconnection of energy system. Supplies customers with power in the event of failure of energy system or generation is inadequate to meet local loads. Can also offtake excess local generation and directly compensate customers through net metering or a similar mechanism

Cost Savings and Revenue

- **Customers**
  - Cost savings: Reduced energy expenditures
- **EaaS Entity (or customers, depending on the contract)**
  - Revenue: Sell RECs, excess energy produced by the system, and energy services to customers
- **Contractors/Integrators**
  - Revenue: Construction of the energy system
- **Investors/Financers**
  - Revenue: Interest from loans and return from EaaS revenue
- **Utilities**
  - Revenue: If energy system can not supply 100% of customers energy needs, utilities supplement with grid energy

EaaS Metrics

For Customers: LCOE, SAIDI, SAIFI

Levelized Cost of Energy (LCOE) – The average cost of useful energy over the system lifetime.

$$LCOE = \frac{\sum_{t=0}^{n} \frac{C_t}{(1+i)^t}}{\sum_{t=0}^{n} \frac{E_t}{(1+i)^t}}$$

$t =$ time, $n =$ lifetime of system
C_t = net cash flow in year t
E_t = useful energy provided in year t
i = discount rate

$$\textbf{SAIDI} = \frac{\text{total duration of sustained customer interruptions } (\geq 5 \text{ min each})}{\text{number of customers served}}$$

$$\textbf{SAIFI} = \frac{\text{frequency of sustained customer interruptions } (\geq 5 \text{ min each})}{\text{number of customers served}}$$

For EaaS Entities: IRR

Internal Rate of Return (IRR) – A metric describing the profitability of an investment. Calculated by setting the NPV equal to zero and solving for the discount rate.

$$\sum_{t=0}^{N} \frac{C_t}{(1+IRR)^t} - C_0 = 0$$

t = time, N = number of periods
C_t = net cash flow at time t
IRR = internal rate of return
C_0 = total initial investment costs

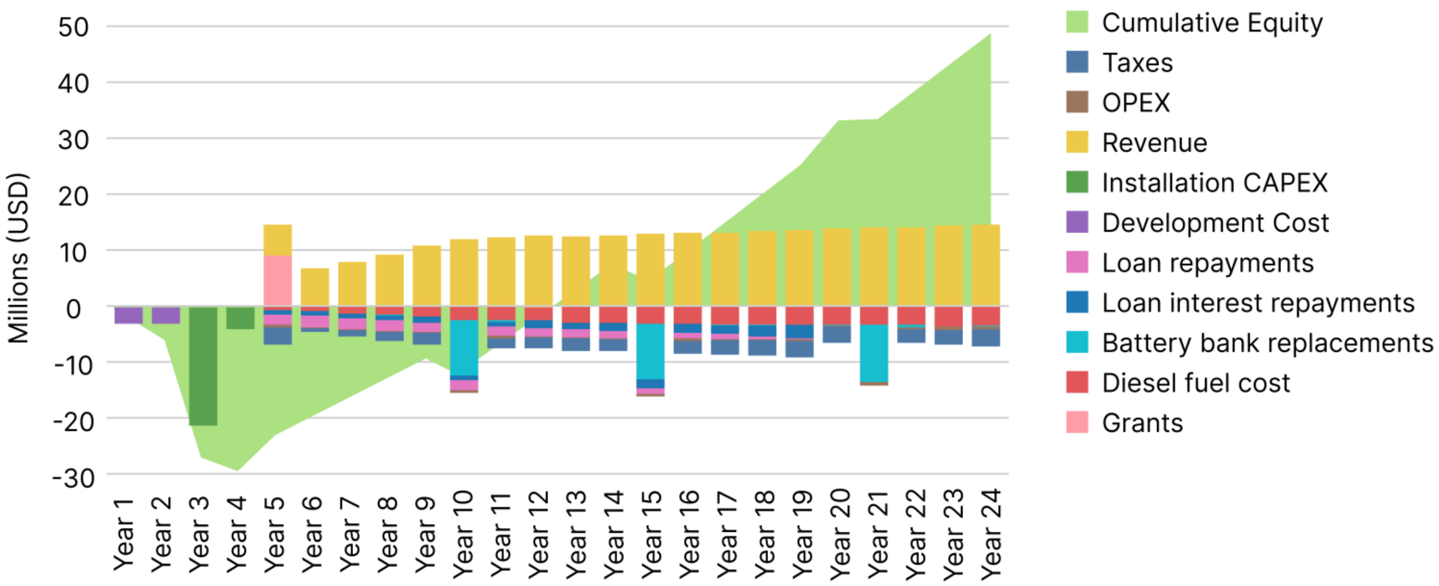
EaaS Pros and Cons

Pros	Cons
✓ Customer avoids construction, and O&M ✓ Structured to be an operating expense for customer aligning with utility budgets ✓ Customer can achieve energy goals without owning energy system ✓ Inclusion of performance guarantees reduces risk for customers	× Higher transaction costs and complicated contracts compared to purchase options × Customer may pay more than utility $/kWh if goals are reliability and resilience

Cash Flow Over a Project Lifecycle

Typical Cash Flow

The cash flow will vary depending on the contracting mechanism, tax structures, financial incentives, etc



Financial Viability

- **Size** – the system should be large enough to be viable
- **Proven technology** – new or unproven technologies will imply higher risks
- **Regulatory framework** – markets with favorable regulations are preferable
- **Banking structure** – project finance and financial mechanisms
- **Risk analysis** – consider historical energy use/cost, due diligence
- **Bankability** – verify that the projects meet investors' criteria