DISCUSSION DRAFT FOR REVIEW ONLY

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Techno-Economic Analysis of Solar Photovoltaics and Battery Energy Storage at two Auto Parts Manufacturing Facilities in Mexico

Kathleen Krah, Jonathan Morgenstein

September 2023

allotrope PARTNERS

WORLD RESOURCES INSTITUTE

NREL NATIONAL RENEWABLE ENERGY LABORATORY

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Analysis Overview

The **Clean Energy Innovation Accelerator (CEIA)** used the National Renewable Energy Laboratory (NREL)'s **REopt**[1] platform, an energy modeling and optimization tool, to evaluate behind-the-meter **solar photovoltaics (PV)** and/or **battery energy storage system (BESS)** for two auto parts manufacturers, ZF[2] and JSP[3] at the Clúster Automotriz del Estado de México[4], to support the energy goals, including:

- Reducing electricity costs
- Decarbonization
- Improving resilience to grid outages

This analysis is intended to provide an initial indication of PV+BESS cost effectiveness at industrial manufacturing facilities in Mexico and help identify questions, barriers, and possible solutions to enable the benefits of this technology.

1 https://reopt.nrel.gov
2 ZF manufactures multiple components for the auto industry in Mexico. (https://www.zf.com)
3 JSP manufactures "High Performance Lightweight Plastic Solutions" for the auto industry in Mexico. (https://www.jsp.mx)
4 https://www.clautedomex.mx

Will Distributed Energy Resources (DERs) Work for Your Site?

Renewable Energy Resource

Technology Costs and Incentives

Site Goals (Economics, Resilience, Clean Energy)

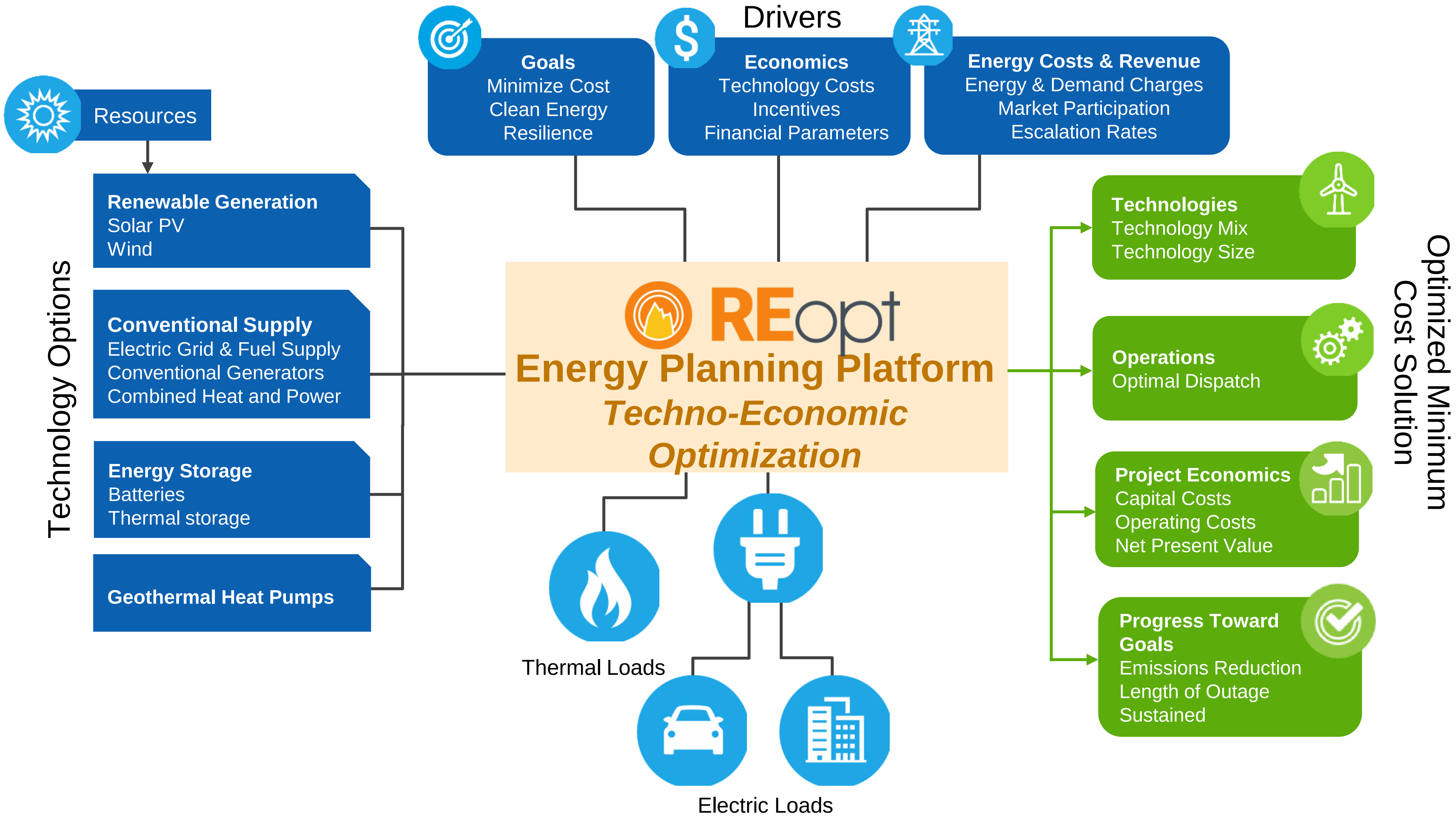
Utility Cost and Consumption

Financial Parameters

Many factors affect whether distributed energy technologies can provide cost savings and resilience to your site, and they must be evaluated concurrently.

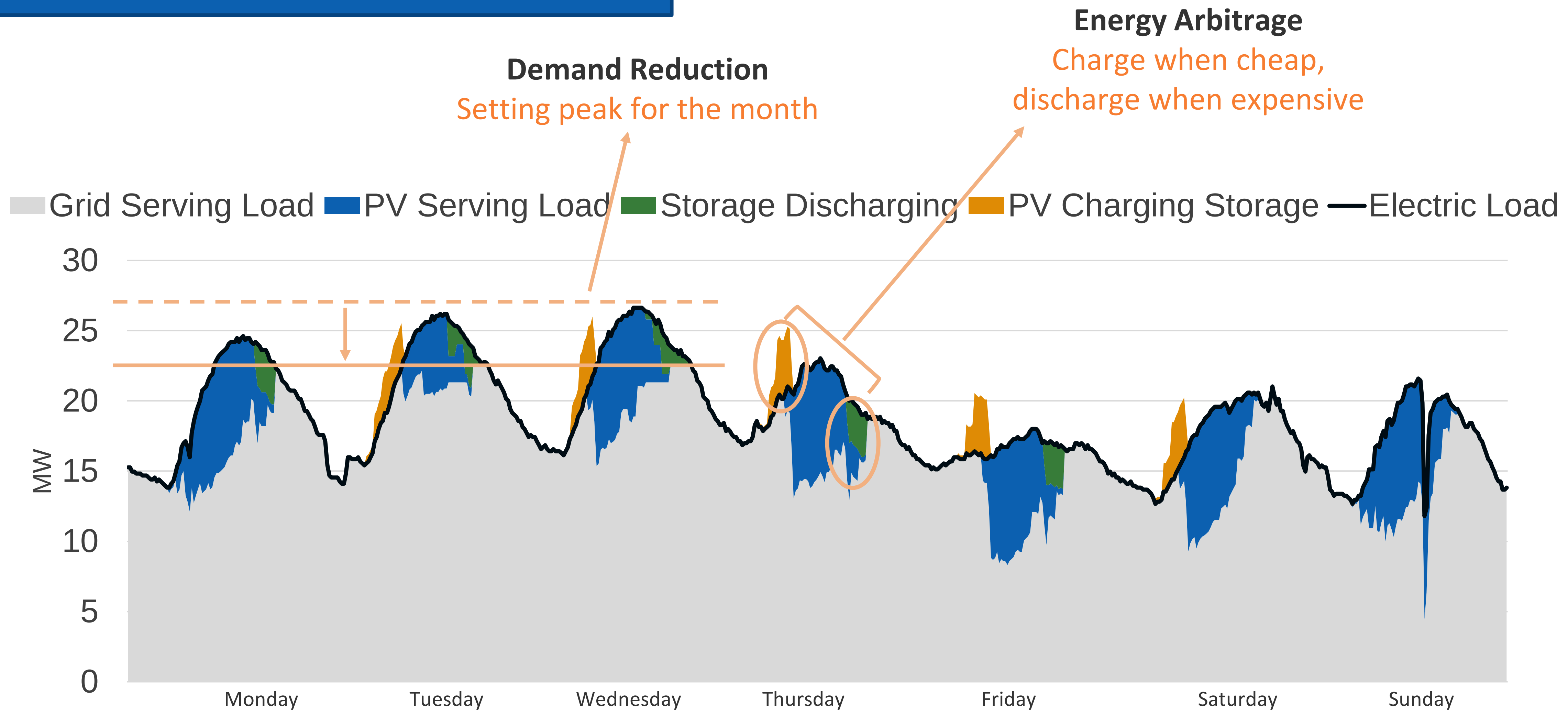
REopt Overview

Formulated as a mixed integer linear program, REopt Lite provides an integrated cost-optimal energy solution.



Grid-Connected Value of PV + Storage

REopt considers the trade-off between ownership costs and savings across multiple value streams to recommend optimal size and dispatch.



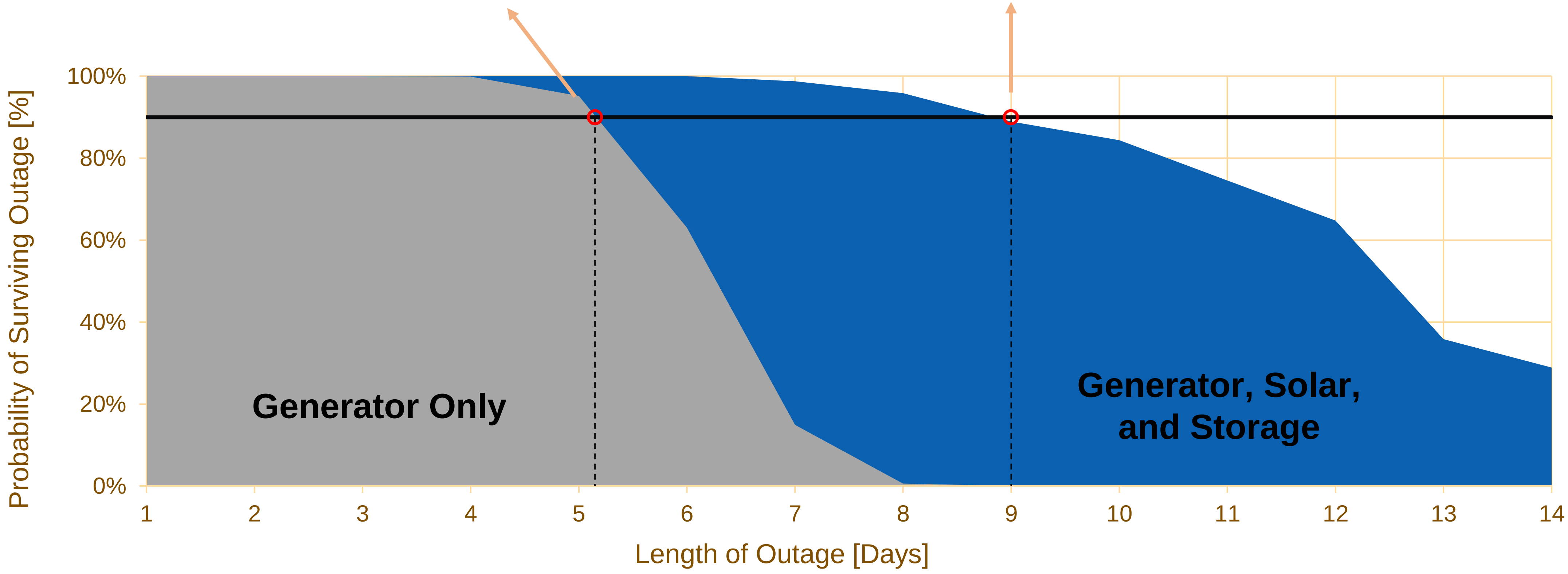
Example of optimal dispatch of PV and BESS

Resilience Value of PV + Storage

REopt finds the system size and dispatch that minimizes life cycle energy costs for grid-connected operations and survives a specified grid outage. It evaluates thousands of random grid outage occurrences and durations to identify the probability of survival.

Existing generator with fixed fuel supply sustains the critical load for 5 days with 90% probability.

Adding solar and storage to the existing generator increases survivability from 5 to 9 days by extending fixed diesel fuel supplies and provides utility cost savings while grid-connected.



Goals and Value Streams Considered

CEIA presented the proposed analysis scope to the CLAUTEDOMEX AutoCluster companies and offered to complete the analysis using site data for whichever company submitted complete data requirements through the presented framework. Two AutoCluster companies (ZF and JSP) expeditiously submitted complete data requirements and CEIA decided to complete analysis for both companies.

The following goals were considered in both analyses:

- **Grid-connected cost savings:** How can PV and/or BESS reduce the lifecycle cost (LCC)* of electricity relative to solely or primarily purchasing from the electric grid?

- **Decarbonization:** How can onsite PV and/or BESS increase renewable energy (RE) penetration at the site and reduce emissions associated with electricity consumption?

This analysis identifies cost-optimal system sizing and dispatch for grid-connected cost savings and presents the clean energy (RE/emissions) impacts of these systems.

***Note**: LCC is calculated as the present value of capital costs, BESS replacement costs, and grid electricity purchases throughout the 25-year analysis period.

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ZF Site & Data Overview

Site Overview – ZF

This and the following 12 slides provide an overview of the analysis completed for ZF:

ZF is a German company with manufacturing plants around the world, including approximately 17 plants and approximately 25,000 employees in Mexico. ZF's CLAUTEDOMEX AutoCluster produces steering and suspension components sold to many other car companies.

- Facility's annual electrical load in 2022 is: 2,768.0 MWh/year with a peak demand of approximately 617.8 kW.
- ZF is planning a facility expansion, after which, the load is estimated to be: 7,808.3 MWh/year with a peak demand of 891.4 kW.
- The site has no existing PV or BESS but does have a backup diesel generator.
- The site has an estimated 11,000 m^2 of existing (4,000 m^2) and future (7,000 m^2) roof space that could host PV, along with approximately 1,500 m^2 of parking lot area that could be used for carport PV.

- ZF currently purchases electricity from Iberdrola.
- 10% of current electricity purchases are contracted for clean energy certificates (CELs)*.
- The analysis assumes a target of 100% CELs and comparing on-site vs. off-site procurement of these CELs.
- Including 100% CELs, grid electricity purchases from Iberdrola are modeled at 1,703.04 MXN/kWh in energy charges plus 489,114 MXN/kW-month in monthly demand charges.

*CELs = "*Certificados de Energías Limpias*" in Spanish.

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Site Layout – ZF

The image to left, provided by ZF, shows the existing ZF facility, pre-expansion. An expansion project is planned for 2023 which will cover the existing ground area with additional building facilities (and thus roof space for PV). **The following table estimates the land, roof, and carport areas for PV *after* that expansion.**

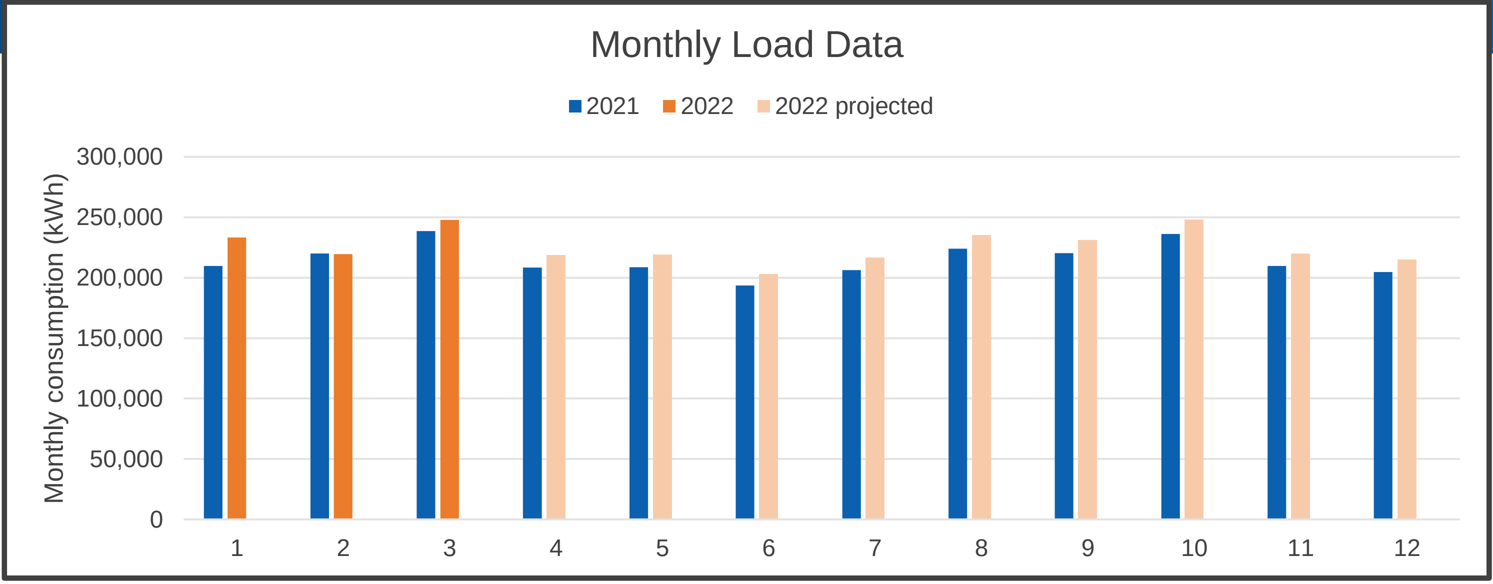
Space	Area (m^2)
Roof	11,000
Carport	1,500
Ground	0
Total	**12,500**

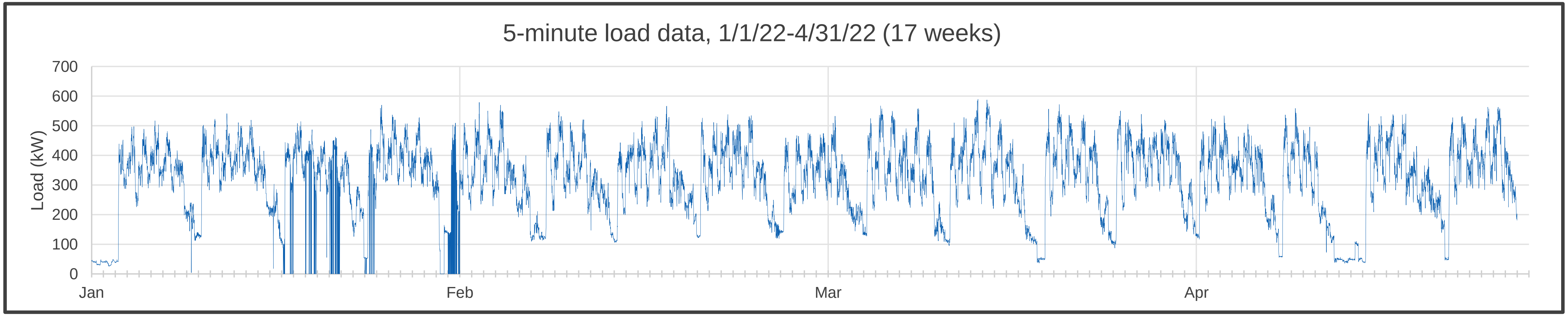
Assuming ~100 W_{DC}/m^2, the site is estimated to be able to host a maximum of ~1,250 kW_{DC} of PV onsite.

Electricity Consumption Data – ZF

ZF provided the following electric consumption data:

- Monthly electric consumption data for January 2021 – March 2022 (15 months)
- 5-minute electric consumption data for 1/1/2022 – 4/31/2022 (17 weeks)
- Annual load projection for 2024 (Note: the annual projection for 2024 (2,101.7 MWh) was less than the load data for 2021 or simulated 2022, so was not incorporated.)

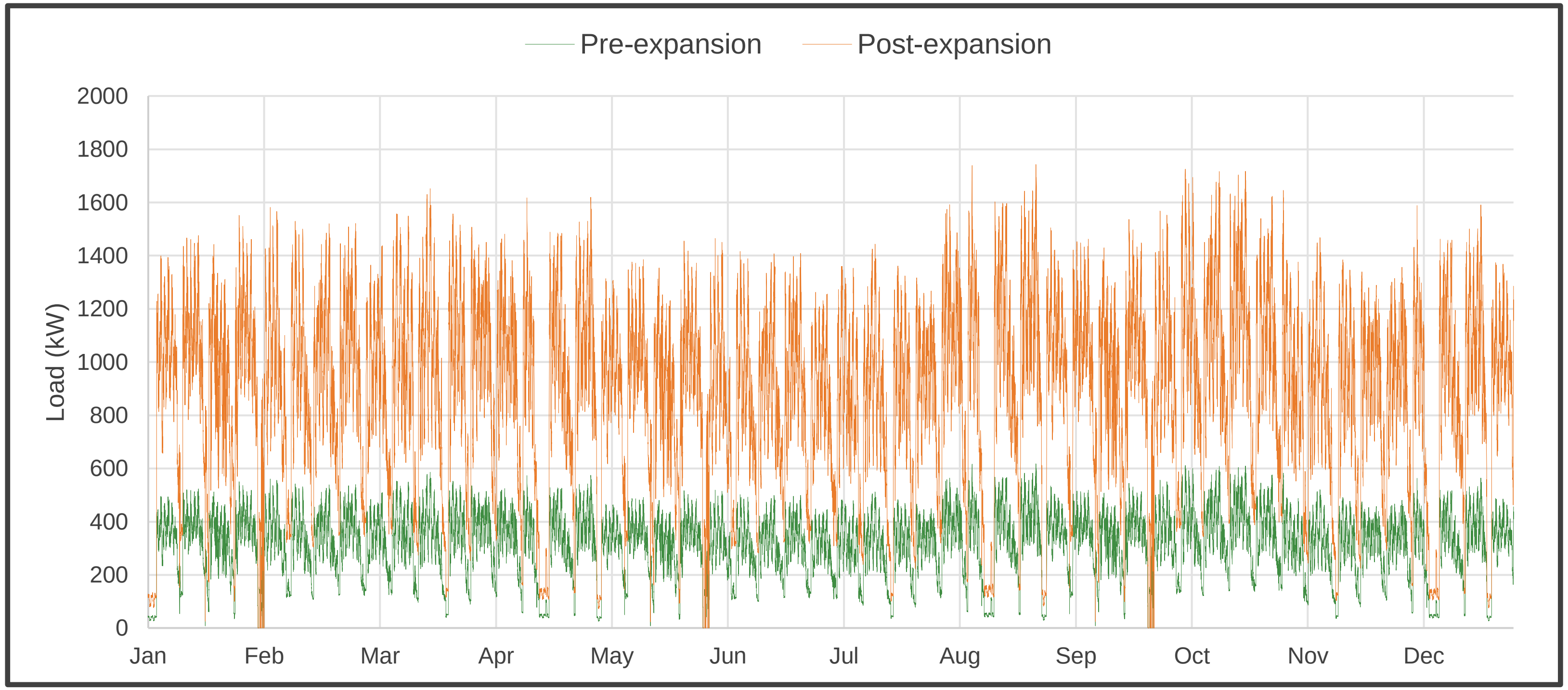




Electricity Consumption – ZF

CEIA used this data to develop a full year representative load profile by:

- Estimating 2022 monthly consumption data as 4.95% higher than 2021, based on the increase observed in Jan-Mar 2022 relative to Jan-Mar 2021
- Averaging the 5-minute interval data into 15-minute interval data
- Repeating the 15-minute interval data profile to span an entire calendar year
- Scaling the shape of the 15-minute interval data to match monthly consumption data
- Scaling this simulated profile by planned square footage increase for the expansion (3,900 m² → 11,000 m²).



Summary	Pre-expansion	Post-expansion
Annual MWh	2,768.0	7,808.3
Average kW	316.0	891.4
Peak kW	617.8	1,742.6

Electricity Tariffs – ZF

ZF purchases their electricity from Iberdrola. ZF provided copies of their electric bills from April 2021 through May 2022.

The site contracts with Iberdrola for a base rate structure that applies to some contracted volume (kWh) and peak demand (kW), and then operates in the real time market for consumption over or under the contracted volume. This analysis focuses on the contracted rate, which makes up ~95% of energy and demand charges, while the real time market rates only make up ~5% of these charges.

This base rate for the contracted volume includes a fixed energy charge of 608.34 MXN/MWh plus a thermal congestion energy charge that varies monthly and ranges from 105.69 MXN/MWh to 386.83 MXN/MWh, averaging at 206.44 MXN/MWh. This yields a total average energy charge of 814.78 MXN/MWh. Additionally, the rate includes a monthly demand charge of 333,965.3 MXN/MW-month, regulated fees charges averaging approximately 26.3% of overall energy and demand charges (the basis for these charges is unclear), and 16% in taxes.

Additionally, the site purchases CELs to meet ~10% of the site load at **348.05 MXN/MWh** (before taxes). Because the organization is targeting 100% RE annually, the analysis applies these CELs to all grid-purchased electricity.

The overall rate, including CELs charges, is summarized below:

- **Energy charges: 1.70304 MXN/kWh; @ 20 cents USD/MXN = 8.5 cents/kWh USD**
- **Demand charges: 489.114 MXN/kW-month**

Techno-Economic Assumptions & Scenarios Evaluated

Economic & Grid Assumptions

Economic & Grid Inputs	Assumptions
Analysis period	25 years
Ownership model	Direct purchase by company
Discount rate (nominal)	10%
Inflation	**4%** per WRI (Inder Rivera) Note: 2.5% per NREL Annual Technology Baseline (ATB) for U.S.
Grid electricity cost escalation rate (nominal)	Analysis assumes **4%/year** to align with inflation assumption, considering the following data points. (A direct forecast for Mexico was not available.) • https://mexicobusiness.news/energy/news/domestic-electricity-tariffs-will-rise-06-percent-january#:~:text=Likewise%2C%20by%20the%20end%20of,not%20rise%20above%20inflation%20growth Indicates a range from "not exceeding inflation" to 4% to 7.4%. • 1.9%/year–projected average for U.S. per U.S. Energy Information Administration (EIA).
Net metering	Assume 500 kW_{DC} net metering limit
Grid emissions rate	0.435 tCO_2e / MWh per https://www.gob.mx/cms/uploads/attachment/file/806468/4_-Aviso_FE_2022__1_.pdf

Solar PV Assumptions

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Solar PV Inputs	Assumptions
Technology resource & performance	Typical meteorological year data accessed via NREL's PVWatts tool
Tilt angle	10°
DC to AC ratio	1.2
System losses	14%
Capital costs (all-in, incl. balance-of-system and installation)	**850 USD/kW$_{DC}$** per https://asolmex.org/intranet/Micrositio_GSD/Monitor-Indice-de-Precios/Monitor_precios_GSD_reporte2aedicion_oct2021.pdf Converts to **17,000 MXN/kW$_{DC}$** (assuming 20 MXN = 1 USD)
O&M costs	**181 MXN/kW/year**, calculated from the following: 17 USD/kW/year U.S. average per NREL ATB converts to **340 MXN/kW/year** Capital cost assumption above is 53% of U.S. average; same assumption applied to O&M costs

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BESS Technology Assumptions

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BESS Inputs	Assumptions
System type	Lithium ion battery
Rectifier & inverter efficiencies	96%
Roundtrip efficiency	97.5% DC-DC, 89.9% AC-AC (including rectifier/inverter efficiencies)
Minimum state of charge	20%
Capital costs, all-in	**6,222 MXN/kW + 5,732 MXN/kWh**, calculated from: EIA estimates for 2025 utility-scale BESS costs (https://www.iea.org/commentaries/battery-storage-is-almost-ready-to-play-the-flexibility-game) And applying a 44% increase to estimate commercial-scale BESS costs relative to utility costs, calculated based on the average relative increase in BESS costs from NREL ATB for 2- and 4-hour batteries, utility scale vs. commercial scale
Replacement costs (year 10)	**5,037 MXN/kW + 4,958 MXN/kWh**, calculated from: EIA estimates for 2025 utility-scale BESS costs (https://www.iea.org/commentaries/battery-storage-is-almost-ready-to-play-the-flexibility-game) And applying a 44% increase to estimate commercial-scale BESS costs relative to utility costs, calculated based on the average relative increase in BESS costs from NREL ATB for 2- and 4-hour batteries, utility scale vs. commercial scale.
Grid charging allowed?	Analysis currently assumes BESS can charge directly from the grid; ZF would need to confirm this policy with the utility during interconnection process.

Scenarios Evaluated

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The following scenarios were evaluated:

- Business-as-usual (BAU): no onsite DERs
- Cost-optimal PV only, with and without 500 kW max. PV applied*
- Cost-optimal BESS only
- Cost-optimal PV+BESS, with and without 500 kW max. PV applied*

**Current regulations allow a maximum of 500 kW of PV to be interconnected at a single meter. The site is estimated to be able to host 1,250 kW_{DC} of PV, which given current regulations may be possible if ZF has three metering interconnection points.*

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Results – ZF

Results Summary - ZF

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Based on analysis assumptions, the **cost-optimal system** at this facility appears to be a **PV system that maxes out the area available** at the site (estimated ~1,250 kW_{DC}) **supplemented by BESS** (~413 kW / 1,554 kWh; ~4-hr duration). This system could provide **35.42M MXN** in cost savings throughout the 25-year analysis period while serving **25%** of the site's electric load with renewable electricity.

Standalone PV or standalone BESS could also provide cost savings, but the two technologies are complementary and the combined value of the two exceeds the sum of the potential value of either being implemented independently.

These results are largely driven by the utility rate, which includes fixed energy charges more expensive than the Levelized cost of electricity (LCOE)[1] of PV and relatively high demand charges for which the BESS can provide peak shaving.

Cost-optimal system sizing, annual renewable electricity penetration, and lifecycle economics.[2]

Technologies considered:	PV only		BESS only	PV + BESS	
Maximum PV kW allowed:	500	1,250	---[3]	500	1,250
PV (kW_{DC})	500	1,250	---	500	1,250
BESS inverter capacity [kW]	---	---	211	324	399
BESS energy capacity [kWh]	---	---	973	1,039	1,344
Annual percent RE electricity [%]	10%	24%	0%	10%	25%
Net present value (NPV)[4] [MXN]	9.59M	18.52M	4.33M	20.55M	32.50M

Footnotes:

[1] Levelized cost of electricity (LCOE) refers to the estimated revenue required to build and operate a PV generator over a specified cost recovery period.

[2] Results depend on assumptions presented in these slides, including 25 year analysis period, 10% nominal discount rate, 4%/year utility cost escalation rate, and assumed technology costs.

[3] A dash (---) indicates that the technology was not considered in that scenario. A zero (0) indicates that the technology was considered but does not appear cost effective in that scenario.

[4] Net present value (NPV) is the difference (savings) in lifecycle costs of electricity facilitated by the new PV and/or BESS, relative to the BAU scenario. Lifecycle costs are calculated as the present value of capital costs, O&M costs, and grid purchases throughout the 25-year analysis period.

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Detailed Results – ZF (Cost-Optimal Sized Systems)

The detailed results table to right shows the costs and savings for each of the scenarios evaluated, expanding on the results presented on the previous slide.[1]

Technologies considered:	BAU	PV only		BESS only	PV + BESS	
Maximum PV kW allowed:	---[2]	500	1,250	---	500	1,250
PV (kW_{DC})	---	500	1,250	---	500	1,250
BESS inverter capacity [kW]	---	---	---	211	324	399
BESS energy capacity [kWh]	---	---	---	973	1,039	1,344
Capital & replacement costs [MXN]	---	8.50M	21.25M	9.18M	19.10M	34.8M
Year 1 PV O&M costs [MXN]	---	0.17M	0.43M	---	0.17M	0.43M
Year 1 energy charges [MXN]	13.30M	11.92M	10.06M	13.30M	11.93M	9.97M
Year 1 demand charges [MXN]	8.85M	8.67M	8.62M	7.81M	7.01M	6.60M
Year 1 grid electricity costs [MXN]	22.15M	20.59M	18.68M	21.11M	18.94M	16.57M
Year 1 energy charge savings [MXN]	---	1.38M	3.24M	-0.01M	1.37M	3.32M
Year 1 demand charge savings [MXN]	---	0.17M	0.23M	1.04M	1.83M	2.25M
Year 1 grid electricity cost savings [MXN]	---	1.55M	3.47M	1.03M	3.20M	5.58M
Year 1 CO_2e emissions reductions [tCO_2e]	---	353	827	-2	350	849
Lifecycle CO_2e emissions reductions [tCO_2e]	---	8,814	20,670	-37	8,750	21,228
Annual percent RE electricity [%]	---	10%	24%	0%	10%	25%
Lifecycle costs [MXN]	289.43M	270.90M	270.90M	285.10M	268.87M	256.93M
Net present value (NPV)[3] [MXN]	---	9.59M	18.52M	4.33M	20.55M	32.50M
Internal Rate of Return (IRR) [%]	---	20.5%	18.3%	16.3%	21.8%	19.8%
Simple payback period (SPB) [years]	---	5.4	6.1	5.8	4.8	5.4

Footnotes:

[1] Results depend on assumptions presented in these slides, including 25 year analysis period, 10% nominal discount rate, 4%/year utility cost escalation rate, and assumed technology costs.

[2] A dash (---) indicates that the technology was not considered in that scenario. A zero (0) indicates that the technology was considered but does not appear cost effective in that scenario.

[3] Net present value (NPV) is the difference (savings) in lifecycle costs of electricity facilitated by the new PV and/or BESS, relative to the BAU scenario. Lifecycle costs are calculated as the present value of capital costs, O&M costs, and grid purchases throughout the 25-year analysis period.

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JSP Site & Data Overview

Site Overview – ZF

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- Facility's annual electrical load in 2022 is: 2,768.0 MWh/year with a peak demand of approximately 617.8 kW.
- ZF is planning a facility expansion, after which, the load is estimated to be: 7,808.3 MWh/year with a peak demand of 891.4 kW.
- The site has no existing PV or BESS but does have a backup diesel generator.
- The site has an estimated 11,000 m^2 of existing (4,000 m^2) and future (7,000 m^2) roof space that could host PV, along with approximately 1,500 m^2 of parking lot area that could be used for carport PV.

- ZF currently purchases electricity from Iberdrola.
- 10% of current electricity purchases are contracted for clean energy certificates (CELs)*.
- The analysis assumes a target of 100% CELs and comparing on-site vs. off-site procurement of these CELs.
- Including 100% CELs, grid electricity purchases from Iberdrola are modeled at 1,703.04 MXN/kWh in energy charges plus 489,114 MXN/kW-month in monthly demand charges.

*CELs = "*Certificados de Energías Limpias*" in Spanish.

Site Overview – JSP

This and the following 12 slides provide an overview of the analysis completed for JSP:

- JSP's CLAUTEDOMEX AutoCluster manufacturing facility's annual electrical load is approximately 3760.4 MWh/year with a peak demand of approximately 914 kW.
- The site has no existing PV, BESS, or backup generator. But it has an estimated 7,700 m^2 of space that could host PV, primarily on the facility roof with a small land area and parking lot for potential carport PV.
- JSP currently purchases electricity from the Comisión Federal de Electricidad (CFE),[1] Mexico's national electric company, with supply (generation) coming approximately half from CFE and half from a wind farm called Bii Hioxo.
- Internationally, JSP has a target of reducing overall emissions each year and in Mexico JSP has a target of reducing emissions each month and/or each year.

[1] https://www.cfe.mx

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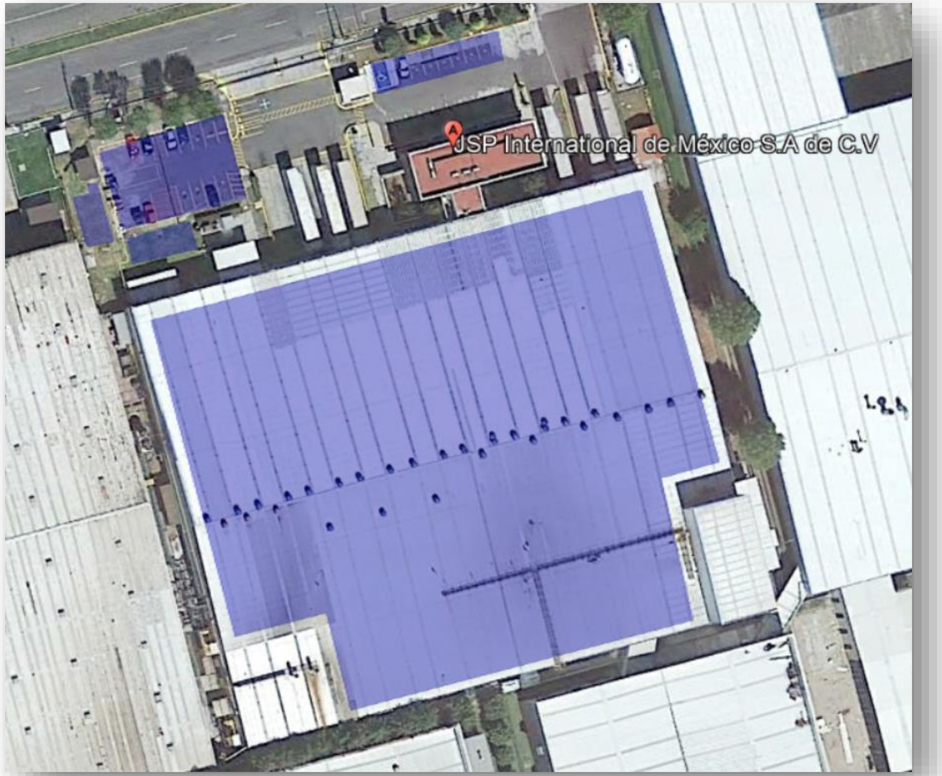
Site Layout – JSP



Google Earth image of the site, with potential PV locations identified by blue.

Based on Google Earth measurements, CEIA estimates the following approximate areas to potentially host PV at the site:

Space	Area (m^2)
Roof	7,100
Carport	500
Ground	100
Total	**7,700**

Assuming ~100 W_{DC}/m^2, the site is estimated to be able to host a maximum of ~770 kW_{DC} of PV onsite.

Electricity Consumption – JSP

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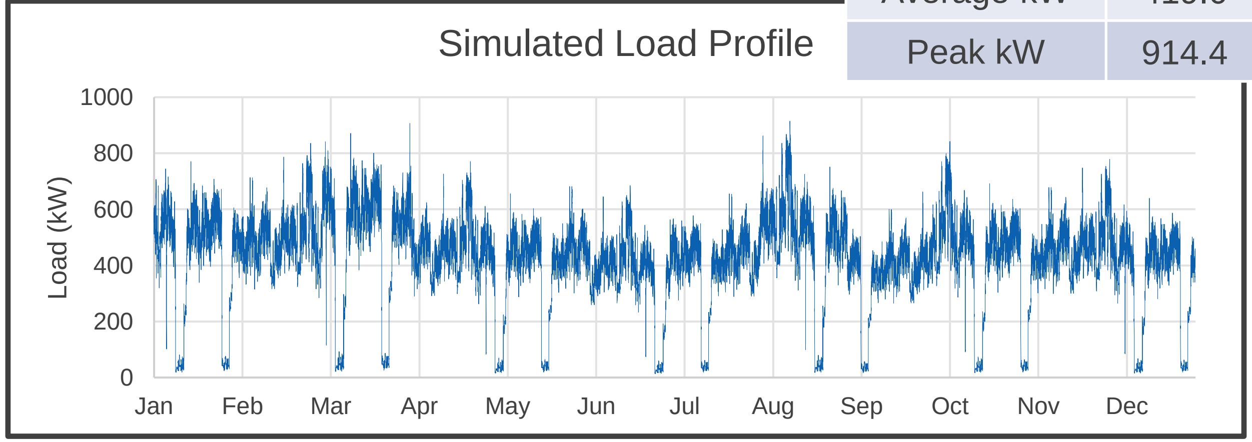
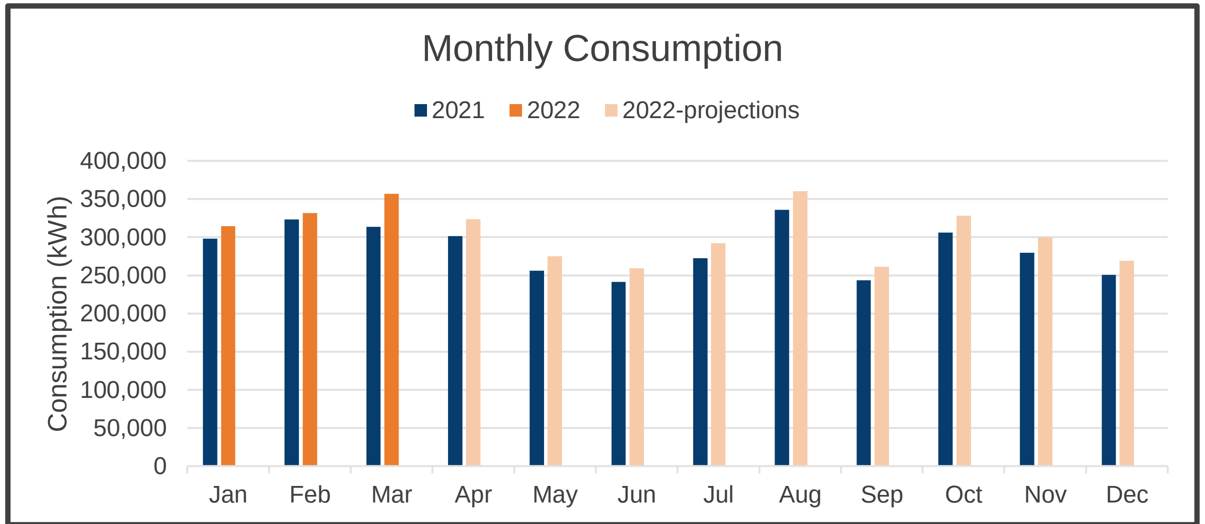
JSP provided the following electric consumption data, plotted to right:
- Monthly electric consumption data for January 2021 – March 2022 (15 months)
- 5-minute electric consumption data for 4/30/2022 – 6/24/2022 (8 weeks)

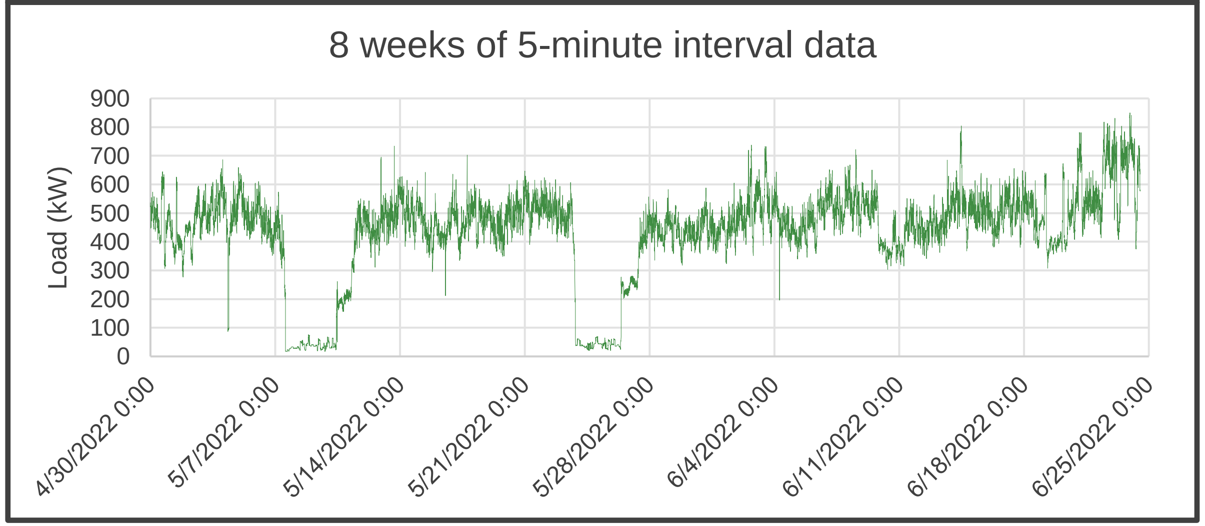
CEIA used this data to develop a full year representative load profile by:
- Estimating 2022 monthly consumption data as 7.2% higher than 2021, based on the increase observed in Jan-Mar 2022 relative to Jan-Mar 2021
- Averaging the 5-minute interval data into 15-minute interval data
- Repeating the 15-minute interval data profile to span an entire calendar year
- Scaling the shape of the 15-minute interval data to match monthly consumption

The representative profile developed is shown below. Future load increases are not expected.

Summary	
Annual MWh	3,760.4
Average kW	419.0
Peak kW	914.4







Electricity Tariffs – JSP

CFE delivers (transmission and distribution) JSP's electricity with supply (generation) coming from both CFE and Bii Hioxo, a wind farm that JSP contracts for approximately 50% of the site's consumption.

JSP provided CFE's bills from March 2021 through March 2022 and Bii Hioxo's bills from November 2021 through March 2022.

JSP has indicated that the government may reduce the ability to purchase from Bii Hioxo after the contract ends in 2025, so this analysis focuses on how PV+BESS could help reduce the cost of electricity relative to the CFE tariff, Gran Demanda en Media Tension Horaria (GDMTH),[1] summarized on the next slide. This rate includes:

- Fixed monthly charge: **680.44 MXN/month**
- Time-of-use energy charges: ranges from **1.21526 MXN/kWh** to **2.33466 MXN/kWh**
- Monthly on-peak (capacity) demand charge: **402.352 MXN/kW**
- Monthly overall (distribution) demand charge: **85.84 MXN/kW**

The values listed above include a 16% tax. Additional surcharges and/or credits, such as a power factor charge or credit, may also apply, but makes up a small (typically <5%) of the bill, and is not modeled in REopt.

[1] In English, GDMTH = high demand, medium voltage schedule (https://app.cfe.mx/Aplicaciones/CCFE/Tarifas/TarifasCRENegocio/Tarifas/GranDemandaMTH.aspx)

GDMTH: Gran demanda en media tension horaria
(“High demand, medium voltage schedule”)

Estado de México – Toluca – Valle de Mexico Sur
January – December 2022

	Base	Inter-mediate	Peak
Fixed charges (MXN/month)	680.44		
Energy charges (MXN/kWh)	1.21526	1.99785	2.33466
Distribution demand charges (MXN/kW)	85.84		
Capacity (on-peak) demand charges (MXN/kW)	---	---	402.352

Note: Values listed above calculated as the average from Jan-Dec 2022, plus a 16% Value Added Tax (IVA) applied to all charges*

Due to REopt utility rate model structure as “weekday” (Monday-Friday) and “weekend” (Saturday-Sunday) rates, Saturday rates were conservatively modeled the same as Sundays. Thus, results may slightly underestimate the value of PV and/or BESS at the site.

* Value Added Tax (IVA) = “Impuesto al Valor Agregado” in Spanish (IVA)

Source:
https://app.cfe.mx/Aplicaciones/CCFE/Tarifas/TarifasCRENegocio/Tarifas/GranDemandaMTH.aspx

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Techno-Economic Assumptions & Scenarios Evaluated

Economic & Grid Assumptions

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Economic & Grid Inputs	Assumptions
Analysis period	25 years
Ownership model	Direct purchase by company
Discount rate (nominal)	10%
Inflation	**4%** per WRI (Inder Rivera) Note: 2.5% per NREL Annual Technology Baseline (ATB) for U.S.
Grid electricity cost escalation rate (nominal)	Analysis assumes **4%/year** to align with inflation assumption, considering the following data points. (A direct forecast for Mexico was not available.) • https://mexicobusiness.news/energy/news/domestic-electricity-tariffs-will-rise-06-percent-january#:~:text=Likewise%2C%20by%20the%20end%20of,not%20rise%20above%20inflation%20growth Indicates a range from "not exceeding inflation" to 4% to 7.4%. • 1.9%/year – projected average for U.S. per US EIA;
Net metering	Assume 500 kW_{DC} net metering limit
Grid emissions rate	0.435 tCO_2e / MWh per https://www.gob.mx/cms/uploads/attachment/file/806468/4_-Aviso_FE_2022__1_.pdf

Solar PV Assumptions

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Solar PV Inputs	Assumptions
Technology resource & performance	Typical meteorological year data accessed via NREL's PVWatts tool
Tilt angle	10°
DC to AC ratio	1.2
System losses	14%
Capital costs (all-in, incl. balance-of-system and installation)	**850 USD/kW$_{DC}$** per https://asolmex.org/intranet/Micrositio_GSD/Monitor-Indice-de-Precios/Monitor_precios_GSD_reporte2aedicion_oct2021.pdf Converts to **17,000 MXN/kW$_{DC}$** (assuming 20 MXN = 1 USD)
O&M costs	**181 MXN/kW/year**, calculated from the following: 17 USD/kW/year U.S. average per NREL ATB converts to **340 MXN/kW/year** Capital cost assumption above is 53% of U.S. average; same assumption applied to O&M costs.

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BESS Technology Assumptions

BESS Inputs	Assumptions
System type	Lithium ion battery
Rectifier & inverter efficiencies	96%
Roundtrip efficiency	97.5% DC-DC, 89.9% AC-AC (incl. rectifier/inverter efficiencies)
Minimum state of charge	20%
Capital costs, all-in	**6,222 MXN/kW + 5,732 MXN/kWh**, calculated from: EIA estimates for 2025 utility-scale BESS costs (https://www.iea.org/commentaries/battery-storage-is-almost-ready-to-play-the-flexibility-game) And applying a 44% increase to estimate commercial-scale BESS costs relative to utility costs, calculated based on the average relative increase in BESS costs from NREL ATB for 2- and 4-hour batteries, utility scale vs. commercial scale.
Replacement costs (year 10)	**5,037 MXN/kW + 4,958 MXN/kWh**, calculated from: EIA estimates for 2025 utility-scale BESS costs (https://www.iea.org/commentaries/battery-storage-is-almost-ready-to-play-the-flexibility-game) And applying a 44% increase to estimate commercial-scale BESS costs relative to utility costs, calculated based on the average relative increase in BESS costs from NREL ATB for 2- and 4-hour batteries, utility scale vs. commercial scale.
Grid charging allowed?	Analysis currently assumes BESS can charge directly from the grid; JSP would need to confirm this policy with the utility during interconnection process.

Scenarios Evaluated

The following scenarios were evaluated:

- Business-as-usual (BAU): no onsite DERs
- Cost-optimal PV and/or BESS
- Max out single meter PV interconnection limit (500 kW)* + cost-optimal BESS
- Max out area available (~770 kW_{DC})* + cost-optimal BESS

**Current regulations allow a maximum of 500 kW of PV to be interconnected at a single meter. The site is estimated to be able to host ~770 kW_{DC} of PV, which given current regulations may be possible if JSP has two metering interconnection points.*

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Results – JSP

Results Summary - JSP

Based on analysis assumptions, the **cost-optimal system** at this facility appears to be a **PV system that maxes out the area available** at the site (estimated ~770 kW_{DC}) **supplemented by BESS** (~657 kW / 1,709 kWh). This system could provide **29.27M MXN** in cost savings throughout the 25-year analysis period while serving **32%** of the site's electric load with renewable electricity.

However, based on the existing maximum of 500 kW of PV per utility meter, this would likely require installing a second meter. Alternatively, the site could install 500 kW of PV with a similarly-sized BESS for only a minor decrease in lifecycle cost savings.

Standalone PV or standalone BESS could also provide cost savings independently, but the two technologies are complementary.

These results are largely driven by the utility rate, which includes time-of-use energy charges some of which are more expensive than the LCOE of PV and relatively high demand charges for which the BESS can provide peak shaving.

Cost-optimal system sizing, annual renewable electricity penetration, and lifecycle economics.[1]

Technologies considered:	PV only		BESS only	PV + BESS	
Maximum PV kW allowed:	500	770	---[2]	500	770
PV (kW_{DC})	500	770	---	500	770
BESS inverter capacity [kW]	---	---	657	657	657
BESS energy capacity [kWh]	---	---	1,704	1,705	1,709
Annual percent RE electricity [%]	22%	29%	0%	22%	32%
Net present value (NPV)[3] [MXN]	**9.59M**	**10.46M**	**17.39M**	**26.55M**	**29.27M**

Footnotes:
[1] Results depend on assumptions presented in these slides, including 25 year analysis period, 10% nominal discount rate, 4%/year utility cost escalation rate, and assumed technology costs.
[2] A dash (---) indicates that the technology was not considered in that scenario.
[3] Net present value (NPV) is the difference (savings) in lifecycle costs of electricity facilitated by the new PV and/or BESS, relative to the BAU scenario. Lifecycle costs are calculated as the present value of capital costs, O&M costs, and grid purchases throughout the 25-year analysis period.

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Detailed Results – JSP (Cost-Optimal Sized Systems)

The detailed results table to right shows the costs and savings for each of the scenarios evaluated, expanding on the results presented on the previous slide.[1]

Technologies considered:	BAU	PV only		BESS only	PV + BESS	
Maximum PV kW allowed:	---[2]	500	770	---	500	770
PV (kW_{DC})	---	500	770	---	500	770
BESS inverter capacity [kW]	---	---	---	657	657	657
BESS energy capacity [kWh]	---	---	---	1,704	1,705	1,709
Capital & replacement costs [MXN]	---	8.50M	13.09M	18.42M	22.36M	31.55M
Year 1 PV O&M costs [MXN]	---	0.09M	0.14M	---	0.09M	0.14M
Year 1 energy charges [MXN]	6.27M	4.84M	4.37M	5.97M	4.54M	3.94M
Year 1 demand charges [MXN]	3.84M	3.80M	3.80M	1.40M	1.38M	1.38M
Year 1 grid electricity costs [MXN]	10.36M	8.88M	8.42M	7.62M	6.18M	5.56M
Year 1 energy charge savings [MXN]	---	1.44M	1.90M	0.31M	1.73M	2.34M
Year 1 demand charge savings [MXN]	---	0.04M	0.04M	2.43M	2.45M	2.46M
Year 1 grid electricity cost savings [MXN]	---	1.47M	1.94M	2.74M	4.18M	4.79M
Year 1 CO_2e emissions reductions [tCO_2e]	---	353	466	-19	334	490
Lifecycle CO_2e emissions reductions [tCO_2e]	---	8,825	11,658	-486	8,342	12,255
Annual percent RE electricity [%]	---	22%	29%	0%	22%	32%
Lifecycle costs [MXN]	135.36M	125.77M	124.91M	117.97M	80.71M	106.09M
Net present value (NPV)[3] [MXN]	---	**9.59M**	**10.46M**	**17.39M**	**26.55M**	**29.27M**
Internal Rate of Return (IRR) [%]	---	20.5%	17.7%	22.1%	21.3%	20.3%
Simple payback period (SPB) [years]	---	5.4	6.3	4.5	4.9	5.1

Footnotes:

[1] Results depend on assumptions presented in these slides, including 25 year analysis period, 10% nominal discount rate, 4%/year utility cost escalation rate, and assumed technology costs.

[2] A dash (---) indicates that the technology was not considered in that scenario.

[3] Net present value (NPV) is the difference (savings) in lifecycle costs of electricity facilitated by the new PV and/or BESS, relative to the BAU scenario. Lifecycle costs are calculated as the present value of capital costs, O&M costs, and grid purchases throughout the 25-year analysis period.

CONTACT US

www.cleanenergyinvest.org

Kathleen Krah, kathleen.krah@nrel.gov

Jonathan Morgenstein, jonathan.morgenstein@nrel.gov