UNIVERSIDAD PONTIFICIA COMILLAS

ESCUELA TÉCNICA SUPERIOR DE INGENIERÍA (ICAI)

OFFICIAL MASTER'S DEGREE IN THE

ELECTRIC POWER INDUSTRY

Annex A

COST-BENEFIT ANALYSIS OF SOLAR ENERGY MODELS FOR LARGE CONSUMERS IN MEXICO: PPA, EPC, AND LEASING

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Introduction

This research delves into the emerging solar energy sector in Mexico, a country with a remarkable potential for renewable energy development. The focus is the comparison of different solar energy procurement and usage models, specifically from the consumer's perspective. Power Purchase Agreements (PPA), Engineering, Procurement and Construction Contracts (EPC) with Net-metering and Net-billing options, and the solar panel leasing model will be examined. Through detailed Excel models, we will seek to compare these schemes in terms of financial viability, profitability, and associated risks.

This analysis not only covers risks to investors, such as fluctuations in electricity prices and energy volumes, but also focuses on risks to customers and how these can be mitigated through these arrangements. In the Mexican context, where energy policy and market conditions are constantly evolving, this study is particularly relevant. It will provide a methodological framework to quantitatively evaluate these schemes, considering a defined time horizon and comparing the benefits obtained.

This work not only offers a comprehensive view of the options available to Mexican consumers in the solar energy sector, but also provides a valuable tool for investors and market participants, helping them to make informed decisions in an increasingly complex and competitive energy market.

Motivation

The motivation for this thesis is grounded in the observed knowledge gap within industrial companies regarding the potential of solar panels as a solution to reduce electricity costs. There is a general lack of awareness about the functioning of solar technology and the mechanisms of energy compensation. This gap in understanding elevates the significance of the Power Purchase Agreement (PPA) scheme, as companies show more interest in reducing electricity bills without the need for substantial investment. This thesis aims to bridge this knowledge gap, providing comprehensive insights into the benefits and operational dynamics of different solar energy schemes, particularly emphasizing the role and potential of PPAs in the industrial sector.

Objectives

The objectives section of this Master's Thesis serves as a roadmap, outlining the key goals and focus areas of the research. It sets the stage for a thorough analysis of various solar energy schemes in the Mexican industrial context, aiming to identify the most beneficial option for large consumers.

- Analyze Different Solar Energy Schemes in Mexico: This includes a comprehensive analysis of various solar energy schemes like PPA, EPC (Net-metering, Net-billing), and leasing of solar panels, with a focus on large industrial consumers.

- Determine the Most Beneficial Scheme: Identify which of the analyzed schemes offers the most benefits to large industrial consumers in terms of cost-effectiveness, sustainability, and practicality.

- Develop Financial Models: Construct Excel models to quantitatively compare the financial outcomes of each scheme.

- Assess Investor and Client Risks: Evaluate risks related to electricity pricing, energy volume, and consumption profiles for investors, and identify risks mitigated for clients through these schemes.

- Review Regulatory Framework: Analyze the current regulatory environment in Mexico, including the process for installing solar panels on industrial buildings, maximum power installation, and compensation models.

- Analyze Electricity Billing Components: Examine the different components of electricity bills such as tariffs, energy, distribution, transmission, capacity, and miscellaneous fees, and their impact on the overall cost.

- Methodological Framework: Establish a methodological approach for the quantitative evaluation and comparison of benefits derived from each solar energy scheme.

- Interpret and Analyze Excel Model Results: Discuss the findings from the Excel models and provide a comprehensive analysis of the results.

Methodology

The methodology that I will be using will be a mixed-methods research methodology. This approach combines qualitative and quantitative methods, allowing for a comprehensive analysis of the solar energy schemes in Mexico.

Quantitative Analysis

For the quantitative aspect of this study, the analysis will primarily focus on key economic indicators crucial for assessing the financial viability of each solar energy scheme. The quantitative analysis is divided into two sections: Inputs and outputs.

Inputs

- Capex (Capital Expenditure): The initial investment required for setting up the solar energy system. (Source: Interview with the CEO of Nova Group)
- Opex (Operational Expenditure): Ongoing operational and maintenance costs associated with the solar energy system, covering expenses like monitoring, repairs, and general upkeep. (Source: Interview with the CEO of Nova Group)
- Inflation: The rate at which the price of goods rises, influencing costs over time. (Source: (Instituto Nacional de Estadística y Geografía e Informat, 2023))
- Generation: Energy generated by the solar energy system. (Source: SolarEdge Designer/PV Syst)
    - Solar Irradiation: The amount of sunlight that reaches the solar panels, impacting the energy production capacity.

    - Orientation and Inclination: The direction and tilt of the solar panels, influencing the efficiency of energy capture.
- Photovoltaic Module Degradation: The rate at which the efficiency of the photovoltaic modules decreases over time, affecting energy output. (Source: Product Sheet)
- Energy Price: The cost per unit of energy, which varies for each node. (Source: (Comisión Federal de Electricidad, s.f.))
- Distribution Tariffs: Charges associated with the local distribution of electricity. (Source: (Comisión Federal de Electricidad, s.f.))
- Transmission Tariffs: Charges related to the transmission of electricity over long distances. (Source: (Comisión Federal de Electricidad, s.f.))
- Capacity Charge: A fee based on the usage of electrical capacity a consumer is using. (Source: (Comisión Federal de Electricidad, s.f.))

Outputs

- Return On Investment (ROI): Calculated as the ratio of net profit to the initial investment, providing insights into the profitability of each scheme.
- Payback Period: The time required for the initial investment to be recouped, offering an understanding of the scheme's financial efficiency.
- Annual Savings: Determining the yearly cost savings associated with each model.
- Net Present Value: Projecting the total benefits accrued over the lifespan of the solar energy systems.

These quantitative analyses will be derived from meticulous financial modeling in Excel. The source data for these calculations will be obtained from the examination of electricity bills and the costs associated with each financing scheme. Notably, significant economic components such as Distribution Tariffs, Transmission Tariffs, Energy Consumption Costs, and Network Capacity Occupancy Costs will be scrutinized for their impact on overall savings and return on investment.

Qualitative Analysis

The qualitative dimension of the methodology aims to assess the regulatory landscape and risks associated with each solar energy model. This will be accomplished through:

- Interviews: Engaging with stakeholders, industry experts, and relevant authorities to gain insights into regulatory nuances and potential challenges.
- Case Studies: Examining real-world examples of solar energy projects, drawing lessons from their implementation and outcomes.
- Policy Document Review: Analyzing existing policy frameworks to understand the regulatory support and constraints associated with each financing scheme.

Comparative Method

Employing a comparative approach, the study will systematically contrast the strengths and weaknesses of the PPA, EPC, and Leasing models. This comparison will be based on both

quantitative and qualitative findings, providing a holistic perspective on the relative merits of each scheme for large industrial consumers in Mexico.

State of the Art

In the evolving landscape of solar energy, various contractual and operational models offer distinct advantages and implications for both providers and consumers. This section delves into the intricacies of three key models: Power Purchase Agreements (PPAs), Lease Contracts, and the EPC (Engineering, Procurement and Construction) scheme. Each model presents a unique approach to the acquisition and management of solar energy, reflecting differing financial and operational commitments.

- "The Power Purchase Agreement or PPA is a service that provides customers with competitive long-term electricity rates without the need to invest in the systems or incur a loan or lease, which would appear as an accounting liability" (Energía Real, s.f.)

- "The Lease Contract allows clients to make use of accelerated depreciation and have fixed payments for a determined period. Unlike the PPA, this type of contract appears as an accounting liability" (Energía Real, n.d.)

- In the EPC scheme, the customer is the one who disburses the capital necessary to make the investment. The client can choose between the following consideration schemes, the first one being generally much more profitable than the second one:

    - "Net metering is the compensation regime associated with the interconnection that considers the exchange of energy flows between the Power Plant and one or more Load Centers with the General Distribution Networks, compensating the energy delivered by the Power Plant" (Diario Oficial de la Federación (DOF), 2017)

    - "Net billing is the consideration regime associated with the interconnection that, on the one hand, considers the delivery of electric power by the Exempt Generator to the General Distribution Networks and, on the other hand, independently considers the reception of electric power by the Load Center from the General Distribution Networks. Energy surpluses are economically compensated at Local Marginal Price" (Diario Oficial de la Federación (DOF), 2017)

Preliminary Table of Content

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Work Plan

Week 1 (Jan 7-13): Literature review on solar energy schemes and Mexican energy sector.

Week 2 (Jan 14-20): Continued literature review; defining research questions.

Week 3 (Jan 21-27): Begin data collection for quantitative analysis; plan Excel model structure.

Week 4 (Jan 28-Feb 3): Continue data collection; start preliminary Excel model.

Week 5 (Feb 4-10): Data collection focusing on PPA, EPC, and leasing models.

Week 6 (Feb 11-17): Collect data on financial aspects and regulatory environment.

Week 7 (Feb 18-24): Finalize data collection; start initial data analysis.

Week 8 (Feb 25-Mar 3): Continue data analysis; refine Excel models.

Week 9 (Mar 4-10): Complete initial data analysis; start drafting methodology section.

Week 10 (Mar 11-17): Begin qualitative research; conduct first set of interviews.

Week 11 (Mar 18-24): Continue interviews; start integrating qualitative data.

Week 12 (Mar 25-31): Complete qualitative data integration; review preliminary findings.

Week 13 (Apr 1-7): Analyze combined data; start drafting results section.

Week 14 (Apr 8-14): Continue drafting results; begin discussions section.

Week 15 (Apr 15-21): Develop conclusions; start drafting conclusion section.

Week 16 (Apr 22-28): Refine discussions and conclusions; review overall thesis structure.

Week 17 (May 1-7): Comprehensive review and revision of the draft.

Week 18 (May 8-14): Second round of revisions; incorporate feedback.

Week 19 (May 15-21): Final revisions; ensure all sections are cohesive.

Week 20 (May 22-28): Finalize formatting; prepare for submission.

Week 21 (Jun 1-7): Last review for any minor edits; submit the thesis.

Week 22 (Jun 8-14): Prepare for thesis defense; create presentation.

Week 23 (Jun 15-21): Practice defense presentation; seek feedback.

Week 24 (Jun 22-28): Final preparations and adjustments for defense; thesis defense.