**Portfolio Project Option Two: SolarEdge Technologies**

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**Introduction**

The portfolio paper will create the framework and business strategy for a renewable energy manufacturer and distributor, SolarEdge Technologies. I describe the renewables industry, company products, and growth, addressing a hypothetical business problem. Knowing that business intelligence aligns with and merges into organizational strategy, I conceptualize a framework and compose several business questions meant to achieve enterprise objectives. Using public reported data compiled from corporate reports, I answer the questions with statistic applications from *SAS* web-based environment. After discussing results and industry-relevant considerations, I endorse ways to make further research and analysis.

**Company Description**

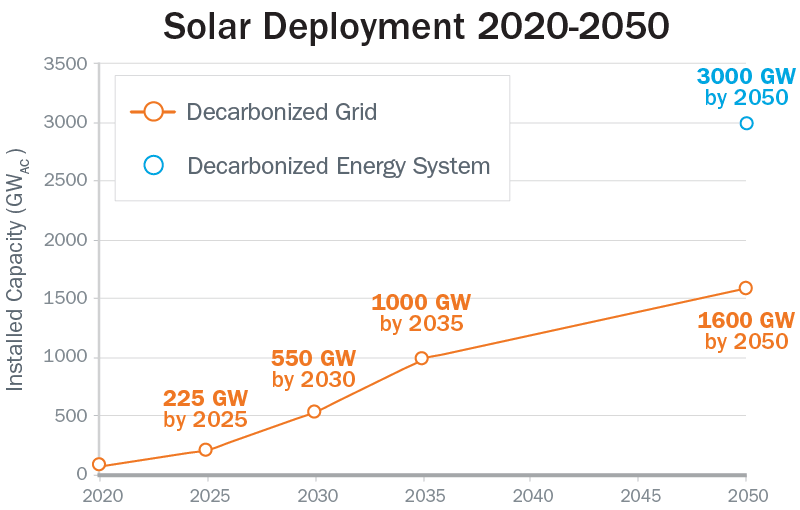
Having an engineering philosophy and practice, SolarEdge delivers innovative energy management products and solutions to power ecosystems and drive progress towards sustainable energy (SolarEdge1, 2021). SolarEdge operates and develops products for three segments of the solar energy market: residential, commercial, and utility scale. The lines of business include residential and commercial photovoltaic (PV) inverters, home energy management, grid incorporation services, energy storage (backup/batteries/uninterrupted supply solutions), and EV charging (SolarEdge2, 2020). Founded in Israel in 2006, the firm now employs over 3900, and ranks #1 globally in photovoltaic inverter revenues (Faier, 2021). The industry of solar products is benchmarked by a 23 percent annual rise of deployed off-grid solar (Kendall and Pais, 2018), and supported by a growing trend of renewables in power capacity expansion (IRENA, 2021). The company has enjoyed incredible growth in recent years, reflected by its 31% compound annual growth rate (Faier, 2021).

**Renewables and Energy Environment**

Solar energy generated can be integrated into an existing power grid or it can be used for domestic microgrid consumption (Sayed and Gabbar, 2016). Decarbonization efforts are underway in developed countries, and many of these governments are drawn to the benefits of solar power and modifying their grid consumption needs. 2020 saw the highest amount financed into large scale solar projects in the U.S. (Bloomberg NEF & BCSE, 2021). As technology costs fall, each dollar of investment supports a higher unit megawatt of solar capacity run in the future (Bloomberg NEF & BCSE, 2021). Additionally, the Office of Energy Efficiency and Renewable Energy’s goal is to reach grid-installed solar capacity of 550 GW by 2030, and 1000 GW in the U.S. by 2035 (figure 1) (Margolis and Ardani, 2021).

Figure 1.

*U.S. solar capacity deployment goal 2020-2050.*



Note: adapted online from figure in Solar Futures Study, by Solar Energy Technologies Office/Energy Efficiency & Renewable Energy (Copyright 2021).

**Strategic Goals**

The SolarEdge mission is to optimally manage solar energy systems, by developing, manufacturing, and distributing PV inverters to meet the energy needs of residential, commercial, and utility companies, as well as energy storage solutions, batteries, and automation equipment in 133 countries (SolarEdge3, 2022). The strategic goals are curated from this mission, company values, stakeholder input, and global expectations. Per the fact sheet (SolarEdge3, 2022):

* Grow revenue and gross margin through strength in its products.
* Drive sustainable energy by developing and maximizing power from inverter and photovoltaic systems.
* Advance smart energy in market segments (residential, commercial, utility).
* Be the preferred partner for industry installers, integrators, and market participants.
* Maintain social responsibility through international energy and electricity standards.

**SolarEdge Products**

There are four types of inverters: microinverters, string inverters, hybrid inverters, and power optimizers. All inverters convert high voltage direct current (DC) from PV panels into alternating current (AC), which is the usable power. SolarEdge hybrid inverters (including power optimizers) track and forecast accurate conversion efficiency during the PV panel lifetime (Sayed and Gabbar, 2016). Conversion efficiency of inverters depends on maintaining a conversion ratio of energy output to energy input closest to 1. Efficient PV inverters reduce maintenance and operation costs and reduce the produced energy from degradation of its lifecycle (Sayed and Gabbar, 2016). Because inverters monitor input and output continuously (figure 2), it creates good potential for ad-hoc and predictive analysis (Henderson, Hade, & Sefa, 2018). Inverters represent the company’s highest revenue products.

Figure 2.

*Data inputs for a typical PV inverter.*

Graphical user interface, application

Description automatically generated

Note: Adapted from figure 1, "inverter inputs" by Zhang and Huang (copyright 2018). Data varies but consistent for voltage, storage, and conversion efficiency.

**Business Problem**

In the renewable energy sector, challenges abound– identify the right data, identify the right tools, build experience, find decentralized data, ensure data integrity, create the shift of culture, and act upon new insight (Hume and West, 2020). The company can build an asset failure model, using enterprise management and inverter data. Performance models help in realizing value through asset reliability, decreasing operation and management costs, improving safety, and providing a systematic approach to replenish the asset base (Henderson, Hade, & Sefa, 2018). Asset replenishment depends on how well decisions are made in allocating capital.

A SolarEdge priority is to capture greater product share in the commercial and utility segments yet maintain a large share of the residential segment (figure 3). Utilities provide the most lucrative outlook, having a strong 8.3% compound annual growth rate, (Dixit and Prasad, 2021). It is estimated that PV inverters will reach a global value of $27B by 2028 (Global Market Insights, 2022), and in cohort, the PV inverter market registered an 8.8% growth rate from 2021 to 2030 (Dixit and Prasad, 2021). Let us tailor the business problem to maximize product growth: **can SolarEdge forecast production of power capacity through 2025?**

Figure 3.

*SolarEdge current and desired solar market segment positions.*

Graphical user interface, application

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Note: adapted from financial presentation in “SolarEdge technologies” slide – segment development, by R. Faier (copyright 2021).

**Business Questions**

Critical to strategy initiatives is knowing the financial data. SolarEdge is a publicly traded company on the US NASDAQ market, so financial and corporate data allows one to undertake financial analysis. Financial reporting covers quarterly and annual accounting practices, counterparty reporting, key performance indices, and historical sales with projected sales (Matijssen, 2020). My data (energydata) uses global solar generation (terawatt-hours) from 2013-2020 from the *Our World in Data* energy explorer (Carlin, 2022), combined with company data from annual 10-K reports from 2013 (company became public) through 2020 (SolarEdge2, 2021). The SAS summary is shown in table 1.

Table 1.

*Select energy data (terawatts), annual SolarEdge assets shipped, EPS, revenue, R&D spend.*

Table

Description automatically generated

Note: adapted from SAS Studio under student user u43067822 (copyright SAS 2022).

I will answer several business questions that pertain to market and financial performance. I will compare growth rates to compound annual growth rate, calculated by **CAGR = (EV / BV)(1 / NY) – 1,** where **BV** is beginning value, **EV** is ending value, and **NY** is the number of periods in the timeframe. I will use visualizations to interpret outcomes and contribute to financial insights.

1. *Is SolarEdge beating the market growth for inverters shipped*?

A goal is to meet new demand for residential markets by expanding manufacturing capacity. I will measure PV inverter sales relative to the inverter growth benchmark of 8.3% year over year (Dixit and Prasad, 2021). CAGR helps to understand strength and position relative to competition.

* + Deliver PV inverters higher than segment benchmark of 8.3% Y/Y.

H01: Annual shipped inverters </= 0.083.

HA1: Annual shipped inverters > 0.083.

**Statistics**. Use **PROC TRANSPOSE, SORT** to format our columns, *Inverters* and *Optimizers*, into rows. Calculate the growth using **LAG** statement in new dataframe. Then, use **PROC MEANS** to calculate mean growth per year (table 1) and **PROC SGPLOT** to visualize the annual numbers as a line chart. Then calculate CAGR using 7 periods.

**Result and visualization.** See table 2 and figure 4 visualizing the results. Annual mean growth is 56.3%, corresponding to a CAGR of 51.5%. Annual shipped inverters are greater than the industry 8.3% benchmark, and we reject the null hypothesis, accepting the alternate.

Table 2, figure 4.

*Annual growth of PV inverter sales and line chart, SolarEdge.*

Graphical user interface, application

Description automatically generated Chart, line chart

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Note: adapted from SAS Studio under student user u43067822 (copyright SAS 2022).

1. *Is growth in gross profit correlated to growth of power capacity (MW) produced?*

Gross profit is determined by subtracting cost of revenues from gross revenues. Let us compare the annual growth rate of power capacity (MW) to the annual growth rate of gross profit. A positive correlation means there is healthy capital allocation in maximizing the capacity of PV inverters and power optimizers.

H02: The correlation of power capacity growth to that of gross profit growth is not statistically significant; that is *p*-value > 0.05.

HA2: The correlation of power capacity growth to that of gross profit growth is statistically significant; that is *p*-value < 0.05.

**Statistics**. Calculate annual growth using the **LAG** statement for *Megawatt\_shipped* and *Gross\_profit* in a new dataframe. Then use **PROC MEANS** to find mean growth. Then apply **PROC CORR** to run Pearson’s correlation coefficient (Rho) and *p*-value for significance.

**Result.** Achieved mean growth of 127% annually for gross profit, and 63.4% annually for power capacity (MW). The correlation is moderately positive (0.494), with a *p*-value of 0.260. Not being significantly correlated, we fail to reject the null hypothesis. See tables 3 and 4.

Tables 3, 4.

*Annual growth rates of power capacity (mw\_growth) and gross profit (gp\_growth), and test of correlation using Pearson’s Rho.*

Table

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Note: adapted from SAS Studio under student user u43067822 (copyright SAS 2022).

1. *Can SolarEdge maintain innovation in product research and development*?

A goal is to foster innovation with patent approvals and patent applications, since rapid development and ease of installation drive the growth of PV inverters (Dixit and Prasad, 2021). Innovation is indirectly measured by research and development spending as a portion of revenues.

* + Target R&D budget (**μ**) between 8-15% of annual revenues.

H03: Proportion of R&D budget to revenues in range; that is, 0.08 < **μ** < 0.15.

HA3: Proportion of R&D budget to revenues outside range; that is, **μ** < 0.08 or **μ** > 0.15.

**Statistics**. Use *energydata* to create a new data frame, *proportion*, where *RD/Revenue* = *proprd*. Use **PROC FREQ** to determine one-way frequencies and **PROC UNIVARIATE** histogram to display distribution by year.

**Result and visualization.** As table 5 and figure 5 show, the proportion of R&D spent fell between 6.8% and 20%, having a mean percentage of 10.6%. Since R&D spend fell within our reference range, we fail to reject the null hypothesis.

Table 5, figure 5.

*Annual R&D spend as percentage of annual revenue, SolarEdge.*

Graphical user interface, text, application

Description automatically generated Chart, bar chart, histogram

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Note: adapted from SAS Studio under student user u43067822 (copyright SAS 2022).

1. *Is product power capacity (GW) a realistic indicator of revenue?*

As of 2010, SolarEdge delivered 27.6GW of cumulative power capacity (SolarEdge3, 2022), and desires a target of 46.6GW by the end of 2025 (Matijssen, 2020). Discover whether annual revenues (dependent variable **Y**) can be predicted from power capacity (independent variable **B1**) using linear regression.

**Statistics.** The model calculates the unknown parameter estimates (**B0, B1**) for the linear regression equation, **Y = B0 + B1X**, where B0 is the y-intercept, and B1 is the slope of the linear equation. Thus, we test for the assumption that the slope is not related to **Y**:

H04: Power capacity (MW) is not statistically significant; that is, **B1** = 0.

HA4: Power capacity (MW) can significantly predict annual revenue; that is, **B1** ≠ 0.

Use dataset to run linear regression, using **PROC REG**for *Revenue* as dependent variable, *Megawatts\_shipped* as independent variable, setting α= 0.1. SAS calculates and displays linear regression line into a fit plot*.*

**Result and visualization.** The linear regression equation becomes *Revenue =* 62018305 *+* 233500 *x MW shipped*. The model shows a high f- statistic of 976, denoting high explanation of variance by the model. *R*2 is close to 1, denoting a model with good fit. The *p*-value is <0.0001, denoting statistical significance of the predictor variable. See table 6, figure 6 for results. The null hypothesis is rejected, and we accept the alternate.

Table 6, figure 6.

*Linear regression estimates for annual revenue, predicted by megawatts capacity.*

Table

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Note: adapted from SAS Studio under student user u43067822 (copyright SAS 2022).

1. *Can we forecast power capacities produced through 2025*?

The last insight is related to capital management strategy. How much power capacity, in megawatts, will be produced in the intermediate term? The autoregressive integrated moving-average (ARIMA) model calculates this value, predicting the change in power capacity as an average change, plus a fraction of the previous change (autocorrelates).

**Statistics.** Model adequacy depends on an autocorrelation check of residuals (r) by the chi-squared statistic (X2). If the residuals highly uncorrelated, Pr will be statistically significantly higher than X2. When the residuals are less uncorrelated (Pr close to X2), the model may be adequate for forecasting (SAS Institute, 2017). The hypotheses are:

H05: The residuals of the megawatt capacity estimates are not significantly uncorrelated (white noise); that is, Pr > X2 is > 0.01.

HA5: The residuals of the megawatt capacity estimates are significantly uncorrelated (other noise); that is, Pr > X2 is < 0.01.

Using **PROC ARIMA**, set **ESTIMATE** to **CLS** (*conditional least squares,* assumes the past, unobserved errors are 0). Set **FORECAST** with an α=0.01, to cover 99% of the possible distribution. Set **LEAD** statement for 5 periods (2021-2025). Since there is 7 years of data, the result will likely produce a high standard error.

**Result and visualization.** With conditional least squares estimates, the model forecasts for 10,297 MW in 2025 (99% CI 7093-13500). See tables 7, 8 and figure 7 for results. As expected, the low number of observations caused a high standard error and *t-*value (556.14 and 3.99), implying low reliability.

Tables 7, 8.

*ARIMA mean, correlation estimates for megawatts; forecast figures for 2021-2025.*

Graphical user interface, table

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Note: adapted from SAS Studio under student user u43067822 (copyright SAS 2022).

However, the residuals show a low X2 statistic, evidenced by the insignificant residual Pr 0.2952 uncorrelation to X2, deeming the model adequate to some degree. One should take caution in this ARIMA model producing forecasts with high certainty, despite accounting for ranges with 99% confidence limits.

Figure 7.

*ARIMA fit line for power capacity (megawatts) 2021-2025.*

Chart, scatter chart

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Note: adapted from SAS Studio under student user u43067822 (copyright SAS 2022).

**Discussion and Further Analysis**

Proper evidence-based decision making is done when the right analytics reach the right levels in the organization. PV inverter growth is driven by good product performance, ancillary monitoring products, and distributor partnerships. Strategic changes to SolarEdge manufacturing assets are based on analysis of system-wide metrics. Comprehensive asset monitoring occurs when data is combined with electricity meters and non-electrical information like utility grid management, meteorological and regional economic data (Zhang, Huang, Bompard, 2018). I consider the three solar energy segments from views in macroeconomics and infrastructure.

The residential and commercial markets serve as high potential for growth, especially in developing nations (Kendall and Pais, 2018). Since 2010, PV system costs have declined 80%, supporting it as an economical way to add new power generation (Office of Energy Efficiency and Renewable Energy, 2021). A building’s power capacity is based on the amount of solar irradiation, system voltage, current, and battery charging. When configured at scale, building PV systems have data redundancy—historical and real-time values are captured, and standalone and client-server configurations are accommodated (figure 8) (Sayed and Gabbar, 2016).

Figure 8.

*Typical PV plant network monitoring setup.*

Diagram

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Note: adapted from figure 6 by Sayed, K and Gabbar, HA (copyright 2016) in Chapter 18 – SCADA and smart energy grid control automation.

SolarEdge is underachieving in the goal to improve inverter lifecycle (Matijssen, 2020). Public data is limited, and proprietary market data comes at a cost, making it difficult to ascertain and strategize initiatives in innovation or marketing. Consideration of PV inverter segment impact forces, growth drivers, supplier and buy bargaining power, and presence of new entrants can provide a better analysis. Secondary research, from government sources, authorized sites, and subsidiary websites may give a clearer assessment.

Growth in the utilities segment highly depends on factors that drive investment of capital and the competitive landscape. Such factors determine how well a company levers long-term initiatives with governments and procures capital to manufacturers and partners, i.e., regulatory requirements, plant infrastructure, and implementation framework (Sayed and Gabbar, 2016). Kendall and Pais (2018) ascertain five factors to support how well investment capital impacts renewable projects. Using such factors, one can further explore growth opportunities:

1. Grid regulations. Solar systems require product standards and assurance for performance across project lifespan.
   * Measure the amount of pro-renewable policies of least-cost models, and delivery instruments for electrification (Energy catalyst, 2020). Example is standard deviation of quality assurance above/below regional benchmark.
2. Business environment. Licensing, legal practices, and state profits are more operable in a stable geopolitical environment. Partner with local companies and consultants up to date with policy development and regulation awareness (Energy catalyst, 2020).
   * Measure amount of regional electricity tariffs and spending on energy projects (Energy catalyst, 2020). Example is percentage of deployed renewable energy provisions, cost-reflective tariffs.
3. Logistics and channels. Rurul areas create electrification opportunities, but tougher logistics than metropolitan areas. Due diligence planning is needed for civil engineering needs and distribution channels.
   * Measure logistics standards regarding distribution channels (Energy catalyst, 2020). Example is percentage of systems compliant.
4. Affordability and willingness to pay. Sufficient cash flow is needed for purchases outright (Kendall and Pais, 2018). Investors should acknowledge and accept trade-offs with asset allocation and spending.
   * Measure the amount of grants, concessional financing, and private sector capital deployed in region (Energy catalyst, 2020). Example is portfolio at risk.
5. Models forpayment. Facilitating payments and costs should have transparency to investors—the pay-as-you-go (PAYG) model versus an upfront allocation.
   * Measure periodic standards and key performance indicators of PAYG companies in region (Energy catalyst, 2020). Example is average unit cost of assets.

Forecasts will require a flexible and constructive posture to their decision-making implications. Data sources for utilities can be retrieved from national offices of energy and renewable energy agencies that set quality standards. One such agency, the International Renewable Energy Agency (IRENA), has 167 member countries, and 17 more in accession (IRENA, 2021). Developing nations need further strategic and economic flexibility, as they may carry volatile socioeconomic conditions. IRENA offers public data to strengthen collection and reporting activities for guidance and training (IRENA, 2021).

**Conclusion**

Enterprise performance management involves business planning and analysis to lay out strategic and operational goals, such as increases to operational efficiency, revenue, and production margins. *SAS* was used to analyze the historical datasets of SolarEdge, a manufacturer of renewable energy products, to analyze financial strength and predict potential growth to improve planning and add value to stakeholders. In the residential foray, SolarEdge inverters have strong sales potential, limited by component performance amidst innovative competition. In the utility foray, public and private sector participation is beneficial in facilitating successful, universal access to off-grid renewable solutions. SolarEdge has established itself as an altruistic company with a targeted strategy for sustainable energy, marked by strong products to address energy needs, a market of strong product demand, showing climate resilience and resource efficiency (SolarEdge, 2020). There are more exciting analyses and work necessary to realize the strategic goals of this company. SolarEdge may realize near-term growth in the industry, energized by favorable macroeconomic and climate-conscious conditions.

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