Commercialization Strategies
For a Novel MPPT Technique

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Abstract

The goal of the project was to create a set of commercialization strategies for starting a profitable business within the solar industry in the US. The business is based on Professor Yousef's novel Maximum Power Point Tracking (MPPT) micro-inverter technique (Mahmoud, Y., 2017). The project involved understanding and explaining the relevant solar technology and building a business plan around the innovation. A SWOT analysis, Porter's Five Forces, and general industry research were conducted in order to assess the business opportunity. The Business Model Canvas was also used to help communicate recommendations for commercialization. Additionally, with the absence of past historical sales data, the business plan also contains Sales Forecast estimates to roughly predict the business profitability in the first year of its operation.

Context

Professor Yousef in the ECE Department at Worcester Polytechnic Institute has patented a novel Maximum Power Point Tracking (MPPT) technique that allows solar PV systems to be much more efficient at generating solar energy (Mahmoud, Y., 2017). He is faced with a decision to either license his innovation to a solar manufacturing company for a one-time profit, or start his own business. The challenge for me as a WPI student was to provide a business plan for his MPPT innovation that would assess whether or not it is possible to start a profitable venture in the US solar industry.

This paper begins with an explanation of the innovation and then provides reasoning for the given recommendations. These recommendations can be found in the last section of this paper (See 'Final Recommendations' Section). The analytical methods used for this paper were SWOT analysis (Professional Academy), industry/market research, sales forecasting methods, the 4 P's for Marketing (Acutt, 2015) and Porter's Five Forces (Porter, 2017)

Technology

A photovoltaic (PV) system or solar PV system refers to a power system that absorbs sunlight and converts it into electricity. It is commonly used to deliver electricity to buildings and houses. The system consists of solar panels, wiring, switches, a mounting system, inverters, a battery bank and a battery charger (Photovoltaic System from Wikipedia, n.d.).

When the power system is on, it absorbs sunlight and converts it into a form of electricity, known as direct current (DC). Most household appliances cannot use this form of electricity, they can only use alternating current (AC) electricity (Kurtus, 2016). It is for this reason that an inverter(s) needs to be purchased.

Micro-Inverter

A micro-inverter is a device used for solar panels to convert energy from one form to another, from DC to AC (Solar micro-inverter from Wikipedia, n.d.). This capability is required so that households can use the electricity generated by their solar panels.

Yet due to various external sources of disturbance such as clouds, trees, other panels or a roof, may cast a shade on a solar panel system and lower its efficiency. It is estimated that the system under shaded conditions may produce 50% less energy than otherwise (Marsh, 2017).

In order to mitigate energy losses caused by shading, a PV system can be rearranged in such a way where only a minimal energy is lost. For example, when solar panels are connected in a string, if one solar panel is shaded and loses its electricity-generating capability, all other solar panels also lose their efficiency to an extent. However, if a PV system is re-arranged so that solar panels are connected in parallel, one shaded solar panel will not cause other solar panels to perform poorly. Hence, major energy loss is mitigated when solar panels are connected in parallel (Hanson, 2014).

Other Types of Solar Inverters

In order for this system re-arrangement to work, a different solar inverter needs to be used, however. There are three different types of solar inverters on the market: power optimizers, strings, and a micro-inverters. As the name suggests, a string inverter is used when solar panels are connected in a string. For that arrangement, only one string inverter is required (EnergySage).

However, to connect solar panels in parallel, there need to be as many micro-inverters as there are solar panels, because each micro-inverter is connected to each panel in the system (EnergySage). Both inverters convert energy from DC to AC, but a micro-inverter has an additional capability to maximize power output by solar panels during conditions when one or more panels are shaded. This capability is referred to as MPPT (Maximum Power Point Tracking) (O'Shea, 2011). It is an algorithm that is included in the micro-inverter. While a regular micro-inverter allows the whole system to be 23% more efficient (SolarEdge, 2013), Professor Yosuef's MPPT algorithm allows a micro-inverter to mitigate additional 15% of energy loss on top of a regular micro-inverter's 23% (Mahmoud, Y.).

Executive Summary

The startup is a Massachusetts-based solar technology company that sells solar micro-inverters to the affluent households who already own solar panels in their homes. The product is based on Yousef Mahmoud's algorithmic innovation that allows micro-inverters to be substantially more efficient than other solar inverters on the market.

The innovation involves an algorithm that enhances the capability for Maximum Power Point Tracking (MPPT). Household solar PV systems need this capability to ensure that the solar

panels extract as much power as possible from the sunlight, to later be converted into an appropriate form of electricity (from DC to AC) to be used by home appliances.

The startup has an opportunity to meet the energy needs of households who already own solar PV systems but suffer from power extraction inefficiencies. While most of these households' PV systems do not possess MPPT capability, some of them still do yet are considerably less efficient than what Yousef's innovation offers. Hence the two market segments that the startup will serve are 1) households which own PV systems with no MPPT capability, and 2) households which own PV systems with inefficient MPPT capability. This can be especially problematic for households when their solar panels are partially covered by shade or interrupted by cloudy weather.

The startup's micro-inverters will resolve that problem by supplying the above-mentioned households with highly efficient, premium solar micro-inverters. The high costs for building the product calls for a higher price point and hence the target market will be the affluent. The state of Massachusetts is considered to be the most strategically effective location for sales due to high electricity costs, low daily peak sunlight hours, proximity and many financial incentive programs offered to solar customers.

In order to launch this business operation, the startup is looking to hire five sales representatives and one marketing specialist as well as cover the costs of material and labor, with manufacturing outsourced to either HelioPower or existing contract manufacturers in Massachusetts. It is also recommended that the startup creates strategic partnerships with solar financing companies such as BlueWave in order to refer potential solar-inverter buyers to companies which offer alternative payment options, given that switching from solar-inverter technology can, in very few instances, be an expensive choice for a small portion of the total available market.

The startups would be looking for an initial investment of $3,815,000 to launch a profitable solar business that can capture 651 customers in its first year of operation. The expected revenue to be collected from that year is roughly $5,000,000. The following set of recommendations describe commercializing strategies for the solar business as well as key initiatives for building long-term relationships with solar customers and strategic partners.

Product Design

In order to realize Professor Yousef's idea, the following bill of materials must be attached to a micro-inverter: a camera, a sensor and mounting hardware (Mahmoud Y., 2017). In other words, a final product design will have all of the above mentioned components. It would also include all of the required materials for building a micro-inverter. So far, the exact design has not been created to demonstrate it here. Yet for the future (after the first year of operation) the business team should self-manufacture the micro-inverters instead of outsourcing it to another company. A special process would need to be adopted that would guide the manufacturing process and point to any potential improvements. A survey is a great way to learn from customers what aspects of the micro-inverter design did they like and which parts need improvement, software or hardware wise.

Bill of Materials

Since the solar product has not been built yet, bill of materials is not available. My personal interview with Bruce Angelis, A Senior Director of Software Engineering at Enphase, has also revealed that such a list of materials is a confidential information that cannot be disclosed. Instead, the following section presents the main assembly parts of Yousef's micro-inverter. There is also a section labeled 'Estimating Materials Cost per One Unit' that discusses materials more in-depth.

Assembly Parts

The following figures illustrate the assembly parts to be put together in order to realize Yousef's MPPT innovation. Keep in mind that these parts are not actual parts. They are intended to illustrate how the product would look like.

Figure 1: Assembly Parts for Yousef's Micro-inverter

A Competitor's Micro-Inverter (Wikipedia, 1995/96)

DSP Camera (Caspa Camera, n.d.)

Interfacing Hardware (Wikipedia, 2016)

Sourcing

Self-manufacturing micro-inverters could be an effective strategy to compete with other micro-inverter manufacturers down the road. However, in the testing phase where the main goal is to learn how customers respond to Yousef's innovation, sourcing micro-inverters from another company would be a much more cost-effective move. Based on the research done on contract manufacturers (CM's) within and outside of Massachusetts, their services likely include building patented products. This means, the startup need would have to educate their CM on how to build and then program the device with Professor Yousef's unique algorithm. While this process likely incurs costs with procuring and asserting the patent, it will help avoid likely more substantial costs associated with inefficient manufacturing (When Outsourcing Manufacturing Can be a Patent Killer, 2013).

Industry Research

Before outlining our marketing strategies, it is important to review the solar panel market. While our startup belongs to a micro-inverter segment, few free reports have been found specifically describing facts and stats about the micro-inverter market. Since the solar market includes our segment, the following facts are a start for micro-inverters, but are mostly about solar industry in general. Studying the overarching industry can help understand the market, including customers and their buying habits/motivations, and give us the knowledge required to make strategically effective decisions for our business plan (Fontinelle, 2017). We assume that customer behavior and motivations do not vary greatly from one solar industry segment to another.

The micro inverter market is a rapidly growing space that is expected to collect around $2.7 billion by 2022 (Bisht, 2016). North America is considered to be one of the main contributors (2nd in ranking), garnering around 19% of the market revenue in 2014 (Statista). The same can be said about solar industry in general. More and more solar PV systems were installed in US since the past decade and a half, from 500 megawatts in 2004, to 20,000 megawatts in 2014 (Solar Industry Research Data, 2018). Logically with that, the prices for buying and installing solar technology near homes and on rooftops has decreased by more than 70% since 2010 (Solar Industry Research Data, 2017). Besides America, Japan is also considered to be one of the biggest potentials for rapid solar market growth (Pentland, 2017).

Buying Motivations

Scott Cooney an author, professor and green startup coach, assures that one of the key decision makers for customers when buying solar technology is price (Cooney, 2014). Rapid decrease in such costs as well as a decrease in energy bills for solar consumers have so far given many customers enough motivation to go solar.

Three factors to consider for the marketing strategy include a jealousy factor, rising costs of fuel and global warming awareness (Cooney, 2014). While financial benefit of adopting solar products may be the main buying motivator for many customers, environmental and social benefits are also considered to be important pain points. The jealousy factor likely means that households who own solar PV systems are proud to own high-tech product and other households who do not own such technology feel jealousy. While this may be an effective tool to use in marketing, there does not seem to be a practical guideline of how this factor can be utilized

effectively. Hence marketing efforts should include mainly communicating financial benefits to customers, higher efficiency due to Yousef's innovation and at the same time promoting environmental awareness.

Market Types

There are three types of end-users: residential, utility and commercial (Goodrich, 2012). According to Solar Cell Central, "the installed PV base is roughly 20% residential rooftops, 20% commercial buildings like hotels and malls, and 60% utility plants connected to the grid" (Solar Central Cell, Last accessed 24 April 2018).

The competition is concentrated by large solar companies such as Enphase, SolarEdge and SMA, soon also by ABB Group after they acquire local micro-inverter manufacturing companies in order to increase their reach. While competition is challenging, a potential for capturing a rapidly expanding solar market is still high considering that the total US electrical generation from solar has grown at an average annual rate of 59% since 2006. This market is expected to hit 100GW installed by 2021 (Solar Industry Research Data), versus around 50 GW in 2017 (Solar Power in the United States in Wikipedia, Last accessed 24 April 2018 .). The global market trend seems to be heading towards ideally operating completely with a renewable energy.

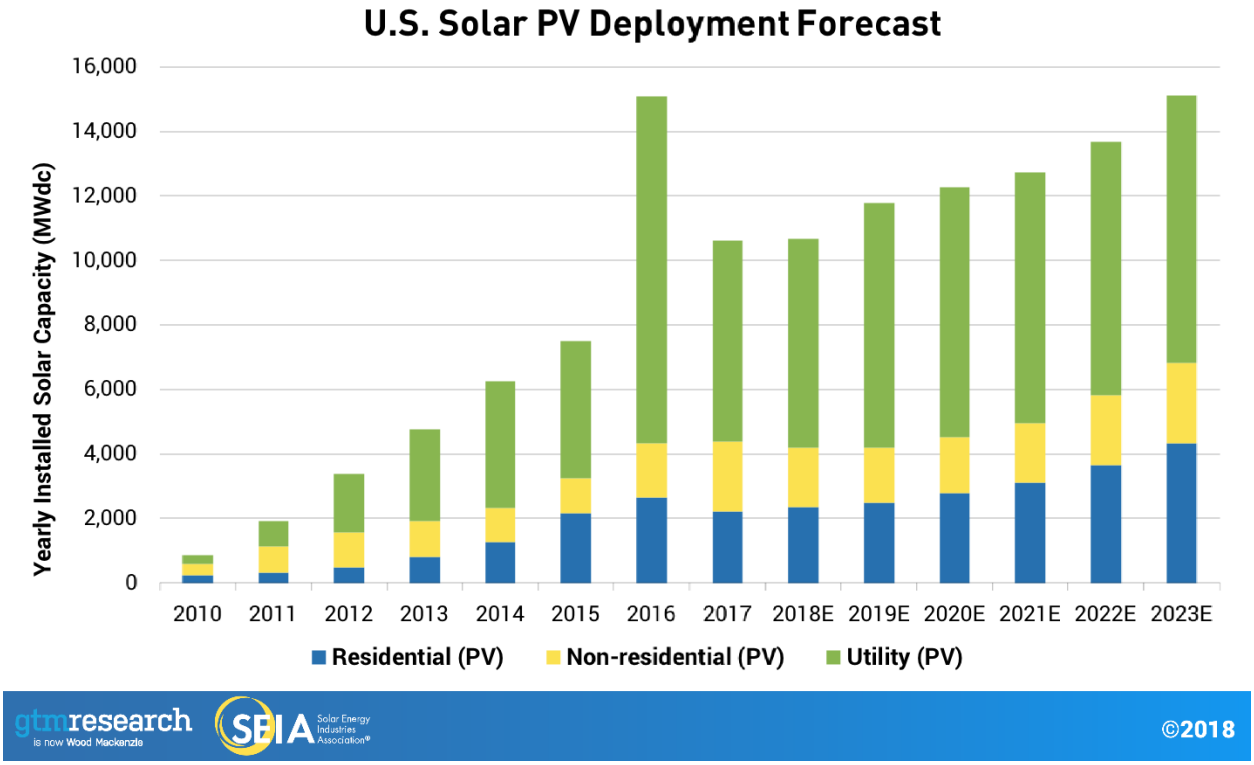
The business environment for solar companies is favorable with many different government subsidies and economic incentives being offered to solar businesses and investors. In the Worcester area alone, there are around 62 financial incentive programs offered (DSIRE Database, Last accessed 24 April 2018)

Customer Profile

Just a decade ago, a community solar farms came around "thatallows households to subscribe to a portion of a local solar farm and generate savings on their electricity costs, has significant potential to address ongoing barriers for solar adoption" (Yeoh, 2017). The emergence of these projects alludes to the notion that some households have a hard time adopting the technology. This is no surprise since when solar panels first came around, they were more expensive than they are now. Solar prices have dropped by 70% since 2010 (Solar Industry Research Data, 2017), and hence more households are starting to afford them as forecasted by SEIA/GTM

Figure 2: Expected Growth of the Solar Residential Market in US

Research. The histogram below demonstrates that (Residential market is illustrated by blue histograms).



Source: SEIA, Solar Energy Industry Association

One study in Australia found that a typical consumer of solar panels in the Residential market is over 55 years-old coming from low-to-middle income families (Sommerfeld, 2017). Another study done by EnergySage has found that about three quarters of consumers of solar panels are male. "A mid-career male in his mid-40s with interests in real estate, financial services, and home services in addition to solar energy." (Pickerel, 2017) This opens an opportunity to potentially tap into a female market and target them in our marketing. Also, since targeting US is more viable due to logistical reasons, the business plan for Yousef's innovation should be based on EnergySage data for customer profile, because the study done by Sommerfeld describes only Australian solar market.

Income range for a typical consumer in Residential market is somewhere between $45,000 and $150,000 (Andorka, 2017). Special programs have also been targeting households with even

lower incomes in order to spread solar technology adoption (DSIRE Database, Last accessed 24 April 2018.).

Studies also observed third-party leasing to be effective financial incentive for buyers to purchase solar technology, especially at times when they can lock in low interest rates for future payments (Third-Party Solar Financing Retrieved from SEIA.org, 2018, April 25.). This particular incentive has only recently been adopted and have shown to work since it sometimes didn't require customers to make any down payments on solar panel purchase, but instead to pay on a month-to-month or a year-to-year basis. Big competitors such as Enphase and Solar Edge offer customers a choice. For example, on the Enphase website one can see that the company offers an extensive product line of its micro-inverters including IQ 7X, IQ 7+, IQ 7 and analogous 6-series. Our brand management should consider offering not one but two or more different types of micro-inverters sometime in the future.

While these facts and observations are useful, more analysis is needed to develop an effective marketing strategy for our brand. Besides motivation points mention above, educating potential customers on why our micro-inverter is more efficient is also crucial. For example, people should become more aware of why they need to consider MPPT when choosing a micro-inverter. A further study need to be setup that demonstrates micro-inverter buying habits of customers – how often they need to replace their micro-inverters, or, when they purchase solar panels, do they buy micro-inverters from the same company that sells panels.

Competition

The solar micro-inverter market is highly competitive, yet also very concentrated. For some customers, micro inverters are synonymous with the Enphase Company (Wesoff, 2014), which holds approximately 24% of the market share. The CEO of the company claims that this is a result of overcoming the competition, not the absence of it (Wesoff, 2014). Indeed there are other powerful players in the market. On the global level, there are famous micro-inverter companies such as Enphase and SolarEdge and also string inverter "heavyweights" such as ABB, SMA and Fronius. (Spector, 2016) There is also a Huawei conglomerate that plans to release its own micro-inverter. Tier 2s and Tier 3s, which refer to local micro-inverter startups and local players are also competing for market share (Spector, 2016).

Market Trends

There are several trends and predictions that are affecting and will affect the micro-inverter market in a certain way and each of these solar companies are responding to these changes in their own way given their financial and other resources.

Big companies are forced to cut costs in order to be able to compete in a market with high downward pressure on price. The prices on micro-inverters have fallen by 33.8% as calculated by GTM Research (Spector, 2016). The stocks are also going down. The only way out as it seems for these companies is to keep finding ways to cut their costs as well as enter new markets. Such new markets also include the Residential market, which amounts to 85% of the whole solar business. The reason for its appeal is an opportunity to mass produce micro-inverters at a low fixed cost, something that cannot be done with string-inverters that in turn signifies strategic advantage of startups such as us and big companies that are selling micro-inverters.

In five years, micro-inverters are predicted to be more complex and more interconnected as well as software-defined. There is a noticeable trend moving away from big, centralized inverters serving a group of solar panels to individual modules such as micro-inverters, which are getting smaller and more self-contained overtime. This trend is partly caused by National Electric Code that pushes for shutdown safety (in case technology is caught on fire), something that solar modules such as micro-inverters can provide.

Some micro-inverters that are software-defined will have many additional software capabilities that will cause them to not be interchangeable. Enphase is currently investing its effort to produce such technology.

Competition Responding to Market Trends

Due to such market conditions for solar micro-inverters, big and small companies have responded in different ways given their resources.

For example, Enphase has chosen to focus on cost-reducing activities, laying off 11% of its workers in order to achieve a substantial cut in fixed cost. Its main strategy is to continue to innovate in “Product Development Life Cycle” (B. Angelis, personal communication, April 8 – April 12, 2018), meaning the process of managing the product from its inception through engineering design to manufacturing and delivery (Rouse, 2013), and also to innovate to reduce

costs at any given opportunity. This innovation results in new features added to the micro-inverter technology and therefore making products more appealing to customers.

One of the key strengths of such big solar companies such as Enphase and SolarEdge (in relation to small-scale startups such as us), is that they generate revenue from multiple markets. If one market loses its revenue-generating capability, they can always switch to another. For example, while Enphase is making money selling high-volume, low-cost micro-inverters, it is also selling high-power, expensive solar technology and is gaining profit from that at a slow but substantial rate.

In contrast to Enphase, SolarEdge's main strategy doesn't include cost-reduction and instead to create value for customers that comes from continuously innovating its products. The company is confident it can handle upcoming market turmoil by relying on its reserve cash amounting to $200 million.

Solar startups and more local companies lack financial resources, so their main focus is to build long-term customer relationships to secure and increase their market share (Spector, 2016).

Advantage of Selling Micro-Inverters to Residential Market

Given such information, our micro-inverter startup has a strategic advantage over string inverters in that we are following the current trend toward module level power electronics. It is also advantageous to enter Residential market because it's a huge market that doesn't require large fixed-cost investment and our products would be more relevant to individual households in terms of cost savings, than it would be for commercial companies where cumulative costs savings may not be worth the investment for the companies.

In the micro-inverter startup world, there are less pressure on prices than it is in big solar company world. Hence this gives our startup price flexibility. The disadvantage is that big companies have already established their brand and hence it would be challenging to persuade customers to buy our products. Hence our marketing efforts will largely be focused on developing long-term customer relationships as well as emphasize how Professor Yousef's innovative micro-inverter technology makes us different.

Sales Forecast

In order to predict short-term performance of the company, a sales forecast was created. The forecast is based on estimates such as expected item sales, estimated materials cost and the price. As discussed in the marketing section of this paper, the price of one micro-inverter will be $200. This gives high enough gross margin to cover up the costs of direct materials as well as hiring staff and outsourcing manufacturing.

Since there is not bill of materials for our solar micro-inverter and a manager at Enphase could not disclose such information about their products either, I made an estimate of what materials would cost for a single micro-inverter. The cost is roughly $115.

Estimating Materials Cost per One Unit

The forecast also includes the labor cost of $35,000 per employee. Since the annual target is 20,000 micro-inverters, that would be a labor cost of $17.5 per unit and that is only a fraction of the total materials cost. Hence, the labor cost could be neglected in materials cost estimation. On GoGreenSolar.com, Enphase standard micro-inverter M250 is priced at $163. In the Energy Sector, the average gross margin is 29.58% (Renewable Energy Services & Equipment Industry Profitability from CSIMarket, Last accessed 25 April 2018). Hence, very rough estimation of the materials cost for Enphase standard micro-inverter is $115. Assuming that our inverter would cost around the same, in addition to a DSP camera, interfacing hardware and a mounting device as per Yousef's innovation (Mahmoud Y., 2017), the total materials cost for our micro-inverter would be $159. The price of the micro-inverter will stand at $200, however.

Given the information provided in Customer Segments Section, our expected item sales in the first year is 20,000 micro-inverters. We would expect to get 651 customers, each purchasing approximately 31 micro-inverters. We also assumed that by each quarter, our sales staff would increase their productivity by 10% due to experience and learning, therefore increasing our item sales by 10% per each quarter.

By hiring 3 door-to-door sales people (with annual salary of $60,000 each), we would expect each sales person to make 11 customers every month to meet our target of 651 customers in the first year. For supplying our sales with warm leads, a marketing specialist will be hired to

promote the solar product via website. This will also the startup establish an online presence and effectively compete with big companies, many of them also having an online presence.

The final costs included in the following Sales Forecast Table are materials costs, creating a website, hiring ten factory workers, one marketing specialist (with annual salary of also $60,000), and 3 door-to-door sales people.

Forecast Table

Figure 3: Forecast for the First Year of the Business

	Quarter 1 (Forecasted)	Quarter 2 (Forecasted)	Quarter 3 (Forecasted)	Quarter 4 (Forecasted)
Sales	$ 862,000	$ 948,200	$ 1,043,020	$ 1,147,322
Cost of Goods Sold	$ 760,715	$ 836,610	$ 920,271	$ 1,012,404
Gross Profit	$ 101,285	$ 111,590	$ 122,749	$ 134,918
SG&A	$ 60,000	$ 60,000	$ 60,000	$ 60,000
Outsource	$ 63,019	$ 63,019	$ 63,019	$ 63,019
Profit before tax	$ (21,734)	$ (11,429)	$ (270)	$ 11,899
Income taxes	$ -	$ -	$ -	$ 1,071
Net Income	$ (21,734)	$ (11,429)	$ (270)	$ 10,828

The table describes the overall sales forecast in the first year of the business. The estimation for the next year's unit sales will be based later when the startup gains sales data from one or two quarters of its operation. The data shows that while the startup may start out with no profit, eventually it will be able to hit a break-even point in Quarter 4.

SWOT Analysis

A Strengths, Weaknesses, Opportunities and Threats Analysis, or commonly referred to as the SWOT analysis, is a strategic business tool that can help businesses figure out their niche in a particular market. By looking at the internal aspects of one's organization, covered by sections Strengths and Weaknesses, as well as covering the external aspects, Threats and Opportunities, the business can uncover strategic solutions to utilize one's advantages and also deal with its disadvantages more optimally.

The method has originally been created by Albert S. Humphrey in the 1960s (SWOT Analysis: Discover New Opportunities, Manage and Eliminate Threats, 2018). The following SWOT

analysis has been conducted on the Yousef's innovation-based startup within the context of today's US solar market.

Strengths: Patented innovation, Innovator is an expert in the pertinent field, proven business model – other solar startups exist

Weaknesses: No funding, no assembled team

Opportunities: Growing market of MLPE, unique value proposition of premium inverters that work better in partially shaded conditions, financial incentives offered to households in MA by the government

Threats: Big competitors (Enphase, SolarEdge, and SMA)

Porter's Five Forces

Michael E. Porter of Harvard University has created the business strategy tool called Porter's Five Forces (Porter, 2017). It is a useful planning method that helps businesses understand their industry and decided how they can effectively position themselves in the market. By studying the Five Forces, which include, Competitive Rivalry, Supplier Power, Buyer Power, Threat of Substitution and Threat of New Entry, one can devise a plan to avoid the negative forces existing in the market and position their business for success (FRM E. M., 2015). The following paragraphs include the analysis of these forces in the US Solar industry today.

Competitive Rivalry

Big competitors who own most of the market share in US are Enphase, SolarEdge and SMA (Spector, 2016)

There are several solar startups in USA, but none of them are either based in the state of Massachusetts or sell there.

Enphase could potentially steal customers from us through price cuts. Their products are higher quality and lower-priced. However, unlike Enphase and other companies, we serve only the affluent households of Massachusetts and provide them with micro-inverters which make their solar panels very efficient and reliable.

Supplier Power

There are approximately one or two solar contract manufacturers that offer construction services in the state of Massachusetts.

Due to such shortage of outsourcing service providers in Massachusetts, suppliers of micro-inverter engineering services could easily increase their price margins or markups to gain higher profit. One potential solution to increase our outsourcing options is to partner with CMs from other states at a cheaper price and have them ship the products at a reasonable additional fee. However, a comprehensive cost analysis need to be created in order to conclude whether switching suppliers is a profitable idea. This analysis is outside of scope of this MQP.

Buyer Power

In an ideal case, in the first year our business is going to attract 0.5% of the total available market in Massachusetts. High number of buyers will decrease their buying power. One household on average will purchase 31 micro-inverters, each priced at $200. An average inverter costs $163 in US market. Hence, high switching costs (31*$163 + replacement fees) will decrease the buyers' motivation to go to another competitor.

The price could be discounted depending on the size of the order.

Threat of Substitution

Our product can easily be copied if not for a patented MPPT innovation. The patent allows our solar micro-inverters to be highly efficient and our competition will not be able to use the same MPPT algorithm for their solar products. However, there is a small possibility that a smart researcher at another company figures out a different algorithm that performs the same function. Nevertheless, the probability of that is small and very likely not pose a threat to our business.

Threat of substation can potentially come from a lower-priced micro-inverters which are efficient enough to satisfy some of our customers.

Threat of New Entry

New regulations from National Electrical Manufacturers Association are setting high reliability standards for solar inverter technology (Enphase Energy, 2014) and are pushing from micro-inverter production (vs string inverters). This may encourage new startups to seek out creating

solutions in MLPE sector and that may pose a threat to our startup in the future by having more competitors to deal with.

However, starting a solar business requires an initial investment of at least $1 million. Hence, if our startup is financed, it is unlikely that the new competition will appear in the near future. The process of manufacturing micro-inverters requires high specialization and as first-comers, we will already have a well-established relationship with contract manufacturers in MA.

Identifying the Need

Industry/market research, SWOT analysis and Porter's Five Forces have laid the foundation for us to transition into investigating if there is an actual need in the market that our product can satisfy. Instead of viewing all the different needs of the market to figure out what product need to be built, we will use our existing product's and the knowledge of its unique benefits to find customers who may benefit from them. We are looking to identify the need.

Based on the assurance of Professor Yousef, the innovator of a novel MPPT technique, the value proposition consists of highly efficient, premium micro-inverters that operate much better than the current competition in US (Mahmoud Y., personal conversation, 2017-2018). Hence the target market would be the state of Massachusetts. Four criteria were looked at in order to assess the best state to target our customers.

1) High electricity costs
2) Proximity
3) Number of daily peak sunlight hours
4) Number of financial incentives offered

Electricity costs

Electricity costs are an important factor to consider when selecting the geo-location for our target market because higher electricity costs means households would have more incentive to switch to solar. The costs are predicted to keep increasing in future years, likely motivating some households to adopt solar technology as their source of energy. Some of the highest bills were found in the states of Connecticut, Maryland, Massachusetts and Pennsylvania (Data acquired from U.S. Energy Information Administration).

Daily Peak Sunlight Hours

Another important criteria for finding the best target market is a number of daily peak sunlight hours. Since solar panels generate electricity via sunlight they absorb, their efficiency depends on receiving a substantial amount of sunlight on a daily basis. If a minimum amount of sunlight is not met, solar panels lose their efficiency and therefore create inconvenience for households. "Peak Sunlight Hours" refer to a full hour during which solar panels receive full sunlight. According to EnergySage (Richardson, 2018), at least 4 of "peak" sunlight hours are required in order to utilize solar panels at their full potential. Anything below that creates energy loss. This website shows which of the states have less than 4 "peak" sunlight hours. Such states are West Virginia, Connecticut, New York, New Jersey and Massachusetts (Renogy, 2013). Since our product specializes in high efficiency during unfavorable conditions, households residing in such states will likely have more need for our product than states with a lot of daily peak sunlight hours.

Number of Financial Incentives Offered and Proximity

Due to high materials cost, our product will be priced high. Hence it would be advantageous to target the state were the government offers households with a lot of financial incentives to purchase solar systems. Only in Worcester, there are 60+ different financial incentives offered, including solar tax credits that discount the purchase of the whole solar system up to 30% (Matasci, 2018). Apart from that, proximity would also be a useful criteria to consider. The first years of a startup are uncertain because it has not yet reached a point of maturity. Not too many people are hired either and hence, the main decision maker is the CEO or in this case, the innovator of the company. Since Professor Yousef works in MA, it would be geographically advantageous if business operations took place near him so that he could effectively lead the company.

Roof Angle

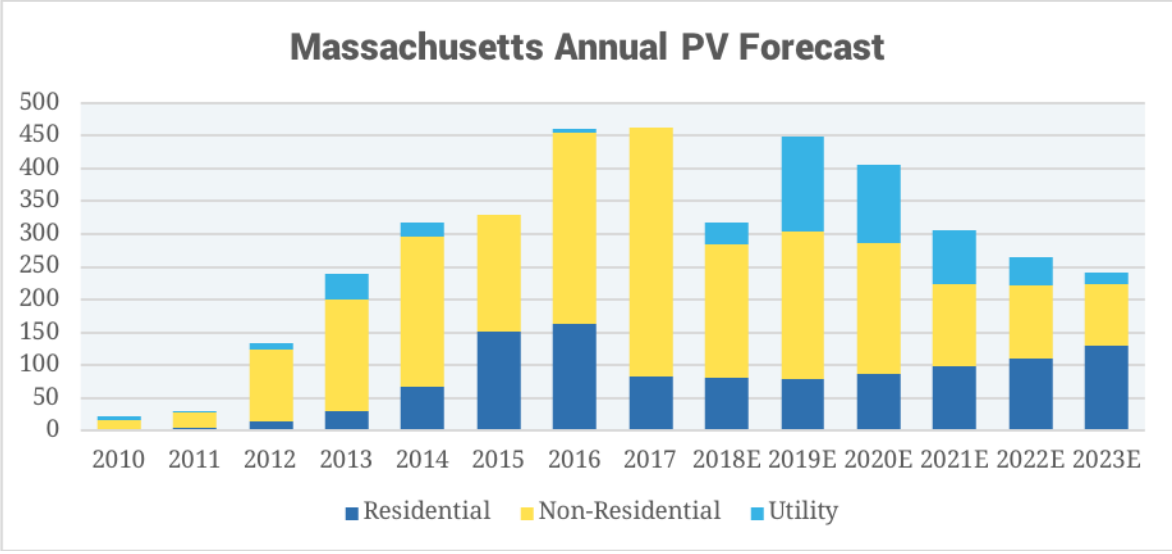
While a correct roof angle can significantly increase solar panel efficiency at absorbing enough sunlight ("What's the best angle for my solar panels?". Retrieved from EnergySage) it ought not to be factored in for the decision of targeting. Solar panels do not necessarily need to be installed on the roof and instead can be installed on the ground. In case households only have a roof space to install solar panels, solar panel's quality to be angle-adjustable can be utilized to solar panels

absorb the sunlight at the maximum efficiency possible. Therefore, roof angle was not considered when choosing a target market.

Due to four factors mentioned above, the state of Massachusetts is a strategically advantageous place where our startup can commence its first phase of operations, the introduction phase (Luecke, 2006). It has a high monthly electricity bill relative to other states. The households experience less than 4 peaks sunlight hours a day. The state offers many financial incentives for households to go solar and it is a geographically advantageous place to lead the startup.

Our reasoning is confirmed by the evidence provided by NREL report (2016). The histogram below demonstrates expected market growth in Massachusetts for solar panels. It demonstrates that while overall the solar market may be stabilizing, the residential market will experience relatively higher growth in the next several years. Hence by targeting Massachusetts, our startup will be able to cut out a significant portion of the market share to grow and become profitable in the first year of the business (See the Sales Forecast section to learn more about the sales/costs).

Figure 4: Expected Growth of the Solar Residential Market in Massachusetts



Source: SEIA, Solar Energy Industry Association

The data above demonstrates that there is a need in the state of Massachusetts that can be satisfied by our solar micro-inverter. The following paragraphs demonstrate a set of

recommendations for a business plan for the solar micro-inverter in the form of a Business Model Canvas.

Business Model Canvas

The following business model canvas is used in this paper to structure the following business strategies into a logical form. It has been used by many businesses including GE and Nestlé. As a startup, this model has been selected to help "move beyond product-centric thinking and towards business model thinking." (Osterwalder, 2017)

Unique Value Proposition

Forming a unique value proposition will help define what set of benefits our customers will receive from our startup. Our micro-inverter, as assured by Professor Yousef, can mitigate 15% more energy loss than a regular micro-inverter, and 23% (SolarEdge, 2013) more energy loss than a string inverter. In other words, our micro-inverter is more efficient and reliable than the competition in partially shaded conditions.

Besides efficiency however, customers can also save money by purchasing our micro-inverter. By using a solar calculator developed by EnergySage, one can calculate the amount of money households will save by going solar. For example, assuming that an average monthly electricity bill in the state of Massachusetts is $114, a household purchasing a solar system for their home will save around $20,000 in the next 20 years. The payback period, a time it takes to break even would be 4.4 years (Assuming that a household would pay anywhere from $10,000 to $15,000 for a solar technology) (Data retrieved from EnergySage Solar Calculator).

The calculator does not specify whether the system contains a micro-inverter or a string inverter. Hence, it is hard to tell which one would be a better option for the customer, to install solar panels with micro-inverters or a string inverter. However, by comparing the costs of the two, one can get a general idea. For example, an average micro-inverter on Amazon costs anywhere from $70 to $250 with a median of roughly $150. A string inverter is approximately $1,800. For 31 solar panels, 31 micro-inverters need to be purchased amounting to the total cost of $4,650 for micro-inverters. Since one string inverter is sufficient for 31 solar panels, the total cost of buying micro-inverters is compared with the cost of one string inverter.

To adjust for 25 years owning a solar panel system, one has to take into account the lifespan. A micro-inverter has a lifespan of 25 years. However, a string inverter need to be changed at least twice in the same period. Hence, the real cost of string inverters in 25 years become $5,400 plus additional replacement fees paid to the solar installer.

Given those numbers, one can conclude that while in the short-term, micro-inverters are much more expensive, in the long-term the reverse is true. However, our micro-inverters are priced at $200 per unit, not $150 and hence the total cost of 31 micro-inverters would be $5,890, which is still more expensive or almost the same price as the string inverter ownership and maintenance in the next 25 years. In the light of this fact, while our startup will drop the inverter price in the near future due to a advancing in the learning curve, we are not going to market our product as the best price option yet, but rather as a highly efficient and reliable, premium product designed for wealthy households. Since unique value proposition is a set of all the benefits customers will receive from the product (Institute for Strategy & Competitiveness), cost savings will also be included. This is because while our micro-inverter is relatively more expensive, a household's choice to go solar will still save them a considerable amount of money ($20,000), with a slightly longer payback period (> 4.4 years).

Customer Segments

Since our micro-inverter delivers high efficiency than a regular micro-inverter, our startup will target households who already own solar panels in their homes and get them to switch their old inverter with our inverter. They are labeled Segment #1.

Segment #2 segment consist household that already owns solar panels with a string inverter. The pain point that our product would resolve that other micro-inverters or string inverters cannot is the efficiency of a household solar panel system during a partially-shaded conditions.

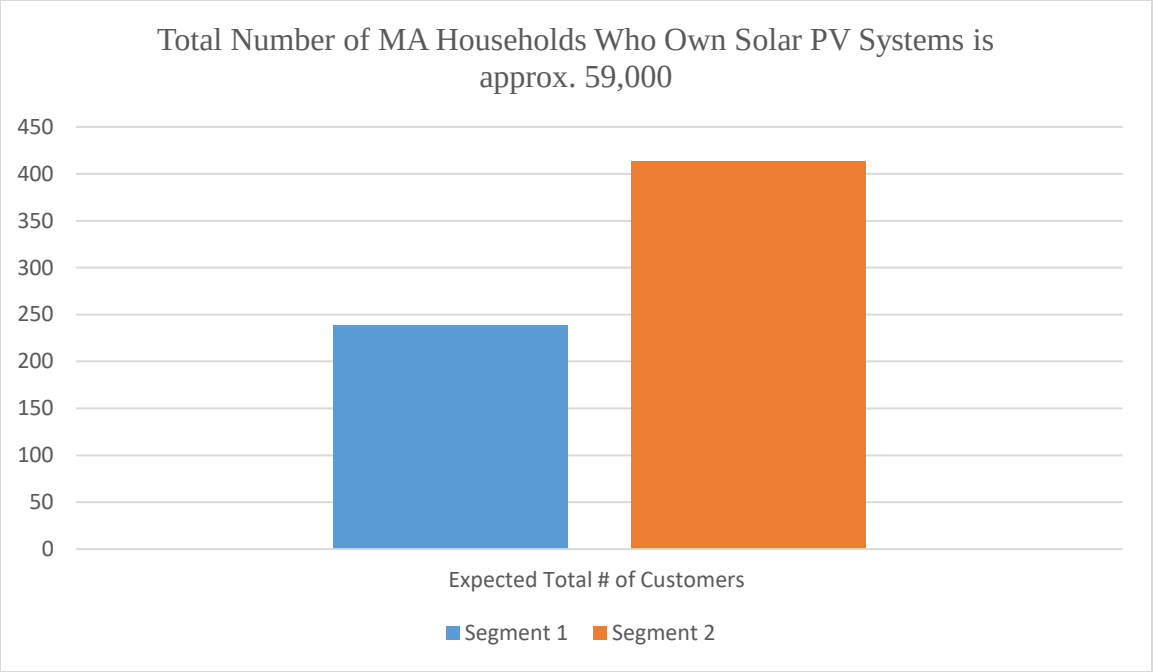
The third segment (Segment #3) would be households who do not yet own solar panels, but either plan to or have a desire to do so sometime in the future.

Based on the chart below, there is approximately 500 mega-watt of residential solar capacity in Massachusetts (Massachusetts Department of Energy Resources, 2017). Assuming that on average one solar panel has a capacity of 275 watts, there are approximately 1.8 million solar panels owned by residents in Massachusetts. Since one household in United States has to install

on average 31 solar panels to meet their electricity needs (Tarbi, 2018), there are approximately 59 thousand households who own a PV system in Massachusetts. That is about 2.4% of total households in the state (Retrieved from U.S. Census Bureau QuickFacts: Massachusetts).

String inverter and micro-inverter owners out of the total residential market in US are 47% and 27% market share-wise, respectively (Feldman, 2017). Assuming that the state of Massachusetts contains the same proportion of owners in 2018, there are approximately 28 thousand households who own solar panels with a string inverter and 16 thousand households who own solar panels with micro-inverters. In an ideal case, we can randomly pick a very low percentage of these two numbers to predict how much our startup could capture in the first year of the business, 0.5%. The total available market for the third segment has not been estimated due to lack of sufficient information on the MA households for their interests in adopting solar technology. Hence, the Sales Forecast only considers Segments #1 and #2 for the first year of the business. The following table demonstrates the expected market that can be captured in year 1 from both segments.

Figure 5: Customer Segments for Solar Micro-inverter



Sales Channel

Secondly, our startup should focus on building lasting relationships with customers. As mentioned in the market research, the industry is experiencing lack of trust between customers and installers. Since buyers and sellers may not necessarily communicate directly, leaving that to the middlemen installers, there may be a potential distrust existing between buyers and sellers. Door-to-door sales can be a great way to break that distrust since it requires to get right in front of the customers and build a valuable connection (Tips from a Door to Door Salesman, 2016). According to Scott Cooney, it is important that there is a "built up layer of trust that is critical to closing a sale." (2014)

The startup should hire three sales representatives who are willing to do door-to-door sales and effectively explain this relatively complex technology to customers. By interacting with households directly, the startup will build trust and long-term relationships with their customers. This will likely prove profitable later on.

Since many competitors in US Solar industry have online presence, our startup should do the same, as established before. Potential customers can learn more about what services the startup offers and the value of enhanced MPPT technology.

Due to recent popularization of internet usage to buy goods and services, the startup will form a partnership with solar distributors AEE Solar or Gexpro. Customers will be able to order micro-inverters online and once the orders are set, the product will go from the nearby manufacturing cell will deliver the product to the customer. In the future, more complex logistics method will be required involving partnerships with strategically-located warehouses around the country to ensure fast delivery, lean supply chain and low cost (Jacobs, 2013).

Customer Relationships

The expectation is that the first year of the business, customers will be a one-time buyers of a solar product. Until the product line is expanded later, the customer will order micro-inverters from our startup and then have them installed on their existing solar PV system in their homes (if they are Customer Segment #1 or #2), or they will install the micro-inverters along with the rest of the system. There will be no need for the customers to reach us back since a micro-inverter

need only be installed once. In cases when inverters malfunction however, we will have them connect with either one of our salespeople or use a contact information listed on the website.

Throughout the whole sales cycle, great customer care will be emphasized among hired sales representatives. However, since our startup won't have a designated office in the beginning, much of our customer perception will be formed in the very first interaction between our sales people and customers. Hence it is important that hired sales people are well-trained. In order to nurture relationships for potential future sales with other products, the website will gather a list of emails of our customers and a hired marketing specialist will send them a weekly, exciting information about solar industry and how it can benefit them. According to this reference, it is proven that customers respond well to free value. Also, according to this reference, customers like to have choices because it increases the likelihood of buying. In the second year of operation, the startup will expand its product line depending on the feedback received from the customers.

Revenue Streams

Much of the revenue will come from selling products directly. Depending on the sales result in the first two quarters of the business, a decision may be made to create an affiliate program. In this program, customer we were able to make will be incentivized to refer to other customers via website, and receive a commission if their referred household became a customer.

Our startup will also run discounts on $200 product on Black Friday and other holidays in order to boost sales.

Key Activities

One of the major focus of our business will be to improve on existing processes including sales people productivity by conducting monthly trainings as well as building relationships with online retail stores to become trusted purchasers and potentially receive a discount for the materials.

A few Key Performance Metrics will also be adopted in order to ensure our startup learns from the customers in an organized manner.

For example, a survey will be sent out to customers by email a couple months after the purchase. Their response will tell us what aspects of the product, software or hardware need to be improved (Validating your Decisions Using Surveys, 2015). By the second year of operation, we

will either educate our contract manufacturers of our findings or incorporate them into our own manufacturing.

Once the product has been sufficiently tested and data is available, the next phase of commercialization will involve decisions such as product re-design and what customer needs are met as well as what needs to be improved.

In the future, the startup will adopt Quality Function Deployment (QFD) method in order to translate the "customer voice" into a specific engineering processes in the solar inverter manufacturing to measurable results (Clausing, 2014). However, during the launch period, manufacturing will be outsourced as mentioned above.

Key Resources

The startup will form strategic partnerships with solar financing companies such as BlueWave. The company provides many services, including offering solar customers with multiple options of covering their solar technology payment. Solar leasing or taking out a loan are two ways where customers can purchase solar panels and our inverters by making a $0-down payment. By referring our customers to such companies, it will increase their payment flexibility thereby increasing the likelihood of them becoming our customer. BlueWave would also benefit from that partnership by getting more customers.

Cost Structure

By following the pricing strategies of high-tech companies, the startup will adopt a skimming pricing strategy that will gradually decrease in price several months after launch. By following this method, our business is going to capture the first wave of customers, also labeled as early adopters, and later on "skim the next tier of interested customers" (Luecke, 2006). The price of one micro-inverters will be $200. The gross profit margin of 16% will be high enough to ensure business profitability in the first year of its operation and still remain below solar Industry median, 24.58% (Hoovers, n.d.).

Through interviewing Bruce Angelis, A Senior Director of Software Engineering at Enphase, I found out that a micro-inverter cannot be built by hand. A complex equipment is likely required to build such technology and currently there doesn't seem to be a close contact who has a deep expertise in this area that we can hire. Hence at least for the first year of the business, the

manufacturing of the business will be outsourced to either Janco Electronics in Massachusetts or HelioPower which is based in California; that will help the startup saves much cost associated with inefficient manufacturing.

Marketing Plan

While Business Model Canvas delivers a substantial information about what is required to start a profitable solar business in US, the following marketing plan will provide a more in-depth explanation of the marketing strategies and advertising messages (used for a sales pitch or future advertising campaigns) that need to be considered for selling the solar micro-inverters.

Currently the startup has not been formed and is still in the preliminary planning phase. Professor Yousef is an innovator of the novel MPPT method and therefore has a technical knowledge of how solar panels and micro-inverters work.

The startup's value proposition is to provide affluent households in the state of Massachusetts with a premium, highly-efficient solar micro-inverters that can satisfy their energy needs continuously (especially during unfavorable conditions).

The following paragraphs describe 4 P's of our marketing strategy created to meet a goal of raising the product awareness locally and start forming long-term relationships with our customers.

P for Product

Our micro-inverter includes features such as a self-contained micro-inverter, a sensor and a camera that allows for Professor Yousef's MPPT method to work (Mahmoud Y., 2017). Namely to eliminate scanning periods and maximize power output from solar panels to which the micro-inverter is attached to.

A set of benefits are the following: a lower utility bill by 60% (Mahmoud Y., personal conversation, 2017) and a highly reliable source of energy during unfavorable conditions such as cloudy weather, a shade cast on solar panels, or similar.

Our technology is different from our competitors in two ways. Hardware-wise, our micro-inverter has a camera and a mounting hardware. Benefit-wise, it is the only micro-inverter that

allows solar panels to mitigate 15% more energy loss than a regular micro-inverter on the US market (Mahmoud Y., personal conversation, 2017-2018).

P for Pricing

Most prices for micro-inverters from Enphase and SolarEdge range anywhere from $150 to $1-2k. For households however, the average price of the micro-inverter can be anywhere from $60 to $200.

Our startup will adopt a skimming model. According to Luecke from Marketer's Toolkit (2006), skimming is one of the most viable options that a business can use in its introductory phase of the product life cycle. This strategy will ensure the capture of the affluent market in the state of Massachusetts and hopefully attract other segments of the residential market as the price point decreases.

P for Place

One option of selling micro inverters is through online retails such as Amazon or similar websites which specialize only in renewable energy products. Many of the solar companies, big or small, have a website listing their product line of solar technologies. There seems to be a benefit of selling solar products online and hence our startup can do the same in the future.

Selling micro inverters through many different channels can also help the startup identify which ones are the most profitable and later during the high-volume production phase focus its resources into one or two channels. Door-to-door sales is a viable way to attract customers and it can also help build long-term relationships (Tips from a Door to Door Salesman, 2016), so it only makes sense to employ this method in the testing phase. In the second year of the business, our company can also send out quotes to households on a monthly basis to increase product likeability and offer many options to potential customers. The more customers receive quotes, the more time they will invest in considering buying our solar product.

P for Promotion

According to a marketing expert Donald Miller, there need to be a compelling message that will get customers to buy micro-inverters from us. It needs to solve a customer's problem on three levels: external, internal and philosophical (Miller, 2017).

The external problem that our micro-inverter technology solves for the customer is that it lowers our customer's utility bill (for Segment #3) as well as provides energy solutions for unfavorable conditions (cloudy weather, a shade cast on solar panels, etc.).

The internal problem that our solar products may solve is a sense of certainty. By providing highly efficient technology, we promise our customers that they will not have to worry about energy losses or electricity shutdowns in their households.

Our startup also solves the philosophical problem. By helping households with lower incomes, we deliver the message that everyone ought to be able to afford a renewable energy technology for their homes. It also solves another philosophical problem, which is that the product lowers the households' utility bill, thereby implying that companies which provide energy services from polluting the environment ought not to be making a lot of money.

These are the key messages that need to be communicated through marketing channels, whether that would be social media, blogs or a website.

Also the marketing message needs to educate potential customers of the financial benefits and purchasing flexibility of solar panels. While we would be selling micro-inverters, we will probably still incorporate similar message into our marketing because our customers will be people who either have already installed a solar panel (and need a replacement for a micro-inverter), or are planning to buy one.

Recommendation Summary

Based on market research, SWOT analysis and sales forecasting, recommendations were developed for starting a profitable solar business. These recommendations follow three main challenges that need to be addressed: Strong competition, high costs for building a micro-inverter that incorporates a new algorithm and lack of technological knowledge to build a micro-inverter.

High Competition

Solar industry in US is very competitive. Two biggest competitors are Enphase and SolarEdge whose strategies include downsizing and incremental innovation. Collectively they hold about 55% of the total solar market share. (Spector, 2016) Since the competition is so concentrated, the

startup needs to carve out a very specific niche in order to become relevant in the solar market. From SWOT analysis, one of the startup's key strengths is its patented algorithm that allows the solar micro-inverter to perform at a much higher efficiency than regular inverters (Mahmoud Y., 2017). Through effective communication with customers, a significant portion of the residential market share can be obtain even in the first year of the business as demonstrated before.

Secondly, our startup should focus on building lasting relationships with customers. As mentioned in the market research, the industry is experiencing lack of trust between customers and installers. The startup should hire three sales representatives who can understand the technology and willing to do door-to-door sales. By interacting with households directly, the startup will build trust and long-term relationships with their customer that will prove to be profitable.

Since many competitors in US Solar industry have online presence, our startup should do the same, as established before. Potential customers can learn more about what services the startup offers and the value of enhanced MPPT technology.

Direct Materials Cost

To address the second challenge of high direct materials cost, a skimming pricing method has been developed that allows the startup to first connect with early adopters and the rest of the market (Luecke, 2006). This will ensure the company's profitability regardless of high materials price and will provide the financial leverage for dealing with the next wave of customers.

While the skimming pricing strategy is geared towards attracting early adopters, I also recommend the startup to form strategic partnerships with solar financing companies such as BlueWave in order to accommodate customers whom may not be able to afford the technology.

Complex Equipment for Building Micro-inverters

To address the third challenge, I recommend outsourcing manufacturing. Through interviewing Bruce Angelis, A Senior Director of Software Engineering at Enphase, I found out that a regular micro-inverter cannot be built by hand. A complex equipment is required to build such technology and currently there doesn't seem to be a close contact who has a deep expertise in this area that we can hire. Hence at least for the first year of the business, the manufacturing of the business will be outsourced and that will help the startup saves much cost associated with inefficient manufacturing.

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