HANESBRANDS RENEWABLE ENERGY PRIORITIZATION

by

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Legal Statement and Master's Project Scope

The authors of this report are Serkan Erdem, Xiaonan Feng, Joseph Moss, Liam Regan and Will Yang, who are members of the student team from Nicholas School of the Environment (NSOE) at Duke University. The student team's advisor was Gale Boyd, who is an associate research professor in the Social Science Research Institute as well as an associate research professor of Economics. This Master's Project was written in partial fulfillment of the requirements for the Master of Environmental Management (MEM) degree in NSOE. HanesBrands was pleased to assist the NSOE student team in this work. However, HanesBrands is not the author of this report and does not make any claim, express or implied, or endorse any claims made by the authors of this report. In addition to this report prepared for Duke University, a more detailed report will be written and submitted to HanesBrands and Gale Boyd for review.

Executive Summary

Renewable energy is quickly becoming an integral component of manufacturing energy consumption portfolios internationally. Activewear apparel company HanesBrands, Inc (Hanes) has made a commitment to increase its global renewable energy proportion by 40% compared to 2007 baseline levels by 2020. As of 2015, Hanes has met 24.9% of this goal but has been investigating a variety of novel infrastructural and financial methods to close the gap to 40% with limited renewable energy project investment capital.

This report details the findings of the Duke University, Nicholas School of the Environment team who engaged with Hanes a year ago to conduct a comprehensive analysis of Hanes' worldwide energy portfolio. Coupling Hanes' primary data provided with academic and industry style literature reviews third-party data, the Duke team developed a diverse strategy composed of multiple recommendations assisting Hanes in attaining their 2020 renewable energy goal. The evaluation was conducted using a sample of 10 Hanes facilities covering a cross section of operational functionality spanning 4 countries with widely varying power markets. While the recommendations derived from the National Renewable Energy Laboratory's System Advisor Model (NREL SAM) are legitimized by the synthesis of primary and proxy market data, they are in no way representative of the entirety of Hanes' international energy portfolio and should not

be solely considered when executing future energy management decisions. As an extension of this Master's Project, all other sites should be considered equally and calculated against the projects this report recommends.

The introduction of this report gives context to Hanes' current renewable energy position: elaborating its progress towards meeting its renewable energy commitments, summarizing its financial statements to determine its ability to invest in renewable energy projects, iterating its pledge to corporate social sustainability practices, and examining its competitors' efforts towards similar renewable energy goals. There is also a literature review of synthetic power purchase agreements (SPPAs) and the sustainability of biomass. Enumerating these variables builds a framework for the later quantitative portion of the report – giving perspective to any assumptions made on extrapolated recommendations.

Following is the explanation of the methodologies that describe the implementation of a uniform energy management software tool (EMS) that was used to objectively dissect Hanes' energy profile electricity constituent. There were limitations to approaching the profile this way in not diving deeper into the biofuel portion of the profile, but the impact of that is assessed in the report's discussion section. There are also site analyses that describe the Hanes facilities' power markets, detailing a facility overview, market analysis, tariff analysis and interval data analysis.

Using the EMS, the study's results illustrate Hanes' overall electricity consumption patterns and behaviors by disseminating the true cost of electricity from monthly bills and pairing it with annual, 15-minute interval data in the NREL SAM. The approach to this studied both financial and infrastructural measures to attain the same results.

The recommendations section magnifies the financially and sustainably lucrative projects, covering SPPAs, solar panel infrastructure, and renewable energy certificates (RECs), that fulfill Hanes' renewable energy quota and weighs the pros and cons associated with certain selections. In following, the team discusses the limitations and assumptions, unexpected results, and further considerations for Hanes to continue investigating as they pursue their 2020 goals.

There is no single solution to achieving the 15.1% renewable energy gap in Hanes' renewable energy target. A comprehensive selection of both financial and physical solutions coupled with new, bolstered energy management efforts are required to realize this goal. Due to the time limitation, the relatively instantaneous effect of SPPAs and RECs are more attractive alternatives to replacing the energy portfolio's non-renewable energy component. However, the negatives such as delocalized power market impact, REC double counting, and public perceived green-washing are attributes associated with these kinds of contracts that should be weighed versus contract term length longevity. Based on the capacity impact on renewable energy percentages, available land for construction, and required time for construction, solar panels alone cannot make up the difference in the 2020 renewable energy goal. While in this report they are more sustainable and financially appealing, the required non-renewable energy replacement difference over time is operationally unviable. To fully realize their renewable energy 2020 vision, implementing these recommendations and executing a study to replace liquid fossil fuels, a majority composition of the energy portfolio, is the strategy endorsed by this report.

Introduction

I. HanesBrands Background

HanesBrands Inc. (Hanes), founded in 1901, is a Fortune500 (490) manufacturer of basic apparel and activewear based in Winston-Salem, NC. Hanes operates as the world's largest marketer of basic apparel in 40 countries spanning 6 continents, and takes pride in being socially and environmentally responsible in its day-to-day operations. Unique to industry competitors, Hanes owns the majority of its own supply chain, and could consequently enact more direct and effective environmental stewardship initiatives over its production and operations worldwide. However, this also means Hanes must take responsibility for more of the apparel supply chain such as manufacturing, which many of Hanes' competitors are not required to do. As a result of its continuous sustainability, Hanes has been awarded Energy Star Partner of the Year – Sustained Excellence Award for seven years in a row, and is the only apparel company to earn this honor (Energy Star, 2017).

II. Hanes Energy/Sustainability Efforts & The Duke Master's Project Goals

Hanes strives for continuous improvement of its corporate sustainability, and has put great focus on enhancing the amount of renewable energy it uses as a percentage of its global energy use. Hanes has set ambitious goals to be achieved by 2020, which include (Hanes, 2017):

- Reduce energy intensity by 40% compared to 2007 base level;
- Increase total renewable energy percentage to 40% compared to 2007 base level;
- Reduce water intensity by 50% compared to 2007 base level;
- Reduce carbon intensity by 40% compared to 2007 base level;

As of 2015, Hanes has made considerable progress towards its 2020 goals:

- Energy use has been reduced by 24%;
- Renewable energy percentage has increased to 25%;
- Water use has been reduced by 31%;
- Carbon emission has been reduced by 21%.

Hanes hosts a corporate culture that values mentorship and has been providing experiential learning opportunities to students and professionals over the years. It has entered into the engagement activity with a Master's Project Student Team from Duke University's, Nicholas School of the Environment (hereafter referred to as the Duke team), with the hope of obtaining the Duke team's recommendations of how they would prioritize the renewable projects under Hanes' fiscal conservative environment. The Duke team consists of five second-year Master of Environmental Management students from the Energy & Environment concentration who have demonstrated genuine interests towards corporate sustainability and renewable energy. The team was chosen to be a broad and diverse group that would be able to provide a cross section of global perspectives from an academic viewpoint to Hanes. Upon communication and discussion, the Duke team has reached a mutual understanding with Hanes that the primary objective of this project is to explore and establish a renewable energy prioritization model that ranks the projects against parameters including but not limited to initial capital investments, net present value, payback periods, and respective renewable energy contribution. As a main deliverable of this project, the group will provide Hanes with a shortlist of actionable renewable projects that could bring Hanes closer towards its 40% renewable energy goals by the year of 2020. In addition to the shortlist, the group will also demonstrate their thinking processes and methodologies adopted in reaching the recommendations in detail. The primary sources of information are provided by

Hanes and are subject to the Non-Disclosure Agreement (NDA) signed by Hanes representatives and the Duke team at the onset of this project.

III. Brand Analysis

HanesBrands is represented widely around the world by either its own brand or through its subsidiaries. Their “Sell More, Spend Less and Make Acquisitions” business strategy has been going full speed with major acquisitions, two of the latest being the Pacific Brands Limited for $800 million, which is the leading intimate apparel & underwear company in Australia (Business Wire, 2016) and Champion Europe for $228 million, a leading innerwear and activewear brand that owns the Champion trademark in Europe, Africa, and Middle East. These are among the 8 major purchases Hanes has made totaling $2.6 billion in the last decade (Craver, 2016).

There are many aspects to Hanes’ brand management, including Corporate Social Responsibility (CSR) efforts and advertisement. Hanes stays involved in local communities around the world where it has facilities. CSR efforts are an important part for a global brand to keep growing and build a good reputation in different locations it operates. This directly feeds into how these local communities think of the brand, with a chance to positively impact its image and distinguish itself among competitors. In addition to the importance it stresses on workplace quality and ethical standards, Hanes has been giving back through the philanthropic program “Green for Good” created in 2010 which brings together the three pillars of their corporate social responsibility: Community improvement, volunteerism, and environmentalism (HanesBrands, n.d.). Hanes’ motto for this program is “Making a difference”, and it helps them maintain a positive brand image throughout the communities they are involved in while giving back. Some CSR stories include a Rotary Club partnership to provide free solar panel kits in San Salvador (Capital of El Salvador) to 120 families who don’t have electric power (HanesBrands, n.d.), supporting United Way of Forsyth County to the amount of $39 million since 1999 (HanesBrands, n.d.), providing critical life-changing surgeries to 200 children of Hanes employees in this country (HanesBrands, n.d.), and Hanes employees being awarded the 2016 CSR Seal in Honduras for their various efforts in community development (HanesBrands, n.d.). Hanes' dedication to CSR is highlighted right away with the first sentence in their home page under the “Our Company” section: “HanesBrands is a socially responsible manufacturer and marketer of leading everyday basic apparel…”. Hanes also shares press releases from its website on important issues like its distribution center achieving a safety milestone, earning a high score in CDP 2016 Climate Change Report, or donating apparel to flood victims in Louisiana to inform the public and investors about its involvements and accomplishments to build up its brand and show it gives back to the community (HanesBrands, 2016).

HanesBrands also stays active with commercials to have a good brand representation. Biggest name from a fame standpoint Hanes has worked with in ads is Michael Jordan. He has long been a brand ambassador for Hanes as he started appearing in commercials in 1990 (HanesBrands, 1990) and kept doing it in 2010s (HanesBrands, 2012). Widely considered to be the best basketball player ever, available public records show that he was paid $14 million between 2000 and 2012 (Janssen, 2015). This shows the extent of willingness and the financial commitment Hanes is willing to make to advertise with a globally known household name. In return, Jordan's endorsement is believed to have had benefited Hanes' sales (Edwards, 2010), (Katje, 2013). As of February 2017, Jordan is still the first picture that pops up in HanesBrands' home page (HanesBrands, 2017). This long-lasting partnership Hanes has been pushing for almost two decades demonstrates a strategy that Hanes wants people to think of its brand as the best in its league.

Hanes takes pride in their ethical business practices by highlighting that they have been the only apparel company to be awarded by Great Place to Work Institute for their facilities in the Caribbean and Central America. They also publicize winning the U.S. Environmental Protection Agency Energy Star sustained excellence recognition for seven years in a row. Hanes' company-wide goal is to create value for all of its shareholders, consumers, retailers, employees and communities. All of their efforts mentioned above and the main goal of this Master's Project (Boosting Hanes' renewables portfolio to meet 2020 goals) feed into Hanes' overall business strategy of building up an ever-growing, competitive and successful brand (HanesBrands, 2017).

IV. 10K Analysis

Hanes Inc. 10K for the fiscal year (FY) ending in January 2, 2016

Hanes' 10K report has been analyzed to understand where Hanes stands in terms of financial performance relative to competitors at the time of this project. Hanes' main goal of creating value for its stakeholders translates to good financial status throughout a fiscal year. The Duke Team aims to assist Hanes in increasing renewable energy use in their portfolio-wide energy consumption. By achieving their sustainability goals, Hanes will be perceived as more environmentally responsible than competitors, giving Hanes a competitive advantage among environmentally and socially conscious consumers. Therefore, an overview of Hanes' 10K is presented below, followed by a competitor analysis with select companies to give context to Hanes' RE goals and compare the company to its competitors.

Based on the common stock price of $33.96 on July 2, 2015 reported on the New York Stock Exchange (NYSE), aggregate market value of Hanes' common stock held by non-affiliates was $13.58 billion. A total of 391,670,911 shares of common stock are outstanding as of February 2, 2016. Owned or leased properties worldwide in the categories of innerwear, activewear, direct to customer and international, total up to 20 million square feet.

Overview of several risk factors

The ability to successfully integrate acquired businesses is considered a risk factor that may impact Hanes' financial results. Hanes has spent $2.6 billion on eight major purchases globally over the last 10 years (Craver, 2016). In addition, due to the extensive nature of Hanes' foreign presence, fluctuations in foreign currency reflect a possible risk factor that negatively affects operations.

Financial Analysis

Payments of cash dividends per share declared by Hanes' Board of Directors (BOD) have varied year-over-year. BOD declared their first ever cash dividends of $0.05 in 2013, and *quarterly* cash dividend rates of $0.075 in 2014, $0.1 in 2015, and $0.11 in 2016.

Last income (loss) from discontinued operations was recorded in December 29, 2012 as $67.8 million. Since then, net sales and operating profit have steadily increased, resulting in an upward trend in net income that most recently reached $429 million. The net sales in the FY2015 were $5.73 billion showing a 7.1% increase from FY2014. In addition, FY2015 earnings per share were $1.06, a 6.6% increase relative to FY2014. Hanes also reported FY2015 long term debt increased 28.4% from FY2014 to reach $2.25 billion. Total cash and cash equivalents have shown a year-over-year increase of 25% and totaled $319 million as of January 2, 2016.

For the FY2016, management expects total sales of $5.8 billion to $5.9 billion and dividend payments of $175 million (Hanes, 2016).

Comparative 10K Analysis with Peer Companies

As per the request of Hanes, a high-level comparison has executed, comparing 2015 10-K reports of VF Corporation (For the FY ended January 2, 2016), Gildan (FY ended January 3, 2016) and Colgate-Palmolive (FY ended December 31, 2016). A breakdown of Total Cash & Equivalents and Long Term Debt parameters from the three competitors' financial reports provide a detailed comparison can be seen below in Tables 1, 2 & 3.

Table 1 indicates that Hanes is the only company, among the three analyzed competitors that has a positive change in cash and equivalents from 2014 to 2015 (+25%), but Hanes has also increased its long-term debt significantly.

Table 1: Cash & Long-term Debt of Companies

	Total Cash & Equivalents		Long Term Debt	
	($ M)	**Change from 2014**	**($ M)**	**Change from 2014**
Hanes	$319	+25%	$2,254	+28.4%
Gildan	$50.68	-22.2%	$375	+139%
VF Corp.	$945.6	-2.7%	$1,415	-0.2%
Colgate-Palmolive	$970	-10.9%	$6,269	+11%

Table 2: Employees, Sales & Net Earnings of Companies

	Total Employees	Net Sales		Net Income/Earnings	
		($ bn)	**Change from 2014**	**($ M)**	**Change from 2014**
Hanes	65,300	$5.73	+7.1%	$429	+6%
Gildan	42,000	$2.96	+25.4%	$304.9	-15.2%
VF Corp.	64,000	$12.25	+0.8%	$1,231.5	+17.6%
Colgate-Palmolive	37,900	$16.03	-7.2%	$1,384	-36.5%

However, Table 3 shows that Gildan still reported increased earnings per share and cash dividends per share. (Gildan, 2016). VF Corp. released a 10-K that illustrates their positive performance in 2015. Their net sales increased less than 1%, which is in total more than twice of Hanes' $5.73 billion, but they increased their net income by 17.6% (highest among the four) to $1.232 billion, which is the only positive change in net income among analyzed competitors excluding Hanes. VF Corp. reported the highest earnings per common share at $2.85, and is also the only company to record a decrease in their long-term debt compared to 2014 (0.2% decrease) (VF Corporation, 2016).

Table 3: Cash dividends and earnings per common share

	Cash Dividends per Common Share ($)			Earnings per Common Share (Diluted)	
	2015	**2014**	**2013**	**Earnings ($)**	**Change from 2014**
Hanes	$0.40	$0.30	$0.15	$1.06	+6.6%
Gildan	$0.065	$0.054	$0.045	$1.46	+21.8%
VF Corp.	$1.33	$1.108	$0.915	$2.85	+19.8%
Colgate-Palmolive	$1.50	$1.42	$1.33	$1.52	-35.6%

V. Competitor Analysis

As part of this Master's Project, a competitor analysis was performed to compare Hanes' sustainability goals and achievements to those of competitors, and understand how competitors were meeting similar goals. To properly benchmark Hanes, a definition of peer organizations needed to be specified. For the purposes of this report, peer organizations were clothing/textile organizations with global operations and high volume sales. After market research was conducted, a total of thirteen organizations fit into the definition of Hanes' peer group. These corporations include: Nike, H&M Group, Levi Strauss & Co, Jockey International, Fruit of the Loom Incorporated, Puma, VF Corporation, C&A, Gildan, Phillips-Van Heusen Corporation, Adidas Group, Under Armour, and Gap Incorporated. Table 4 company's current energy sustainability status and future goals. A more detailed description of each company's current sustainability status and future goals can be found in Appendix A.

Table 4: Competitor analysis

Competitor	Current Status	Future Goals
Nike (Nike Corporation, 2016)	Reduced energy consumed/unit produced by 50% relative to 2008 Reduced CO2e emissions/unit produced by 18% relative to 2011 Reduced retail store energy intensity (kWh/sq. ft) by 14% relative to 2011 Reduced retail store carbon intensity (CO2e/sq. ft) by 13% relative to 2011 Absolute energy use & CO2e emissions have increased by 14% relative to 2011	100% renewable energy powered in owned & operated facilities by 2025 Reduce energy/unit produced & CO2e/unit produced in key operations by 25% by 2020 Reduce energy/unit produced & CO2e/unit produced in dyeing and finishing operations by 35% by 2020 Reduce scope 3 CO2e emissions by 10% by 2020
H&M Group (H&M Group, n.d.)	Reached 78% renewable energy use in owned & operated facilities in 2016 56% reduction in scope 1 & 2 CO2e emissions relative to 2014 Reduced CO2e emissions/million SEK (Swedish Currency) sales by 65% relative to 2011 Requires that transport service providers are Smartway partners (North America) or Wayahead registered (Europe & Asia)	Aim to "work for 100% renewable electricity" wherever RECs meet internal evaluation criteria for quality and impact. No hard date Reduce electricity use in brand retail stores 20% (kWh/ft2) by 2020 relative to 2007 Align with best practices in responsible corporate engagement in climate policy by 2016
Levi Strauss & Co (Levi Strauss & Co, 2015) (Levi Strauss & Co, July, 2016)	Reduced scope 1 & scope 2 CO2e emissions by 21% in 2014 relative to 2007 In 2014 sourced 13% of total energy consumption from renewable sources In 2014 reduced CO2e intensity (kg CO2e/unit) by 17% relative to 2011 In 2016 Reduced CO2e emissions by 2% from 2015 from energy efficiency improvements In 2016 Reduced CO2e emissions by 15% from 2015 by closing manufacturing site in Turkey	Source 100% renewable energy first in their own operations and later throughout their supply chain, no hard date 25% reduction in GHG emissions by 2020 5% annual reduction in GHG emissions/lb product shipped by 2020 Purchase 20% of energy in "all of Levi Strauss & Co" from renewable sources by 2020
Jockey International	N/A	N/A
Fruit of The Loom Inc. (Fruit Of The Loom Inc., n.d.)	Reduced electricity consumption by 5.7 million kWh & CO2e emissions by 3914 metric tons (no baseline/percentage) Achieved 100% renewable energy in their Honduras facilities, (27% of western hemisphere energy consumption)	N/A
Puma (Puma Corp, n.d.)	20% scope 1 CO2e emissions reduction in 2015 relative to 2011 13% scope 2 CO2e emissions reduction in 2015 relative to 2011 Source 14% of energy consumption from renewable electricity Reduced water consumption 50% in 2015 relative to 2011 Achieved carbon neutrality in 2010 Include environmental profit and loss statement in annual reports	In 2016 Puma is re-evaluating corporate energy & environment goals and setting new goals for the 2016-2020 time period
VF Corp (VF Corp, n.d.)	Reduced GHG emissions by 12% in 2015 relative to 2009 Reduced total energy consumption by 5% in 2015 relative to 2009 Sourced 1% of direct energy use from renewable sources in 2013 Headquarters in Switzerland, Germany and North Carolina source up to 100% renewable energy	Source 100% renewable energy in owned & operated sites by 2025 Reduce carbon emissions/dollar retail revenue 50% by 2020 relative to 2009 Reduce carbon emissions/unit manufactured 10% 2020 relative to 2009 Reduce carbon emissions/unit shipped 40% 2020 relative to 2009 Reduce carbon emissions/office employee 25% by 2020 relative to 2009 Reduce landfill waste 40% by 2020 relative to 2009

Table 4: Competitor analysis (cont.)

Competitor	Current Status	Future Goals
C&A (C&A, 2016)	Source 30% of purchased energy comes from renewable sources Improved carbon efficiency (lb CO2e/unit produced) by 9% Reduced total carbon emissions by 1.4% in 2016 relative to 2012 Developed carbon footprint report to identify sources of carbon emissions to be improved upon	20% carbon footprint reduction in stores, offices and distribution centers (no date)
Gildan (Gildan Corp, n.d.)	51% renewable energy use companywide (almost exclusively biomass) Reduced energy intensity 14% by 2015 relative to 2010 Reduced GHG intensity (lb CO2e/unit produced) 34% by 2015 relative to 2010 Reduced water intensity 17% by 2015 relative to 2010	Reduce GHG intensity 10% by 2020 relative to 2015 Reduce energy intensity 10% by 2020 relative to 2015 Reduce water inetensity 10% by 2020 relative to 2015
Philips Van-Heusen Corp. (PVH Corp, n.d.)	2015 implemented global GHG report into annual reports 2016 PVH began developing targeted energy reduction strategies in partnership with company associates & business partners to be implemented in the future Currently implementing aerodynamic upgrades to shipping fleet which are expected to improve fleet fuel efficiency by 35%	"Measure and reduce GHG emissions by reducing energy consumption, increasing energy efficiency and utilizing clean energy both in our owned and operated facilities and across our value chain" No concrete goals yet released (currently under development)
Adidas Group (Adidas Group, n.d.)	Reduced company "relative environmental footprint" 15% by 2015 relative to 2010. 30% reduction in carbon emissions/m2 by 2015 relative to 2008 (energy efficiency projects & REC purchases)	20% energy savings at "strategic suppliers" by 2020 3% absolute reduction in scope 1 & 2 emissions at company owned sites by 2020 Reach carbon neutrality in company owned sites by 2050
UnderArmour (Under Armour Inc, n.d.)	Suppliers and subcontractors must comply with all environmental rules, regulations and standards applicable to operations	N/A
The Gap (Gap Inc., n.d.)	33% reduction in GHG emissions from 2008-2014 in U.S. operations	50% reduction in absolute GHG emissions at company owned and operated facilities by 2020 relative to 2015 80% landfill waste diversion in U.S. operations by 2020

Literature Research

At the request of Hanes energy management team, there were two subjects that they suggested may be relevant to the project to do background literature reviews on. The topics were an overview of synthetic purchase power agreements and whether biomass energy should be considered renewable. They are interested in both as they relate to their corporate renewable energy goals.

I. Synthetic Power Purchase Agreements

Because of their growing popularity as a financial tool for developing renewable energy projects, Hanes requested information on the relatively new method synthetic purchase power agreements (SPPAs). Similar to a traditional purchase power agreement, a synthetic or virtual PPA, is a contractual arrangement between a corporate buyer or entity who does not take physical delivery of power and a generator that is comprised of 'a long-term financial hedge for the energy produced by' the generator, as well as 'a purchase-and-sale agreement for the associated renewable energy credits (RECs) (Lance & Opadiran, 2016)'. With a traditional PPA, businesses may lack grid connections to facilitate a standard PPA or the available real estate for onsite generation. Thus, the connection of the electricity off-taker (end-user/corporate entity) in an SPPA to the generator is only a financial one – no longer making geography the limiting factor. This is the 'key element to attracting project financing and investment' in renewables. SPPAs are used to reduce volatility in energy prices, not necessarily guarantee savings, and their terms usually 'range from 12 to 15 years but may be up to 20 or 25 years'.

There is a great deal of growing momentum behind PPAs, particularly synthetics. Of the 3.44 GW capacity signed in PPAs in 2015, over 75% of them were synthetic. SPPAs continue to garner a majority proportion of the type of PPAs as "corporations have sought to contract directly with project developers for the purchase" of RECs. The financial transaction assists with this relationship. While the transaction has a variety of contracts and terms associated with it, there are three main structures to them: contract for differences, options, and pure commodity hedging.

Contract for Differences

In a contract for differences (CFD), the end-user or corporation signs a contract with the renewable energy generator for energy at a fixed rate. The fixed rate is known as the strike price of the contract. The generator owner sells RECs to the end-user and the generated power to the market where the generator is geographically located (Bolinger, 2013). The end-user takes the RECs and purchases brown power from its own local market to serve its required load but the generator pays the end-user if the price is higher than the set strike price and the end-user pays the generator if the price falls below the strike price. There are different elements that can alter the CFD like a zone of indifference on the strike price where the price is allowed to vary around the strike on certain pre-approved margins and the parties still pay the strike price, but those depend on the contract between the two parties and the current and future power market conditions. The CFD is the most common of the three types of SPPA structures and is closest in form to a traditional PPA. The difference is the fact that a hedger does not have to buy the energy directly from the generator. The hedger buys the brown power from their local grid and settles the difference in prices with the generator after the sale has been made.

Options

Options provide an alternative structure but similar function to a CFD, and many varieties of options exist. Like a CFD, a strike price is set, but like an options market trade, the buyer has the right to put or call an option on the electricity if the electricity drops or rises above the strike price. The collar option, a hybrid of the two options, is when the buyer sells a call option and buys a put option or vice-versa. This places a cap on gains and a floor on losses, while also eliminating the cost of the option. In both cases, option prices are pre-set. The additional cost associated with exercising an option is determined by the proximity of it to the strike prices to forward price forecasts and the length of the option term. Again, options work as insurance for the power generator in the case that price falls significantly and gives the financier and the corporate entity a chance to make a profit depending on the price volatility in power. A 3rd party financier may also trade in options as they are merely financial transactions. They may choose to buy options directly from the generator and they can be banks, hedge funds, utilities and any entity with the credit that can support these kinds of deals.

Pure Commodity Hedging

Pure commodity hedging is when the parties choose to hedge the price on the underlying commodities. Similar to the CFD, as the price of the commodity varies around the agreed hedging price or the strike price, the seller is compensated for the price falling below that strike price and the buyer is compensated when the price is above it. In pure commodity hedging, the price of unbundled RECs can also be hedged and sold separately from generated electricity. The REC value will fluctuate, so a party may buy a forward swap to secure price certainty and hedge their risk.

There are positives and negatives to each of the structures, and if Hanes wants to pursue this type of financial contract to meet their renewable energy goals, they will have to consider the more overarching advantages and disadvantages of SPPAs.

SPPA Advantages

The aforementioned advantage of SPPAs is the removal of geography as a limiting factor for the end-user. They do not have to build the asset onsite or have it located closer to the consumption location. Another benefit is the shorter contract life, which can be less than 10 years if desired and agreed to by both parties (Chadbourne, 2016). This caps the debt capacity and limits refinancing risk due to the recourse of the holding company. It also allows generators to re-leverage their investment once the term of the contract has been exhausted so they can capitalize on higher future energy prices. This assumes they have mitigated their capital and principal costs and are chiefly responsible for only their competitive variable costs in relation to the other power market generators. It removes variability from the cash stream and provides certainty for the project developer or holding company who pays the operations and maintenance (O&M) costs.

Beyond their intrinsic benefits, SPPAs provide an alternative to standard financing options for renewable energy projects. Solar typically relies heavily on complex tax equity structures that can be avoided by financing with SPPAs. Navigating the regulations that manage both state and federal solar tax breaks and benefits is an added cost to the preliminary financing stages that can be avoided. This assists in growing the renewable energy sector without shifting costs to the consumer and driving the penetration of renewables by market innovation while realizing a strong return on investment.

SPPA Disadvantages

While the benefits of SPPAs have driven them to become the market majority share of all PPAs, there are some significant risks to consider. The market price risk is a larger barrier to PPA growth and must be understood by all parties involved. This means the energy intensity of industries will heavily define their risk appetite. If the power market price bottoms out, the hedger will be stuck paying high relative energy costs when compared to competitors without hedged PPAs. End-users with many competitors may need to employ closer management of their energy costs. However, corporate end-users can structure deals to share market price risk with generators in mutually beneficial ways and hedge-effectiveness tests may be considered to evaluate PPA performance.

Other issues include inexperience, expanding regulatory jurisdiction and credit issues of conflicting lien rights. Synthetic PPAs are intricate, require understanding between multiple stakeholders and lack of experience with these deals is a major barrier (Trabish, 2016). Also, the Commodity Futures Trading Commission (CFTC) may extend regulatory jurisdiction via Dodd-Frank. There is limited exemption for end-users if this happens, especially if derivative trading of this kind of transaction becomes popular. For the same reasons the 2008 housing crisis happened, derivative accounting should be avoided and all issues with transactions should be dealt with auditors to solve. There are legal issues with competing claims for senior lien rights on collateral package of assets can create conflict. There are more complicated issues with the competing claims that are not necessary for the sake of the objective of this paper. An in-depth analysis of them exists in the referenced material.

II. Is Biomass Renewable?

According to multiple government agencies including NREL (U.S. NREL, n.d.), DOE (U.S. DOE, n.d.), EIA (U.S. EIA, n.d.) and EPA (U.S. EPA, n.d.), biomass is regarded as a renewable fuel. The Energy Security Act (PL 96-294) of 1980 (Energy Security Act, 1979) defines biomass for renewable energy production as "any organic matter which is available on a renewable basis, including agricultural crops and agricultural wastes and residues, wood and wood wastes and residues, animal wastes, municipal wastes, and aquatic plants." According to the government agencies listed above, the absorption of carbon from the atmosphere through photosynthesis in a relatively short time period offsets the carbon released upon burning the biomass, making biomass a renewable energy source. The Greenhouse Gas Protocol Corporate Standard dictates that direct CO2 emissions from combustion of biomass should not be included in a firm's Scope 1 emissions, but should be accounted for separately to maintain accurate records of overall GHG emissions (Greenhouse Gas Protocol, 2004). To ensure minimal environmental impact, Hanes should also employ sustainable biomass harvesting practices, such as those outlined by the Sustainable Forestry Initiative or Sustainable Biomass Partnership, or even pursue certification through these organizations.

Materials & Methods

I. Materials and Data Inventory

Over the course of a year and a half, the team utilized a variety of primary and secondary sources of data that were acquired from Hanes. In terms of the scope of the project, each data source was used differently and with varying degrees of success. The majority of the data collected from Hanes was divided into three types: the portfolio encompassing master file, utility invoices for select facilities, and interval data from select facilities.

Master File

The Hanes Master File was the densest data file presented to the team and was received after the first meeting with Hanes. It is an excel file that details the energy mix and consumption of each facility that Hanes owns. There is an energy cost/usage summary for each month of 2015 for each facility that is broken down by types of utilities used versus monthly production use. The types of fuels it considers are electricity, water, natural gas, propane, #2 fuel oil, heavy fuel oil, biomass, steam and alternative energy sources. It gives descriptions of emissions and which percentage of the fuels are generated onsite and offsite. In order to document their renewable energy, they list a "percent renewable energy" rating in the top right corner of the sheet, which indicates the percentage of renewable electricity of the site. They used US Environmental Protection Agency (EPA) eGRID for their US locations and the International Energy Agency (IEA) for their international locations. The last eight sheets in the excel file summarize the findings across the portfolio and detail which facilities require more attention from a renewable energy stand point. This was done for two designations of Hanes sites, dubbed "Large Facility" or "Distribution Center." The distribution center sheet was not used. Each of the facilities are color coded with red, yellow or green to give a qualitative overview of how the site had performed in the previous year in terms of renewable energy use. The red-yellow-green color designation of the Master File is determined by conditional formatting thresholds set – 5% from green to yellow and 10% from yellow to red from 2014 to 2015. The RYG coloring was set by the Hanes energy management team and is relative to the previous year's renewable energy progress – for year-to-year tracking purposes only. It does not convey the magnitude of overall impact at the site. Many of the sheets that detailed other sites were not used for this project apart from the sheet illustrated above and the CO_2 emission factors sheets detailing the emissions of each site. The only way they were used was in developing a site selection list in partnership with the Hanes energy management team.

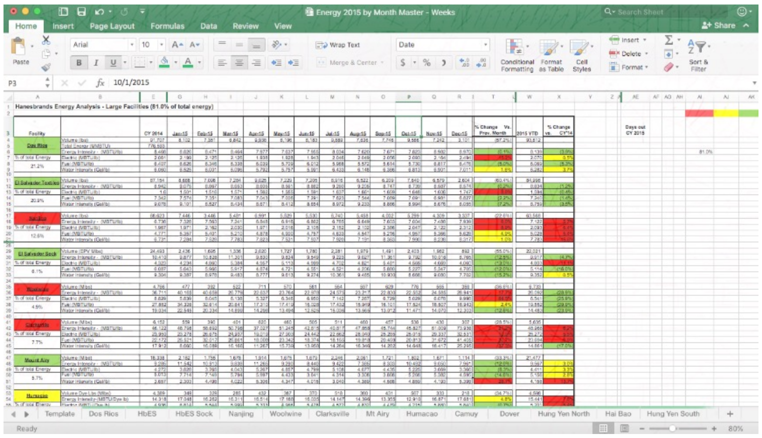

Figure 1: Master file of Hanes Energy Portfolio in MS Excel. This image was blurred to protect the private information protected by an NDA.

As we designed our approach to assisting Hanes meet their renewable energy goals, the master file was used as a high-level summary to screen for viable candidates before collecting and analyzing invoices. It was used in meetings with Hanes to identify viable targets for the EMS (Energy Management System) that we developed with the use of utility bills from the targeted sites.

Utility Bills

Early in the design of our approach, the team realized that having the utility bills for as many sites in Hanes' portfolio would allow for the coupling of financial information to the consumption, demand, administrative, and KVAR (Reactive power) charges. The utility bills for each site were not readily available to the Hanes energy management team and they requested them from the identified sites. From April 2016 through January 2017, the Hanes energy management team would receive and forward historic utility bills from high-priority sites that were chosen in an iterative process for calendar years 2015 and 2016. They were the sites at Central America, 2, Asia, 1, North America, 3, North America, 1, North America, 2, North America, 4, Central America, 1, Central America, 3, Asia, 2, and Asia, 3.

The utility bills were aggregated and organized into the utility compilation file that was eventually used for a second screening of the focus sites after the first one had been completed with the master file. Because of the international nature of Hanes' production assets, the utility bills often had to be translated from either a romance or Asian language. This was done either by members of the team, Hanes' energy management team, or the facility managers themselves. The utility compilation file is a Microsoft Excel file that hosts the utility bill information broken out monthly by line item. It is the primary source for screening the facilities in a rational and unbiased manner based on their electricity consumption after they had been identified by the Duke team using the master file and confirmed by the Hanes energy management team as a sample of their portfolio to move forward with analyzing. It does not consider their fuel or other utility use, unless they are bundled into the utility bill. For the tool that was developed, none of the identified sites bundled their utilities in this manner.

Interval Data

At the recommendation of Philip Henson, Senior Manager of Energy and Environmental Sustainability at Hanes, interval data was gathered with the utility bills for each of the priority sites. The interval data illustrated the energy consumption for calendar years 2015 and 2016. It varied by site and was either listed in increments of 15 minutes or by hour. The interval data was used in tandem with the National Renewable Energy Laboratory's System Advisor Model (NREL SAM), allowing more accurate projections when considering installing onsite generation assets such as photovoltaic solar panels or storage technologies like batteries. An interval analysis of each of the high priority sites was also conducted to understand the variability patterns in consumption use by site over each day and hour. Interval data was collected from 10 sites: Central America, 2, Asia, 1, North America, 3, North America, 1, North America, 2, Central America, 1, Central America, 3, Asia, 2, Asia, 3.

II. Methodology

Hanes seeks to increase their renewable energy percentage to 40% compared to 2007 base levels and have already increased their renewable energy share by 25% in 2017. For this Master's Project, the partnership between the Duke University Nicholas School of the Environment and the Hanes energy management teams initially set to fulfill five objectives over the course of a year.

1. Perform feasibility study utilizing data
2. Identify patterns of volatile energy use portfolio-wide
3. Investigate applicable RE tech; develop cost-benefit analysis for global operations
4. Explore novel financial models through market research
5. Build scalable 1MW RE system model applicable to global operations

Because of the iterative, consulting style process with Hanes, the amount of time allotted for the project, and the availability of data and resources, these goals changed over time. For a more thorough vetting and deeper analysis of the sites, a model that requires more resources and time to create would be needed. The limitations presented for this project disallowed for this scale of a model to be built. However, the Duke team succeeded in utilizing primary data collected from Hanes to synthesize and develop demo tools that Hanes could either use/build themselves, or contract other companies that perform this kind of service to replicate fuller, more actionable versions of the Duke demo. The data-informed proof of concept that the Duke team has developed for Hanes demonstrates the power in energy management strategic decision making that can be pulled from historic utility bills and interval data – information that is accessible to the Hanes energy management team. The following details the methodology the Duke team took to achieve the goals set out by Hanes.

1. Design Feasibility Database
2. Create Utility Tariff Targeting & Decision Analysis Tool
3. Geo-Market Research and Facility Deep Dive
4. NREL SAM Modeling for High Priority Renewable Energy Projects

Feasibility Database and Utility Tariff & Decision Analysis Tool

From the first meeting of the Duke team, a clear, adaptive project management strategy was put in place to assist Hanes in executing the project objectives. Understanding the project would change based on the data we were going to be given, and that being caught up to speed with Hanes was the most important first step we could take. Therefore, we requested any data that would bring us to this point.

The first objective is to perform a feasibility study of Hanes' manufacturing portfolio to identify which sites may be the most heavily impacted by installing renewable energy assets. Hanes elected not to share their current energy management decision analysis infrastructure to insure bias would not be put into this study. The energy data resource they shared with us is the aforementioned 2015 master. After discussion with the Hanes energy management team, a list of sites used as a sample for determining qualified sites for energy asset investment was developed. Because of the selected focus on utility energy to understand what the avoided cost could be if renewable energy assets replaced utility brown energy, we decided to formulate a screening tool based on experience from our own former internships and classes. This tool would shape utility bills into metrics that would accurately describe the utility energy consumption behavior of each site on a comparative basis.

The tool would work in three stages. The first stage would require collecting all the historical utility bills that Hanes had available and categorize each line item in the bills by consumption, demand, administrative, and KVAR changes – the typical charges that are often associated with the common utility bill. We received a year's worth of utility bill information for the sites that were chosen for the analysis. Each of the bills was itemized by the kind of charges that facility was receiving.

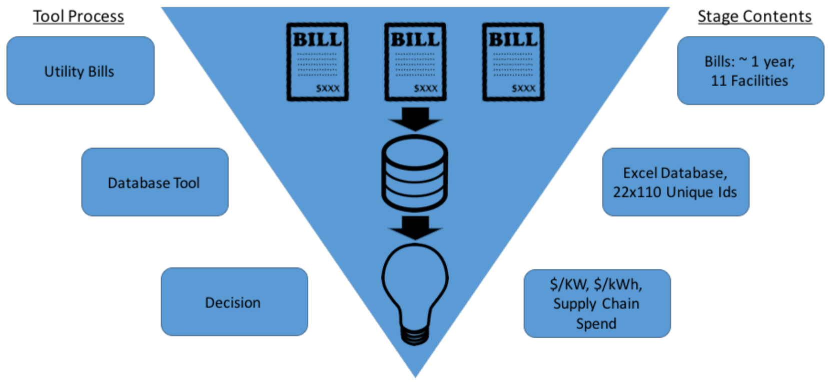

Figure 2: Model of EMS Tool

In the second stage of the tool, the database was built and compiled using the utility bills. The utility bills are put into an excel file by line item so each metric can be analyzed individually rather than as a blended rate. This method was chosen for two reasons. The first reason is any renewable energy asset that is installed onsite may offset the energy consumption charges, which would lead to both utility bill cost avoidance that can be allocated to the investment payback, and increase the renewable energy proportion of their portfolio. The second reason is, that like most modern companies, Hanes has been making their energy management decisions based on a blended rate of electricity, which combines all of the charges in the bills and finds the monthly, average dollar per kilowatt-hour rate. For example, if 3 sites have the same blended rate but have different capacity, consumption or administrative charges, the true cost of energy is not being described. This can result in a problem misdiagnosis of the true cost of energy at the site. This is not a unique problem to Hanes or the apparel industry. It is a relatively new practice of determining the true cost of energy to itemize the different costs of electricity and divide them by their real metric standard.

In the third stage of the tool, the excel database is imported to Tableau to execute a cross comparison analysis of each of the sites by their various metrics. Tableau's flexibility in comparing data in a graphically friendly way was one of the main reasons it was chosen as the software to develop decisions from. The results of the analysis were discussed with Hanes to decide where to focus the team's efforts in the geo-market research. Thus, Tableau proved to be the optimal software choice to illustrate these choices. The used metrics were $/kWh to make decisions for solar PV, $/KW to make decisions for storage technologies, and absolute spend ($ total) for combined heat and power technologies. We determined that technologies like solar PV and battery storage remedy different issues at the site. Solar PV addresses consumption and battery storage addresses demand. We do understand that energy can be stored at night at lower prices and drive the cost of energy down, but this would only contribute to Hanes' primary goal of increasing their energy portfolio's renewable energy composition if they produced more renewable energy at the site than they consumed.

Geo-Market Research and Facility Deep Dive

The geo-market research and facility deep dive stage of the methodology are two closely related elements of the project. They sought to understand the power markets that each of the priority facilities exist from an economics and renewable energy standpoint and to gain a more detailed understanding of the sites' layouts and operations in terms of their energy consumption. Another iterative process, the geo-market research took place over two different efforts – the latter confirming the prior's choices. It first took place in the fall 2016 when the Duke team was attempting to get ahead of the initial demo build by researching the sites that were known to have the largest share of Hanes energy consumption. That effort was spearheaded by using the master file to determine which sites should be researched. From a practical perspective, it made the most sense to first analyze the large production facilities with the largest total non-renewable electricity consumption (MWh) and then focus on the larger, more inefficient distribution centers. The other parameters that were considered when choosing facilities from the master file were blended rate electricity cost ($/kWh), total annual electricity costs ($), percent renewable energy used (%), and total annual electricity consumption (MWh). The sites chosen after several meetings with Hanes were Central America, 4, Central America, 2, Camuy, Asia, 1, North America, 3, North America, 1, North America, 2, and North America, 4. Each of these facility's electricity markets were analyzed in terms of their openness to renewable energy generation installation and any financing that may be associated with them. This first pass of research was done to get a general scope of the behavior of the largest facilities in Hanes' manufacturing portfolio.

The second geo-market research effort was executed after the completion of the utility tariff and decision analysis tool, and was completed in spring 2017. Because of the small sample size of sites that had available utility data, the effort was somewhat redundant to what had been done in the fall. The sites that were analyzed now using their utility data and cross comparing their energy use metrics against each other were Central America, 2, Asia, 1, North America, 3, North America, 1, North America, 2, North America, 4, Central America, 1, Central America, 3, Asia, 2, and Asia, 3. However, there was input from the Hanes management team that altered the direction of the research. They agreed based on the $/kWh and absolute energy spend ($) rates that Central America, 2, North America, 4, Asia, 1, North America, 3, Central America, 3, and Central America, 1 should all receive facility deep dives. They also thought that because North America, 2 is their corporate office and North America, 3 and North America, 1 are domestically located, they should also receive deep dives of their power markets. Again, the sample size of the facilities with available data was small compared to the overall size of Hanes' manufacturing portfolio. The only sites that did not receive deep dive or geo-market research were Asia, 2 and Asia, 3, both of which were dropped. We consider it a victory of the utility tariff and decision analysis tool that informed the relatively low absolute annual energy spend ($) and average $/kWh of both sites.

One of the important realizations that was made during this part of the methodology was that each of these sites have very distinct and different power markets which do not have simple, scalable solution that can remedy their energy consumption needs. Because each power market has different rules and regulations regarding the installation of renewable energy assets and financial transactions regarding power purchase agreements, we realized that the Hanes objective of "build scalable 1MW RE system model applicable to global operations" is very difficult to attain. For example, the Central America, 1, Central America, 2 and Central America, 3 facilities are all within the Central American country. While they all reside in the same jurisdiction, each of the facilities vary in site set-up. Central America, 3 and Central America, 1 belong to private industrial parks without room for scalable PV systems while Central America, 2 is a stand-alone site with its own steam generator and over an acre of usable space next to it. To develop a model that incorporates even these three facilities, intensive programming capabilities beyond the experience of the team would be required. There was also a lack of information to do a proper escalation analysis for each of the utility types that would be required of the model. Thus, we substituted this objective with NREL's System Advisor Model - a more comprehensive model that was readily available to us and could be seamlessly used by Hanes. Employing this model would still provide the necessary support in satisfying Hanes' other objectives and in a manner beyond what we could have on our own.

NREL SAM Modeling for High Priority Renewable Energy Projects

Developed by the National Renewable Energy Laboratory (NREL), System Advisor Model (SAM) is a powerful tool that models energy performance and financing for renewables. Used by engineers, policy makers & developers, it provides a wide-ranging scenario analysis by considering the many variables that are in play to develop a project. Due to the ever-changing locations, markets and conditions of facilities that were qualified upon initial screening to analyze in detail for feasibility, Duke Team opted to use this verified and industry-wide known, scalable, uniform model to present its work in validity to broad audiences. SAM lets us make feasibility studies on varying systems and accounted for the many variables that rooted from the developers' experience that our team may not have thought of. The latest version that is "Version 2017.1.17" was used in all the modeling scenarios of this project. In addition to various scales & combinations of Solar PV & battery storage scenarios Duke Team simulated, SAM can also be used to model the performance of concentrated solar power (CSP), wind, geothermal and biomass. Hanes can therefore make use of this model for further investment opportunities with a broader scope & budget.

Following sites were analyzed for feasibility in SAM;

- Asia, 1
- Central America, 1
- Central America, 2
- North America, 1
- North America, 2
- North America, 3

Duke Team could incorporate the interval data collected by Hanes at their above-mentioned sites to make a thorough performance & financing simulation. Some results the model provides that we included in this report are the system cost, energy generation, cash flows, NPV, payback period, energy savings (How much of yearly consumption can be met and how much would that save), and carbon reduction. To get these results, some inputs entered into the model include: Load (Interval data), available land, cost/W for PV and storage, depreciation rate, discount rate & how the investment is financed (% debt with a % loan rate, which was obtained from Hanes), and state & federal incentives (NREL, 2010). As mentioned throughout the SAM Results Chapter, a lot of parameters were kept at their default value, which are mostly what would be gathered from literature research, thus they are safe assumptions. This is one of the reasons the Duke team was content with using SAM rather than creating a new performance and financing tool. Although the upcoming parts go into more detail, some of those default parameters can be listed as DC:AC ratio, system loss estimates, and azimuth & tilt degrees. Another reason why we are sticking to SAM is that NREL is constantly updating the model with its top-notch engineers & programmers, and upon completion of this Master's project, Hanes wouldn't have to dedicate a lot time & effort to maintain it. If Hanes chooses to continue using SAM, it would have an analysis tool that would provide uniform platform for investment decisions.

Site Analyses

After doing a high-level screening with the EMS tool, narrowing down the nominee sites to ten and receiving available data from Hanes, the following site analyses were conducted. Facilities have been grouped with respect to their countries. A facility overview, market analysis, tariff analysis, and interval data analysis was conducted on each site. Results of the site analyses, paired with Tableau illustrations assisted the decision-making process of determining which sites to further consider for financial & performance feasibility in the SAM model.

I. Asian Countries

Asia, 1

Facility Overview

Hanes' Asia, 1 site specializes in knitting and gets its electric power from a power grid in an Asian country.

Market Analysis

The Asian country state where this facility resides in pursuing renewable energy. The feed-in tariffs for wind and solar are determined by adding provincial subsidies on top of the benchmark feed-in tariffs set by the Central Government, and the state subsidies usually vary across regions and projects (Hong, 2013). In the first half of 2016, 10 wind farms were successfully connected to the grid with a total added capacity of more than 800 MW. These wind farms get different feed-in tariffs each determined by the Price Bureau on a project-by-project basis, where the highest is $0.142/kWh and most of the farms get $0.102/kWh. The government also provides a separate subsidy of $0.002/kWh for grid connection. In the first half of 2016, 89 solar projects were successfully connected to the grid with a total added capacity of 948.17 MW; similar to the wind projects, these solar projects get different feed-in tariffs. To encourage the utilization of renewable energy while at the same time alleviating poverty problems in some regions, the government introduces "Solar for Poverty Alleviation" program (Zeng, 2013). Solar projects that are eligible for such program will get higher feed-tariffs of $0.192/kWh, other solar projects get an average feed-in tariff of $0.167/kWh, which is more than 2 times that of coal-fired power plants. For on-site solar PV, the credit is $0.07/kWh for all the electric power generated from the PV panels (Fialka, 2016).

Tariff Analysis

The electric power market in the state is currently regulated, while it is predicted that the market is slowly moving toward deregulation. It may act as a pilot area for the unregulated market in 5 years. During a typical month, Asia, 1 facility is billed by its demand charge (basic charge), active power charge, and charge based on power factor. For demand charge, the price is $6.153/kW. For active power charge, the energy consumption is charged by real-time pricing, which divides time to critical peak (only in summer time, 10:00 A.M. – 11:00 A.M., 2:00 P.M. – 3:00 P.M.), peak (8:00 A.M. – 12:00 A.M., 5:00P.M. – 9:00 P.M.), normal (12:00 P.M. – 5:00 P.M.), and off-peak (0:00A.M. – 8:00 A.M.) slots. The prices are $0.165/kWh, $0.165/kWh, $0.099/kWh, and $0.048/kWh respectively. For power factor charge, the baseline is 90%. A bonus is disbursed if power factor is higher than 90% and a charge incurred if it is lower than 90%.

From October 2015 to September 2016, about 20% of Asia, 1's total electricity spending is on demand (kW) and 80% is on energy (kWh). The high ratio of energy consumption charge means a high priority to allocate operation hours wisely. The peak time pricing ($0.165/kWh) is 3.4 times higher than off-peak time pricing ($0.048/kWh), which represents a significant potential for consumption time shifting.

Interval data analysis

After analyzing the hourly interval data by month, it was found that the demand kept stable through the whole year except a sharp decrease in February. The energy demand and consumption valley in February can be explained by production volume variations such as the traditional holiday break. Additionally, considering the low ratio of demand charge in total energy charge, there are limited incentives to improve the performance of demand management.

Our group also analyzed Asia, 1's hourly interval data by calculating the average daily energy consumption data during the same interval (Figure 3), and found that the energy consumption is the highest from 0:00 A.M. to 5:00 A.M. and 1:00 P.M. to 5:00 P.M., and is the lowest from 8:00 A.M. - 9:00 A.M. and 8:00 P.M. - 9:00 P.M. The energy consumption varies significantly throughout the day and was more intensive in off-peak hours than in peak hours, suggesting that it is likely that Asia, 1 has already attempted to shift its energy consumption to non-peak hours (0:00 A.M. to 8:00 A.M.).

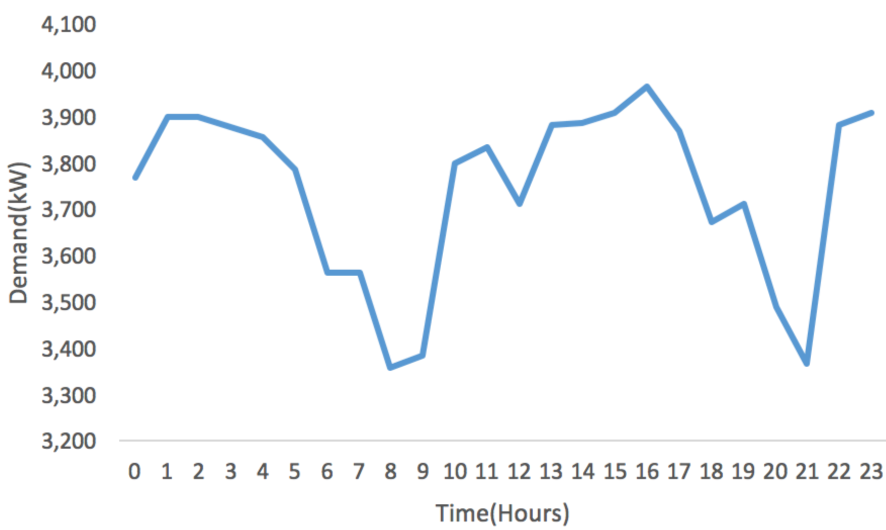

Figure 3: Hourly Demand Distribution. Showing evident valleys to avoid peak hour charge

Based on the analysis above, three suggestions would be given by our group. First, the high credits ($0.065/kWh) for on-site solar PV and the high weighted electricity price ($0.138/kWh) during daytime (8:00 A.M. - 8:00 P.M) show a good opportunity to generate electric power from on-site PV panels. It is also notable that there is a large area (around 320,000 m2) in Asia, 1 facility, indicating a good fit for on-site solar PV implementation. Second, it would be beneficial to use batteries to store electric power from night time and utilize it in the day time because of the high ratio (3.4) between peak time pricing ($0.165/kWh) and off-peak time pricing ($0.048/kWh). Last but not least, Hanes should further investigate whether it is feasible to reallocate more operation time to night time via administrative way by taking both labor cost and energy cost into consideration.

II. Central American Countries

This Central American country has one electricity market and the market analysis is same for each facility. It is included in the Central America, 2 facility analysis.

Central America, 1

Facility Overview

Central America, 1 facility is located in an industrial park in the central America and primarily operates as a sewing, office and warehousing facility for Hanes. It also serves as a warehouse for their underwear products. The Free Zone Park is an industrial park organized for foreign entities to conduct business in a similar space. It began operations in May, 1994 and had an addition built in 1996, bringing its footprint to approximately 170,000 square feet. It is important to note that the Central America, 1 facility achieved the Energy Star Challenge of Industry in 2011 for reducing its energy intensity by 22.8% compared to its 2009 baseline. This resulted in 12,938 MMBTU of energy avoidance in 2011. According to the Energy Star report on the 2011 Challenge of Industry, Hanes met their goals by instituting the following energy management measures.

- Lighting: Installing T12 fluorescent fixtures combined with T8 fixtures and motion sensors that improve energy efficiency (Hanes Brand Inc, 2017)
- Air Compression: Removing the need for an air compressor by sealing air leaks and altering the air distribution system

- Air Conditioning: Replacing older, more inefficient air conditioning units for newer ones – directly impacting the entire air conditioning system

Currently, all of Central America, 1's energy consumption is in the form of electricity and provided by 44 MW electrical sub-station in the Free Zone Park (Infrastruction, 2017).

Tariff Analysis

The electric power in the Free Zone Park is charged by energy consumption (kWh) and demand (kW). Of the total billing charges, approximately 87% is for consumption (kWh) and 13% is for demand (kW). The average price for these two parts from Jan 2016 to Sept 2016 are $0.1574/kWh and $5.1230/kW, respectively. The price varies slightly in different months and both demand charge price and energy consumption price are higher in the summer (June, July, and August), relative to the rest of the year. The price variability gap between summer and the other months is approximately 5% higher.

Interval Data Analysis

The analyzed Central America, 1's interval data (15 minutes per interval) reveals the monthly, daily, and hourly consumption trends. In terms of the monthly billing and consumption data, energy consumption in July (630.54kWh) was relatively more than other months (ranging from 298.89kWh to 399.15kWh) in 2016. However, the trends were different in 2016 relative to 2015. In 2015, the consumption reached peaks in February, March, June, September, and December. Considering the analysis covered only the invoices from 2016, more information is required for a thorough investigation to give a concrete conclusion based on monthly consumption trends. From a weekly perspective, the energy consumption on Sunday is the lowest, and consumption levels on Monday, Tuesday, and Friday are the peaks. Considering the low average demand charge, the daily distribution of energy consumption is acceptable relative to the trends at other Hanes facilities. The hourly trends are almost identical in 2015 and 2016 (Figure 5). The consumption rapidly rises from 5:00 AM to 6:00 AM, slightly decreases from 6:00 AM to 7:00 PM, and slashes quickly from 7:00 PM to 9:00 PM. It shows a stable demand schedule for its sewing operation which should be considered when implementing more demand side management projects. Battery or fuel cells may alleviate the base load power reliably because the consistency in the consumption trends. More than 90% of the energy is used from 7:00 AM to

8:00 PM, which has a coupled high energy price. This indicates a potential to implement on-site PV panel technology, especially during daylight hours.

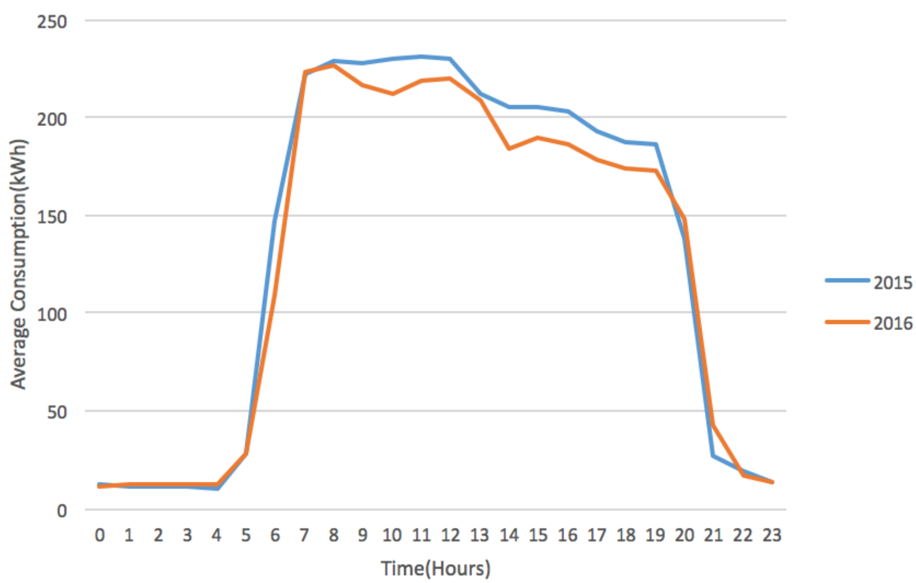

Figure 4: Hourly demand trends. Showing peak demand during daytime from 7:00am to 7:00pm.

Central America, 2

Facility Overview

Central America, 2 facility operates as a textile knitting facility. Central America, 2's electricity is supplied by a power corporation. Electricity is approximately 25% of its total annual energy consumption. Of the other 75% energy consumption, biomass contributes to 57% (Energy Transition Initiative, 2015). In the context that biomass is counted as a renewable fuel, the high biomass consumption increases the renewables proportion for this facility.

Market Analysis

Biomass

75% of Central America, 2' total energy consumption is powered by fuel, including biomass, natural gas, propane, and heavy fuel oil, among which non-biomass fuel accounts for approximately 25% of total fuel use. This suggests that if Central America, 2 could manage to increase its use of biomass in replacement of other non-renewable fuel types to the extent possible, it would be able to increase its renewable energy percentage by a maximum of 19%

holding everything else constant. This represents an extreme case that is highly unrealistic under real business settings, since factors such as costs, technical feasibility, and biomass feedstock availability all restrict Hanes' ability to become 100% biomass-fueled. Nonetheless, it could still be inferred that huge renewable potential lies with biomass, and further opportunities should be exploited to unleash the benefits.

In this central American country, biomass represents an increasingly important source of energy for electricity and heat generation, and is one of the renewable energy resources that serves the interests of many businesses that seek to "green" their operations. Where Hanes' Central America, 2 facility is located, biomass has been used to generate electricity and heat for some 30 years. As a matter of fact, Hanes participates in the Clean Development Mechanisms and has already been utilizing biomass in its Central America, 2 facility to satisfy a significant portion of its energy consumption since the year of 2008. The facility uses residues from rice husk, coconut shell, sawdust, and other biomass sources to power its 615 kW on-site generator (UNFCCC, 26 June 2012). Another textile mill located in the Central America, 2 Free Trade Zone relies on wood, bagasse, rice, and other crop residues for steam production (CDM, Steam Generation Using Biomass, 2012).

It is estimated that the the country has abundant biomass resources that could be potentially utilized for electricity generation, although the utilization is highly dependent upon various factors including availability of local biomass resources, processing infrastructure, and transportation networks. Among the many biomass resources, sugarcane bagasse has the highest potential to become the country's main biomass feedstock (M. Adams et al., 2013). The latest data informs that the domestic production of sugarcane bagasse totals 1.5 million tons per year, of which only 30% was used for electricity or heat generation in the year of 2015 (CDM, Steam Generation Using Biomass, 2009). According to a report released by WorldWatch Institute in 2015, the unused sugarcane bagasse, if utilized to its full potential for electricity generation, could add 88.7 MW-122.3 MW of generation capacity to the country, and would be able to supply 2.9%-4% of the total national electricity consumption (WWI, 2015). Aside from sugarcane bagasse, the country also produces approximately 48,000 tons of risk husk as a by-product of grain every year, whose energy content is about two times as higher than sugarcane bagasse (M. Adams et al., 2013). This makes rice husk the second most important source of biomass feedstock in the country. However, risk husks are seldom used in biomass boilers since they are found to be abrasive to the internal boiler parts

Solar

Considering the high upfront investment associated with biomass technologies, it may be optimal for Hanes to install a medium-size gasifier and supplement with a small PV system on the rooftop to further reduce its electricity costs.

This country is blessed with huge solar potential. Global Horizontal Irradiance (GHI), a measure of total surface solar radiation that includes both Direct Normal Irradiance (DNI) and Diffuse Horizontal Irradiance (DHI), ranges from 5-7 kWh/m2/day in most areas throughout the country and could be as high as 8 kWh/m2/day in some regions (3TIER, 2010). Although no GHI data is directly available for city where the facility resides through open sources of information, it is shown in the National Solar Radiation Database that the region has an average DNI of 4.71 kWh/m2/day (NREL, 2017). It can thus be inferred that GHI in city where the facility resides likely lands in the range of 5-6 kWh/m2/day, making it suitable for solar PV installations.

Thanks to the encouraging renewable energy incentives, a growing number of solar companies have entered this country, though the total number is still quite limited. Aside from a few domestic companies that design and manufacture solar panels in this country, such as North American Solar Solutions and Green Renewable Energy Consultants S.A, there are also many foreign-based companies such as SolarWorld and AIMS Power that supply solar systems to the market (Posharp, 2017).

Our group obtained several quotes from AIMS Power to roughly estimate the solar PV system costs in this country (AIMS, 2017). For a 250 kW PV system, the panel and inverter would cost approximately $300,000 and $30,000 respectively. After adding up the ancillary and installation costs, the total cost is roughly in line with the cost assumptions given by SAM, which is $2.2 per watt installed for small systems. Our group will thus apply the SAM assumptions in the subsequent financial analysis.

Renewable energy incentives

The government of this country has put forward a series of renewable energy incentives as part of the Renewable Energy Incentive Law 57-07, in order to invigorate electricity generation from renewable sources as well as to encourage distributed self-generation in face of frequent supply shortfalls and blackouts (IEA, 2017). Incentives pertinent to the renewable energy technologies under consideration include: 100% tax exemption on imported renewable energy components (e.g. imported solar panels), exemption for value-added tax for certain equipment expressly listed in the law, exemption for income taxes on all profits up to the year of 2020, a 5% reduction on interest on foreign financing of renewable energy projects, a single tax credit of up to 75% of the cost of the capital equipment used, and grants of up to 50% of investments in renewable energy systems less than 5 MW (to be decided on a case-by-case basis).

Tariff Analysis

According to the invoices from Central America, 2's utility, power corporation, the electricity bills are charged by demand (kW) and total energy consumption (kWh). Approximately, 20% of the spending is in demand (kW), 78% in energy consumption (kWh), and the remaining 2% is in administrative fees. Compared to Central America, 1 facility in its industrial park, Central America, 2 has a higher demand charge percentage due to the high demand pricing - $12.51/kW on average. It has a lower energy consumption percentage due to the low energy pricing - $0.074/kWh on average.

Interval Analysis

The hourly interval data is collected from September 2015 to September 2016. Monthly, daily, and hourly trends are summarized from the interval data. From a monthly perspective, peak energy consumptions occurred during the summer. It is important to note that in March, energy consumption dipped compared to the preceding and proceeding months. From a weekly perspective, energy consumption peaked on Wednesday, Thursday and Friday, and were at their lowest levels on the weekend - especially Sunday. The hourly trend is complicated for Central America, 2 (Figure 4). From a high level, the energy consumption was stable throughout the day, ranging from 5 MWh to 7 MWh, on average. However, there are valleys in consumption at approximately 7:00 AM and 7:00 PM, which may be caused by a regular operation pause.

Although Central America, 2 has a high energy intensity, the electricity consumption (kWh) price is low compared to some other Hanes facilities. However, there is an associated high demand (kW) charge, indicating a potential opportunity to implement battery or demand-side management technologies for peak shaving. Also, three-quarters of energy consumption is from fuel - 24% of which is non-renewable fossil fuels. Considering the absolute total energy consumption of Central America, 2, this energy proportion could be replaced with other biomass or other alternatives depending on the price and applicability.

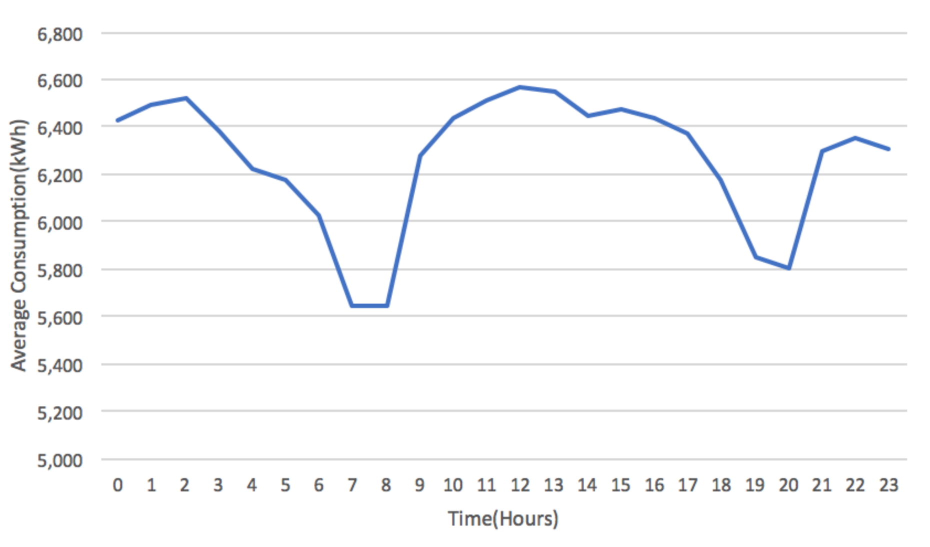

Figure 5: Hourly Demand Distribution. Showing two evident valleys around 7:00 AM and 7:00 PM.

Central America, 3

Facility Overview

Hanes' Central America, 3 facility specializes in knitting. The Central America, 3 plant is one of four sites the company operates in the central America and represents 30% of the country's textile exports (AMCHAM Central America, 2, 2017). The facility acquires its electricity from the industrial park where it is located (ZFSI). The ZFSI was established in March, 1986 and is one of the "most modern, diversified and successful free zone parks of the region". It is a member of many international chambers of commerce as well as of an Association of Free Zones (ADOZONA).

In 2016, Central America, 3 won the Energy Star Challenge of Industry by the US Environmental Protection Agency. It won this award by reducing its energy consumption by over

10% in under 5 years. Over four years, Central America, 3 reduced its energy consumption by 14.7% due to its energy efficiency program.

Tariff Analysis

Electricity for this site is provided by the industrial park and Hanes is currently in the middle of complex negotiations for electricity at this site. Hanes is being careful with the amount of inquiry made into the electricity provider. As a result, we based our subsequent analysis using the average energy consumption and demand charges implied in the monthly electricity bills of Central America, 3.

Based on the 9 months' electricity bills that we have, the average implied demand charge is $7.35/kW, and the average implied energy charge is $0.07/kWh. However, it is important to note that the average charges calculated in this way could only provide us with very limited information as of how the real charges vary across months and different times of the day, and the tariff structure needs to be obtained from the utility provider for the purpose of further analysis.

On average, 35.86% of Central America, 3's total electricity spending is on demand (kW) and 64.14% is on energy (kWh). The percentage spent on demand ranks the second highest among the facilities that our group has analyzed as a result of the high demand charges incurred by Central America, 3.

Different from other facilities, the fact that Central America, 3 ceases operation during weekends would greatly reduce the capacity factor of many potential renewable energy technologies, consequently limiting the financial viability.

Interval Analysis

Our group has analyzed the interval consumption trends over months, days, and hours respectively. Our analysis shows that the average energy consumption peaks in June and stays at relatively high levels throughout the summer months. We also find an interesting pattern that its energy consumption in January is comparatively much higher than the other winter months, rendering further analysis to determine the cause of this observation.

Over the course of a week, we have found that the average consumption during weekdays is more than ten times higher than that of weekends, indicating that the facility usually ceases most of its production during weekends. The hourly interval consumption resembles a typical business profile where it picks up quickly after 6 AM when operation starts, peaks around 8 AM, and drops back to very low levels after production ceases around 6 PM.

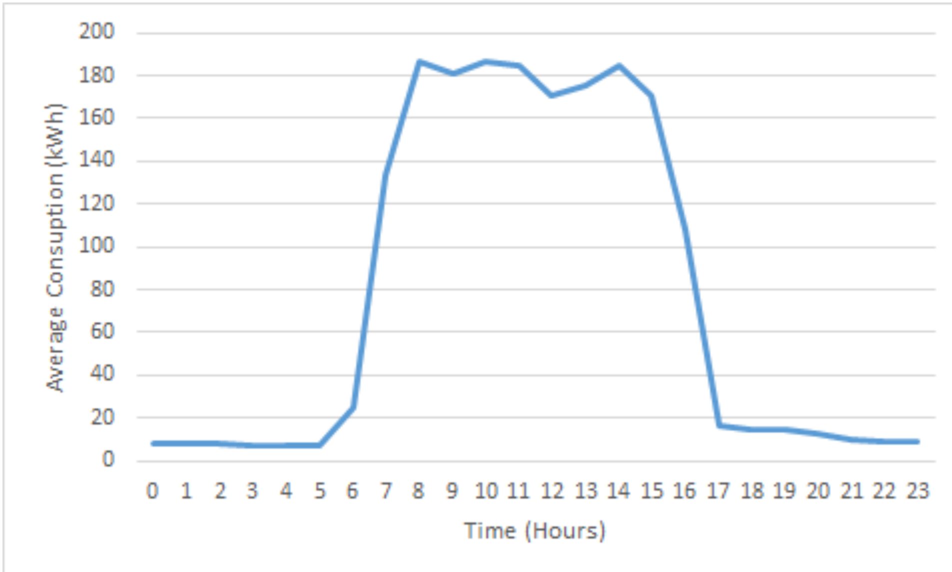

Figure 6: Hourly Demand Distribution. Demand peaks and plateaus from 8:00 AM to 3:00 PM

Central America, 4

Facility Overview

While Hanes operates a manufacturing site at Central America, 4, it was not a focus of the deep dive for the team due to limited interval data access. A market analysis was conducted in fall 2016 as a parallel effort to the preparation and building of the EMS.

Market Analysis

Market Structure

Central America 4's electricity is supplied by a government owned and operated utility which owns the electricity distribution system as well as most generating systems in the country. Electricity mix of this country is 50% petroleum, 32% natural gas, 16% coal and 2% renewables. This government entity sets wholesale & retail electricity rates & regulates the generation and distribution of electricity. Central America 4's country set an RPS goal to source 12% of electricity from renewables by 2012, 15% by 2020 & 20% by 2035. Currently, there is no limit on distributed renewable generation capacity that can be connected to the government utility's grid. Industrial energy prices are currently \$0.1461/kWh, whereas U.S. Prices are \$0.1039/kWh for comparison (U.S. EIA, 2017).

Power Purchase Agreements

Distributed renewable energy is still a small portion of Central America 4's country's overall energy mix. Due to the lack of development, the government has not enacted legislation regarding 3rd party PPA's yet. It appears that they are allowing them in limited quantities in some areas, but this is in very small amounts and is subject to change.

Central America, 5

Facility Overview

While Central America, 5 does have Hanes manufacturing infrastructure within it, it was not a focus of the deep dive for the team. A market analysis was done in fall 2016 as a parallel effort to the preparation and building of the EMS.

Market Analysis

Regulatory Authorities

Central America, 5 is located in a country which has heavy government regulation surrounding the electricity markets. There are multiple sub-entities acting under the authority of a central government agency to set prices and regulations of the generation and distribution of electricity.

Market Structure

Central America 5's regulatory framework allows all the players freely interact and operate in the wholesale market, which guarantees investors profit and aims for affordable energy or end users. Players in the wholesale market include the electricity generators, transmission agent, distribution companies, "electricity marketers" (Buyers and sellers in the regional market), market and system operator, and regulatory entity. The electricity market revolves around the "Transmission System and Wholesale Electricity Market Operation based on Production Cost" Regulation (ROBCP) and two main business areas are observed: Long Term Contract Market (CLP) and the Spot Market (MRS). ROBCP dispatches electricity from the generators depending on the variable marginal production costs. CLP is equivalent to what's known as PPAs in the US and has been active since 2011. SIGET oversees the free competition bidding process of distribution companies to CLPs. Similar to PPAs, CLPs stabilize the energy prices for the end users, guarantees income, and energy supply for the demand side. The four ways of bidding into CLPs are 355MW bidding, 15MW non-conventional Renewable Energy bidding, 100MW Renewable Energy bidding, and 150MW non-conventional Renewable Energy resources. The spot market (MRS) is based on production costs and its price varies by the marginal unit every hour based on the variable costs like fuel costs and compensation for available power. According to this hourly production, marginal cost is paid to all the generating units (National Energy Council (CNE), 2015).

Incentives

Energy demand for Central America, 5 has been steadily increasing and the country has been looking to diversify its energy matrix via promoting the integration of renewable energy and attracting investment from abroad. A total capacity of 1.66GW resulted in the 2015 electricity generation of 43% thermoelectric, 26% geothermal, 25% hydropower and 6% biomass. 3 main incentives of the legal framework catch the attention for RE projects. Fiscal Incentives Law for Renewable Energy provides the opportunity to import equipment for RE generation duty-free for the first 10 years, and exempts the generator from income tax for 5 years in projects bigger than 10MW and 10 years for projects smaller than 10MW. Additionally, the generator is also exempt from tax of direct sales of the Certified Emission Reductions (CERs) or similar carbon markets. Second main incentive Public-Private Partnerships (PPP) Special Law promises an effective and efficient process for PPPs in infrastructure provision and public services. Lastly, the Investment Law tries attract investments by putting forth equal treatment for national and foreign investors, gives access to local funding and lets related profits and payments be freely transferred out of the country. (National Energy Council (CNE), 2015).

V. North American Country

North America, 1

Facility Overview

Hanes Brands' North America, 1 Facility specializes in warp knitting. North America, 1 currently uses only 3.45% renewable energy according to Hanes Master File. North America, 1 has a physical footprint of 176,105 ft^2. Throughout the year, anywhere from 15-35% of the facility's total energy consumption comes from electricity use with the remainder coming from propane consumption. The North America, 1 facility has recently had LED lighting retrofits which resulted in a 50% reduction in lighting energy consumption.

Market Analysis

The North America, 1 facility’s electricity is supplied by a regulated investor owned utility.

North America 1's rate structure charges North America, 1 a flat energy fee and a demand charge based on their demand during peak hours.

North America 1's state has no mandatory Renewable Portfolio Standard or cost reduction incentives for renewable energy technologies. The lack of state incentives combined with somewhat limited solar irradiance (4.08 kWh/m^2/day at NA1 vs 5.28 kWh/m^2/day in AZ) result in the North America 1's state lagging in non-hydro renewable power. However, the state has a net metering policy mandating that non-residential Investor Owned Utility customers with on-site renewable energy technologies less than 1 MW compensated at the retail electricity rate for excess electricity generation. The customers can carry any excess monthly generation on to the next month and maintain ownership of all RECs. Any excess generation accumulated at the end of the calendar year can be carried over at the retail rate to the next year or sold to the utility at the cost avoided rate (State Legislation, 2015). the state where the facility resides also encourages adoption of solar PV by granting 100% property tax exemption of any solar PV facility under 5 MW requested to interconnect before 1/1/2019 (State HB 1305, 2016). While the state does allow for certain purchase power agreements, they can only be conducted by one specific utility and may only have a capacity of 1MW ("SB 148 Renewable Energy; SCC to Establish Third-Party Power Purchase Agreements."). Thus, the North America, 1 facility is not eligible for PPAs.

Tariff Analysis

Under the utility's rate structure, the North America, 1 facility must contract for a defined capacity demand of at least 1,000 kW during on peak hours (7:00 A.M. – 8:00 P.M.) and off-peak hours (8:00 P.M. – 7:00 A.M.). North America, 1 is currently contracted for up to 2,700 kW of power during both on-peak and off-peak demand. Under LP-306, North America, 1 is charged for energy at a fixed rate of $0.03571/kWh and for on-peak demand at a fixed rate of $16.87/kW with a Basic Service Charge of $290 every month. Should North America, 1 exceed their contracted demand during off-peak hours, they will be charged an additional $2.08/kW in excess of their contracted capacity (Utility Company, 2016). Throughout the year, roughly 45% of North America, 1's electricity bill is attributed to demand charges (kW) with the remaining 55% coming from energy charges (kWh). Compared to similar facilities throughout Hanes portfolio, an incredibly large portion of North America, 1's electricity bill is associated with demand charges ($/kW). This is obviously due to the low energy ($/kWh) prices and very high demand ($/kW) prices.

Interval Data Analysis

After analyzing North America, 1's 30-minute demand data by month, it was found that the highest bill ($76,847) came in the month of August 2016. August 2016 also saw the highest energy consumption (1,159,200 kWh) maximum demand of 2016 kW occurring on 8/15/2016 at hour 16:30. Throughout the year, North America, 1 experienced a smooth increase in maximum demand from January to August, with maximum demand falling smoothly to December. However, when average demand is considered, the month of August is significantly higher in hourly demand (Figure 8). This suggests that Hanes could save significant energy and demand expenses by targeting reductions in energy consumption in the month of August or renewable energy technologies which are most effective during the month of August such as solar PV or thermal.

Analyzing North America, 1's interval data by hour revealed a fairly smooth power consumption profile. On average, demand begins the day at approximately 1,310 kW at hour 03:00, dips slightly to 1,290 kW at hour 04:30, rises to 1,365 kW at hour 15:30 and then drops again to 1310 kW at hour 24:00. The maximum load profile follows a similar pattern with peak load occurring slightly later, at hour 16:30 as previously mentioned. Given this smooth load profile, it appears that North America, 1 is already implementing measures to prevent sharp peaks in demand.

Given the extremely high demand charges, it would be most effective for North America, 1 to pursue an energy solution which would most reduce their on-peak demand. Solar PV is a viable option given that North America, 1's peak demand occurs in the midafternoon of August, a very sunny month. However, because on-peak hours last until 8:00 P.M., North America, 1 may still experience high demand charges after the sun sets but operations continue. To combat this, one-axis trackers could be installed on the solar panels or a battery solution could be implemented to compliment any solar installations. One factor that may play into any decision for Hanes to invest in solar is Hanes' internal discount rate. If Hanes could achieve cheap debt financing to finance a solar investment, Hanes could purchase a PV system and take advantage of the 30% Federal ITC up front. With an internal discount rate and cheap debt financing, future payments are much less costly than immediate payments and Hanes could achieve significant savings up-front through the Federal ITC.

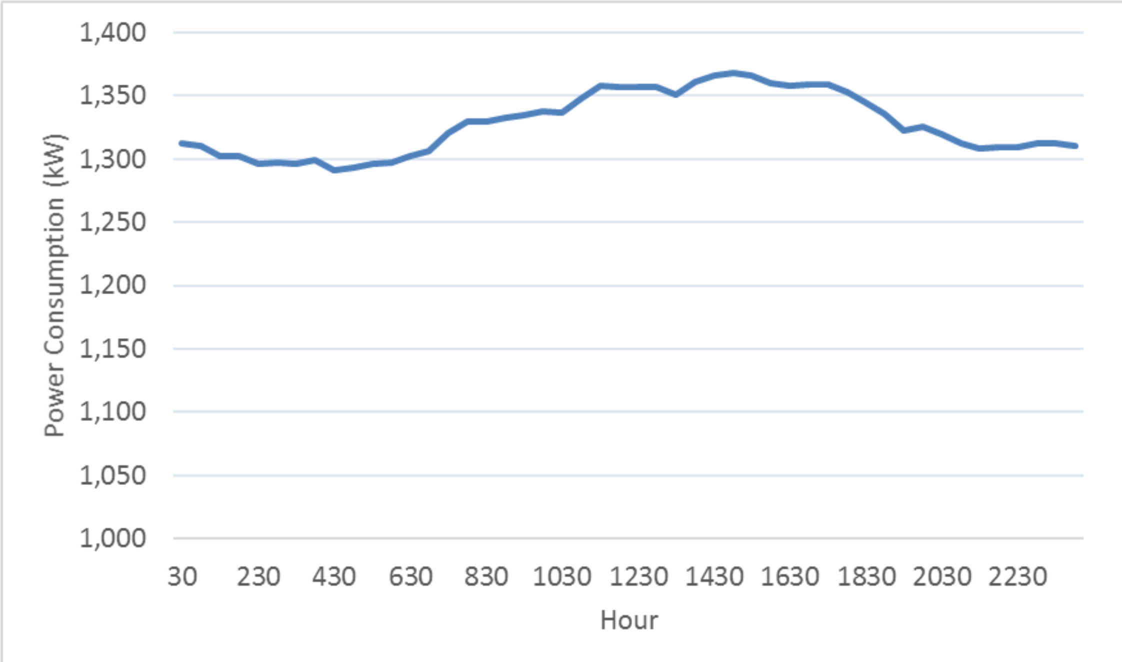

Figure 7: Average North America 1 hourly demand throughout the day is relatively flat, never varying more than 100 kW

North America, 2

Facility Overview

North America, 2 is the corporate headquarters of Hanes Brands International.

Tariff Analysis

North America, 2 is served by a regulated investor owned utility. North America, 2 pays a fixed Basic Facilities Charge of $23.91 per month. It gets no charge for the first 30 kW of billing demand in a given month, and pays $3.8094 for every kW of billing demand over 30 kW. It gets a complicated tiered energy charge that depends both on its demand and consumption, and for the sake of this analysis an average rate of $/kWh is used for simplicity.

From October 2015 to October 2016, about 12% of North America, 2's total electricity spending is on demand (kW) and 88% is on energy (kWh). The percentage spent on energy is relatively higher compared with other facilities that our group has analyzed, and this is primarily due to the fact that the demand charge is significantly lower in North America, 2.

Interval Analysis

Since North America, 2 is an office, its energy consumption pattern follows a typical business profile. On average, the lowest average consumption recorded by Meter 1 is from 12AM to 1AM at 135 kWh, it then slowly climbs to above 170 kWh after 6AM, and reaches its peak at 1PM at a little over 200 kWh. In the afternoon, its energy consumption slowly drops back to a low level of 135 kWh after 11 PM. The energy consumption that goes through Meter 2 is much smaller, but the profile exhibits pretty similar patterns to that of Meter 1. The lowest consumption occurs from 1AM to 3AM at 45 kWh, rises to 137 kWh after 8 AM, stays flat for the next 8 hours before it slowly drops back.

Because North America, 2's peak energy consumption is roughly 51% higher than the valley for Meter 1 and 2 times higher in the case of Meter 2, North America, 2 could explore potential peak shaving measures such as installing PV to smoothen its consumption profile.

North America, 3

Facility Overview

North America, 3 facility specializes in socks production. North America, 3 gets its electricity from a regulated investor owned utility.

Market Analysis

The solar industry in the state where the facility resides has experienced a notable boom in recent years. Before December 31st 2015, the boom had largely been created by the state's generous credit for solar investments, however, the policymakers later decided to let the credit expire. Absent of the state tax credit, and hence the financial incentives it brings, the industry prospects are likely to grow dimmer beyond 2016, but with costs falling substantially over the years, policymakers argue that the industry has a better chance than ever to stand on its own. Besides, the extension of the federal solar tax credits through 2021 could continue to serve as one of the important supporting legs of the state of this country's solar industry.

During a typical month, North America, 3 gets charged for its on-peak demand, on-peak energy as well as off-peak energy. North America, 3 is also enrolled in PowerShare program offered by Duke Energy. PowerShare is a demand response program that involves customers curtailing their electricity demand during peak hours in exchange for credits. Each month, North America, 3 gets $3.5 for every kW of capacity that it is able to curtail should the program be activated (known as

PowerShare Capacity), even though actual activation is not necessary for North America, 3 to get the credits. During the month when actual curtailment is demanded by Utility, North America, 3 could also get extra energy credits of $0.1 for every kWh of energy it saves, or a $2.0 penalty for every kWh of energy it uses above its stated demand.

Tariff Analysis

North America, 3's electricity rates are in accordance with Schedule OPT-V, Optional Power Service, Time of Use schedule under Duke Energy (Duke Energy Carolinas, LLC, 2016). It pays a Basic Facilities Charge of $32.17 per month. It pays a higher demand charge of $13.9066 per kW of its on-peak demand during summer months from June 1 to September 30, and a lower charge of $7.5951 per kW of its on-peak demand during winter months from October 1 to May 31. It gets a flat rate of 6.2860 cents for every kWh of on-peak energy it consumes, and 3.3736 cents for every kWh of energy it consumes during off-peak hours.

From September 2015 to September 2016, about 24% of North America, 3's total electricity spending is on demand (kW) and 76% is on energy (kWh). The percentage spent on demand is relatively higher compared with other facilities that our group has analyzed. This is partly due to the fact that unlike other facilities, North America, 3 faces different demand charges in summer and winter, and that the summer demand charge could get very high.

Interval Analysis

Our group analyzed North America, 3's half-hour interval data by calculating the annual average energy consumption data during the same interval, and found that the energy consumption is the highest from 13:30 to 14:00 at 1472.83 kWh, and is the lowest from 4:30-5:00 at 1402.93 kWh. This indicates that the energy consumption does not vary significantly throughout the day, suggesting that it is likely that North America, 3 has already adopted certain peak shaving measures by shifting its energy consumption to non-peak hours.

From the above analysis, our group suggests that North America, 3 seek measures to cut its peak demand during summer times in order to achieve the greatest amount of savings. Since room for further peak shaving is likely to be limited, it may be optimal for North America, 3 to install solar panels as a way to curtail its energy demand from the grid especially during summer days. By doing so, North America, 3 could cut its direct demand charges. However, it is possible that North America, 3 could see reduced PowerShare credits since the curtailment amount calculated as the difference between average demand level and the curtailment threshold level would become smaller.

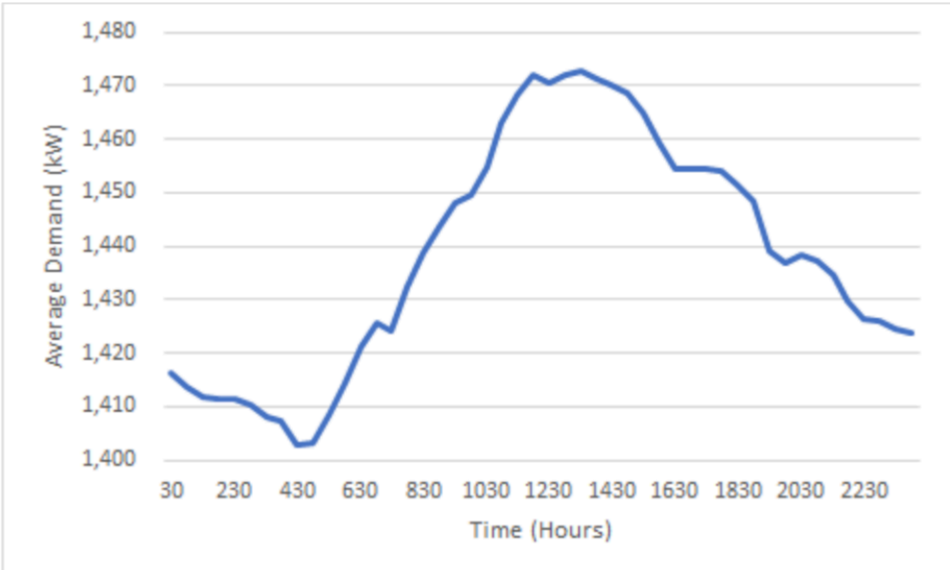

Figure 8: Hourly Demand Distribution. Demand is relatively flat and smooth throughout the day

North America, 4

Facility Overview

North America, 4 facility is used for hosiery manufacturing and is served by a regulated investor owned utility.

Market Analysis

North America 4's utility has a supply mix of 47% renewables compared to the State average electricity generation of 8.6 % from renewables (EIA, 2016), which is predominantly hydro (41.7% of overall supply) and some wind (5.3%) (Utility reference, n.d.). In the state of North America 4's state there are no direct incentives towards renewable energy generation for big industry; the state is focusing on programs for homes (State Energy Office, n.d.). Thus, federal incentives like ITC and PTC are the only significant options as of January 2017. The state is also behind 29 states, Washington, D.C. and 3 US territories in terms of renewable energy by not having a renewable portfolio standard or goals (DSIRE, 2016).

Tariff Analysis

The facility is charged by its utility for water and electricity use. During the period of September 2015 – October 2016, for its electricity use, Hanes paid a base customer charge of $100/month and a $3.5/kW demand charge. By October 2016, the utility was charging a fixed $0.034243/kWh, on top of $0.0276/kWh for the first 100 hours of use of billing demand, $0.0233/kWh for the next 260 hours of use of billing demand, and $0.0215/kWh for all additional kWh (Utility Company, n.d.).

Upon analyzing this tiered rate structure during this billing period, it is calculated that Hanes has paid an average demand charge of $3.5/kW and $0.05671/kWh overall. North America, 4 ranks third for its average electricity bill expenditure among the eight facilities initially analyzed by the Duke team. Even under a low demand charge, Hanes is paying an average of $26,771.40 because of a high average maximum demand of 7,649 kW. Similarly, the utility charges a low amount on average on kWh, however the site averages a consumption of 3,400 MWh, hence the contribution to the high electricity bill.

Energy Management Tool Results

Energy Management Tool Metrics

The energy metrics describing the behavior of each of the analyzed sites and comparing them across the portfolio are summarized in combinations of their energy consumption and demand usage versus their total spend in each category. The rates were generated by deriving the average cost per month for a year's worth of utility bill data. Because of the incongruence of available utility bill data and variability of utility billing cycles, the data covers different ranges of time. Thus, only the most recent full year of data was used under the assumption that the variability between years is negligible when cross comparing facilities due to their constant production patterns and climate environments. The average month metrics standardize any rates under this assumption.

Energy Consumption

This was the primary metric that was used to address Hanes' 2020 goal of increasing their total renewable energy percentage to 40% compared to 2007 base level as it is the only metric that directly relates to renewable energy cost in $/kWh. In combination with the average monthly total spend on energy consumption, the rates assist in narrating which facilities are the most energy intensive and have the highest potential for cost avoidance when considering installing renewable energy assets.

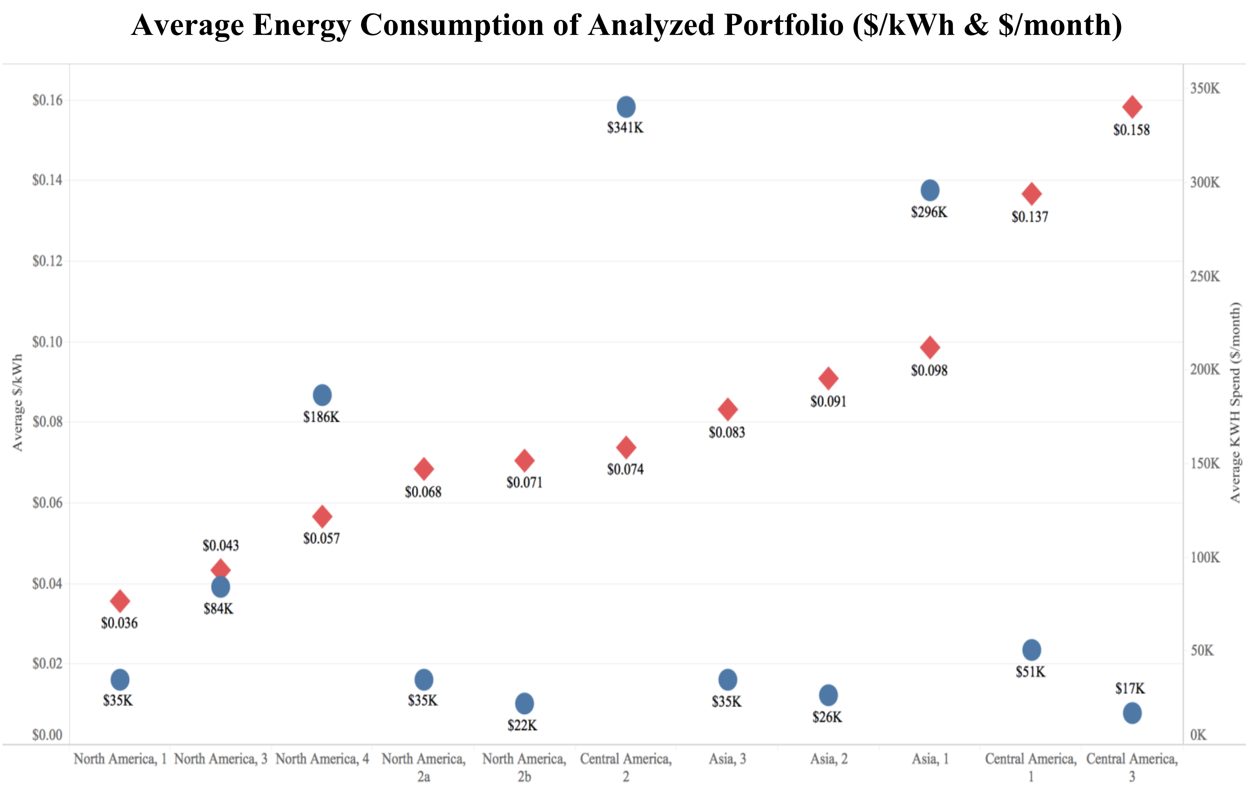

Figure 9: A comparison of the absolute spend versus the true cost of energy by month for each analyzed facility

The facility with the most expensive rate of energy is Central America, 3, followed by Central America, 1 – two central America Facilities. North America, 1 has the cheapest rate of energy of the analyzed portfolio but the fifth highest average monthly spend. Central America, 2 and Asia, 1 have the highest average monthly spend on energy, but have the fifth and eighth highest rates of electricity cost. The average cost per kilowatt-hour and the average cost of energy per month are not significantly correlated ($R^2 = 0.0014$, $p = 0.7205$). Their low correlation is due to the facilities having a range of different utility tariffs they follow in dramatically different power markets. These different utility tariffs impact the rate at which energy is charged and can vary from month-to-month or due to energy availability. Within each country, the charges subjected to each facility vary because of different industrial zoning regulations or provincial/state laws. It is common to see this variation in a manufacturing portfolio. All of the facilities besides Central America, 1 and Central America, 3 pay less than 0.1039 $/kWh - the north America country average commercial cost (*EIA - Electricity Data*, 2017). Central America, 1 and Central America, 3 are both located in industrial parks in the central America that pay a premium for energy consistency and shift the costs of it to their customers. Central America, 2, Asia, 1, and

North America, 4 all have the highest average monthly spend on energy. They are also three of Hanes' highest production volume facilities and are therefore more energy intensive.

Energy Demand

However initially considered, energy demand charges at each of the facilities do not directly address the Hanes' renewable energy objective. Demand management energy technologies, such as batteries, do not remove or replace non-renewable electricity consumption from Hanes' energy ledger; they decrease the cost of it by peak shaving. The demand results generated by the EMS are meant to illustrate the power of understanding the demand behavior and cost of each facility's electricity use – which would assist them in making energy management decisions in a proactive manner relative to Hanes' reduce energy intensity by 40% compared to 2007 base level goal.

Average Energy Demand of Analyzed Portfolio ($/kW & $/month)

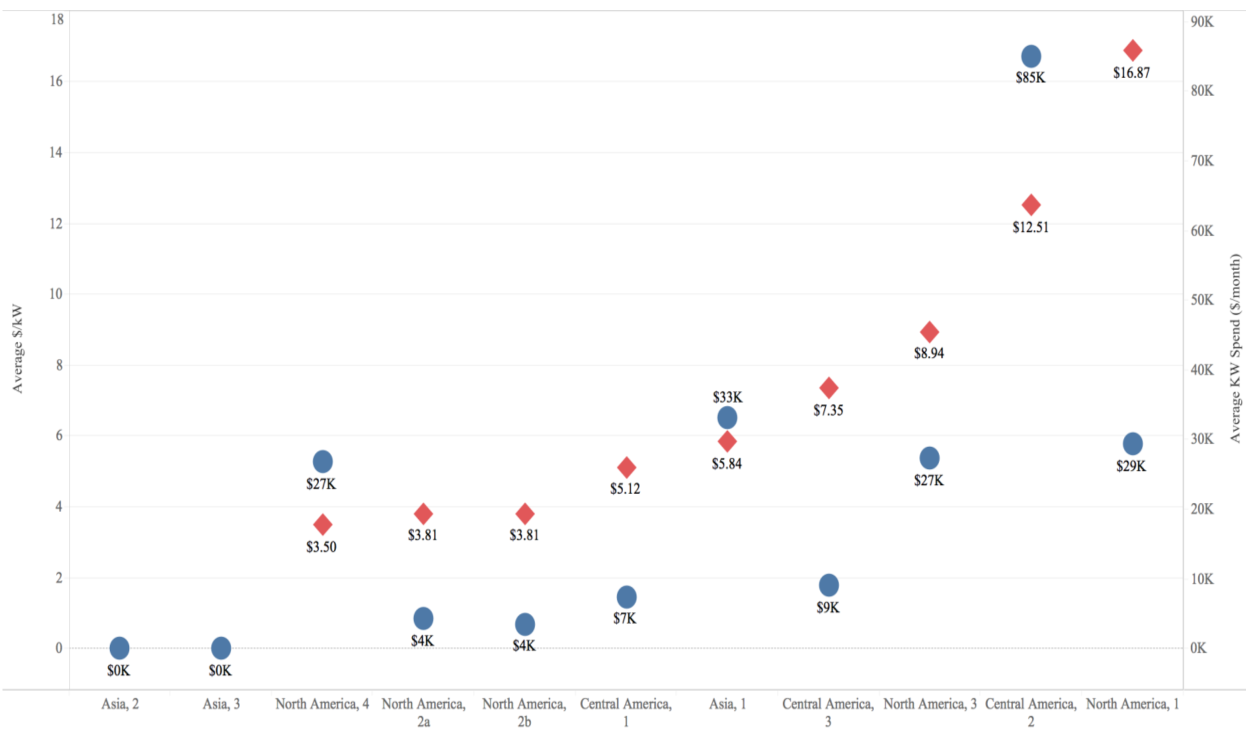

Figure 10: A comparison of the absolute spend on demand versus the true cost of capacity

Analyzed in the same method as the energy consumption was, the facilities with higher levels of consumption tend to spend more on their average monthly bill. Contrary to energy consumption results, North America, 1 is the facility with the highest demand charge rate, and the third most expensive facility, monthly. Asia, 3 and Asia, 2 do not receive demand charges, making those two sites more inexpensive than the others from an aggregated consumption, demand perspective. Central America, 2 remains the most expensive facility in terms of total spending of the analyzed portfolio but also has the second highest demand charge rate.

Because of the relationship between Central America, 2 demand charge rate and its total monthly, average spend, we investigated the correlation between the variables and found that they are significantly correlated ($R^2 = 0.0433$; $p = 0.0277$). Capacity must be made available for the facilities that have high loads. It is more expensive to provide more capacity to a facility. Utilities typically tier their commercial tariff structures in a way that allows for monthly volatility within a range of scaled capacities. As a facility requires higher capacities, they are charged at a higher rate. Across the sample of Hanes' portfolio we analyzed, we found that this is true even if it is a different country or a facility has an alternative function to manufacturing (North America, 2).

Energy Spend Total

The aggregated monthly demand and consumption charges do not directly diagnose which facility is the greatest candidate for renewable energy technologies, but similar to the demand metrics, it describes energy intensity from a joined demand-consumption perspective. The energy spends total is to be used as a proxy for which facilities are prime for combined heat and power (CHP or cogeneration) technologies. While CHP technologies have been controversially touted for their ability to use biofuels or fossil fuels for cogeneration as renewable energy technologies, they do provide useful heat, often in the form of steam, and electricity (U.S. DOE, n.d.). If biofuel was the sourced fuel for a cogeneration plant, Hanes would be able to count the energy generated as renewable. However, many of the sites do not have CHP thermal load applications. Only the textile manufacturing sites do.

Average Total Cost of Consumption & Demand ($/month)

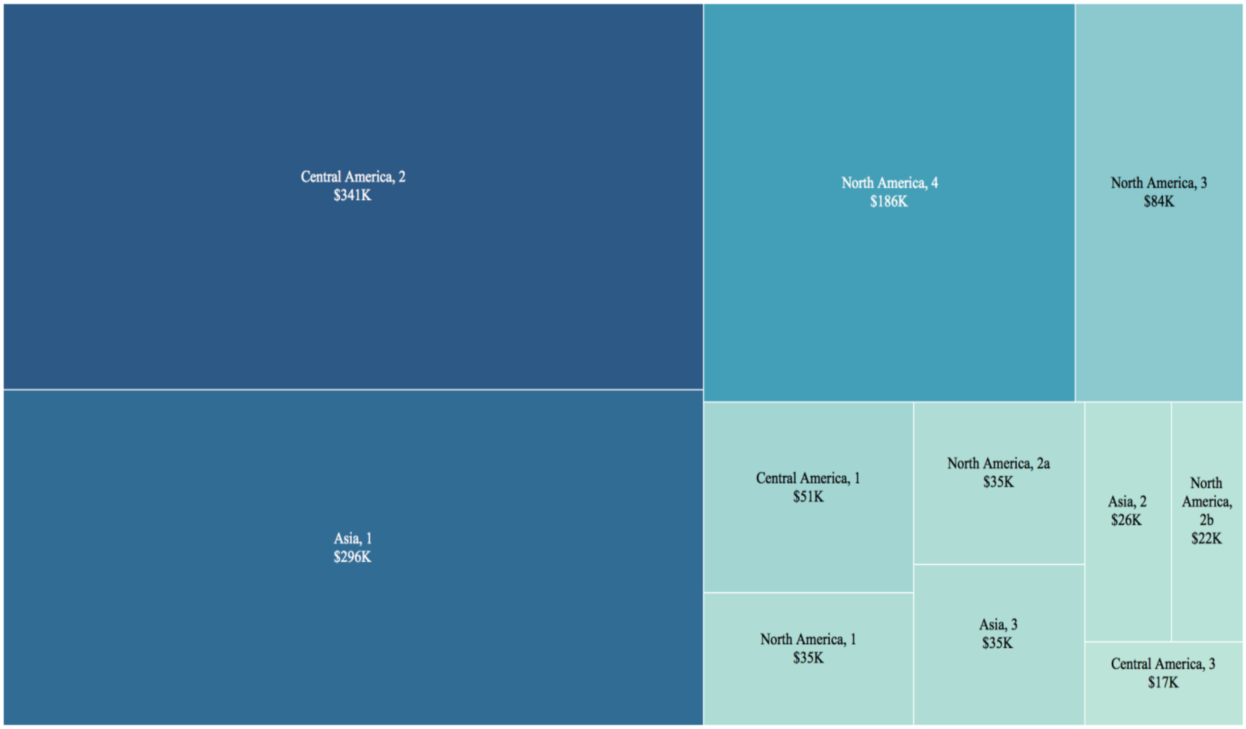

Figure 11: Total average monthly cost of consumption and demand

Central America, 2, as it was for demand, is the most expensive facility in terms of demand and consumption charges. When Hanes' energy management team was made aware of this as a potential site for CHP installation, we were informed that they already had an onsite steam generator that is providing the facilities heat requirements. North America, 2a and North America, 2b are two separate accounts that Hanes wanted to treat as different cases. Combined they would be the fifth most expensive site. It is important to note that while Central America, 3 had the highest rate of electricity, they have the lowest total spend.

Blended Rate versus True Cost of Energy

Currently, Hanes energy management uses the blended rate of energy to describe energy consumption at each of their facility sites. This involves summing the entirety of the monthly bill, regardless of the type of charge, and dividing it by the total monthly consumption (kWh). This does not accurately describe the true cost of electricity of the facility.

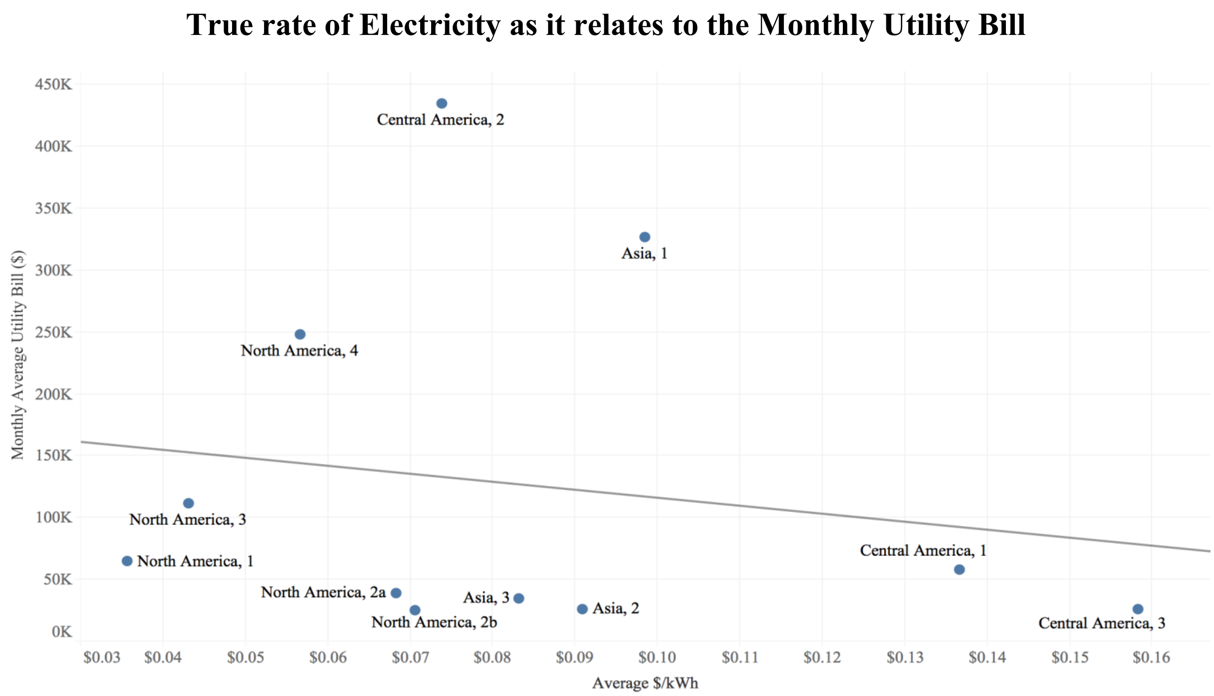

Figure 12: A comparison between the true rate of electricity and the total monthly utility spending

The true cost of energy at the site is not significantly correlated with the monthly average utility bill ($R^2 = 0.028$, $p = 0.622$). The rate of electricity would be the main driver of statistical significance if the utility bill was divided by the total monthly consumption (kWh). The blended rate cannot describe the facility consumption patterns if the true rate of energy is not significantly correlated with the utility bill.

Rate of Energy Cost as it Relates to Rate of Demand Cost (Average Monthly Rates)

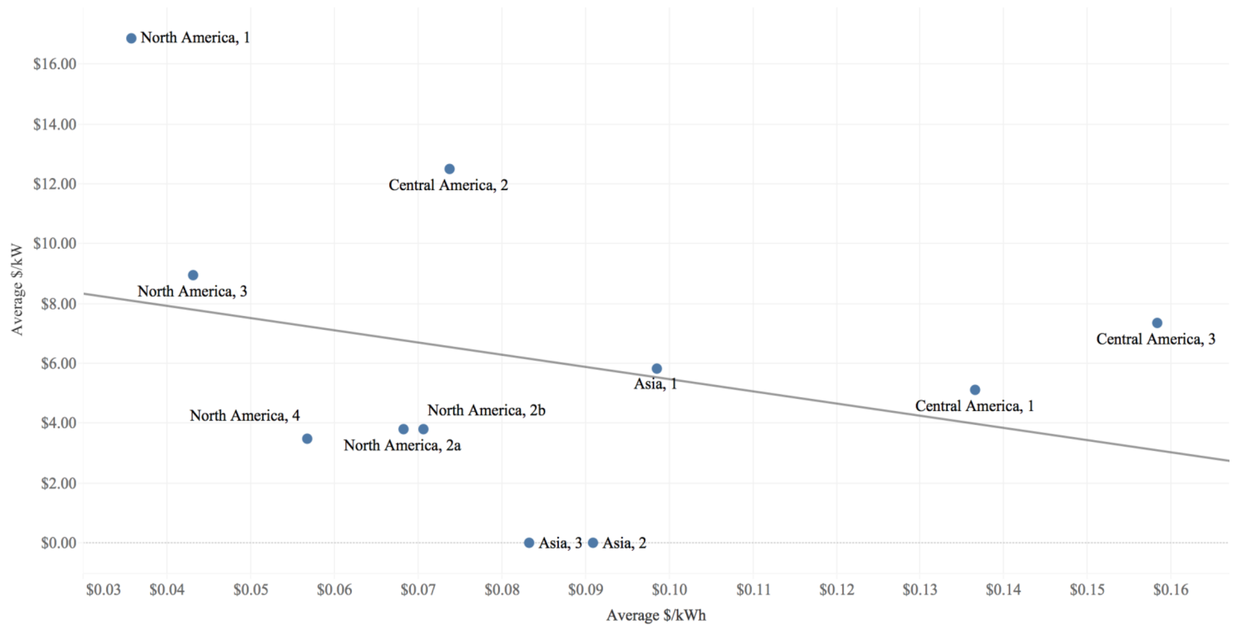

Figure 13: A comparison between the rate of energy cost and the rate of demand cost

Taking a closer look at the components of the utility bill, the average monthly rate of energy and the average monthly rate of demand are not significantly correlated with each other ($R^2 = 0.089$, $p = 0.374$). Using this comparison as a proxy for the relationship between energy usage and the total utility bill, at least segregating the demand from the consumption is required when considering the true cost of energy. Adding them together and dividing by the total consumption (kWh) will skew the results because of the lack of significance in the relationship between the two variables.

NREL SAM Results

Table 5[1] below lists the net costs, simple payback period, NPV, estimated lifetime savings and

[1] Our financial analyses were based on the SAM model from National Renewable Energy Laboratory (NREL), where site specific weather condition data were automatically acquired from Solar Resources Library. As an alternative, the weather condition data can also be manually acquired from National Solar Radiation Data Base (NSRDB). However, the weather data for Vietnam facilities are missing in both databases, which poses a barrier for our team to conduct a standardized analysis on Vietnam facilities as we did for other facilities. The analysis for Vietnam sites can be conducted upon availability of weather data.

impact of the investment on Hanes global renewable energy consumption and CO_2e emissions of multiple SAM facilities investments and REC purchases. Details of each facility's analysis including system and financial specifications can be seen in the sections below.

Table 5: Financial results of renewable energy investments at all facilities analyzed and impact on Hanes' renewable energy consumption & CO2e emissions

Site	System	NPV ($000)	Simple Payback (Yrs)	Net Cost ($000)	Lifetime Savings ($000)	Life Savings/ Net Cost	Global Energy	Global CO2e Reduction
Central America, 1	250 kW	$470	2.3	$270	$2,380	8.8	<0.25%	<0.5%
	750 kW	$1,350	2.3	$790	$6,840	8.7	<0.25%	<0.5%
	1.2 MW + Battery	$1,550	3	$1,360	$8,130	6.0	<0.25%	<0.5%
Central America, 2	250 kW	$390	2.6	$270	$1,990	7.4	<0.25%	<0.5%
	750 kW	$870	3	$790	$4,600	5.8	<0.25%	<0.5%
	1.2 MW + Battery	$1,370	3.2	$1,360	$7,210	5.3	<0.25%	<0.5%
Asia, 1	250 kW	$280	5.8	$500	$1,410	2.8	<0.25%	<0.5%
	500 kW	$550	5.9	$990	$2,750	2.8	<0.25%	<0.5%
	1.0 MW + Battery	$1,060	6	$1,980	$5,330	2.7	<0.25%	<0.5%
North America, 1	250 kW	$130	11.7	$380	$1,250	3.3	<0.25%	<0.5%
	750 kW	$150	16.9	$1,100	$2,530	2.3	<0.25%	<0.5%
	1.2 MW + Battery	$320	15.8	$1,900	$4,580	2.4	<0.25%	<0.5%
North America, 2	250 kW	$80	14.9	$380	$1,070	2.8	<0.25%	<0.5%
	750 kW	$220	14.8	$1,100	$3,090	2.8	<0.25%	<0.5%
	1.2 MW + Battery	$310	16	$1,900	$4,890	2.6	<0.25%	<0.5%
North America, 3	250 kW	$50	16.8	$380	$890	2.3	<0.25%	<0.5%
	750 kW	$110	18.6	$1,100	$2,330	2.1	<0.25%	<0.5%
	1.2 MW + Battery	$140	20.1	$1,900	$3,670	1.9	<0.25%	<0.5%
Annual REC Purchase:	$50,000/yr	N/A	N/A	$50	N/A	N/A	1%	1%
	$150,000/yr	N/A	N/A	$150	N/A	N/A	2%	3%
	$250,000/yr	N/A	N/A	$250	N/A	N/A	3%	5%
Lump REC Purchases	$500,000	N/A	N/A	$500	N/A	N/A	6%	10%
	$1,000,000	N/A	N/A	$1,000	N/A	N/A	13%	20%
	$2,000,000	N/A	N/A	$2,000	N/A	N/A	25%	41%

Detailed financial and technical specifications of each PV system can be seen in Appendix B, but there are four significant findings resulting from this analysis. Firstly, as can be seen in the "Simple Payback" column, only two facilities provide the financial returns Hanes is seeking from renewable energy investments, Central America, 1 and Central America, 2. At both of these facilities, PV investments can achieve paybacks of 3.2 years or less. This is due to the fact that both facilities pay high energy ($/kWh) and demand ($/kW) charges, $0.155/kWh and $5.10/kW at Central America, 1 and $0.07/kWh and $12.20/kW at Central America, 2. Because these facilities are paying such high prices for electricity, solar PV provides larger savings than at most other facilities who are paying significantly less. Additionally, Central America 1&2 are eligible for a 50% grant available for solar PV installments (Export.gov, 2016) available day-one which greatly aids the payback of any systems installed at these two facilities. Finally, being in

Central America, both sites receive strong irradiation compared to North American and an Asian sites (5.47 $kWh/m^2/day$ vs ~4.8 $kWh/m^2/day$)

Secondly, it is important to notice that smaller systems tend to outperform larger systems on a relative basis. The "Lifetime Savings/Net Cost" column in Table 5 divides the systems lifetime savings over 25 years by its net cost post-incentives. Since larger systems provide larger lifetime savings but also cost more up front, it is difficult to compare relative performance, and this metric gives a relative performance score to each system. As can be seen, smaller systems tend to score higher in this category, even though economies of scale were employed in the pricing of the systems. This outperformance is due to the fact that in most facilities, Hanes has already taken effective measures to flatten peaks in power demand to avoid high demand charges. The particular facilities analyzed are charged a peak demand charge at the same rate no matter when the peak demand occurs, so solar PV does little to alleviate any demand charges since demand at night is approximately the same as demand during the day, but solar does not produce at night time.

Thirdly, the "% Global Renewable Energy" column of Table 5 demonstrate that no single PV investment makes significant progress towards Hanes 2020 goal of 40% renewable energy. This result makes clear that Hanes will have to turn to other measures besides on-site renewable energy to reach their renewable energy goals. Although some of these investments provide strong enough financial returns for Hanes to pursue them for monetary reasons alone, solar PV will not be enough to reach 40% renewable energy.

Lastly, the annual and lump REC purchase rows at the bottom of the table demonstrate that on a dollar to dollar basis, REC purchases provide much more progress towards Hanes' goal of 40% renewable energy than actual PV investment. The annual REC purchases were priced at the approximate annual payment costs of the various size PV systems and the lump sum REC purchases were priced at the approximate total net costs of the various size PV systems. While REC purchases do provide significant progress towards Hanes ability to claim the use of 40% renewable energy, they provide no direct financial returns. It will be up to Hanes management to decide whether to pursue PV investments with low impacts on renewable energy use but strong financial returns or REC purchases which make significant progress towards reaching 40% renewable energy but provide no monetary returns with their competitive budget.

IV. Synthetic PPA

Southeastern Texas

Background

Synthetic purchase power agreements (SPPAs) are exceptionally unique contracts that allow corporations to increase the renewable energy proportions of their consumption portfolios. Because SPPAs are not bound by geographical location and are a financial contract that exchanges power prices based on project cost, they are an appealing alternative to installing physical onsite or offsite infrastructure for Hanes. The contract element of the agreement allows Hanes to execute this quickly before 2020, instead of negotiating a contract renewable energy technologies and installing them. The SPPA we modeled may vary from one that Hanes would enter in actuality. This model is meant to provide a quote for what it may cost to execute a SPPA.

Wind Power Purchase Agreement

A financial and performance analysis of a synthetic wind purchase power agreement was proxied using NREL's System Advisor Model (SAM). It was built with the caveat that the model does not have an input for SPPAs and it was based highly on the specifications for the very successful MARS Corporation SPPA (EPA, 2017). Thus, the results should be considered as a proof of concept based on a case study.

System Specifications

A single owner, wind power purchase agreement was selected for the analysis. The Mars SPPA is a 22 year PPA for 100% of a 200 MW project that was signed in April 1st of 2014. It met the equivalent of 100% of Mars's US non-renewable electricity needs and 24% of their global demand. Hanes' domestic non-renewable energy consumption was 114,804.12 MWh in 2015, which comprises 10.895% of their global portfolio. To meet this demand, a Hanes requires 39MW of capacity based in Southeastern TX (823 meters elevation above sea level) – the location of Mars' wind farm. The farm chosen to model this selection is Sherbino Wind Farm because of its size and success in the region (*BP*, 2008). The wind turbines used were 13 Vestas V-90 Mk3.0 generators – each with a rated capacity of 3MW (Thomas, 2008). The turbine has a rotor diameter of 90 meters, hub height of 80 meters and shear coefficient of 0.14. They were left in the default turbine layout map positioning with a turbulence coefficient of 0.1. To simplify the model, a simple wake model was used to describe the wind wake patterns the turbines generated. The system performance degradation was set to 1.6% per year (Staffell, I. & Green, R, 2014). Because the SPPA is purely a financial transaction, the time of delivery factors were all set to 1 to simulate the contract's equivocated strike price.

Financial Specifications

The system was modeled to be financed by 100% debt with a loan rate of 7.5%. The previously mentioned real discount rate of 8%/yr was used. The system was modeled to have a lifetime of 22 years, no salvage value, and was to be depreciated using MACRS 5-year depreciation. This is modeled after the Mars SPPA term length. It is assumed that the company Hanes enters into the PPA with can take full advantage of the 30 year Federal ITC and a federal 0.0184 $/kWh production tax credit over ten years for wind projects. Additionally, in the state of Texas, wind systems are eligible for 100% property tax exemption, 6.25% sales tax of total direct cost, and 0% state income tax rates (SECO, 2017).

Results

This simulation produces 113,962 MWh in the first year of production at 0.0619 $/kWh. This covers Hanes' current consumption and more, so the excess would have to be sold back to the wholesale market or another entity interested in the renewable energy. The project has a NPV of $936,463 and the IRR of the project (11.47%) is achieved in year 20 of 22 years. Again, these figures are relative because of the variability of SPPA contracts. For example, one of the factors that would have to be negotiated in the outset of the contract is the $64,918,436 of capital cost. Hanes would have to determine whether they were going to buy into a collective SPPA with other entities or not and whether they were going to finance a brand-new wind farm or buy a share of a preexisting one.

Recommendations

Overarching Recommendation

To achieve their 2020 renewable energy goal, we recommend Hanes replace their north America country non-renewable electricity with a synthetic power purchase agreement and invest in onsite renewable energy generation assets at their facilities in Central America, 2 and Central America, 1 in the central America to move their global renewable energy portfolio proportion from 24.9% to 36.02%. To make up the remaining 3.98% of the goal, we recommend Hanes pursue replacing some use of liquid fossil fuels in favor of renewable biomass.

Feasibility Database

We recommend Hanes dedicate a centralized space to inventory their entire portfolio's utility energy bills. They should collect every utility bill across their sites to build a historic impact analysis of their electricity use at each site. If Hanes possessed the entire utility bill history for each site, they would be to perform a robust escalation analysis on the electricity rates and make predictions that could influence the viability of installing onsite renewable energy assets using projected cost avoidance over years.

Itemizing each utility bill line item would enable Hanes to make energy management decisions based on the true cost of energy consumption and demand rather than a less informative blended rate. Dividing the entire cost of a utility bill by the number of kilowatt-hours used in the billing cycle does not accurately describe the rate of energy consumption ($/kWh). Adding other charges - such as demand, KVAR or administrative – distorts the actual cost of energy at that site. By itemizing and describing the true costs, the energy management team can make more accurate assumptions about the energy usage patterns and expenditures at each facility – whether they choose to strategically address consumption, demand or both.

Energy Management Tool

We recommend Hanes continue to build out and further detail their existing master file by itemized charge when considering investment in renewable energy for their manufacturing portfolio. There is currently no structure to cross compare facilities in terms of their renewable energy project viability. Hanes should develop an internal method, whether driven by an external consulting company or their own effort, to remove any bias towards projects and maximize the renewable potential of their investment. From an expertise level, Hanes could implement a system as simple as the one this team has developed using Microsoft Excel and Tableau with at a very small cost with the potential of large payoffs through making wise investment decisions in the future.

Demo Alternatives

Our group figured that in order to develop the renewable energy prioritization model, tariff analysis is essentially the first step to screen and select the facilities where the greatest saving potential lies across all fuel types – not solely electricity. However, this process generally takes enormous time and effort to complete, especially for Hanes whose operations span over 6 continents. As an alternative to performing the analysis in-house, it may be an option for Hanes to outsource the data collection, analysis, and interpretation to third party energy services companies. These companies, generally known as Energy Service Companies (ESCOs), have grown rapidly in number in the past decade in response to greater demand of energy management from all kinds of businesses and organizations. They offer a wide range of professional products and services tailored to suit each business' unique needs, and are highly specialized in areas such as energy data analytics, electricity bill management, and interval data monitoring. By potentially partnering with ESCOs, Hanes could get access to comprehensive and readily available data through advanced data analysis software, which could then serve as the basis for subsequent analysis on renewable energy technologies.

Our group has conducted a preliminary search on ESCOs both in U.S. and abroad, and found that among others, EnerNoc, a U.S-based company founded in 2003, provides the kind of products that may well suit Hanes' energy analysis needs. Our group also discussed service offerings with the CEO of a small, private energy consulting firm called Reneu Energy that may be able to provide the kind of energy management program support that Hanes requires.

EnerNoc provides services in four main areas, namely energy use management, energy procurement, demand response, and professional consultation services. As its icon product, EnerNoc offers Energy Intelligence Software (EIS) especially designed for large industrial and manufacturing users. Most pertinent to Hanes' needs, EIS comes with a centralized utility bill management tool-kit, with which Hanes could effortlessly keep track of and get insights into where each dollar is being spent across its global portfolio. This is similar to the tariff analysis that our group performed in the "demo", and the analysis results could then be used as one of the major criteria against which the financial viability of each renewable energy technology is assessed.

EIS could also enable Hanes to monitor its energy use across different facilities on a real-time basis, as well as to visualize energy use patterns over time and across regions. With EIS, Hanes could easily identify each facility's consumption peaks and valleys, which serves as another important criterion to assess the suitability of each renewable energy technology.

Aside from EnerNoc, some of the big companies that offer similar services to large industrial and manufacturing users include Schneider Electric, EFT Energy, eSight Energy, and Panoramic Power.

At the request of Philip Henson, Senior Manager of Energy and Environmental Sustainability at Hanes, our team was tasked to meet with Reneu Energy CEO, Benoy Thanjan, to explore what kind of service offerings may be beneficial to Hanes. Reneu Energy is a consulting firm that offers services aligned with Hanes corporate energy objectives and goals. They run many different kind of energy management programs, some of them being "capital advisory for solar energy projects, energy hedging, environmental commodity brokerage, and consulting services for companies looking to go solar" (Home, 2017). Philip was interested in Reneu Energy's abilities to set up and structure SPPA contracts, which Benoy confirmed as a possibility. Benoy also made points as to which kind of services Reneu Energy may perform best for Hanes.

- Review Hanes' property locations and determine which is best for solar based site suitability and financial return
- Create and manage a RFP process for Hanes to move forward with a solar installer at selected property locations
- Source renewable energy projects for PPA offtake provided by Hanes
- Source Renewable Energy Credits to retire and qualify as credible renewable energy

We believe it may be worth Hanes' time to continue conversations with Reneu Energy, especially if Hanes is considering pursuing PPAs in the future. Reneu Energy could offer a more concentrated effort with more professional tools as an extension of what our Duke team is completing for Hanes

Geo-Market Research & Deep Dive

One of the consistently requested deliverables from the Hanes energy management team was information pertaining to facilities the electricity markets. We recommend building a centralized database with the current information on the power markets of each of the facilities and maintaining it at least on a bi-annual basis. This would enhance Hanes' understanding of how electricity rate structures are determined, how the rate structures may be changing and evolving over time, and how pending government policies might affect the cost of electricity that the firm will be paying different markets. The geo-market information could greatly complement the utility data in helping Hanes reaching better decisions in renewable energy investments.

NREL SAM

Facilities

To reach the 2020 energy goals, Hanes should physically invest in renewable energy generation technology at the Central America, 2 and Central America, 1 sites located in the central America. Solar PV investments at Hanes' Central America, 2 and Central America, 1 facilities provide the strongest financial performance as well as power generation output of the facilities analyzed. Assuming that Hanes could take full advantage of the 50% government grant (export.gov, 2016) Hanes could install a 1.2 MW PV + 200 kW/600 kWh battery system at the larger Central America, 2 site and a 250 kW PV system at the smaller Central America, 1 site. Combined, these investments sum to a post-incentive cost of $1,631,974. Individually, these investments have post-incentive costs of $1,357,014 and $274,960 respectively and simple payback periods of 3.2 and 2.3 years respectively. Combined, the investments are estimated to produce 2,179 MWh of electricity annually, enough to supply 0.276% of Hanes global non-renewable energy use annually and offset 0.616% of Hanes global CO_2e emissions. While this appears to be an insignificant offset, the high prices of electricity at Central America, 2 and Central America, 1, available government grant and abundant solar resources make this combination of investments attractive purely from a financial perspective.

In the case that Hanes decides not to invest in renewable energy generation at Central America, 2 and Central America, 1, investment at Hanes Asia, 1 facility provides a strong alternative. Physically investing in a 1.0 MW solar PV system at Asia, 1 costs Hanes $1,982,645 after incentives and produces a simple payback period of 6 years. A 1.0 MW PV system at Asia, 1 is estimated to produce 1,200 MWh of electricity annually, enough to supply 0.152% of Hanes global non-renewable energy use and offset 0.370% of Hanes global CO2e emissions annually.

The strong financial returns as well as concrete demonstration of Hanes' commitment to sustainability make solar PV investments at Central America, 2 and Central America, 1 optimal use of Hanes resources, and Asia, 1 a solid alternative.

Power Purchase Agreements

Included are considerations for both traditional and synthetic type purchase power agreements. The only markets considered were ones under the north America country jurisdiction and facilities that comprised over 5% of the north America country non-renewable electricity consumption. There may be opportunities for facilities that consume under this volume of electricity, but for the sake of scalar impact of the study, only ones surpassing 5% were considered.

Traditional

There are no recommendations to consider traditional PPAs because of the location of Hanes' US facilities. The considered facilities exist in the state where the facility resides, Arkansas and the state where the facility resides. The state where the facility resides and Arkansas have legislation actively blocking the use of 3rd party power purchase agreements (DSIRE, 2017). The state where the facility resides has limited PPA access only for 1MW projects within the state where the facility resides Dominion Power's service area.

Synthetic

Based off market research and a limited NREL SAM analysis, we recommend Hanes pursue SPPAs in the US market to replace the 114,804.12 MWh of non-renewable electricity with a wind power SPPA. Replacing this non-renewable electricity with wind power will increase the renewables percentage of their portfolio from 24.9% to 35.8%. Hanes has a credit rating of Ba1, so while it is possible for Hanes to finance an SPPA with debt, it will still need talents who are familiar with the various structures of SPPAs to properly position it for these types of deals. Another consideration for Hanes is understanding the needs of any 3rd party financier. Investment banks will typically not be involved for a project less than $50 million. Thus, Hanes will have to leverage its relationships with its other creditors to manage smaller deals. Setting the right strike price is crucial and if Hanes wants to make larger deals, they can form a consortium between small and mid-sized companies. This single effort will allow Hanes to be within 5% of their 2020 goal.

Renewable Energy Credit Purchases

Globally, Hanes is an incredibly large energy user and consumes 1,053,684 MWh of energy annually, 790,841 MWh of which is from non-renewable sources. Of the renewable energy investments analyzed, the system with the most output, Central America, 2 1.2 MW PV + 200 kW/600 kWh battery produces enough energy to offset only 0.228% of Hanes' annual global non-renewable energy use and 0.51% of Hanes' annual CO_2e emissions.

To make significant progress towards Hanes' renewable energy and carbon reduction goals, Hanes will be able to achieve a much larger offset through Renewable Energy Certificates (REC) purchases. In the U.S. a 1 MWh REC costs as little as $1.00 (U.S. DOE, 2017) translating to a cost of $14.71/Metric Ton CO_2e avoided. To compare, annual debt payments on the 1.2 MW PV + 200 kW/600 kWh Central America, 2 system result in a cost of $0.068/kWh translating to a cost of $87.08/Metric Ton CO_2e avoided. While a 1.2 MW PV + 200 kW/600 kWh PV system results in annual production of approximately 1.7 million kWh of renewable energy (0.5% Hanes global annual non-renewable energy use), annual REC purchases similar to debt payments on the 1.2 MW system ($250,000/yr) would allow Hanes to offset 25 million kWh of non-renewable energy, equivalent to offsetting 3.16% of Hanes' global annual non-renewable energy use and 6.2% of Hanes global annual CO_2e emissions. Hanes also has the option of purchasing a single lump sum of RECs as the 2020 energy goals deadline draws closer. A one-time REC purchase similar to the total cost of a 1.2 MW PV + 200 kW/600 kWh battery system ($2 million) would allow Hanes to offset 200 million kWh of non-renewable energy, equivalent to 25.29% of Hanes' global annual energy use and 49.58% of Hanes global annual CO_2e emissions.

The purchase of RECs is a much more attractive option compared to actual renewable energy generation investment when only considering renewable energy consumption and carbon offset. However, once a REC is purchased and claimed, that REC cannot be counted again towards Hanes renewable energy use or carbon offsets in future years. Also, purchase of RECs are considered by some hardcore environmentalists as an "easy way out" of the companies' renewable energy commitments, as they are simply paying to claim the renewable energy that they probably have never actually consumed. On the other hand, actual investment in renewable energy generation technology produces energy year after year which can be counted towards Hanes' renewable energy use and carbon offsets for the lifetime of the system. Ultimately, the decision of investment falls on Hanes to decide between better financial performance or a larger renewable energy use and carbon offset impact.

A table summarizing the impact of various renewable energy investments and REC purchases can be seen in Table 5 (SAM investments table).

Discussion & Conclusion

Discussion

General

Currently, Hanes sits at 24.9% renewable energy and there are currently no planned projects to bolster their renewable energy use beyond their development of a CHP plant in Central America, 5. We have been assured by Hanes that this will contribute a large portion of renewable energy to the percentage. The installed infrastructure we are proposing increases their renewables percentage by 0.276%, after the assets have been negotiated for and constructed at a cost of ~$1.1M. The construction could take at least a year to fully implement and integrate. Hanes cannot realistically build onsite generation assets to counteract the remaining 15.1% and should consider other methods of increasing their renewable energy portfolio proportion.

Biomass

In the year of 2015, Hanes consumes 2,223,793.3 MMBtu of fuel, representing a significant 61.86% of its total energy consumption of 3,595,170 MMBtu. Fuels are mostly used either for steam generation throughout Hanes' production processes, or for general heating purposes in production facilities, distribution centers, and offices. The major types of fuel utilized in Hanes' global operations include propane, #2 fuel oil, heavy fuel oil, and biomass. For the 2015 reporting year, biomass was only used at Central America, 2 where it accounts for as much as 78% of the facility's total fuel consumption. However, when put into the context of Hanes' total annual fuel consumption around the globe, the percentage of biomass use drops significantly to as low as 19.84%. If Hanes were able to replace all of its non-renewable fuel use by biomass, it will be able to increase its renewable energy percentage drastically to 78%. This, of course, only represents an extreme case that can never be realized under real business settings. Factors such as biomass feedstock availability, infrastructure, technical feasibility, and high upfront capital investments all limit Hanes' ability to become 100% fueled by biomass. Nonetheless, this simple thought experiment is sufficient to demonstrate the important role that biomass could potentially play in bringing Hanes closer to its 2020 goals, and should thus be given high priority should such opportunities arise.

However, unlike solar PV systems whose costs and benefits can be readily modelled by software, it is much more challenging to assess the financial viability of most of the biomass projects. For biomass gasification systems, the upfront capital investments usually vary significantly by system design, the type of technology adopted in the gasification process as well as the type of biomass feedstock used. The cost of biomass feedstock is also highly unpredictable under most cases, as it is dependent upon a lot of factors including but not limited to local availability, handling and transportation cost, and whether there are any other competitive uses associated with the biomass feedstock. Even after the biomass gasification systems are put in place, the cost avoidance is not clear cut if biomass is mainly used to replace the use of other fuels instead of electricity unless the cost comparison between biomass and the replaced fuel could be established. For these abovementioned reasons, the team was not able to perform any financial analysis on biomass technologies throughout this project. Consultation with companies that specializes in biomass technologies may provide Hanes with the data and information needed in feasibility analysis.

Unexpected Results

Over the course of the project, Duke Team has experienced some unexpected results & observations. Six locations have been analyzed for on-site renewables investments in small, medium and large scales, where the overall goal of the Master's Project has been finding the investment that makes the most business sense while increasing renewables generation for Hanes from 24.9% to 40%. However, as presented in the NREL Results section, even simulated large systems have minimal effect on increasing the percentage of energy from renewables. Ineffectiveness of on-site generation scenarios across the board for meeting the 40% goal has been a surprising result for the Duke team. Therefore, pursing SPPAs is heavily recommended.

Another unexpected aspect of Hanes' energy consumption has been to observe from the Master File that in CY2015, liquid fuels have met 21.2% of the energy need across the portfolio. Hence the switching to biomass recommendation in the paper to reach 40%. Hanes consumed approximately 3.6 million MMBTUs worth of energy in CY2015, of which only 27% was in the US, and electricity use only made up for 38% of the energy usage across the portfolio. Hanes has an intriguing energy usage profile where the unexpected breakdown and pattern of its energy consumption gives them room for different combinations of technical (PV and PV + Battery as detailed in this report, and other technologies like wind & fuel cells with increased budget) & financial (Debt, Cash, PPAs, SPPAs) types of investments to reach their sustainability goals.

Carbon Pricing

Carbon pricing is a method of charging carbon-emitting entities with a price of carbon, aiming to reduce emissions. It can reduce emissions by levying charges against carbon emitters to ensure they shoulder the burden of the social cost of their emissions. This method decreases economic emissions level from the perspective of emitters. Carbon pricing aims to benefit society by fixing the discrepancy of economic emissions level between society and emitters caused by negative externalities of carbon emission. Carbon pricing spurs emission reduction not only by financial incentives but also by defining the cost of carbon emissions to increase the awareness of sustainability and quantify emission damages. There are to major forms of carbon pricing: Cap-and-Trade, also known as Emission Trading System (ETS), and Carbon Tax.

More than 40 countries have implemented carbon pricing schemes to reduce greenhouse gas (GHG) emissions. Among which, 15 countries have been implementing or planning to implement carbon tax policies since the first carbon tax policy created in Finland in 1991. Also, since the international community united at COP21 in December 2015, there have been more than 90 countries indicating their interests in participant into global carbon market to curb carbon emissions to reduce climate impacts.

Because so many countries are considering some type of carbon pricing and Hanes operates globally, carbon pricing policies would have far-reaching impacts on Hanes’ energy consumption for manufacturing and operations. Carbon pricing would incentivize more investment in renewable energy across Hanes' portfolio, due to their low-carbon traits and ability to produce energy without incurring costs associated with carbon pricing. Particularly, the carbon pricing systems & considerations in Europe, China, and the US are leading the portfolio while other countries in which Hanes operates may also implement carbon pricing in the future. Based on the assumption carbon pricing will be more popular in the upcoming decades, the Duke Team recommends considering scenarios where carbon prices (also known as shadow price) are implemented into financial analyses of projects.

Further Research

While the analyses of PV investments at six of Hanes operational sites provide in-depth system performance detail, these six analyses are only a small portion of Hanes global portfolio. The largest benefits to Hanes of the research and analyses conducted by the Duke Team is in the form of a repeatable process enabling Hanes to make informed decisions about energy related investments. To this end, there is still a large amount of research which should be done to allow Hanes to optimally meet their 2020 energy sustainability goals. As a company, Hanes should use the process developed in this study to begin detailed energy record-keeping and continue detailed modeling of the financial performance of renewable energy investments throughout their portfolio, understand the structure of SPPAs available on a case-by-case basis, analyze the cost of converting fossil-fueled heating applications to biomass heating and consider partnering with companies in Hanes' supply chain and peer companies to achieve energy sustainability.

Hanes should begin a centralized database of purchased fuel and energy, utility bills and interval data to grant the Energy Management team a strong understanding of exactly how each site is being charged for energy consumption and how the site is using energy. Each of the components would be logged and reported separately versus the blended energy use and cost data currently being reported. Hanes should then use this knowledge continue modeling the performance of various renewable energy investments throughout its portfolio. It would grant Hanes deeper insight into the energy segregation and consumption within their entire portfolio and allow for more fuel-specific targeted decisions.

SPPA's offer an immediate tool for Hanes to make significant progress toward its energy sustainability goals. However, due to the complex nature of SPPA's, Hanes should seek out multiple renewable energy project developers to understand how contracts can be structured with each individual developer. Because an SPPA can be structured an essentially infinite number of ways, developing an SPPA model to accurately predict SPPA performance is impossible until after a contract has already been at least partially structured. The contract can be designed to address energy charges, demand charges, administrative charges and REC sales among many other things. For this reason, Hanes should consider sending out RFPs to various developers and incent the developers to compete amongst themselves to earn Hanes business in a way most beneficial to Hanes.

Converting fossil-fueled heating applications to biomass heating also offers large potential to increase the amount of renewable energy use throughout Hanes portfolio, especially in Southeast Asia and Central/South America. However, there is surprisingly little data available regarding the cost of this conversion. Hanes should research the local markets of facilities that use a large amount of fossil fuels for heating purposes, especially solid or liquid fuels due to the fact that converting from solid/liquid fossil fuels to biomass would be much easier than converting from gaseous fuels to biomass. It is likely that hardware costs for biomass conversion remain relatively constant throughout Hanes portfolio, but labor and other soft costs likely vary a significant amount depending on the local labor market and local regulations. For this reason, Hanes should target sites that use and spend the largest amount on solid/liquid fossil fuels and utilize local plant energy managers to research the costs of converting from fossil fuels to biomass.

Finally, Hanes should research and consider partnering with firms pursuing similar energy sustainability goals such as various governments, NGOs, supply chain partners or even peer companies. Many national or local governments of countries in which Hanes operates desire to improve the environmental performance of industrial operations within their countries. These governments may be willing to grant Hanes special incentives to encourage environmental/energy performance in the interests of the country's citizens and Hanes should proactively seek partnerships in countries where Hanes has a large presence. NGOs such as the Rocky Mountain Institute, Environmental Defense Fund and World Wildlife Fund seek to promote business sustainability through partnering with global firms. These organizations may already have knowledge Hanes has not yet developed, possibly surrounding complicated topics such as SPPAs which they can offer Hanes at a low price due to their non-profit, mission oriented nature. Furthermore, partners in Hanes' supply chain and peer businesses are likely seeking similar energy sustainability. Hanes should research their interests and consider pooling with other large firms to invest in larger renewable energy projects. Pooling with other firms to develop larger projects would take advantage of economies of scale and reduce the cost/unit of any renewable energy project, making it cheaper for all parties involved.

Conclusion

This report demonstrates the proof of concept that continuing to enhance Hanes existing Energy Management System (EMS) model will enable Hanes to manage its global renewable energy portfolio with a more informed knowledge base. The model introduced in this report works in three sequential stages, starting from the initial utility bill compilation, to site analysis and feasibility study, and finally to decision making as of which projects to pursue in meeting Hanes' 2020 renewable energy goals. In each of the three stages, the Duke team has performed comprehensive demonstrations that the team hopes could serve as a demo for Hanes to adopt and adapt to meet its energy needs in the future.

To synthesize, the initial step of utility bill compilation, as demonstrated in the Utility Analysis Compilation, involves gathering as much data as available for all sites and itemizing each bill line item into demand charges, energy consumption charges, KVAR charges, and administration charges. This sets up complete electricity cost profiles that inform the true costs of electricity of each facility under analysis. The preliminary cost figures are then fed into Tableau that ranks each facility in terms of spending and unit cost parameters to nail down the facilities that justify for a deeper dive. The facilities that passed the screening are Central America, 2, Central America, 1, Central America, 3, Asia, 1, North America, 4, North America, 1, North America, 3, North America, 2, and Central America, 4. Of each facility selected, specific site analyses are performed to examine site-specific information regarding geo-market, electricity tariff, as well as interval consumption trends. The data and information thus obtained serve as the primary sources of input into the NREL SAM model for subsequent feasibility study. Specifically, the financial viability of small, medium, and large PV systems are analyzed, with detailed NPV and payback period figures provided to facilitate cross comparisons between facilities.

By following the three steps as described above, the Duke team arrives at an overarching recommendation for Hanes to install renewable energy generation assets at Central America, 2 and Central America, 1 thanks to the high cost avoidance achievable and favorable government incentives in this central America country. On top of that, we also recommend Hanes to pursue synthetic PPAs in the US market and to replace a certain percentage of its liquid fossil fuel use by biomass. This will bring Hanes closer to meeting its 2020 renewable energy goal of 40% in a significantly shorter period of time compared to the situation when only on-site renewable energy generation technologies are considered.

Recommendations are also given pertaining to Hanes' development of an internal Energy Management System tool (EMS), similar to the one as demonstrated in this project. This involves establishing a comprehensive and complete database of utility energy bills for all the facilities to keep record of itemized energy costs, and to take a proactive approach in appraising renewable energy projects. As an alternative to developing an in-house EMS, Hanes also has the option to partner with third-party companies that provide professional products and services in renewable energy areas that replicate a fuller and more actionable version of the demo demonstrated in this project.

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Appendix

Appendix A: Competitor Analysis

Nike

Current Status:

As of October 2016, Nike has reduced energy/unit produced by 50% relative to 2008 and reduced CO2e/unit produced by 18% relative to 2011. Nike has reduced retail store kWh/ft^2 by 14% and CO2e/ft^2 by 13% relative to 2011. However, Nike's absolute energy use & CO2e emissions have increased by 14% relative to 2011.

Future Goals:

Nike has stated that it aims to be powered by 100% renewable energy in owned and operated facilities by 2025. Nike is also striving to decrease energy/unit and CO2e emissions/unit by 25% in "key operations" (inbound/outbound logistics, distribution centers, HQ locations, finished goods manufacturing and Nike Owned retail), 35%/kg in dyeing and finishing processes, and reduce scope 3 CO2e emissions by 10% all by 2020 (Nike Corporation, 2016).

H&M

Current Status:

As of October 2016, H&M has reached 78% renewable energy use in owned and operated facilities, a 51% increase from 2014. This resulted in a 56% reduction in scope 1 & 2 CO2e emissions relative to 2014. H&M has reduced CO2e emissions/million SEK (Swiss Currency) sales by 65% relative to 2011. Finally, H&M requires that transport service providers are Smartway partners (North America) or Wayahead registered (Europe & Asia) to reduce CO2e emissions from shipping activities (H&M Group, n.d.).

Future Goals:

H&M has stated that it aims to "work for 100% renewable electricity in our own operations wherever there are credible renewable energy certifications which meet our evaluation criteria for quality and impact" without setting a hard date. H&M has also set a concrete goal of reducing electricity use in brand retail stores by 20% (kWh/ft^2) by 2020 relative to 2007. Finally, H&M has set the goal of aligning with best practices in responsible corporate engagement in climate policy by 2016 (H&M Group, n.d.).

Levi Strauss & Co

Current Status:

In 2014, Levi Strauss & Co has reduced scope 1 & scope 2 CO2e emissions by 21% relative to 2007. Also in 2014, Levi Strauss & Co sourced 13% of total energy consumption from renewable sources, through REC purchases or renewable energy contracts (PPAs). As of 2014, CO2e intensity (kg CO2e/unit) decreased by 17% relative to 2011 (Levi Strauss & Co, 2015). In 2015, Levi Strauss & Co further reduced CO2e emissions by 2% through energy efficiency measures and 15% through closing a factory in Turkey (Levi Strauss & Co, 2016)

Future Goals:

Levi Strauss & Co have set the goal of sourcing 100% renewable energy first in their own operations and later throughout their supply chain, but have not given a date which they aim to achieve this goal. Levi Strauss & Co have set a concrete goal of 25% reduction in GHG emissions by 2020 in office, retail & distribution operations, as well as a 5% annual reduction in GHG emissions/lb product shipped from owned and operated manufacturing plants by 2020. Finally, Levi Strauss & Co aim to purchase 20% of energy in "all of Levi Strauss & Co" from renewable sources by 2020 (Levi Strauss & Co, 2016.).

Jockey International

To the knowledge of the Duke Team, Jockey does not openly communicate a policy to reduce carbon emissions, if indeed the brand has one. If it exists, sustainability information should be easily accessible to enable consumers to make more responsible choices.

Fruit of The Loom Inc.

Current Status:

Fruit Of The Loom Inc. states that the company has reduced electricity consumption by 5.7 million kWh & CO2e emissions by 3914 metric tons without giving a baseline or percentage reductions to these numbers. Fruit Of The Loom set a_goal to reduce electricity related GHG emissions by 40% in 2015 vs SCS Global Services verified baseline but has not released any information on whether this goal has been achieved or not. Finally, Fruit of The Loom has achieved 100% renewable energy in their Honduras facilities, which account for 27% of their western hemisphere energy consumption (Fruit Of The Loom Inc., n.d.).

Future Goals:

Fruit Of The Loom has not communicated or made available any future energy sustainability goals on their corporate website.

Puma

Current Status:

As of October 2016, Puma has achieved a 20% reduction in scope 1 and 13% reduction in scope 2 CO_2e emissions from 2011-2015. During that same time period, Puma has increased the purchase of renewable electricity from 10% to 14%, and reduced water consumption/unit by 50%. Puma became carbon neutral in 2010 by offsetting CO_2 emissions although they have not mentioned how carbon neutrality was actually achieved. Finally, Puma has made the decision to include an environmental profit & loss report in their annual reports to quantify environmental impacts of the company (Puma Corp, n.d.).

Future Goals:

As of October 2016, Puma is going through a re-evaluation of corporate energy & environment goals and setting new goals for the 2016-2020 time period which have not been released.

VF Corporation

Current Status:

From 2009-2015, VF Corp. Reduced GHG emissions by 12% and total energy consumption by 5%. In 2013, VF Corp. Sourced 1% of direct energy use from renewable sources, and company headquarters in Switzerland, Germany and the state where the facility resides source up to 100% renewable energy through on-site power generation or the purchase of RECs (or European equivalent) (VF Corp, n.d.).

Future Goals:

VF Corp. has set ambitious energy & environment goals of sourcing 100% renewable energy in owned & operated sites by 2025. VF Corp has also set goals of reducing carbon emissions/dollar retail revenue by 50%, reducing carbon emissions/unit manufactured by 10%, reducing carbon emissions/unit shipped by 40%, reducing carbon emissions/office employee by 25% and a 40% reduction in landfill waste all by 2020 relative to 2009 (VF Corp, n.d.).

C&A

Current Status:

As of October 2016, C&A has stated that 30% of purchased energy comes from renewable sources. C&A has improved carbon efficiency by 9% and reduced total carbon emissions by 1.4% relative to 2012, mostly though energy efficiency renovations/refurbishments. Finally, C&A has developed a carbon footprint report to identify sources of carbon emissions to be improved upon within the company (C&A, 2016).

Future Goals:

C&A has stated that the company is pursuing a 20% carbon footprint reduction in stores, offices and distribution centers, although no timeline for this goal has been given (C&A, 2016).

Gildan

Current Status:

Gildan has been able to achieve 51% renewable energy use companywide almost exclusively through the use of biomass heating processes and converting bunker fuel (fuel oil & coal) heating processes to biomass. Gildan has reduced energy intensity 14%, GHG intensity 34% and water intensity 17% all within the 2010-2015 timeframe (Gildan Corp, n.d.).

Future Goals:

According to the Gildan corporate sustainability site, the company aims to reduce GHG intensity (currently 0.00129 tons CO2e/kg product) energy intensity (through heat recovery processes) and water intensity all 10% by 2020 relative to 2015 levels (Gildan Corp, n.d.).

Philips Van-Heusen Corporation

Current Status:

Philips Van-Heusen Corporation (PVH) implemented a global GHG report into its annual reports in 2015. In 2016, PVH began developing targeted energy reduction strategies in partnership with company associates & business partners which will be implemented in the future. PVH is also currently implementing aerodynamic upgrades to the company shipping fleet which are expected to improve fleet fuel efficiency by 35% (PVH Corp, n.d.).

Future Goals:

PVH states that the company aims to "Measure and reduce GHG emissions by reducing energy consumption, increasing energy efficiency and utilizing clean energy both in our owned and operated facilities and across our value chain". However, the company has not yet set concrete goals, which are currently being developed as previously stated (PVH Corp, n.d.).

Adidas Group

Current Status:

The Adidas group has reduced company "relative environmental footprint" by 15% from 2010-2015. Adidas has also achieved a 30% reduction in carbon emissions/m^2 (through energy efficiency projects, carbon offset initiatives & purchasing RECs & equivalents) as well as reducing energy consumption/m^2 (by implementing ISO 14001 employee focused energy conservation policies) from 2008-2015 (Adidas Group, n.d.).

Future Goals:

The Adidas Group has set goals of 20% energy savings at "strategic suppliers" and 3% absolute reduction in scope 1 & 2 emissions at company owned sites by 2020. Adidas has also set a goal of reaching carbon neutrality in company owned sites by 2050 (Adidas Group, n.d.).

Under Armour

Current Status:

Under Armour has stated that suppliers and subcontractors must comply with all environmental rules, regulations and standards applicable to their operations, but other than this has not communicated company-wide energy conservation/sustainability policy or goals (Under Armour Inc., n.d.).

Future Goals:

Under Armour has not publicly set any energy conservation/sustainability goals.

The Gap

Current Status:

The Gap achieved a 33% reduction in GHG emissions from 2008-2014 in U.S. operations (Gap Inc., n.d.).

Future Goals:

The Gap has stated the company is pursuing a 50% reduction in absolute GHG emissions at company owned and operated facilities by 2020 relative to 2015 and an 80% landfill waste diversion in U.S. operations by 2020 (Gap Inc., n.d.).

Appendix B: Detailed PV Investment Specifications and Results

I. Asia

Asia, 1

Background

The electric power market in Asia, 1is regulated, which means the efforts to increase the renewables should lie on the on-site renewable technologies such as solar PV panels. The large demand from Asia, 1 facility, high credits for renewables, and high electricity price in daytime make it attractive to investigate the feasibility of solar tech in this facility.

Solar PV

A financial and performance analysis of a solar PV investment was conducted using NREL's System Advisor Model (SAM). Three different solar PV systems were modeled. Small (250 kW, $0.5M) medium (500 kW, $1M) and large (1MW, $2M) systems were analyzed, using installation prices of $1.98/W. Specifically, prices for module and inverter are $0.6/W and $0.03/W according to the interview with experts in PV industry (hereafter referred to as the interview).

System Specifications

In these analyses, the default settings of SAM were unchanged. A DC: AC ratio of 1.2:1, system loss estimates of 14.08%, 180o azimuth and 20o tilt were used. A degradation rate of 0.25%/yr was used according to the interview. System outputs were modeled by SAM which draws from NREL's PV Watts calculator.

Financial Specifications

The system was modeled to be financed by 100% debt with a loan rate of 7.5%. After discussion with Hanes representatives, the real discount rate (not accounting for an estimated inflation rate of 2.5%/yr) was set at to match Hanes' internal rate. The system was modeled to have a lifetime of 25 years, no salvage value, and was to be depreciated using MACRS 5-year depreciation. It was assumed that Hanes could take full advantage of the 25-year Federal credits for each system ($0.06/kWh for electricity generated from PV system). Additionally, in Asia 1's province, system owners are eligible for additional $0.06/kWh for electricity generated from PV system. However, the duration of this provincial credit is not guaranteed in the long term, so we ignored this credit currently in our analysis.

It's notable that the Carbon Trading System (ETS) is piloted in parts of Asia (Zhang, 2014). Asian governments are planning to spread out this policy across nations from 2017 and established a national market before 2020 (Auffhammer, 2015). This means carbon pricing would be an important factor to consider when evaluating an energy project. It is predicted the emerging price for carbon would be around $7/Metric Ton (MT) in the future (De Boer, 2015). Besides the financial analysis from SAM, we will further incorporate the carbon emission fee into our analysis.

Result:

Small

Cost - Priced at $1.98/W DC installed, the gross cost of a 250 kW system comes to $496,000 pre-incentives.

NPV - Using Hanes' internal discount rate the NPV of a 250 kW PV system comes to $280,000.

Payback Period - A 250 kW system results in a payback period of 5.8 years.

Energy Savings - Detailed estimates of monthly energy production and monthly bills with and without the system in place can be seen in the supporting documentation. Cumulative savings over the 25-year lifetime of the system amount to a value of $1,410,000. It is estimated that a 250 kW system would meet 1.4% of Asia, 1's annual electrical energy needs.

Carbon Reduction and Emission Trading Savings - Over 25 years a 250 kW PV system at Asia, 1 is estimated to produce 7,429,185 kWh. With a carbon intensity of 6.04*10-4 MTCO2/kWh in Asia 1, this results avoiding emitting 4,485 tons of CO2. If Carbon Trading System or other carbon pricing schemes are implemented in Asia with a predicted price of $7/(MT), the total saving in carbon trading market would be $31,395 without considering the time value of money.

Medium

Cost - Priced at $1.98/W DC installed, the gross cost of a 500 kW system comes to $990,000.

NPV - Using a real discount rate of 8%, the NPV of a 500 kW system is valued at $550,000.

Payback Period - Investment in a 500 kW system will result in a payback period of 5.9 years.

Energy Savings - Detailed estimates of monthly energy production and monthly bills with and without the system in place can be seen in the supporting documentation. Cumulative savings over the 25-year lifetime of the system amount to a value of $2,749,000. It is estimated that a 500 kW system would meet 4.6% of Asia, 1's annual electricity demand.

Carbon Reduction and Emission Trading Savings - Over 25 years a 250 kW PV system at Asia, 1 is estimated to produce 14,858,368 kWh. With a carbon intensity of 6.04*10-4 MTCO2/kWh in Asia 1, this results avoiding emitting 8,974 tons of CO2. If Carbon Trading System or other carbon pricing schemes are implemented in Asia with a predicted price of $7/(MT), the total saving in carbon trading market would be $62,821 without considering the time value of money.

Large

Cost - With PV Priced at $1.98/W DC, the gross cost comes to $1,983,000.

NPV - Using a real discount rate of 8%, the NPV of a 1 MW PV system has an NPV of $1,065,000.

Payback Period - The payback period of a 1 MW PV system 6.0 years.

Energy Savings - Detailed estimates of monthly energy production and monthly bills with and without the system in place can be seen in the supporting documentation. Cumulative savings over the 25-year lifetime of the system amount to a value of $5,332,000. It is estimated that a 1 MW system would meet 9.0% of Asia, 1's annual electrical energy demand.

Carbon Reduction and Emission Trading Savings - Over 25 years a 1 MW PV system at Asia, 1 is estimated to produce 29,716,738 kWh. With a carbon intensity of 6.04*10-4 MTCO2/kWh in Asia 1, this results avoiding emitting 17,948 tons of CO2. If Carbon Trading System or other carbon pricing schemes are implemented in Asia with a predicted price of $7/(MT), the total saving in carbon trading market would be $125,642 without considering the time value of money.

II. Central America

Central America, 2

Background

When conducting the financial analyses for Hanes investment in renewable energy technologies, a discount rate and debt rate equal to those of Hanes internal rates were used. An electricity price escalation rate of 1%/year was assumed due to the lack of information available for electricity prices in the central America country. Central America, 2 is served by an investor owned utility. Central America, 2 appears to pay varying energy ($/kWh) and demand ($/kW) charges related to the spot price of electricity. Because the spot price of electricity cannot be accurately predicted, the average energy and demand charges of the last year, $0.078462/kWh and $12.51/kW respectively were used to model the performance of renewable energy investments at Central America, 2.

Solar PV

A financial and performance analysis of a solar PV investment was conducted using NREL's System Advisor Model (SAM). Three different solar PV systems were modeled. A small (250 kW, $0.5M) medium (750 kW, $1.5M) and large (1.2 MW + 200 kW/600 kWh battery, $2.7M) were analyzed, using installed prices of $2.20/W, $2.10/W, and $2.00/W PV + $1.55/W battery to (Chung, D., Davidson, C., Fu, R., Ardani, K., Margolis, R., & U.S. NREL, 2015).

System Specifications

In these analyses, the default settings of SAM were unchanged. A DC:AC ratio of 1.2:1, system loss estimate of 14.08%, 180° azimuth and 20° tilt were used. A degradation rate of 0.25%/yr was used (SunPower, 2013). The systems were priced at decreasing rates to represent the economies of scale associated with solar PV installations (Chung, D., Davidson, C., Fu, R., Ardani, K., Margolis, R., & U.S. NREL, 2015). System outputs were modeled by SAM which draws from NREL's PV Watts calculator.

Financial Specifications

The system was modeled to be financed by 100% debt with a loan rate equal to that of Hanes' internal rate. After discussion with Hanes representatives, the real discount rate (not accounting for an estimated inflation rate of 2.5%/yr) was set at the internal rate. The system was modeled to have a lifetime of 25 years, no salvage value, and was to be depreciated using MACRS 5 year depreciation. It was assumed that Hanes could take full advantage of a national incentive at Central America 2, which provides grants of up to 50% of renewable energy system costs on a case by case basis (export.gov, 2016). Additionally Central America 2's solar PV systems would be eligible for 100% property tax exemption (IRENA, 2016). In the SAM program, electricity load can be set hour by hour for an entire year. Interval load data was available was taken directly from Central America, 2 utility bills and input into the SAM model.

Results

Small

Cost - Priced at $2.20/W DC Installed, the gross cost of a 250 kW system comes to $550,000 pre-incentives. After the 50% grant is applied, the net system cost comes to $275,000.

Cash Flows - Detailed cash flows of this system can be seen in the supporting documentation. Cumulative cash flows ignoring the time value of money (0% discount rate) sum to $49,000.

NPV - Using a real discount rate equal to Hanes' internal rate, the NPV of a 250 kW PV system comes to $388,000.

Payback Period - A 250 kW system results in a simple payback period of only 2.6 years.

Energy Savings - Detailed estimates of monthly energy production and monthly bills with and without the system in place can be seen in the supporting documentation. Cumulative savings over the 25-year lifetime of the system amount to a value of $1,987,000. It is estimated that a 250 kW system would meet 0.5% of Central America, 2's annual electrical energy needs.

Carbon Reduction - Over 25 years a 250 kW PV system at Central America, 2 is estimated to produce 9,114,000 kWh. With a carbon intensity of 1.709 lbs CO_2/kWh (Hanes Brands International, 2015) this results avoiding emitting 7064 metric tons of CO_2e.

Medium

Cost - Priced at $2.10/W DC Installed, the gross cost of a 750 kW system comes to $1,572,000 pre-incentives. After the 50% grant is applied, the net system cost comes to $786,000.

Cash Flows - Detailed cash flows of this system can be seen in the supporting documentation. Cumulative cash flows ignoring the time value of money (0% discount rate) sum to $94,000.

NPV - Using a real discount rate equal to Hanes' internal rate, the NPV of a 750 kW PV system comes to $874,000.

Payback Period - A 750 kW system results in a simple payback period of only 3.0 years.

Energy Savings - Detailed estimates of monthly energy production and monthly bills with and without the system in place can be seen in the supporting documentation. Cumulative savings over the 25 year lifetime of the system amount to a value of $4,602,000. It is estimated that a 750 kW system would meet 2% of Central America, 2' annual electrical energy needs.

Carbon Reduction - Over 25 years a 750 kW PV system at Central America, 2 is estimated to produce 27,342,750 kWh. With a carbon intensity of 1.709 lbs CO_2/kWh (Hanes Brands International, 2015) this results avoiding emitting 21,193 metric tons of CO_2e.

Large

Cost - Priced at $2.00/W DC + $1.55/W Battery Installed, the gross cost of a 1.2 MW PV + 200 kW/600 kWh system comes to $2,714,000 pre-incentives. After the 50% grant is applied, the net system cost comes to $1,357,000.

Cash Flows - Detailed cash flows of this system can be seen in the supporting documentation. Cumulative cash flows ignoring the time value of money (0% discount rate) sum to $133,000.

NPV - Using a real discount rate equal to Hanes' internal rage, the NPV of a 1.2 MW PV + 200 kW/600 kWh system comes to $1,336,000.

Payback Period - A 1.2 MW + 200 kW/600 kWh system results in a simple payback period of only 3.2 years.

Energy Savings - Detailed estimates of monthly energy production and monthly bills with and without the system in place can be seen in the supporting documentation. Cumulative savings over the 25-year lifetime of the system amount to a value of $7,208,000. It is estimated that a 1.2 MW PV + 200 kW/600 kWh system would meet 3% of Central America, 2' annual electrical energy needs.

Carbon Reduction - Over 25 years a 1.2 MW PV + 200 kW/600 kWh system at Central America, 2 is estimated to produce 43,714,070 kWh. With a carbon intensity of 1.709 lbs CO2/kWh (Hanes Brands International, 2015) this results avoiding emitting 33,882 metric tons of CO2e.

Central America, 1

Background

When conducting the financial analyses for Hanes investment in renewable energy technologies, a discount rate and debt rate equal to Hanes' internal rates were used. An electricity price escalation rate of 1%/year was assumed due to the lack of information available for electricity prices at Central America 1. Central America, 1 purchases electricity directly from its industrial park. Central America, 1 appears to pay varying energy ($/kWh) and demand ($/kW) charges related to the supply and demand of electricity. Because the spot price of electricity cannot be accurately predicted, the average energy and demand charges of the last year, $0.1574/kWh and $5.123/kW respectively were used to model the performance of renewable energy investments at Central America, 1.

Financial Specifications

The financial specifications in the SAM model of Central America, 1 were left identical to those of the Central America, 2 SAM model other than the electricity prices.

System Specifications

The system specifications in the SAM model of Central America, 1 were left identical to those of the Central America, 2 SAM model. Because the Central America, 1 facility is located in an industrial complex with limited ground area available for solar PV, it was assumed that only rooftop area was available for PV installations. It was also assumed that because Central America, 1 has 170,000 ft^2 of internal space available, there was 170,000 ft^2 of roof space available for installation as well.

Small

Cost - Priced at $2.20/W DC Installed, the gross cost of a 250 kW system comes to $550,000 pre-incentives. After the 50% grant is applied, the net system cost comes to $275,00.

Cash Flows - Detailed cash flows of this system can be seen in the supporting documentation. Cumulative cash flows ignoring the time value of money (0% discount rate) sum to $65,000.

NPV - Using a real discount rate equal to Hanes' internal rate, the NPV of a 250 kW PV system comes to $474,000.

Payback Period - A 250 kW system results in a simple payback period of only 2.3 years.

Energy Savings - Detailed estimates of monthly energy production and monthly bills with and without the system in place can be seen in the supporting documentation. Cumulative savings over the 25 year lifetime of the system amount to a value of $2,139,000. It is estimated that a 250 kW system would meet 8% of Central America, 1's annual electrical energy needs.

Carbon Reduction - Over 25 years a 250 kW PV system at Central America, 1 is estimated to produce 9,114,257 kWh. With a carbon intensity of 1.709 lbs CO_2/kWh (Hanes Brands International, 2015) this results avoiding emitting 7064 metric tons of CO_2e.

Medium

Cost - Priced at $2.10/W DC Installed, the gross cost of a 750 kW system comes to $1,572,000 pre-incentives. After the 50% grant is applied, the net system cost comes to $786,000.

Cash Flows - Detailed cash flows of this system can be seen in the supporting documentation. Cumulative cash flows ignoring the time value of money (0% discount rate) sum to $186,000.

NPV - Using a real discount rate equal to Hanes' internal rate, the NPV of a 750 kW PV system comes to $1,355,000.

Payback Period - A 750 kW system results in a simple payback period of only 2.3 years.

Energy Savings - Detailed estimates of monthly energy production and monthly bills with and without the system in place can be seen in the supporting documentation. Cumulative savings over the 25-year lifetime of the system amount to a value of $6,836,000. It is estimated that a 750 kW system would meet 24% of Central America, 1's annual electrical energy needs.

Carbon Reduction - Over 25 years a 750 kW PV system at Central America, 1 is estimated to produce 27,342,750 kWh. With a carbon intensity of 1.709 lbs CO2/kWh (Hanes Brands International, 2015) this results avoiding emitting 21,193 metric tons of CO2e.

Large

Cost - Priced at $2.00/W DC + $1.55/W Battery Installed, the gross cost of a 1.2 MW PV + 200 kW/600 kWh system comes to $2,714,000 pre-incentives. After the 50% grant is applied, the net system cost comes to $1,357,000.

Cash Flows - Detailed cash flows of this system can be seen in the supporting documentation. Cumulative cash flows ignoring the time value of money (0% discount rate) sum to $177,000.

NPV - Using a real discount rate equal to Hanes' internal rate, the NPV of a 1.2 MW PV + 200 kW/600 kWh system comes to $1,552,000.

Payback Period - A 1.2 MW + 200 kW/600 kWh system results in a simple payback period of only 3.0 years.

Energy Savings - Detailed estimates of monthly energy production and monthly bills with and without the system in place can be seen in the supporting documentation. Cumulative savings over the 25-year lifetime of the system amount to a value of $8,130,940. It is estimated that a 1.2 MW PV + 200 kW/600 kWh system would meet 37.48% of Central America, 1's annual electrical energy needs. Central America, 1 is a relatively small electricity user. Central America 1's net metering laws allow excess generation to be carried over as kWh credits on monthly bills, but these credits only address energy charges (kWh) not demand charges (kW). (International Renewable Energy Agency, 2016). A 1.2 MW + Battery system begins to generate excess electricity resulting in kWh credits being earned on Central America, 1 bill. However, the demand aspect of the bill is unaffected by these credits. For this reason and the limited space available in the Central America, 1 Industrial Park, it is not recommended that Hanes pursue a 1.2 MW + Battery system at Central America, 1 and consider using any excess funds to pursue renewable energy investments elsewhere.

Carbon Reduction - Over 25 years a 1.2 MW PV + 200 kW/600 kWh system at Central America, 1 is estimated to produce 43,714,070 kWh. With a carbon intensity of 1.709 lbs CO2/kWh (Hanes Brands International, 2015) this results avoiding emitting 33,882 metric tons of CO2e

III. North America Country

North America, 3

Background

When conducting the financial analyses for Hanes investment in renewable energy technologies, a discount rate and debt rate equal to Hanes' internal rates were used, and electricity escalation was set to 0.15% (U.S. EIA, 2016). North America, 3 is served by an investor owned utility. Under its utility rate structure, North America, 3 is charged for demand and energy at different rates depending on the day and time that they demand power & consume energy.

Solar PV

A financial and performance analysis of a solar PV investment was conducted using NREL's System Advisor Model (SAM). Three different solar PV systems were modeled. A small (250 kW, $0.5M) medium (750 kW, $1.5M) and large (1.2 MW + 200 kW/600 kWh battery, $2.7M) were analyzed, using installed prices of $2.20/W, $2.10/W, and $2.00/W PV + $1.55/W battery (Chung, D., Davidson, C., Fu, R., Ardani, K., Margolis, R., & U.S. NREL, 2015).

System Specifications

In these analyses, the default settings of SAM were unchanged. A DC:AC ratio of 1.2:1, system loss estimate of 14.08%, 180o azimuth and 20o tilt were used. A degradation rate of 0.25%/yr was used (SunPower, 2013). The systems were priced at decreasing rates to represent the economies of scale associated with solar PV installations (Chung, D., Davidson, C., Fu, R., Ardani, K., Margolis, R., & U.S. NREL, 2015). System outputs were modeled by SAM which draws from NREL's PV Watts calculator.

Financial Specifications

The system was modeled to be financed by 100% debt with a loan rate equal to Hanes' internal debt rate. After discussion with Hanes representatives, the real discount rate (not accounting for an estimated inflation rate of 2.5%/yr) was set at Hanes' internal discount rate. The system was modeled to have a lifetime of 25 years, no salvage value, and was to be depreciated using MACRS 5-year depreciation. It was assumed that Hanes could take full advantage of the 30 year Federal ITC for each system. Additionally, in the state of the state where the facility resides, solar PV systems are eligible for 80% property tax exemption (DSIRE, 2015). In the SAM program, electricity load can be set hour by hour for an entire year. Interval load data was available for the North America, 3 facilities in 30 minute increments. To input 30minute load data of North America, 2 into the model, the loads at the four different time periods within an hour (:30, :00) were averaged.

Results

Small

Cost - Priced at $2.20/W DC Installed, the gross cost of a 250 kW system comes to $545,000 pre-incentives. After the Federal ITC is applied, the net system cost comes to $385,000.

Cash Flows - Detailed cash flows of this system can be seen in the supporting documentation. Cumulative cash flows ignoring the time value of money (0% discount rate) sum to -$22,000. However, it is important to note that this PV investment results in large savings in Year 1 from the Federal ITC and small payments in later years. Due to Hanes' discount rate this early lump savings may have more value than future small payments.

NPV - Using a real discount rate equal to Hanes' internal rate, the NPV of a 250 kW PV system comes to $55,000. The NPV remains positive despite negative cumulative cash flows due to the large savings in Year 1 and Hanes' high discount rate.

Payback Period - A 250 kW system results in a payback period of 16.9 years.

Energy Savings - Detailed estimates of monthly energy production and monthly bills with and without the system in place can be seen in the supporting documentation. Cumulative savings over the 25-year lifetime of the system amount to a value of $886,000. It is estimated that a 250 kW system would meet 2% of North America, 3's annual electrical energy needs.

Carbon Reduction - Over 25 years a 250 kW PV system at North America, 2 is estimated to produce 8,552,777 kWh. With a carbon intensity of 0.922 lbs CO_2/kWh (U.S. EIA, 2015) this results avoiding emitting 3,942 tons of CO_2.

Medium

Cost- Priced at $2.10/W DC installed, the gross cost of a 750 kW system comes to $1,572,000. After the 30% federal ITC is applied, the system cost is reduced to $1,100,000.

Cash Flows- Detailed cash flows of this system can be seen in the supporting documentation. Cumulative cash flows ignoring the time value of money sum to $-72,000. Again, this value is ignoring the large savings in Year 1 from the Federal ITC which is valued higher than later payments due to Hanes high discount rate.

NPV- Using a real discount rate equal to Hanes internal rate, the NPV of a 750 kW system is valued at $112,000 due to the high valuation of near-term cash flows and discount of future payments.

Payback Period - Investment in a 750 kW system will result in a payback period of 18.6 years.

Energy Savings - Detailed estimates of monthly energy production and monthly bills with and without the system in place can be seen in the supporting documentation. Cumulative savings over the 25-year lifetime of the system amount to a value of $2,331,000. It is estimated that a 750 kW system would meet 5% of North America, 3's annual electricity demand.

Carbon Savings - Over 25 years a 750 kW system is estimated to produce a total of 25,658,327 kWh. In the state where the facility resides, this results in an estimated 11,828 tons of CO_2 avoided.

Large

Cost - With PV Priced at $2.00/W DC installed and a battery system of $1.55/W, the gross cost of a 1.2 MW PV + battery system comes to $2,714,000. After the 30% federal ITC is applied, the system cost is reduced to $1,899,000.

Cash Flows - Detailed cash flows of this system can be seen in the supporting documentation. Cumulative cash flows ignoring the time value of money sum to $-136,000. Again, this value is ignoring the large savings in Year 1 from the Federal ITC which is valued higher than later payments due to Hanes high discount rate.

NPV - Using a real discount rate equal to Hanes' internal rate, the NPV of a 1.2 MW PV system + 200 kW/600 kWh battery has an NPV of $139,000 due to the increased value of near term savings relative to long term payments associated with the system.

Payback Period - The payback period of a 1.2 MW PV system + 200 kW/600 kWh battery is 20.1 years.

Energy Savings - Detailed estimates of monthly energy production and monthly bills with and without the system in place can be seen in the supporting documentation. Cumulative savings over the 25-year lifetime of the system amount to a value of $$3,666,000. It is estimated that a 1.2 MW system combined with a 200 kW/600 kWh battery would meet 8% of North America, 3's annual electrical energy demand.

Carbon Savings - While using battery reserve alters the actual carbon emissions avoided due to peaks shifting away from times when utilities are dispatching their most expensive and inefficient plants, for this calculation the NC average of 0.922 lb CO_2/kWh was used. Over 25 years a 1.2 MW system is estimated to produce a total of 40,955,420 kWh equating to 18,880 tons of CO_2 avoided.

North America, 2

Background

Hanes' North America, 2, being an office building, is powered 100% by electricity. North America, 2 is served by an investor owned utility. Per the utility's rate structure, any net excess electricity generation is rolled over to the next month's bill as a kWh credit. However, this credit does not offset any demand charges ($/kW) on the next bill, which are between 10-20% of North America, 2's monthly bill. Because excess generation left over at the end of the month is transferred as a kWh credit to the following month's bill, excess energy at the end of the month only decreases energy charges, not demand charges. For this reason, North America, 2 should not install a renewable energy system that generates an excessive amount of surplus energy without any sort of storage technology. On average, the North America, 2 facility draws approximately 330 kW of power during typical business hours (8:00 AM – 6:00 PM) and approximately 220 kW of power during non-business hours (6:00 PM – 8:00 AM), with a peak demand of 648 kW from Sept. 2015 – Oct. 2016.

When conducting the financial analyses for Hanes investment in renewable energy technologies, a discount rate and debt rate equal to Hanes' internal rates were used, and electricity escalation was set to a rate of 0.15% (U.S. EIA, 2016).

Solar PV

A financial and performance analysis of a solar PV investment was conducted using NREL's System Advisor Model (SAM). Three different solar PV systems were modeled. A small (250 kW, $0.5M) medium (750 kW, $1.5M) and large (1.2 MW + 600 kWh battery, $2.7M) were analyzed, using installed prices of $2.20/W, $2.10/W, and $2.00/W PV + $1.55/W battery (Chung, D., Davidson, C., Fu, R., Ardani, K., Margolis, R., & NREL, 2015).

System Specifications

In these analyses, the default settings of SAM were unchanged. A DC:AC ratio of 1.2:1, system loss estimate of 14.08%, 180o azimuth and 20o tilt were used. A degradation rate of 0.25%/yr was used (SunPower, 2013). The systems were priced at decreasing rates to represent the economies of scale associated with solar PV installations (Chung, D., Davidson, C., Fu, R., Ardani, K., Margolis, R., & NREL, 2015). System outputs were modeled by SAM which draws from NREL's PV Watts calculator.

Financial Specifications

The system was modeled to be financed by 100% debt with a loan rate equal to Hanes' internal rate. After discussion with Hanes representatives, the real discount rate (not accounting for an estimated inflation rate of 2.5%/yr) was set at Hanes' internal discount rate. The system was modeled to have a lifetime of 25 years, no salvage value, and was to be depreciated using MACRS 5-year depreciation. It was assumed that Hanes could take full advantage of the 30 year Federal ITC for each system. Additionally, PV investments at North America 2 are eligible for 80% property tax exemption (DSIRE, 2015). In the SAM program, electricity load can be set hour by hour for an entire year. Interval load data was available for the North America, 2 facility in 15 minute increments. To input 15 minute load data of North America, 2 into the model, the loads at the four different time periods within an hour (:15,:30,:45,:00) were averaged.

Results

Small

Background -Investing in a 250 kW PV system on site at the corporate headquarters would demonstrate a concrete commitment by Hanes to their sustainability goals without extremely capital intensive expenses. This 250 kW only require approximately ⅓ acres of available space and could easily fit into the available surrounding area. This system would be estimated to produce 352,486 kWh resulting in savings of $26,000 in year one.

Cost - Priced at $2.20/W DC Installed, the gross cost of a 250 kW system comes to $545,000 pre-incentives. After the Federal ITC is applied, the net system cost comes to $385,000.

Cash Flows - Detailed cash flows of this system can be seen in the supporting documentation. Cumulative cash flows ignoring the time value of money (0% discount rate) sum to -$16,000. However, it is important to note that this PV investment results in large savings in Year 1 from the Federal ITC and small payments in later years. Due to Hanes' high discount rate this early lump savings may have more value than future small payments.

NPV - Using a real discount rate equal to Hanes' internal rate, the NPV of a 250 kW PV system comes to $77,000. The NPV remains positive despite negative cumulative cash flows due to the large savings in Year 1 and Hanes' discount rate.

Payback Period - The payback period of a 250 kW system is expected to be 14.9 years.

Energy Savings - Detailed estimates of monthly energy production and monthly bills with and without the system in place can be seen in the supporting documentation. Cumulative savings over the 25-year lifetime of the system amount to a value of $1,067,000. A 250 kW system is expected to meet 14% of North America, 2's annual electrical energy needs.

Carbon Reduction - Over 25 years a 250 kW PV system at North America, 2 is estimated to produce 8,552,777 kWh. With a carbon intensity of 0.922 lbs CO_2/kWh (U.S. EIA, 2017) this results in avoiding emitting 3,942 tons of CO_2.

Medium

Background - Investing in a 750 kW PV system would require approximately 1 acre of available space, still easily available within the area surrounding North America, 2. A 750 kW system is estimated to produce 1,057,471 kWh resulting in savings of $77,000 in year one.

Cost- Priced at $2.10/W DC installed, the gross cost of a 750 kW system comes to $1,572,000. After the 30% federal ITC is applied, the system cost is reduced to $1,100,000.

Cash Flows - Detailed cash flows of this system can be seen in the supporting documentation. Cumulative cash flows ignoring the time value of money sum to $-45,000. Again, this value is ignoring the large savings in Year 1 from the Federal ITC which is valued higher than later payments due to Hanes high discount rate.

NPV - Using a real discount rate equal to Hanes' internal rate, the NPV of a 750 kW system is valued at $222,000 due to the high valuation of near-term cash flows and discount of future payments.

Payback Period - The payback period of a 750 kW system is estimated to be 14.8 years.

Energy Savings - Detailed estimates of monthly energy production and monthly bills with and without the system in place can be seen in the supporting documentation. Cumulative savings over the 25-year lifetime of the system amount to a value of $3,087,000. A 750 kW system is expected to meet 42% of North America, 2's electrical energy needs.

Carbon Savings - Over 25 years a 750 kW system is estimated to produce a total of 25,658,327 kWh. In the state where the facility resides, this results in an estimated 11,828 tons of CO_2 avoided.

Large System + Battery

Background - Investing in a 1.2 MW PV system with a 200 kW/600 kWh battery would require approximately 1.5 acres of available space, easily available within the area surrounding North America, 2. A 1.2 MW system is estimated to produce 1,691,931 kWh resulting in savings of $121,000 in year one.

Cost - With PV Priced at $2.00/W DC installed and a battery system of $1.55/W, the gross cost of a 1.2 MW PV + battery system comes to $2,714,000. After the 30% federal ITC is applied, the system cost is reduced to $1,899,000.

Cash Flows - Detailed cash flows of this system can be seen in the supporting documentation. Cumulative cash flows ignoring the time value of money sum to $-94,000. Again, this value is ignoring the large savings in Year 1 from the Federal ITC which is valued higher than later payments due to Hanes discount rate.

NPV - Using a real discount rate equal to Hanes' internal rate, the NPV of a 1.2 MW PV system + 200 kW/600 kWh battery has an NPV of $312,000 due to the increased value of near term savings relative to long term payments associated with the system.

Payback Period - The payback period of a 1.2 MW PV system + 200 kW/600 kWh is estimated to be 16 years.

Energy Savings - Detailed estimates of monthly energy production and monthly bills with and without the system in place can be seen in the supporting documentation. Cumulative savings over the 25 year lifetime of the system amount to a value of $$4,894,000. A 1.2 MW PV system + 200 kW/600 kWh battery is estimated to meet 67% of North America, 2's annual electrical energy needs.

Carbon Savings - While using battery reserve alters the actual carbon emissions avoided due to peaks shifting away from times when utilities are dispatching their most expensive and inefficient plants, for this calculation the NC average of 0.922 lb CO_2/kWh was used (U.S. EIA, 2017). Over 25 years a 1.2 MW system is estimated to produce a total of 40,025,160 kWh equating to 18,452 tons of CO_2 avoided.

North America, 1

Background

The North America, 1 facility is served by an investor owned utility. Under its utility rate structure, North America, 1 pays a steep fixed demand charge and a low fixed energy charge. Any net excess generation from on-site renewable energy technologies under 1 MW are rolled over to the next month as kWh credits. However, this credit does not offset any demand charges which are nealy half of North America, 1's demand. Demand charges consistently account for approximately 45% of North America, 1's energy bill.

When conducting the financial analyses for Hanes investment in renewable energy technologies, a discount rate and debt rate equal to Hanes' internal rates were used and electricity escalation was set to 0.1314% (U.S. EIA, 2015).

Solar PV

A financial and performance analysis of a solar PV investment was conducted using NREL's System Advisor Model (SAM). Three different solar PV systems were modeled. A small (250 kW, $0.5M) medium (750 kW, $1.5M) and large (1.2 MW + 600 kWh battery, $2.7M) were analyzed, using installed prices of $2.20/W, $2.10/W, and $2.00/W PV + $1.55/W battery (Chung, D., Davidson, C., Fu, R., Ardani, K., Margolis, R., & NREL, 2015)

System Specifications

In these analyses, the default settings of SAM were unchanged. A DC:AC ratio of 1.2:1, system loss estimate of 14.08%, 180o azimuth and 20o tilt were used. A degradation rate of 0.25%/yr was used (SunPower, 2013). The systems were priced at decreasing rates to represent the economies of scale associated with solar PV installations (Chung, D., Davidson, C., Fu, R., Ardani, K., Margolis, R., & NREL, 2015). System outputs were modeled by SAM which draws from NREL's PV Watts calculator. Weather data was referenced from Roanoke, VA.

Financial Specifications

The system was modeled to be financed by 100% debt with a loan rate equal to Hanes' internal rate. After discussion with Hanes representatives, the real discount rate (not accounting for an estimated inflation rate of 2.5%/yr) was set at Hanes' internal rate. The system was modeled to have a lifetime of 25 years, no salvage value, and was to be depreciated using MACRS 5 year depreciation. It was assumed that Hanes could take full advantage of the 30 year Federal ITC for each system. Additionally, in the state of the state where the facility resides, solar PV systems are eligible for 100% property tax exemption (DSIRE, 2016). In the SAM program, electricity load can be set hour by hour for an entire year. Interval load data was available for the North America, 1 facility in 30 minute increments. To input 30-minute load data of North America, 2 into the model, the loads at the two different time periods within an hour (:30, :00) were averaged.

Results

Small

Background - Investing in a 250 kW PV system on site at North America, 1 would alleviate some of the high demand charges for the site without capital intensive expenses. A 250 kW system would require approximately ⅓ acres of available space and could easily fit onto the roof of the facility. This system is estimated to produce 342,209 kWh resulting in savings of $31,000 in year one.

Cost - Priced at $2.20/W DC Installed, the gross cost of a 250 kW system comes to $545,000 pre-incentives. After the Federal ITC is applied, the net system cost comes to $385,000.

Cash Flows- Detailed cash flows of this system can be seen in the supporting documentation. Cumulative cash flows ignoring the time value of money (0% discount rate) sum to -$8,000.

NPV- Using a real discount rate equal to Hanes' internal rate, the NPV of a 250 kW PV system comes to $126,000. The NPV remains positive despite negative cumulative cash flows due to the large savings in Year 1 and Hanes' high discount rate.

Payback Period - The payback period of a 250 kW system is expected to be 11.7 years.

Energy Savings - Detailed estimates of monthly energy production and monthly bills with and without the system in place can be seen in the supporting documentation. It is estimated that a 250 kW system would offset 3% of North America, 1's annual electricity consumption. Cumulative savings over the 25-year lifetime of the system amount to a value of $1,248,000. A 250 kW system is expected to meet 1% of North America, 1's annual electrical energy needs.

Carbon Reduction - Over 25 years a 250 kW PV system at North America, 2 is estimated to produce 8,552,777 kWh. With a carbon intensity of 0.91 lbs CO_2/kWh (U.S. EIA, 2017) this results avoiding emitting 3,778 tons of CO_2.

Medium

Background - Investing in a 750 kW PV would alleviate some demand charges but do more to reduce overall energy consumption of the facility. A 750 kW system would require approximately 1 acre, and would be able to fit on the roof of the North America, 1 facility. A 750 kW system is expected to produce 1,026,627 kWh resulting in savings of $64,000 in year one. However, because North America, 1 is billed for peak kW demand any time throughout the day, not just peak hours, the larger 750 kW system cannot alleviate demand charges incurred when the sun is not shining. This fact combined with North America, 1's relatively flat demand curve means that the full potential of a 750 kW system cannot be realized unless demand is shifted from night hours to day hours.

Cost - Priced at $2.10/W DC Installed, the gross cost of a 750 kW system comes to $1,572,000 pre-incentives. After the Federal ITC is applied, the net system cost comes to $1,100,000.

Cash Flows - Detailed cash flows of this system can be seen in the supporting documentation. Cumulative cash flows ignoring the time value of money (0% discount rate) sum to -$65,000.

NPV - Using a real discount rate equal to Hanes' internal rate, the NPV of a 750 kW PV system comes to $154,000. The NPV remains positive despite negative cumulative cash flows due to the large savings in Year 1 and Hanes' discount rate.

Payback Period - The payback period of a 750 kW system is expected to be 16.9 years.

Energy Savings - Detailed estimates of monthly energy production and monthly bills with and without the system in place can be seen in the supporting documentation. It is estimated that a 750 kW system would offset 8.7% of North America, 1's annual electricity consumption. Cumulative savings over the 25-year lifetime of the system amount to a value of $2,533,000. A 750 kW system is expected to meet 4% of North America, 1's annual electrical energy demand.

Carbon Reduction - Over 25 years a 750 kW PV system at North America, 2 is estimated to produce 24,910,258 kWh. With a carbon intensity of 0.91 lbs CO_2/kWh (U.S. EIA, 2017) this results avoiding emitting 11,334 tons of CO_2.

Large

Background - Investing in a 1.2 MW PV and 200 kW/600 kWh battery would alleviate demand charges as well as do more to reduce overall energy consumption of the facility, because the battery can be used to spread energy reductions across the day. A 1.2 MW PV system would require approximately 1.5 acres, and may be able to fit on the roof of the North America, 1 facility, although if necessary would certainly fit if combined between the roof and surrounding area of the facility. A 1.2 MW system is expected to produce 1,642,602 kWh resulting in savings of $114,000 in year one. Again, because North America, 1 is billed for peak kW demand any time throughout the day, not just peak hours, the larger 1.2 MW system with a battery backup does little to alleviate the high demand charges at night.

Cost - With PV Priced at $2.00/W DC installed and a battery system of $1.55/W, the gross cost of a 1.2 MW PV + battery system comes to $2,714,028. After the 30% federal ITC is applied, the system cost is reduced to $1,899,000.

Cash Flows - Detailed cash flows of this system can be seen in the supporting documentation. Cumulative cash flows ignoring the time value of money sum to $-102,000. Again, this value is ignoring the large savings in Year 1 from the Federal ITC which is valued higher than later payments due to Hanes high discount rate.

NPV - Using a real discount rate equal to Hanes' internal rate, the NPV of a 1.2 MW PV system + 200 kW/600 kWh battery has an NPV of $320,000 due to the increased value of near term savings relative to long term payments associated with the system.

Payback Period - The payback period of a 1.2 MW PV system + 200 kW/600 kWh battery is expected to be 15.8 years.

Energy Savings - Detailed estimates of monthly energy production and monthly bills with and without the system in place can be seen in the supporting documentation. Cumulative savings over the 25-year lifetime of the system amount to a value of $4,579,000. A 1.2 MW PV system with 200 kW/600 kWh battery is expected to meet 7% of North America, 1's annual electrical energy demand.

Carbon Reduction - Over 25 years a 1.2 MW PV system at North America, 1 is estimated to produce 39,752,970 kWh. With a carbon intensity of 0.91 lbs CO_2/kWh (U.S. EIA, 2017) this results avoiding emitting 18,088 tons of CO_2