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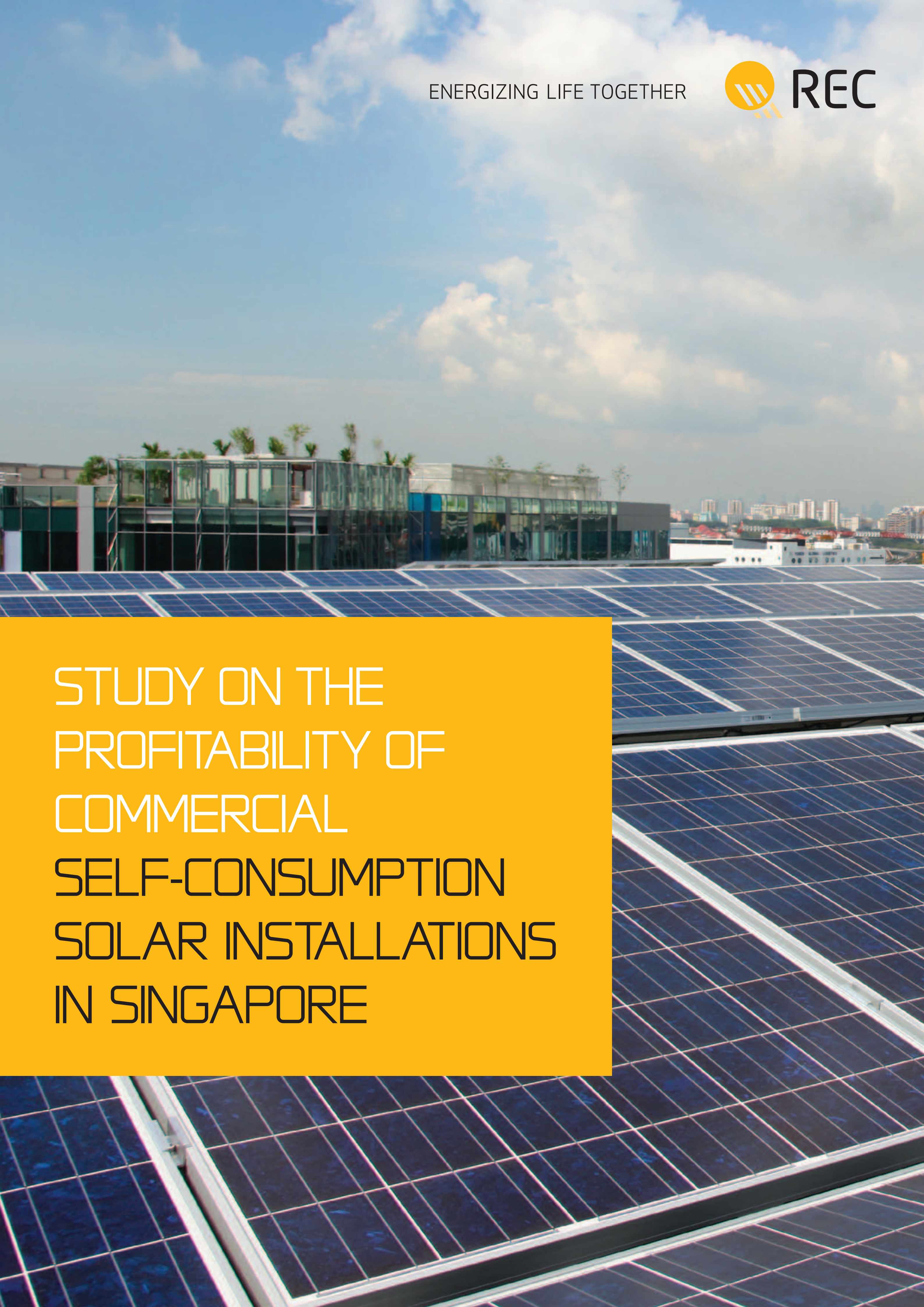

STUDY ON THE PROFITABILITY OF COMMERCIAL SELF-CONSUMPTION SOLAR INSTALLATIONS IN SINGAPORE

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Standard Chartered Bank, Singapore – 264 REC solar panels – 61 kW solar installation for commercial self consumption

Contents

Purpose

The power generation sector is going through a period of significant change, driven by the expansion of new technologies and the disruptive impact of self consumption (otherwise known as "distributed generation"). Self consumption refers to the co-location of power generation and consumption – meaning that electricity is consumed where it is produced. It can drive significant reductions in cost and reduce the reliance on over-stretched grids and provides security against electricity prices in the future.

REC's experience as a market leader in solar led to the development of a review of several markets in Europe to understand which customers have the most to gain from generating power on their own rooftops. Given recent market developments in Singapore, REC has conducted a similar study in conjunction with Solar Energy Research Institute of Singapore (SERIS) to identify whether Singaporean customers can also benefit from the global trend towards self-consumption solar power.

Main findings

- The cost of conventional electricity and the associated grid management costs continue to rise. In Singapore, from 2005 to 2013, the retail electricity prices rose by 9 SGD cents/kWh, which is equivalent to a Compounded Annual Growth Rate (CAGR) of 5.1%. This trend is set to continue in the long run as the major drivers of electricity prices (such as gas prices and reserve power margin) continue to push prices up.
- The average total cost of a solar system has reduced globally by almost 40% in the period from 2011 to 2014. The drivers behind this reduction are mainly technology improvements, economies of scale from production, overcapacity of power generation, standardized business models and optimized installation processes. The price of solar has hit an inflection point in Singapore.
- For many Singaporean companies, it is more expensive to buy electricity from the grid than it is to build a solar system and use the power from the sun. By consuming electricity generated from a solar installation (self consumption), system owners can reduce their electricity demand from the grid. Predictably, the cost savings are most attractive for heavier consumers of power and the payback period can be as little as 8 years.
- Self consumption for commercial & industrial (C&I) companies is especially attractive in Singapore because:
  - Grid electricity prices are relatively high
  - High levels of sunlight (irradiance) and little seasonality mean solar systems produce ~30% more power than in Central Europe
  - It provides a hedge against increase in future electricity prices
  - It can add strong positive branding impact as a CSR initiative, especially when considering the region's concerns about pollution

- After analyzing three different market segments, REC discovered the following characteristics:
  - Commerce & trade companies that do not consume electricity on weekends and public holidays tend to find that the solar system size is constrained by the reduced return from excess electricity being sold through the grid. The EMA (Energy Market Authority of Singapore) has declared their intent to compensate rooftop system owners for the excess electricity fed into the grid starting early 2015,[1] which would support larger installations and therefore lower costs per watt of power generated. Since energy consumption is relatively low for commerce & trade companies, the system size will not be constrained by the available roof space.
  - Manufacturing companies that operate seven days a week, with increased electricity demand during daytime hours, can benefit from having large self-sufficiency ratios (ratio of energy generated from solar to total energy demand). This is because power demand and solar power supply follow similar patterns. Manufacturing companies that have high energy consumption, often find that the roof area is the limiting factor when sizing the system.
  - Heavy-duty industry companies have very high energy demand per unit area, which means the system size will ultimately be limited by the available roof space. With that in mind, they usually have quite large roofs compared to other segments so they will benefit from economies of scale. This means, although heavy-duty industry companies tend to have low wholesale electricity prices, the system cost is quite low as well and will result in signifi cant savings for the system owner.
- The higher the tariff on the purchased electricity, the greater the net present value (NPV), which is the profitability of the solar installation once all the investment costs have been paid, taking into account the cost of capital and operational expenses. Conversely, lower tariffs will cause the net present value to fall. The reason is that the profitability of the solar installation is dependent upon the avoided electricity purchase price. The higher the taxes and duties on the electricity purchase price, the more money is saved by the installation owner through solar self consumption.
- The analysis for this study is based on a 20-year timeline. However, to realize the full potential of the benefits of self-consumption, the rooftop system should last 25 years or more and be able maintain good performance. That is why investing in good quality components is crucial when building a rooftop system.

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[1] *Source: EMA – "Enhancements to the regulatory framework for intermittent generation sources in the national electricity market of Singapore", July 1, 2014*

1. Introduction

Solar markets have undergone substantial changes over the last few years. For quite some time, solar energy was expensive compared to other sources of renewable or fossil fuel-based energy. It is now becoming affordable because the total costs of solar energy are declining rapidly while the grid electricity prices continue to rise.

This cost reduction is mainly the result of rapid technical advancements, global competition and overcapacity of solar panels in the market. With declining capital costs, solar energy is becoming a competitive source of energy. The levelized cost of solar electricity (LCOE)[2] is below the residential electricity rates in many places.

For small and medium-sized companies, which mainly need energy during the day, commercial grid parity is already achievable at current electricity tariff levels. This is especially relevant because solar energy provides companies with planning certainty as electricity prices increase. The higher the electricity price, the greater the financial benefit for the owner of the solar installation.

In Singapore, a commerce and trade business pays on average around 21 SGD cents/kWh, whereas manufacturing customers pay between 17 and 20 SGD cents/kWh. The point at which the investment in solar pays off depends on the grid electricity price and the levelized cost of electricity. This is the context in which new business models are flourishing. Self-generation of solar electricity with little or no government subsidies is changing the ground rules.

As a way of understanding the issues and contributing to the current debate about system design for self consumption, REC has conducted this study on the profitability of commercial self-consumption installations in Singapore, with the assistance of the Solar Energy Research Institute of Singapore (SERIS).

2. Issues and methodology

The study is primarily concerned with the conditions under which self consumption is attractive for commercial customers.

Companies in Singapore were first divided into three segments – commerce & trade, manufacturing and heavy-duty production industries – on the basis of the prices they pay for electricity and their typical load consumption and profile.

The profitability of self-consumption installations was then examined for each group. To do this, REC used actual load profiles from a typical distribution center (commerce & trade), a technology manufacturing company, and a heavy-duty production company, and then calculated the key financial metrics for each segment (including payback period, net present value, and internal rate of return).

The calculations took account of the installation size, the investment costs, the construction and maintenance costs, and projected changes to electricity prices over 20 years. The modeling was done on an hourly basis over a period of 20 years – i.e. an hour-by-hour comparison was carried

[2] Levelized Cost of Electricity (LCOE) is the sum of the capital and operational cost of the energy generation source over the lifetime divided by the total electricity produced during that timeframe . It is a useful metric to compare the cost of different types of electricity generation sources (e.g.: wind, coal-fired power plant, etc.)

out to determine whether it is more cost effective to purchase electricity from the grid or to install a rooftop solar system and benefit from the avoided electricity purchase cost.

2.1. Definition of self consumption and self-consumption ratio

In the context of this study, self consumption is defined as electricity that is generated and then consumed at the same location.

The self-consumption ratios indicated for each segment are percentages of the self-generated solar electricity. The distribution center, for example, has an electricity requirement of 1,024 MWh per year, and its solar installation replaces about 13.1% of the purchased electricity („self-sufficiency ratio"). It achieves a self-consumption ratio of 99.6%, which means very little electricity is fed to the grid.

2.2. Contestable versus Non-Contestable Customers

There are two types of electricity customers in Singapore.

The first type, non-contestable consumer (NCC), is mandated to buy electricity from the national electricity company, SP Services. Typical NCC's include residential customers as well as commercial businesses with lower energy needs (e.g. small restaurants and shops).

The second type, contestable consumer (CC), refers to a consumer that qualifies to buy electricity from the private electricity retail market. Qualification is limited to commercial businesses consuming more than a certain amount of energy. The focus of this paper will be on the contestable consumer because most of the commercial segment will fit this profile in the near future, especially since eligibility criteria have been lowered twice in 2014 by the SIngapore Electricity Market Authority (as of October 1, 2014: >4,000 kWh/month). Contestable consumers sign agreements with electricity retailers to guarantee supply rather than SP Services.

2.3. Changes to electricity prices for companies in Singapore over the next 20 years

This section is an extraction from a study[3] completed in collaboration with the Solar Energy Research Institute in Singapore (SERIS). The following section was summarized from the complete report which was composed by SERIS. For the full version of the study, please contact SERIS directly.

[3] *Source: SERIS*

Most Likely Price Development Scenario

Regulated Tariff, Average CC Price

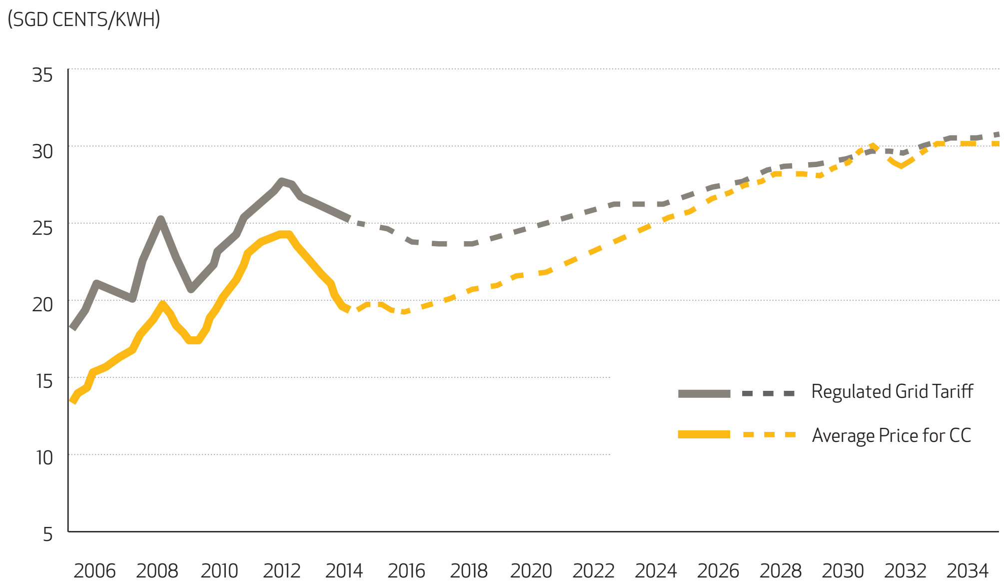


Figure 1: Electricity price forecast for the regulated electricity tariff and the average CC price based on the most likely scenario regarding wholesale electricity price development.

Looking at the historic development allows identifying important drivers of Singapore's wholesale electricity prices:

a) Oil Price – Although gas is the main feedstock for power plants in Singapore, the gas price is mainly determined by the oil price. As an example, the high-sulfur fuel oil index is widely used as a benchmark in piped gas import contracts from Malaysia and Indonesia, while the Brent oil price index is currently used for LNG gas.

b) Demand for Electricity – The amount of demand in the market obviously influences electricity prices. Major drivers for demand include growth in GDP, growth of population size, but also potential efficiency savings and in the future displacement by renewable energies.

c) Reserve Margin – The amount of capacity available in excess of the peak demand. The higher the availability of excess capacity the higher the pressure in the market to reduce their prices.

d) Steam Plant Capacity Factor – The steam plants are typically the most expensive generation plants in Singapore and hence are only active when demand is higher than the available supply from gas plants.

e) Vesting Contract Level – The amount of total demand which is vested under a 'contract for difference' scheme based on the regulated vesting price.

f) Contestable Customer's Share of Demand – The share of electricity consumption attributed to contestable customers in the market.

From 2005 to 2012, the regulated electricity tariff rose by 10.2 SGD cents/kWh, equivalent to Compounded Annual Growth Rate (CAGR) of 6.7%. The CAGRs for the USEP and the average price for CC were even higher with 10.6% and 9.2% respectively. After running a regression model on the drivers, the oil prices together with the reserve margin appear to be the most significant independent variables for determining electricity prices.

This also helps to explain two important phenomena in the history of the Singapore electricity market. In 2008, the reserve margin was very small, leading to blackouts during peak demand hours. Due to this low reserve margin and the increase in gas prices, the market acted in line with the aforementioned drivers and caused a 30% rise in the wholesale electricity price. Then in 2013, there was a significant drop in the electricity prices from the year before. While the regulated electricity tariff declined by 6%, the average price for CC dropped by 10% and even the USEP by 22%. The reason for this is the increase in the reserve margin from 62% to 94% from January 2012 to August 2014, while gas prices fell with -6.4% in this timeframe.

A forecast of electricity prices was developed for contestable and non-contestable consumers shown by extracting this regression model (most-likely scenario shown in the graph above). There is currently an oversupply of generation capacity which is creating an artificially low electricity price today.

In the future, however, the market will again begin to correct itself as the demand for electricity and oil prices most likely rise. Non-contestable consumers, which include most commerce & trade consumers, will very closely follow the wholesale market price trend. They will, however, have to additionally pay the transmission and distribution costs, the retailer's margin, as well as the GST.

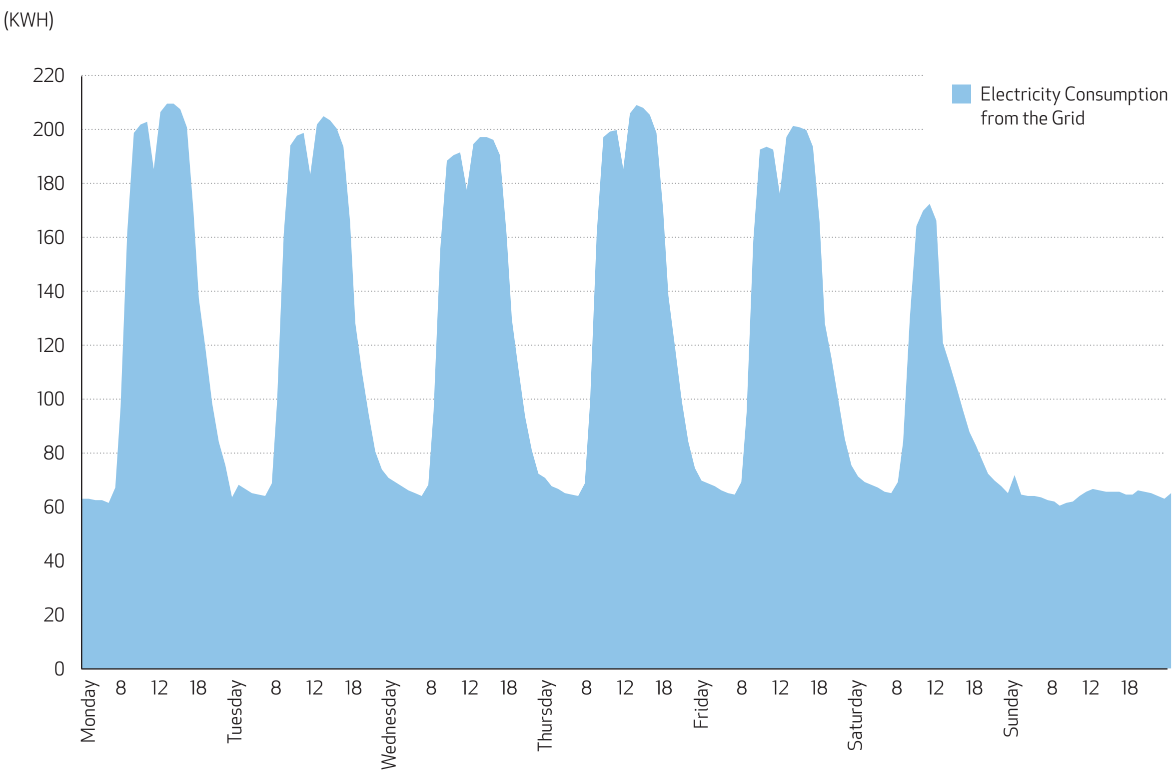
3. Results of the study for contestable customers in Singapore

3.1. Commerce & trade segment

For the commerce & trade segment, the study investigated a potential self-consumption installation in Singapore. The calculation was based on the actual load profile of a consumer goods distribution center. The rooftop of the facility is made of corrugated roof material, which is quite standard in Singapore. The roof is slightly inclined, making for a straightforward installation with relatively high yield.

The profile of electricity consumption was suitable for self consumption. The warehouse has a constant base load dedicated to maintaining ambient temperature of the warehouse in addition to the refrigerated rooms. During the work week, there is substantial activity in the facility, resulting in a bulge in the demand for electricity. Furthermore, the heat generated during the day increases the demand for cooling energy, resulting in additional demand for electricity.

Annual Average Hourly Consumption of Electricity — Commerce & Trade

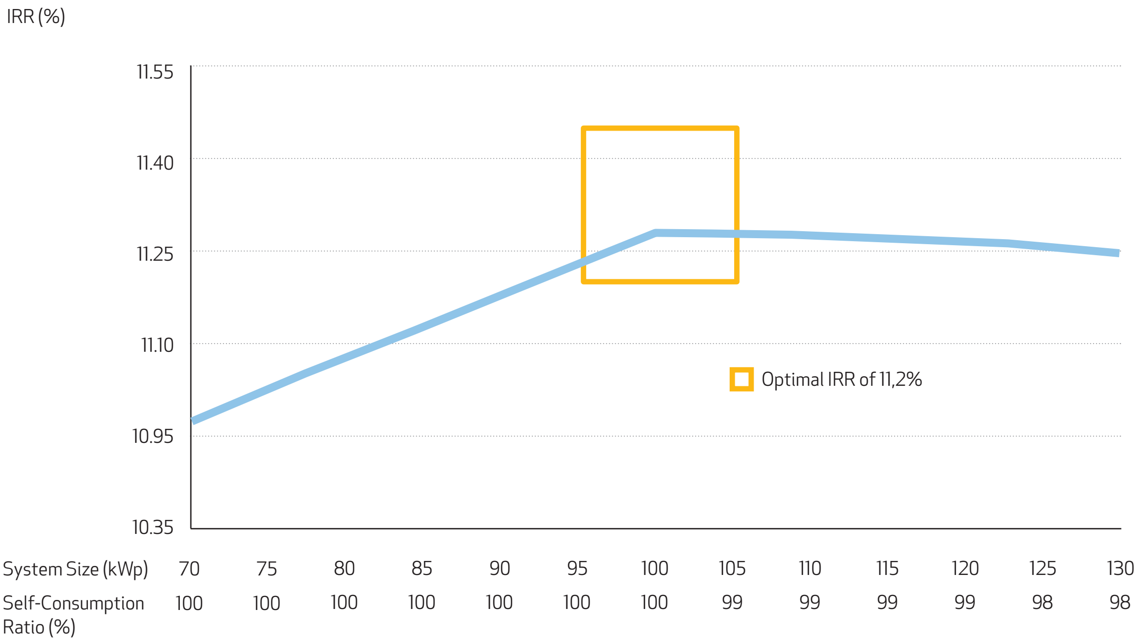


[4] The IRR of an investment is the discount rate at which the net present value of costs (negative cash flows) of the investment equals the net present value of the benefits (positive cash flows) of the investment. It can also be defined as the discount rate at which the present value of all future cash flow is equal to the initial investment, or in other words, the rate at which an investment breaks even.

3.1.1. Optimizing the system size for maximum returns

To assess if a rooftop system is a good investment decision, it is important to estimate the return on the investment. To do so, this study will use the Internal Rate of Return (IRR)[4] as a method to value the return on investment. By analyzing electricity consumption data for the customer, the self-consumption financial model evaluates the IRR for different sized rooftop systems. The graph below depicts the return on investment for different rooftop size systems.

IRR for varying PV System Size — Commerce & Trade



The IRR of the system increases with the system size up to the point at which self consumption leaves the 100% mark. This phenomenon can be described quite simply: as the system size increases, the fixed costs (e.g. engineering & design costs) of the installation remain the same. This means the installation costs will drop overall per unit energy. Since the amount of electricity produced increases proportionally to the size of the system, the ratio of electricity generated to the cost increases, therefore making the investment more attractive.

On the graph above, it can also be noticed that exceeding the 100 kWp threshold, the self-consumption ratio drops below 100%. This means that there are periods of the day where the amount of electricity generated is greater than the amount of electricity needed. This excess electricity generated gets fed into the Singapore power grid and – under today's rules and regulations – cannot contribute to the returns on the system. Therefore, the ratio of electricity generated to the cost decreases, making the investment less attractive. However, it is important to note that Singapore is planning to introduce financial compensation for excess electricity injected to the grid in early 2015.[5] This will particularly benefit installations by allowing them to scale and sell excess power to the grid (especially on the weekend, when schools or distribution centers are closed).

[5] *Source: EMA – "Enhancements to the regulatory framework for intermittent generation sources in the national electricity market of Singapore", July 1, 2014*

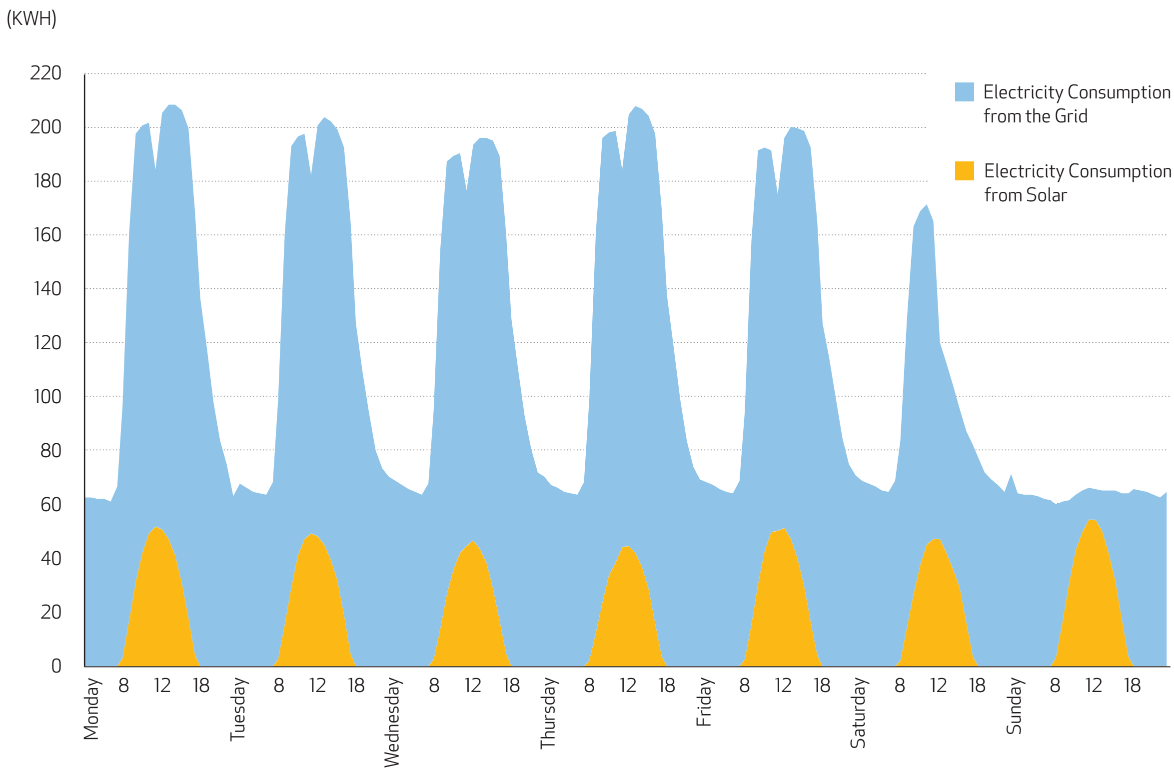
[6] *1000 W/m2 of sunlight intensity, at a cell temperature of 25 degrees Celsius and an airmass of 1.5*

For the case of this customer, there is significantly less activity on the weekend, and our analysis shows that the system size would be constrained by the base load of the customers' electricity demand. Making the system larger would reduce the consumption from the grid during the week; though the excess electricity on the weekend would be wasted.

The graph below illustrates the concept of the base load, showing how much electricity will be contributed by the rooftop system. The hourly average peak solar power for the day is approximately 50 kW for a 100kWp system. kWp refers to the power output of the solar panels under standard test conditions.[6] This is not the common ambient condition in Singapore, since the air is humid and carries many particles which scatter the sunlight, and the ambient temperature is quite high.

The model above uses the average electricity price paid by the customer to calculate their savings. In practice, a customer that has an agreement with an electricity retailer is likely to be charged differently for peak and off-peak charges by the retailer. Since the electricity from the solar system is being generated during peak hours, the savings are therefore likely to be even higher.

Annual Average Hourly Consumption of Electricity — Commerce & Trade



[7] *For information on how these values, as well as the table values, are calculated please refer to the Glossary*

3.1.2. Conclusion

After sizing the system for maximum returns, this particular customer was recommended a 100 kWp system. The constraint that limited the size of the system was electricity consumption on the weekends.

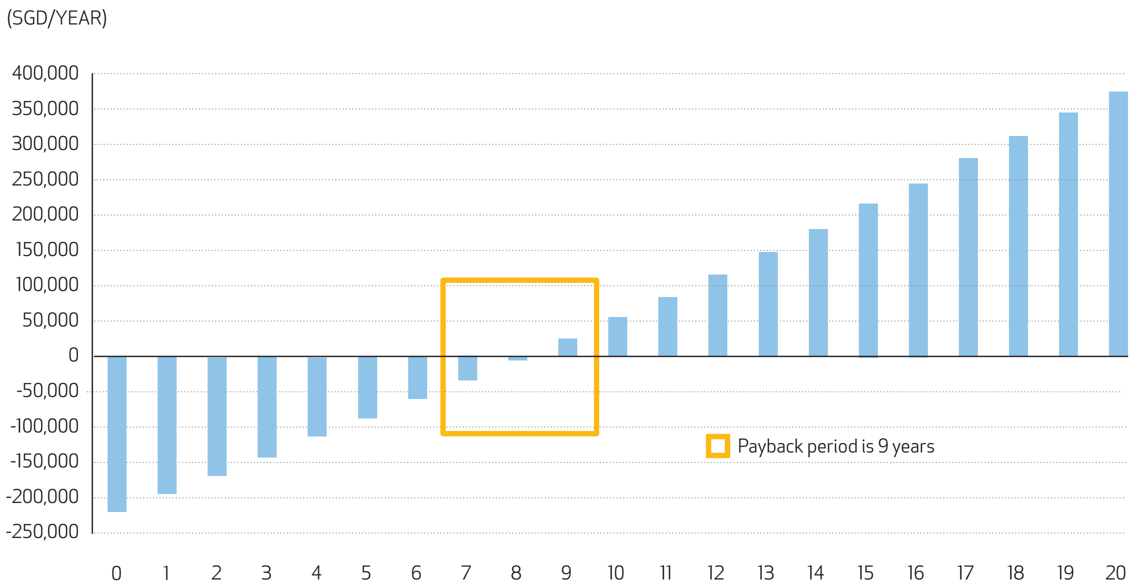
If the system was sized larger than the base load, then the revenue losses from the excess electricity on the weekends would outweigh the returns from the excess electricity generated during the week, resulting in reduced returns on the investment.

Commerce & Trade	
Energy Requirement [MWh/year]	1,024,830
Installation Size [kWp]	100
Solar Installation Investment Costs [SGD]	220,000
Full Load Hours	3,706
Self Consumption Ratio [%]	99.6
Net Present Value of Self Consumption [SGD]	115,602
Net Present Value of Self Consumption [SGD/kWp]	1,156
Project Internal Rate of Return [%]	11.2
Payback Period [years]	9
Current Tariff [SGD cents/kWh]	21
LCOE of Solar [SGD cents/kWh]	19

The key advantage for the commerce & trade segment of maximizing the self-consumption ratio is to maximize the IRR, since every watt of electricity generated contributes to returns and none is wasted. If Singapore introduces a compensation scheme for electricity fed into to the grid, then the customer could potentially benefit from installing larger systems.

For this rooftop system, the payback period is nine years. The IRR realized is 11.2%.[7]

Cumulative Cash Flow for Shortest Payback Period — Commerce & Trade Segment

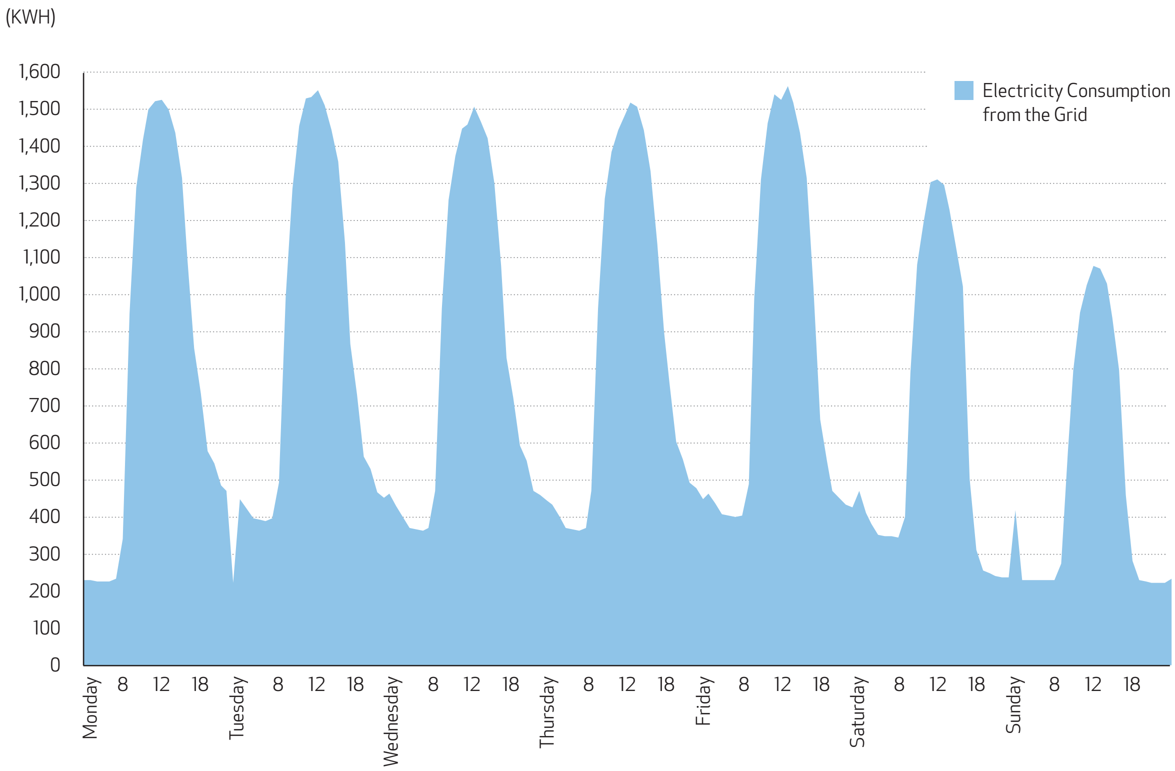


3.2. Manufacturing

For the manufacturing segment, the selected customer owns and operates a machinery manufacturing facility. The rooftop of the facility is made of corrugated roof material and is slightly inclined, making for a straightforward installation with relatively high yield.

The profile of electricity consumption is suitable for self consumption. The facility operates seven days a week, with increased activity during the afternoon. This creates a large hump in demand for electricity during the day. Other factors, such as the heat generated during the day from the sun and outdoor temperature, cause an increase of the demand for cooling energy, resulting in additional demand for electricity.

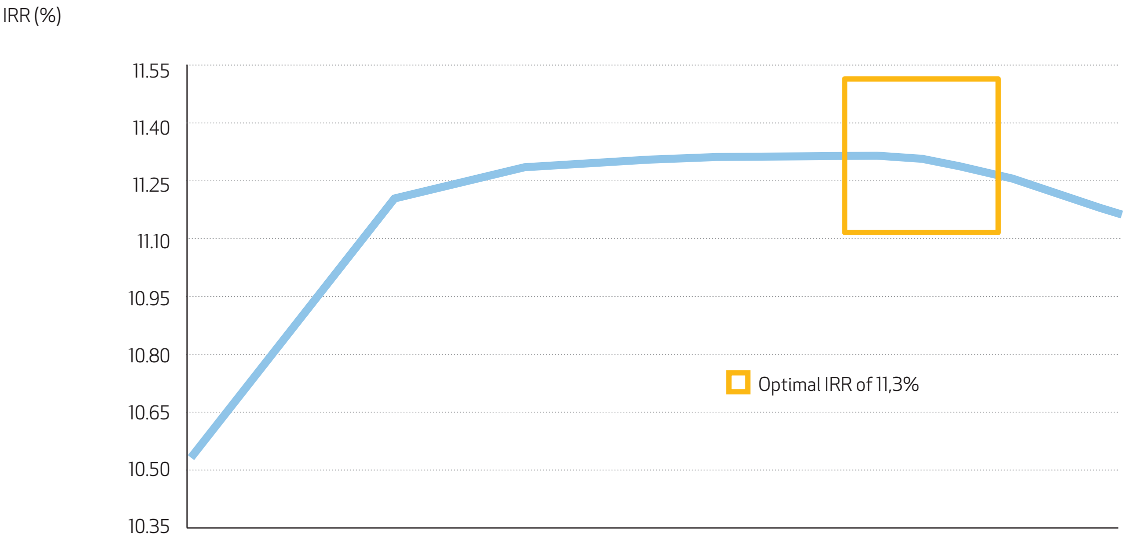
Annual Average Hourly Consumption of Electricity — Manufacturing



3.2.1. Optimizing system size for maximum returns

One major difference between the commerce & trade customer and the manufacturing customer is their electricity consumption pattern. The manufacturing customer operates their facility seven days a week with a similar consumption pattern each day (peaking at mid-day). The implications for self consumption are significant, as will be demonstrated in the calculations below.

IRR for varying PV System Size — Manufacturing



System Size (kWp)	300	500	600	660	700	800	840	860	880	900	920	940	960
Self-Consumption Ratio (%)	99	99	98	98	97	97	97	95	95	95	95	95	95

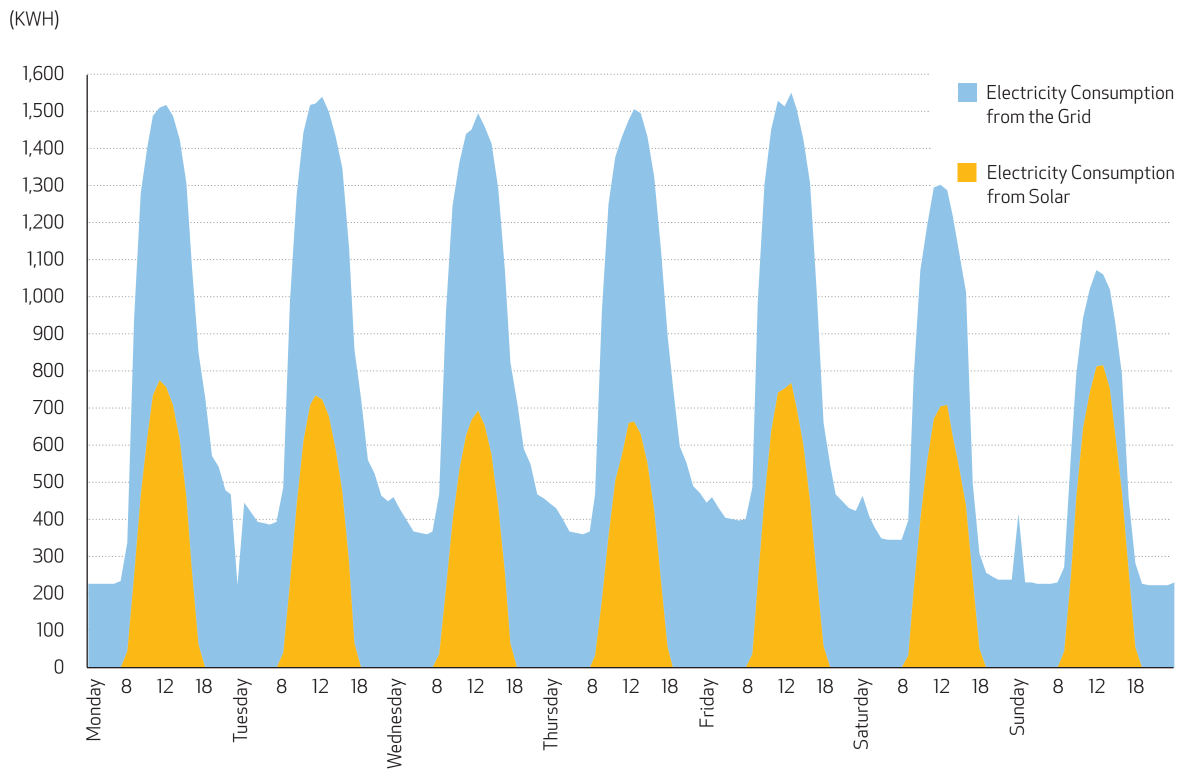
The IRR of the system continues to increase as the system size increases, maintaining a self-consumption of 100% while the installation costs drop overall per unit energy due to the relative reduction of the fixed cost.

For installations between 600 kWp and 1,000 kWp, the financial returns of increasing the system size plateaus. This means that the cost benefits from increasing the size are quite balanced by the periodic financial losses of electricity wasted when the rooftop system produces more electricity than needed. In the commercial building example, 100% of the electricity generated from increasing the system size beyond 100 kWp was wasted on Sundays. In this case here, the amount of electricity lost due to increasing the system size is marginal since most of the additional electricity generated is captured during the peak hours. See graph below.

Once the system size increases beyond 1,000 kWp, the amount of electricity produced exceeds the peak of electricity demand on the day with the least demand for electricity. The marginal amount of excess electricity that gets wasted increases then continously, making the investment less attractive.

The analysis showed that a system size of 800-1,000 kWp will give the optimal IRR of 11.3%. However, with a system of this size, it is necessary to evaluate whether the roof could accommodate such a large system in the first place. Manufacturing industries tend to employ large machinery and equipment which require much more electricity per unit floor area than buildings with commercial applications. The rule of thumb in Singapore for assessing how large a system the roof can accommodate is 120 Wp/m^2. This means a 100 kWp system will require 850 m^2 of available roof space. For this particular customer, the amount of available roof space was more than 10,000 m^2, so it could easily accommodate the optimal range. Therefore, the customer can maximize their use of clean energy using a 1,000 kWp rooftop system.

Annual Average Hourly Consumption of Electricity — Manufacturing



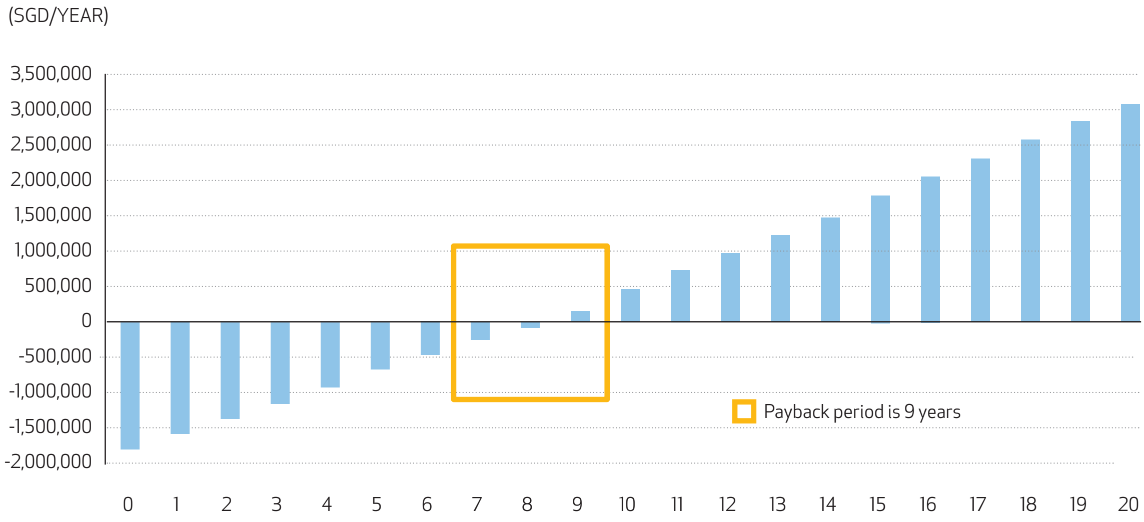
3.2.2. Conclusion

After sizing the system correctly, this particular customer was recommended a 1,000 kWp system. As the self-consumption ratio decreased, the cost benefits of increasing the system size get balanced with the cost of wasted electricity.

This phenomenon occurred since the customer operates seven days a week, which means the "sweet-spot" system size is when the peak power produced by the system exceeds the baseload and is less than the shortest daily average peak. Since manufacturing facilities consume a high amount of power per unit floor area, one important constraint to consider is the available rooftop space. For this rooftop system, the payback period is nine years. The IRR is 11.3%.

Manufacturing	
Energy Requirement [MWh/year]	5,167,437
Installation Size [kWp]	1,000
Solar Installation Investment Costs [SGD]	1,800,000
Full Load Hours	3,756
Self Consumption Ratio [%]	95.4
Net Present Value of Self Consumption [SGD]	965,194
Net Present Value of Self Consumption [SGD/kWp]	965
Project Internal Rate of Return [%]	11.3
Payback Period [years]	9
Current Tariff [SGD cents/kWh]	18.5
LCOE of Solar [SGD cents/kWh]	15.5

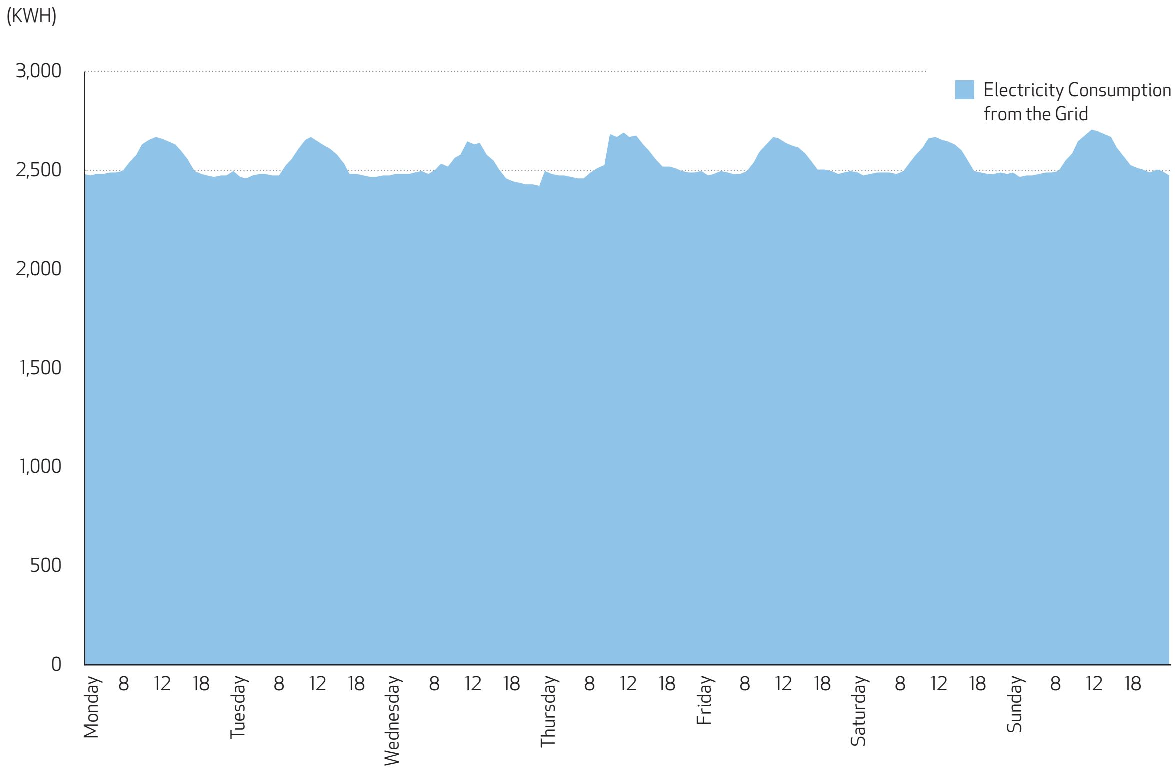
Cumulative Cash Flow for Shortest Payback Period — Manufacturing Segment



3.3. Heavy-duty industry

For the heavy-duty industry segment, the study investigated a potential self-consumption installations in Singapore, based on the actual load profile of a large industrial customer. The facility operates around the clock, with very mild fluctuation throughout the day.

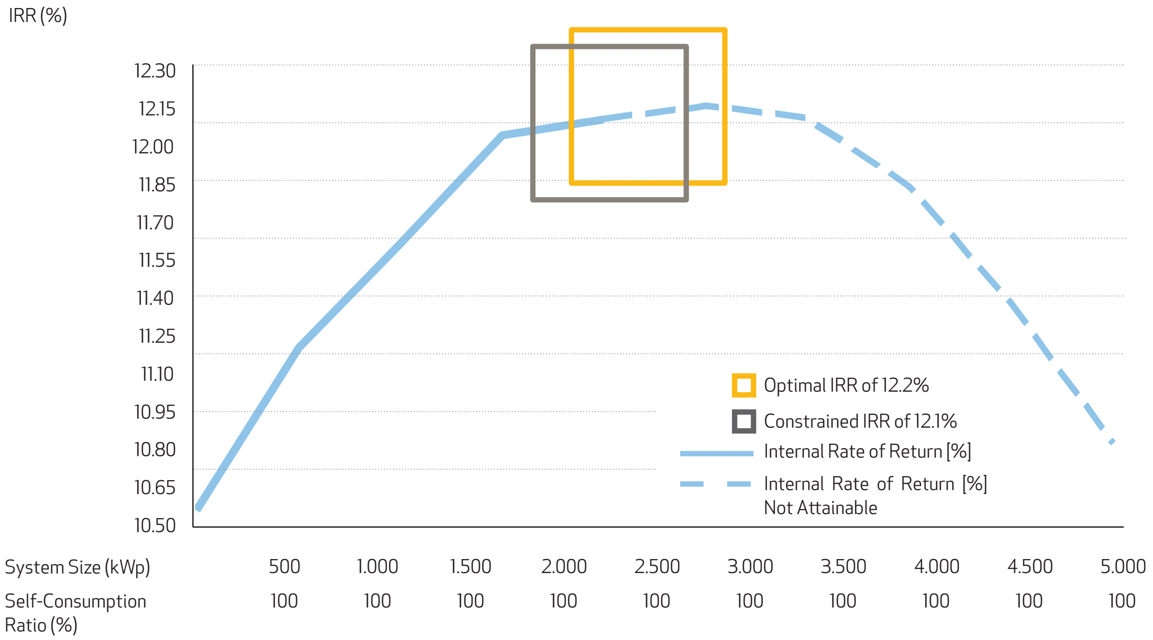
Annual Average Hourly Consumption of Electricity — Heavy Industry



3.3.1. Optimizing System Size for Maximum Returns

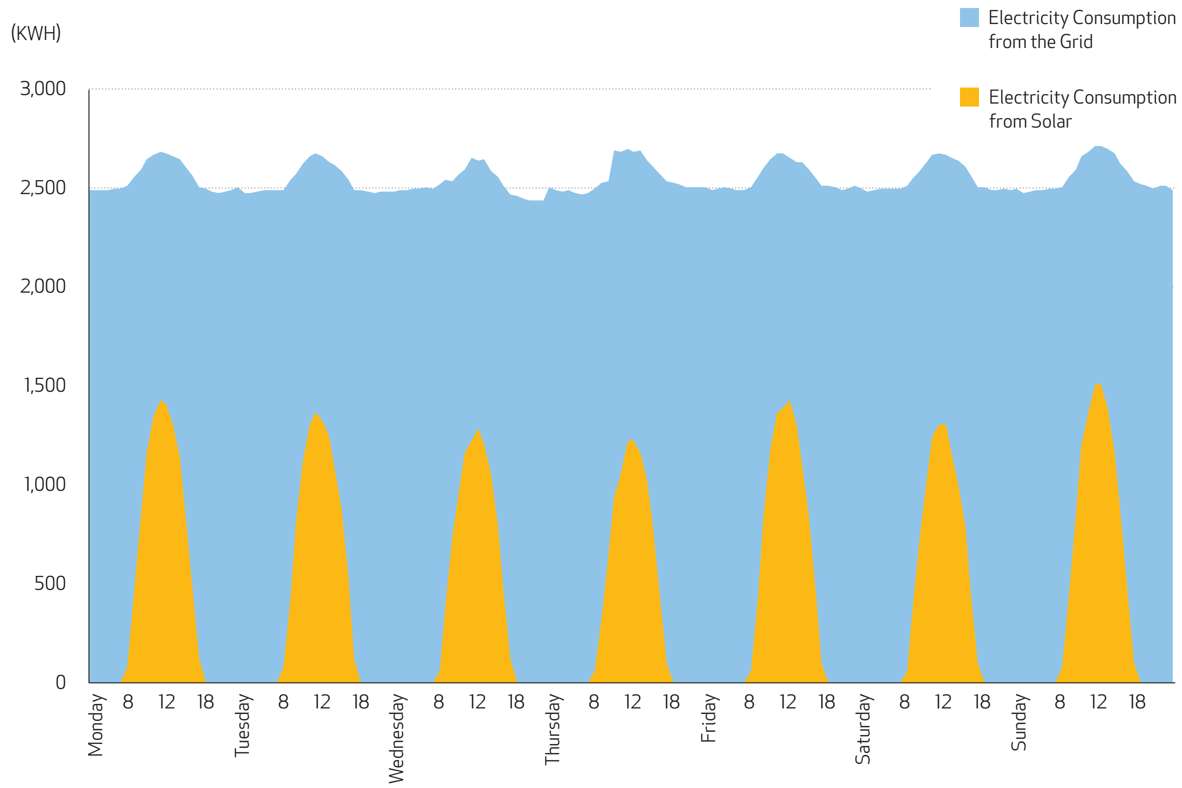
The ratio of the base load to the average peak height is very small compared to the commerce & trade and manufacturing customers. Therefore, the system size will also be limited to the base load power demand, however at a much higher level.

IRR for varying PV System Size — Heavy Industry



As in the previous cases, the IRR of the system continues to increase as the system size increases (fixed cost reduction with increased system size, leading to a drop of installation costs per unit energy). Since the amount of electricity produced increases proportionally to the size of the system, the ratio of electricity generated to the cost increases, thus making the investment more attractive.

Annual Average Hourly Consumption of Electricity — Heavy Industry



Since the demand for electricity is high, the potential IRR of the system can also be large. However, this IRR can only be realized if the available rooftop space is large enough to fully harvest the IRR. In the actual case, the customer's rooftop cannot accommodate such a large system. The available roof space can only host a rooftop system that is 2.5 MWp in size, which provides the system owner with an IRR of 12.1%.

Heavy Industry	
Energy Requirement [MWh/year]	135,803,808
Installation Size [kWp]	2,500
Solar Installation Investment Costs [SGD]	4,250,000
Full Load Hours	4,258.51
Self Consumption Ratio [%]	99.91
Net Present Value of Self Consumption [SGD]	2,612,815
Net Present Value of Self Consumption [SGD/kWp]	1,045.13
Project Internal Rate of Return [%]	12.112
Payback Period [years]	8
Current Tariff [SGD cents/kWh]	17.5
LCOE of Solar [SGD cents/kWh]	14.6

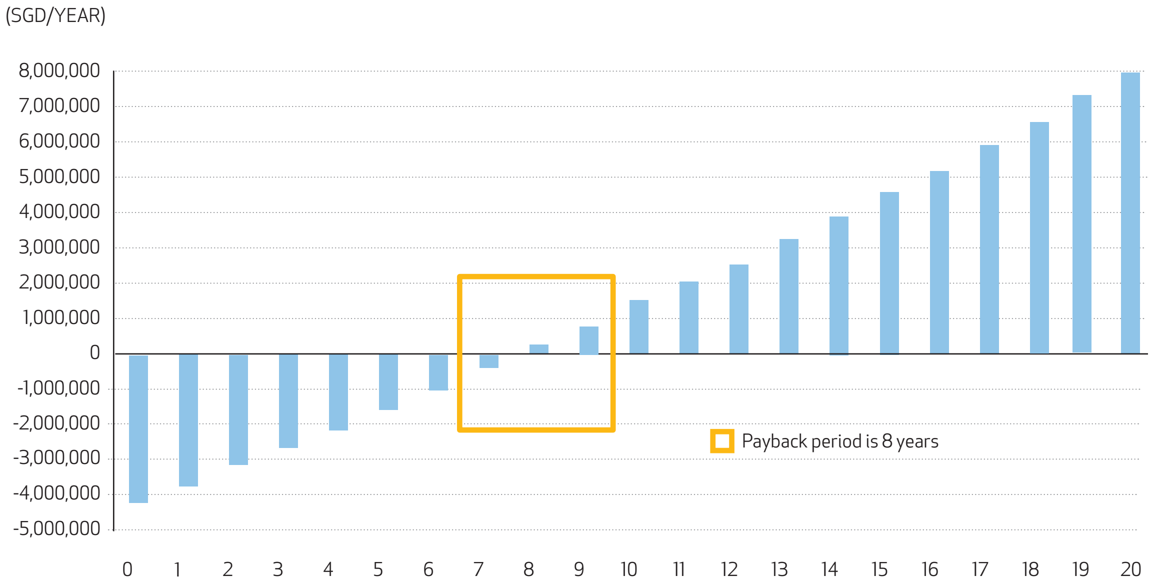
One common misperception of high-energy users is the belief that energy retailers would provide very cheap electricity and therefore the savings for solar are quite negligible. The above model proves the contrary. Since the available roof size is very large, the rooftop system is also very large and therefore the installation costs decrease per unit energy compared to facilities with smaller roofs. In this case, the LCOE of solar is less than 15 SGD cents/kWh versus the customer's grid tariff of 17 SGD cents/kWh. This low cost of solar electricity drives the solar business case for heavy-duty industry customers.

3.3.2. Conclusion

Heavy-duty industry customers tend to have a very large and steady energy demand per unit floor area. Therefore, the main constraint for the rooftop system size is the available roof space. Installation costs are cheaper than commercial and manufacturing customers since the system sizes tend to be larger.

For this customer, a 2.5 MWp system was recommended to maximize the available rooftop space. The payback period of this investment is eight years, with an anticipated IRR of 12.1%.

Cumulative Cash Flow for Shortest Payback Period — Heavy Industry Segment



4. Conclusion

4.1. The profitability of the PV installation is related to the electricity purchase price

The main driver for self consumption in Singapore is the fact that the levelized cost of solar electricity (LCOE) is in many cases lower than the contestable electricity price. For example, LCOE for solar for the commerce & trade, manufacturing, and heavy-duty industry segments in this study were 14.6, 15.5 and 19 SGD cents/kWh respectively while their tariffs for the first year were 17.5 (+20%), 18.5 (+20%), and 21 (+11%) SGD cents/kWh. In the "Changes to Electricity Prices" section, we showed the results of a detailed market study on the drivers for the future electricity prices in Singapore and found that the electricity prices are forecasted to rise in the medium term, reinforcing the business case for self consumption in Singapore.

Since LCOE for solar in Singapore is already cheaper for many sectors than the grid electricity price, the Electricity Market Authority of Singapore has decided to introduce a "net-settlement" compensation scheme for excess electricity injected into the grid. Essentially, the system owner will be compensated the fair market value for electricity generated, which in many cases will be equivalent to the current electricity price minus the grid utilization charges. It is nevertheless more attractive for commercial rooftop owners who will be exporting excess electricity to the grid.

4.2. Investment decisions by companies

For all three segments (commerce & trade, manufacturing, and heavy-duty industry), the payback period is between eight and nine years, which is typical for an infrastructure-related investment, but often too long to prompt a company to invest. Executives tend to make investment decisions for a period of three to five years.

Each business could have a different way to measure the effectiveness of their system. Some companies value an investment that will have higher returns over its lifetime, while others will value a shorter payback period. Each of the above customers highly valued the brand impact. Having solar on the roof promotes a responsible image that resonates well with customers and employees. Many also view rooftop solar as a Corporate Social Responsibility initiative that pays back itself and has a large impact on the lives of those around them. Another key investment benefit is the ability to use solar energy to hedge electricity prices for the future. Investing in a solar system will provide reliable power generation at a known cost, below the expected future market electricity price.

Innovative financing models for solar are already available in Singapore. An external party can own and operate a solar installation on the tenant's rooftop and sell the electricity just like an electricity retailer. With such an arrangement, the parties sign a so-called "Power Purchase Agreement" (PPA). The tenant can benefit from immediate savings from their discounted electricity price without the hassle and need for an upfront investment. REC is now also offering this arrangement for customers in Singapore.

4.3. Benefits of solar

The Singapore government has introduced measures to reward building owners who install solar photovoltaic rooftop systems. One such example is the Building and Construction Authority (BCA) Green Mark Scheme[8], which acknowledges non-residential building owners for their environmentally conscious practices and rewards them accordingly. Rooftop solar system owners receive credits which can contribute to a higher Green Mark tier rating, from certified to Gold, or Gold to Platinum. In some cases, a customer can receive up to 20 Green Mark points by installing rooftop solar[8]. As an example, a rooftop owner in Singapore was seeking a way to increase their Green Mark ranking from Gold to Platinum. They conducted an analysis of their building and found that there was available unused rooftop space for a rooftop solar system. REC worked with the rooftop owner to identify the financial gains and other associated benefits of a rooftop solar system and concluded that it would be the right investment to reach their objective.

From a corporate brand perspective, customers are becoming increasingly aware of global warming and environmental issues, and thus look up to companies who are environmentally conscious. Furthermore, the labor force is increasingly conscious of these environmental issues and it is a sense of pride for them to be working for a company contributing towards sustainable practices.

Finally, an installation will also contribute to Singapore becoming more energy independent as well as diversifying the national power generation landscape. This is important to mitigate the impact of international shocks in the energy commodities industry which could negatively impact Singapore's economy, and in return affect local businesses there.

To summarize, apart from the economic returns on investment, the societal gains are very high because it contributes strongly towards a company's brand, raises the morale of employees, supports the development of self-sustaining and diversified national power generation, reduces electricity costs significantly and provides government-sponsored financial benefits.

4.4. Social change

The stakeholders in the solar industry – solar panel manufacturers, distributors and installers – need to reposition themselves and make the most of the opportunity for self consumption to succeed in the market. If self consumption is being used to measure the benefits of solar installations, professional advice, planning, and implementation are necessary in order to align the products with the company's electricity requirements. Solutions could also include storage and smart building management solutions, etc. in the future. It will no longer simply be a matter of generating as many kWh as possible and feeding it into the grid to maximize the feed-in tariff. The winners will be those who invest in an intelligent installation. The greater complexity opens up new and exciting development opportunities for innovative companies as well as creating skilled jobs and an exciting new industry for Singapore and beyond.

[8] *BCA Green Mark for New Non-Residential Buildings Version NRB/4.1*

Glossary

Cash flow

The cash flow is the movement of money in a specified period of time (e.g. per month or year; throughout this study, per year). The cash flow takes into account investments as well as operating costs (e.g. maintenance) and generated sales. When the purpose is to determine the profitability of a solar installation, the cash flow also considers the "avoided costs" such as savings in electricity costs. The cash flow is usually negative in the first year (when the investment is made), turning positive in subsequent years.

Cost of capital

This is the cost incurred in obtaining the company's funds, and includes both equity and debt. The calculation uses the weighted average of the cost of each type of capital (WACC). In other words, the cost of debt is weighted with the debt ratio and the cost of equity is weighted with the equity ratio.

Full Load Hours

The time that the facility would spend at full load if it always operated at that level. It is equivalent to the total energy consumed per year (kWh/year) divided by the peak demand Pmax [kW]. It is a measure of the variability in the load (higher number means lower variability) and an indication to your power producer of your load behavior.

Internal rate of return (IRR)

The internal rate of return measures the profitability of an investment or a project as a percentage. The following applies if the investment is made in full in the first year and there is a positive cash flow in all subsequent years. The IRR x percentage is the following interest rate: if the total amount is invested today at the fixed interest rate of x, the investor receives the same rate of return as for this project. To this extent, the IRR is the average annual return as a percentage.

Net present value

This is the sum of the cash flow, which is discounted by the WACC (see "Cost of capital"). Because the installation sizes vary according to the segment, both the absolute net present value and the relative net present value are used, in SGD and SGD/kWp respectively.

Payback period

The payback period is the period until the accumulated cash flow equals or exceeds 0 for the first time.

Self-consumption ratio

In the context of this study, the “self-consumption ratio” expresses the proportion of self-consumed electricity as a percentage of the total electricity generated by the solar installation.

About REC

REC is a leading global provider of solar energy solutions. With more than 15 years of experience, we offer sustainable, high performing products, services and investments for the solar industry. Together with our partners, we create value by providing solutions that better meet the world's growing energy needs. REC is headquartered in Norway and listed on the Oslo Stock Exchange (ticker: RECSOL). Our 1,600 employees worldwide generated revenues of USD 647 million in 2013. To learn more, visit www.recgroup.com

About SERIS

The Solar Energy Research Institute of Singapore (SERIS) is Singapore's national institute for applied solar energy research. SERIS is sponsored by Singapore's National Research Foundation (NRF) via the Economic Development Board (EDB), as well as the National University of Singapore (NUS). It has the stature of an NUS University-level Research Institute and is endowed with considerable autonomy and flexibility. The institute conducts research, development, testing and consulting in the fields of solar energy conversion and solar building technologies, to contribute towards a sustainable global energy supply and reduced greenhouse gas emissions. SERIS' R&D focus is on materials, components, processes and systems for (i) photovoltaic electricity generation and (ii) solar and energy efficient buildings. SERIS is globally active but focuses on technologies and services for tropical regions, in particular for Singapore and South-East Asia.

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