The Business Case For: Solar PV in Cambodia

June 2015

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This document was prepared by:

<table>
<thead>
<tr>
<th>Author</th>
<th>Organization</th>
<th>Contact Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laura Anderson</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Przemyslaw Garbaczewski</td>
<td>Johns Hopkins University: School of Advanced International Studies</td>
<td><a href="mailto:idev.pfan@gmail.com">idev.pfan@gmail.com</a></td>
</tr>
<tr>
<td>Noah Schlosser</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gregor Schueler</td>
<td></td>
<td></td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Advisor</th>
<th>Organization</th>
<th>Contact details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Darius Li</td>
<td>SSG Advisors</td>
<td><a href="mailto:darius@ssg-advisors.com">darius@ssg-advisors.com</a></td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Reviewer</th>
<th>Organization</th>
<th>Contact details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dan Potash</td>
<td>Deloitte Consulting LLP</td>
<td><a href="mailto:dpotash@deloitte.com">dpotash@deloitte.com</a></td>
</tr>
</tbody>
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ABBREVIATIONS AND ACRONYMS

AFD  Agence Francaise de Developpement
ASEAN  Association of Southeast Asian Nations
BoP  Base of the Pyramid
CAPEX  Capital Expenses
EAC  Electricity Authority of Cambodia
GDP  Gross Domestic Product
GMAC  Garment Manufacturers Association of Cambodia
IPP  Independent Power Producer
IRR  Internal Rate of Return
kW  Kilowatt
kWh  Kilowatt-hour
MW  Megawatt
NPV  Net Present Value
O&M  Operations and Maintenance
OPEX  Operating Expenses
PFAN  Private Financing Advisory Network
PPA  Power Purchase Agreement
PV  Photovoltaic
SEZ  Special Economic Zone
SHS  Solar Home System
SNV  SNV Netherlands Development Organisation
SME  Small and Medium Enterprises
USAID  US Agency for International Development
PREFACE

The Private Financing Advisory Network (PFAN) – Asia program is a 5-year regional effort funded by the US Agency for International Development Regional Development Mission for Asia (USAID/RDMA), and implemented by Deloitte Consulting LLP (prime contractor) and partner organizations. In 2014, PFAN-Asia entered into a collaboration with The Johns Hopkins School of Advanced International Studies (SAIS) IDEV Program.

The SAIS International Development (IDEV) Program has been training international development practitioners for leadership roles in policy and practice for over seventy years. IDEV provides rigorous academic training in the economic, political and social dimensions of development, and practical skills to prepare students for the challenges of a career in international development. Students also choose a professional field within IDEV, building specialized expertise. IDEV offers its own courses and draws on development-relevant courses offered by other programs, especially in regional studies and international economics.

This report is the culmination of a practicum for students, which will be leveraged to attract investment and support from interested entrepreneurs and investors. This final report is intended to provide an in-depth market analysis that will back up an initial hypothesis with data, detailing the breadth and depth of specific commercial business opportunities in the off-grid solar market in Cambodia. The PFAN-Asia and the SAIS Practicum team worked together on this report, and we are very pleased to present to you our findings.
1. EXECUTIVE SUMMARY

With one of the highest electricity tariffs in the world, poor infrastructure, and limited electricity access, there exists a significant opportunity for solar PV to markedly change the energy landscape in Cambodia in coming years. This paper presents an analysis on the viability of various solar PV business models in Cambodia, with a particular focus on energy-intensive users such as factories and commercial buildings. This segment of the market has been identified as the most promising for private-sector investment in solar PV because of the attractive dynamics offered through scale, ability to pay, and sensitivity to high electricity tariffs relative to other customer segments. Other potential business models considered include solar home systems and solar-powered mini grids, but these were ultimately found to be less attractive. The recommendations and accompanying financial model are meant to provide entrepreneurs and investors details on the breadth and depth of the investment opportunity for solar PV in Cambodia, charting the outline of a path for intrepid entrepreneurs to take forward.

2. CAMBODIAN ECONOMY

Cambodia’s economy has enjoyed sustained and robust GDP growth since 2000, averaging 7.8% growth per year. Although the economy contracted following the 2008 global economic crisis, dropping to only 0.1% GDP growth in 2009, it rebounded more quickly than expected to reach 6% in 2010. The economy is expected to grow by 7.5% in 2015 and continue at this pace into the medium-term future, driven mainly by the garments, construction, agriculture, and tourism industries. It is worth noting that the garment industry has been growing at double-digit rates and exported close to $5 billion in goods in 2013, representing nearly a third of GDP. As a result of the strong economic growth, Cambodia’s poverty rate has fallen from 45% in 2007 to 17.7% in 2012 (See Table 1 for a regional comparison).

The majority of Cambodians (81%) live in rural areas where incomes are significantly lower than in the cities. Agriculture, the main occupation of the rural population, constitutes a large portion of the country’s economy, representing 34.8% of GDP as of 2013. Population density is very low outside of the corridor between Phnom Penh and Siem Reap, the two largest cities in the country (Annex 1) in which most middle- and high-income households are found. The economy of Siem Reap is dominated by the tourism industry, while Phnom Penh has a more diversified mix of manufacturing, tourism, and services. Most existing industrial facilities are located in or near Phnom Penh, though the government is expanding industrial development to smaller urban areas through Special Economic Zones (SEZs).

3. BUSINESS ENVIRONMENT

3.1 Foreign Investment

Cambodia has one of the most favorable foreign investment policies in Southeast Asia. There are no restrictions on foreign ownership and no sectors are closed to foreign investment. In comparison, Thailand’s Foreign Business Act lists three different categories of businesses, which are subject to varying levels of foreign investment restrictions, applicable if more than half of its ownership is not...
held by Thai nationals.\(^6\) Additionally, foreign investment in Cambodia does not require Central Bank approval, as in neighboring countries such as Vietnam, Laos, and Myanmar. The Foreign Exchange Law of 1997 states that there are no restrictions on foreign exchange operations through authorized banks (with the exception that transfers exceeding US$10,000 must be reported to the National Bank of Cambodia). Cambodian residents are allowed to hold foreign currency freely. However, foreigners are restricted from owning land under the Law on Investment, although they are allowed to hold long-term leases.\(^7\)

Further, under Article 11 of the Amended Law on Investment, Qualified Investment Projects are guaranteed to be able to freely remit foreign currencies for the discharge of financial obligations incurred in connection with their investment. These protected capital outflows include payment for imports, repayment of principal and interest on loans, payment of royalties and management fees, remittance of profits, and repatriation of invested capital in the case of dissolution.\(^8\) These guarantees increase investors’ confidence in their ability to recoup their investment.

### 3.2 Ease of Doing Business

Overall, Cambodia ranks poorly on the World Bank’s Ease of Doing Business indicators, placing 135\(^{\text{th}}\) out of 189 countries overall. Compared to other countries in Southeast Asia, Cambodia ranks below Thailand and Vietnam (26\(^{\text{th}}\) and 78\(^{\text{th}}\), respectively), but above Lao PDR (148\(^{\text{th}}\)) and Myanmar (177\(^{\text{th}}\)). Specifically, Cambodia ranks lowest on the indicators for Starting a Business, Enforcing Contracts, and Getting Electricity. It ranks highest on Getting Credit (see Table 2).

Despite these poor World Bank rankings, information gathered during multiple in-person interviews with foreign investors in Cambodia suggests that the process for foreigners to start a business is fairly straightforward, especially compared to other countries in Southeast Asia. Foreign investors are required to register the full name of the company, address, nationality of the foreign investor, and the number of shares held in the company to the Ministry of Commerce.\(^9\) Additionally, it seems that the government has a fairly well functioning public dialogue mechanism for addressing constraints on business. It also became clear in meetings that networking and communicating with the correct people is a very important aspect of doing business in Cambodia. It can be difficult to get things done efficiently and quickly without knowing the right people to talk to and negotiate with.

<table>
<thead>
<tr>
<th>Country</th>
<th>Ease of Doing Business Rank</th>
<th>Starting a Business</th>
<th>Dealing with Construction Permits</th>
<th>Getting Electricity</th>
<th>Trading Across Borders</th>
<th>Enforcing Contracts</th>
<th>Getting Credit</th>
<th>Protecting Minority Investors</th>
<th>Paying Taxes</th>
<th>Resolving Insolvency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thailand</td>
<td>26</td>
<td>75</td>
<td>6</td>
<td>12</td>
<td>36</td>
<td>25</td>
<td>89</td>
<td>25</td>
<td>62</td>
<td>45</td>
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<tr>
<td>Vietnam</td>
<td>78</td>
<td>125</td>
<td>22</td>
<td>135</td>
<td>75</td>
<td>47</td>
<td>36</td>
<td>117</td>
<td>173</td>
<td>104</td>
</tr>
<tr>
<td>Cambodia</td>
<td>135</td>
<td>184</td>
<td>183</td>
<td>139</td>
<td>124</td>
<td>178</td>
<td>12</td>
<td>92</td>
<td>90</td>
<td>84</td>
</tr>
<tr>
<td>Lao PDR</td>
<td>148</td>
<td>154</td>
<td>107</td>
<td>128</td>
<td>156</td>
<td>99</td>
<td>116</td>
<td>178</td>
<td>129</td>
<td>189</td>
</tr>
<tr>
<td>Myanmar</td>
<td>177</td>
<td>189</td>
<td>130</td>
<td>121</td>
<td>103</td>
<td>185</td>
<td>171</td>
<td>178</td>
<td>116</td>
<td>160</td>
</tr>
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</table>


### 3.3 Competitiveness

Cambodia has become an attractive location to set up factories, mainly due to low labor costs and the lack of foreign ownership restrictions, which have resulted in the relocation of many factories from China and Vietnam. Increasing industry competitiveness and improving infrastructure to
facilitate trade are among the top priorities laid out in Cambodia’s National Development Plan for 2014-2018.\textsuperscript{11}

However, there are several challenges to developing competitive industries. Lack of skilled labor makes industry diversification difficult. Currently, Cambodia’s industry is concentrated in low value-added manufacturing such as garments, footwear, and wood products.\textsuperscript{12} Manufacturing is power intensive, and the high cost of electricity makes production expensive and therefore exports less price competitive compared with neighboring countries. Other business constraints include lack of access to capital, under-developed infrastructure, and corruption.

Cambodia ranked 156\textsuperscript{th} out of 175 countries on the 2014 Transparency International Corruption Perceptions Index, a slight improvement over its 2013 ranking of 160\textsuperscript{th}.\textsuperscript{13} Corruption is generally perceived to be pervasive throughout all levels and sectors of the government and business. Despite this, corruption usually takes the form of facilitation payments and bribes, and seizure of assets is very rare. Multiple local businesses and investors we spoke with stated that corruption is not as big of a challenge to doing business as it appears externally. The government has made some progress in dealing with corruption with the passing of the Anti-Corruption Law and establishment of the Anti-Corruption Unit in 2010; however, enforcement remains an issue.\textsuperscript{14}

4. CAMBODIAN ELECTRICITY MARKET

With only 35\% of the population having access to electricity in 2015, Cambodia has one of the lowest electrification rates in the world, falling well short of it neighbors. As of 2012, Laos, Vietnam, and Thailand had achieved electrification rates of 78\%, 97\%, and 99\% respectively (see Table 3). While current data is unavailable, in 2010, the situation was worst in rural Cambodia where only 19\% of households had access to the grid, as compared to 91\% of the urban population.\textsuperscript{16} In addition, electricity consumption per capita in Cambodia was only 216 kWh per capita in 2011, a very low rate when compared to Thailand at 2,316 kWh per capita and Vietnam at 1,073 kWh per capita.\textsuperscript{17}

<table>
<thead>
<tr>
<th>Table 3: Electrification Rates in 2012 in %</th>
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<tbody>
<tr>
<td><strong>Country</strong></td>
</tr>
<tr>
<td>Cambodia</td>
</tr>
<tr>
<td>Myanmar</td>
</tr>
<tr>
<td>Lao PDR</td>
</tr>
<tr>
<td>Vietnam</td>
</tr>
<tr>
<td>Thailand</td>
</tr>
</tbody>
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4.1 Generation Capacity and Demand

The Central Grid

The central grid currently covers the urban and semi-urban area between Phnom Penh and Siem Reap. In 2013, Cambodia consumed a total of 3,552 million kWh of electricity, of which about 64\% (2,281.6 million kWh) was imported from neighboring countries, mainly Thailand, Vietnam, and Laos. Of domestically generated power, licensed independent power producers (IPPs) generated 96\% of the power supplied by the central grid. Hydropower accounted for 57.4\% of power supplied, with diesel (32.7\%), coal (9.5\%) and biofuel (0.4\%) powered plants making up the rest.
Due to inefficiencies in power generation, general administration, and transmission infrastructure, the cost of electricity in Cambodia is among the highest in the world. Moreover, the actual cost of generation remains very difficult to ascertain, with limited transparency on the driving factors that contribute to the high tariffs. In Phnom Penh, 1 kWh of electricity costs between $0.17 and $0.26, significantly above average prices in neighboring countries (see Table 4). On top of the high prices, sustained reliability continues to be an issue, and consumers or businesses that cannot afford periodic interruptions also commonly invest in expensive back-up generators.

Table 4: Average Electricity Tariffs in 2014/15

<table>
<thead>
<tr>
<th>Country</th>
<th>Average Residential Tariff (USD/kWh)</th>
<th>Average Industrial Tariff (USD/kWh)</th>
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<tbody>
<tr>
<td>Lao PDR</td>
<td>0.05 - 0.12</td>
<td>0.09</td>
</tr>
<tr>
<td>Vietnam</td>
<td>0.06 - 0.12 (applies to both)</td>
<td>0.09</td>
</tr>
<tr>
<td>Thailand</td>
<td>0.12</td>
<td>0.13</td>
</tr>
<tr>
<td>Cambodia</td>
<td>0.18-0.26</td>
<td>0.17-0.21</td>
</tr>
</tbody>
</table>

While the Electricity Authority of Cambodia (EAC) is making an effort to unify the tariff structure, prices across the country remained highly variable as of 2013. The tariffs are determined by a host of variables, including region, type of consumer, amount consumed, license holder, and type of connection, resulting in almost 100 different tariffs ranging from $0.13 to $0.42 per kWh.

In rural areas, electricity, if available at all, is often provided by privately owned, low-voltage mini-grids. Rural households pay upwards of $0.50/kWh, and average consumption is low at about 5 kWh/month per person. Mini-grids normally only operate for a few hours per day, and power is almost exclusively diesel-generated.

Expected Grid Expansion, Tariff Changes, and Associated Uncertainties
The government’s stated goal is to extend the grid to 100% of villages by 2020 and 70% of all households by 2030. According to regulators, the grid and capacity expansion efforts are ahead of schedule and grid tariffs will continue to decline as additional capacity – most of which is currently
hydropower – comes online. Actual average tariffs paid in Phnom Penh have decreased by about 10% between 2012 and 2013, however this decrease occurred following a nearly equal increase in 2011.\textsuperscript{23} Individuals interviewed for this report expressed skepticism about the government’s promise of grid expansion and lower tariffs, pointing out that the government does not have a strong track record in delivering on such promises in the past. Furthermore, the government grid expansion plans are opaque, making it difficult to predict where and when the grid will expand, and in turn to make related investment decisions. Officials have stated that, due to their distance from existing infrastructure, the provinces where the grid is likely to arrive last are Mondolkiri, Ratanakiri, and Stung Treng, all of which are in the Northeast, bordering Laos and Vietnam.

\begin{figure}
\centering
\includegraphics[width=\textwidth]{national_grid_2018_forecast.png}
\caption{National Transmission Grid 2018 Forecast}
\end{figure}

\textbf{Source:} The Institute of Energy Economics, Japan

\textbf{Expected Capacity Expansion and Demand Growth}

With the rapidly growing economy, increasing population, and modernization of the country, energy demand is expected to continue to increase by 18% annually.\textsuperscript{24} To keep up with the growth in demand, the government is attempting to boost domestic energy production, with a particular focus on increasing hydropower capacity. The country has an estimated 10,000MW of hydropower capacity, only 1% of which is currently developed and operational. Hydropower resources are concentrated around the Mekong River in the East, the Siem Reap area in the Northwest, and along the coast in the Southwest. Over 1000MW of hydropower generation projects are already under construction, with a further 3000MW under study by various project developers.

Even with these planned expansions, Cambodia will struggle to meet its anticipated electricity needs in the coming decades. Figure 3 demonstrates the growing gap between electricity capacity and consumption that has arisen as a result of population and economic growth, as well as the grid expansion that has increased access to a greater number of households.

\begin{figure}
\centering
\includegraphics[width=\textwidth]{electricity_consumption_production_2004-2013.png}
\caption{Electricity Consumption and Production 2004-2013}
\end{figure}
In anticipation of its increased generation capacity, Cambodia is also expanding its network of high-voltage transmission lines. Prior to 2009, all transmission lines in the country were 115kV lines, a low voltage that led to high distribution losses. Currently, the country is investing in 230kV lines, and expects to have 1500 km of these in operation by 2019.

Regulatory Environment

The electricity sector is tightly regulated by the EAC. The EAC grants licenses for the distribution of electricity and determines the tariffs at which each licensee may sell their electricity. According to EAC officials interviewed for this report in January 2015, there are no plans to issue any further licenses. Licenses typically cover between 100 and 15,000 households, but operators often serve as little as 8-10% of the households in their territory because of the low population and their limited ability to pay creates disincentives to connecting more households. The tariffs that off-grid license holders are allowed to charge their customers are set by the EAC and calculated on a cost-plus-margin basis. This eliminates the incentive to invest in more efficient power generation, since any reductions in cost would be met with corresponding reductions in the tariff the operators could charge.

The current regulatory framework therefore makes it very difficult for new entrants to develop a business model that sells electricity directly to customers. In order to do so, one would have to either purchase a license from an existing licensee, which according to a local investment firm is prohibitively expensive, or enter into a sub-contracting arrangement with a license holder (subject to EAC approval). Current regulations also do not include net-metering, meaning that any excess electricity generated by a solar PV system cannot be sold back to the utility, reducing the value of such systems.
5. MAKING THE BUSINESS CASE FOR INDUSTRIAL SOLUTIONS

Cambodia’s continued economic growth entails industrial expansion and diversification, both in textiles and heavy manufacturing. However, the continued high cost and low dependability of electricity threatens to push manufacturers into competing neighbors such as Thailand and Vietnam, where electricity tariffs are lower. Therefore, there is an opportunity for solar PV to provide significant base-load capacity at below-grid prices to industrial facilities located throughout the country. We estimate the total potential market to be approximately $100-115 million, growing to $400-460 million in 2020, and $650-750 million by 2025.26

5.1 Business Model

Electricity tariffs in Phnom Penh are $0.18/kwh for households and industrial consumers pay as much as $0.21/kwh.27 Tariffs are even higher outside of Phnom Penh, and the supply is even less dependable. There exists an opportunity to offer industrial and commercial businesses solar PV to meet much of their base load demand at a lower cost, partially displacing their reliance on electricity supplied by the grid.

Solar installations are long-term investments with a typical life of 20+ years and either the customer, the developer, or a third party, must bear the risks related to not only the initial installation of the system, but also its ongoing maintenance in the long run. Therefore, end-user financing is an incredibly important consideration, as the method dictates to whom these risks and responsibilities fall. For the purposes of this paper, two primary models of financing are put forth for further consideration: direct and third party ownership. Each approach has a different set of benefits and drawbacks for various stakeholders, and the right choice is dependent on individual circumstances and operating environment.28

Third Party Ownership (Power Purchase Agreement): Under this model, the customer is charged for the electricity generated by the solar system under the terms of the long-term PPA that is negotiated prior to installation.29 The customer bears limited-to-no risk associated with the solar system and, in exchange, pays a higher tariff (relative to direct ownership) to the system owner on the basis of power produced and consumed. There are many variations on pricing models for end-users, but we will not delve into the specifics here—it is sufficient to say that the offering must be attractive enough to convince customers to purchase the service, whether that is on the basis of price, stability, or other relevant factors for the specific customer segment and location. The power purchase model generally results in a lower return per transaction to the developer. However, because it transfers the risks and upfront costs away from the customer, this approach has become increasingly popular option for customers that are willing to accept the tradeoffs. We anticipate that this option will be very attractive, especially for individual facilities operating outside of industrial zones.
Direct Ownership Model: Under the direct ownership model, the end-user owns the solar system and contracts with the developer to design and install the system. The developer may also consider providing financing through local institutions and/or Development Finance Institutions, or some combination thereof, as well as offering after-sales support needed to keep the system operating reliably. This is the preferable model from the developer’s perspective, as the capital requirements to finance this business are much lower, and results in far less complexity and risk. Long-term risks – such as ongoing maintenance, grid-price uncertainty, as well as payment risk – are transferred to the customer, who must ascertain the costs and benefits of owning a solar system. We expect that this approach will be less popular with customers because of the higher upfront costs and long-term risks involved. Developers should offer both options in order to maximize their market share.

Table 5: Solar system ownership models

<table>
<thead>
<tr>
<th>Description</th>
<th>Third Party Ownership</th>
<th>Direct Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Developer or 3rd party owns and maintains system, selling electricity to customer at negotiated tariff</td>
<td>Customer owns the system and hires the developer to install and maintain</td>
</tr>
</tbody>
</table>
| Pros        | • Less risk and no upfront capital expenditure for the customer  
              • Broader appeal to a wider range of customers | • Long-term risks, such as maintenance and grid-tariff, borne by customer  
              • Possibly larger returns for developer  
              • Greater savings for the customer |
| Cons        | • Long-term risks  
              • Generally lower returns | • Expected smaller market share |
| Target Customers | • Customers with limited appetite or ability to finance upfront costs  
                   • Customers with lower energy demands | • Customers with greater scale and/or more energy-intensive  
                   • Customers willing, interested in, and able to make the upfront investment and commitment to long-term ownership |

5.2 Environmental Impact

Increasing solar PV-generated electricity will also have a number of environmental benefits to Cambodia, primarily through displacement of existing generation fueled by carbon intensive fuels such as diesel. For each MWh of solar-generated electricity in Cambodia, 0.67 tons of CO₂ emissions are displaced, implying that a 165 kW system will avoid or reduce annual GHG emissions by 183.5 tons. 30
5.3 Customer Segments and Market Size

Customers are segmented into three main types: factories and other large commercial buildings, special economic zones, and Independent Power Producers. Each segment and its estimated market size is presented and analyzed below.

Factories and Other Large Commercial Buildings: $130M¹

The Cambodian manufacturing industry is dominated by low value-added manufacturing, such as garment and shoe factories. Due to low labor costs, Cambodia has become an attractive location to establish manufacturing operations and many companies have relocated to Cambodia from China and Vietnam. Commercial construction in Cambodia is growing at 7% annually.¹ⁱ According to the Garment Manufacturers Association of Cambodia (GMAC), as of December 2014 there were 747 factories in Cambodia.³² In 2011, the garment industry accounted for 70% of total manufacturing in the country and 75% of export revenue. Other industries include household goods, textiles, tires, and pharmaceutical products.³³ The Cambodian Center for Human Rights has published a list of garment factories in Cambodia, including the name of the factory, location, type of products manufactured, contact person, and contact information. This list can be accessed via the sithi.org website.³⁴

Energy is one of the largest expenses for factories, at an estimated 30-50% of total operating costs.³⁵ Supplementing energy from the grid with cheaper solar energy could provide attractive cost-savings for factory owners. Further, industrial clients offer greater scale and stability, lowering overall risk when compared to residential customers. Additionally, commercial building energy consumption typically peaks during the day, better matching solar output than households, which demand more power at night.

Special Economic Zones: $250M²

The Cambodian government has established a number of SEZs around the country in order to attract foreign direct investment and promote export competitiveness. SEZs are designated areas that operate under different regulation from the rest of the country. They benefit from certain income and VAT tax incentives, streamlined customs processes, and lower tariffs. SEZs were first introduced in Cambodia in 2005, and as of 2013, SEZs had received $USD 1.65 billion in total investment.³⁶

Although technically there are at least 30 approved SEZs in Cambodia, the vast majority are not operational (see Annex 2 for a map of SEZs).³⁷ The Phnom Penh SEZ is the only one in which most land has already been leased (see Annex 3 for a map of the Phnom Penh SEZ), though construction had still not begun on many of those factories as of January 2015. There are 11 SEZs listed on the Cambodian government website.³⁸

¹ According to the Garment Manufacturers Association of Cambodia, there are 747 garment factories in the country. Installation revenues are expected to be $177K per system, suggesting a market size of roughly $130 million.
² We estimate there to be 1400 potential factories in SEZs once all have been developed. Installation revenues are expected to be $177K per system, suggesting a market size of roughly $250 million.
SEZs present a particularly appealing customer segment for a number of reasons:

- In aggregate, they represent large-scale customers, creating significant scale for sales, servicing, and power delivery
- SEZs hold energy distribution licenses, so factories on-site could sell excess electricity between each other
- SEZs do not face import duties for goods invested into the SEZs, so panels and other components sourced from outside Cambodia would not be taxed

Furthermore, SEZs are generally located in remote areas where land is cheaper and more accessible, but the grid tends to be less reliable and tariffs are even higher. This combination of factors can boost the economics of a solar investment, resulting in quicker payback and higher returns.

A Closer Look: Phnom Penh SEZ

One of the major barriers to continued development of the Phnom Penh SEZ has been high electricity tariffs; currently, $0.19/kwh. Even factory owners who already hold leases on land are timid about investing further in the SEZ when competing sites in neighboring countries with much lower energy costs are available. However, as the economics on solar have continued to improve, installing solar systems to displace existing grid usage and lower overall energy costs is becoming a viable solution. Lowering electricity tariffs is a major priority for the Phnom Penh SEZ, and we expect it will be for other Cambodian SEZs as well.

Independent Power Producers

IPPs hold licenses granted by the EAC that authorize them to distribute and sell electricity within their geographic jurisdiction. At the end of 2013, there were 339 licenses approved by the EAC in operation, although officials state that they are no longer granting any new licenses. Many IPPs are off-grid, distributed generation systems that rely on diesel for fuel. Solar offers a way for these IPPs to improve the economics of their business by lowering the cost of generation.

However, for several reasons, IPPs are a less attractive customer segment than industrial clients. IPPs are required to charge a regulated tariff dictated by the EAC that is based on their marginal costs. This means that any cost savings realized through improved efficiency would be passed directly on to consumers, eliminating any incentive for license holders to pursue such investments. Additionally, if and when the grid reaches the area where the mini-grid is located, the IPP would be required to use power from the grid rather than continuing to generate their own electricity. Because grid expansion plans are opaque, it would be difficult to ascertain whether or not entering into a solar contract would be beneficial and over what timeframe. Therefore, it is our assessment that only a limited number of IPPs would be interested in solar.

5.4 Risks

Grid Expansion and Tariff

Grid expansion and tariffs are uncertain over the long-term. Cambodia’s recent investments in hydropower also means that grid tariffs are expected to fall over the coming years, but when, where, and by how much remain unclear. Even if domestic generation can meet the rising demand, significant investment still needs to be made in transmission infrastructure across the country in order to provide power efficiently and reliably. Even though the proposed model remains financially feasible over a wide range of possible tariffs, especially outside of Phnom Penh where tariffs are
highest and service outages most frequent, customers may be hesitant to invest in solar if they expect tariffs to decrease significantly in the years ahead.

**Contract Enforcement**

Contract enforcement is a significant risk to the third party ownership model. Cambodia ranks low on contract enforceability by ASEAN standards, and once a solar system has been installed, the developer is dependent on those long-term, predictable revenues to survive. Working with larger customers, such as SEZs, can help mitigate this risk, since these companies are likely to be more credit worthy and stable.

Business interruptions or shutdowns would also present a risk to the PPA-model. Over the life of the PPA, there are any number of variables that would result in the customer no longer being able to meet their obligations. For example, other locations or countries may become more attractive for factories to operate in due to cheaper labor or easing of regulation, and factories could decide to relocate. Developers can attempt to mitigate this risk by incorporating early termination penalties into the PPA or other provisions that require transference of the solar asset to the new tenant. However, in reality, enforcing such provisions may not be feasible or practical.

**Adverse Macroeconomics Developments**

Adverse shocks to the global economy could reduce demand for solar. The target market for the proposed business consists in large part of the export-oriented manufacturing sector. If global demand for goods from Cambodia decreases, factory owner’s appetites for investment may be impacted. The business’ input costs could also be negatively impacted if Chinese manufacturers of solar system were to go out of business. Furthermore, changes in the domestic economy could also impact the business. For example, inflation and interest rates impact the cost of financing available to customers, and less than expected economic growth may erode investor confidence.

**Table 6: Risks and Mitigation**

<table>
<thead>
<tr>
<th>Risk</th>
<th>Mitigation Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expansion and Grid Tariff</td>
<td>Foster relationship with officials to be up to date on expansion and tariff changes</td>
</tr>
<tr>
<td>Contract Enforcement</td>
<td>Push sales model over PPA-model</td>
</tr>
<tr>
<td></td>
<td>Require collateral as part of PPA-model</td>
</tr>
<tr>
<td></td>
<td>Partner with SEZ management</td>
</tr>
<tr>
<td></td>
<td>Check customers’ reputation and financial health</td>
</tr>
<tr>
<td></td>
<td>Penalty provisions in PPA</td>
</tr>
<tr>
<td>Adverse Macroeconomic Developments</td>
<td>Diversify customer base</td>
</tr>
<tr>
<td></td>
<td>Partially self-mitigating since some inputs will become cheaper during an economic crisis if demand for them falls.</td>
</tr>
</tbody>
</table>

**5.5 Expected Returns and Hypothetical Business Model Discussion**

In evaluating the solar market in Cambodia, we consider a business model that includes both third party and direct ownership models. The business model’s revenue sources include the sale of electricity generated through third party owned systems, direct sale of solar systems, as well as through ongoing maintenance services. For example, returns from the sale of electricity produced by a 165kW solar system over 24 years yield $65,000 in risk adjusted 2016 dollars, implying an IRR of 19% and a payback period of seven years. At the same time, the customer return is equal to real savings of $124,000 over the life of the installation creating a significant incentive to invest in a solar
system owned by a third party. Under the direct ownership model the gross profit on the sale of an equally sized system is $25,000 (assuming a 12% retail margin) and the customer saves approximately $725,000 over the system’s lifetime. Discussed returns to the developer and the customer are largely based on a number of assumptions that hold throughout the business model (see Table 7).

Table 7: Financial Model Assumptions

<table>
<thead>
<tr>
<th>Category</th>
<th>Highlights</th>
<th>Impact on IRR and NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Cost</td>
<td>Original system cost of USD 176K based on a pricing quote from local supplier in Cambodia – lowering the system cost will lead to profitability improvements.</td>
<td>![Graph]</td>
</tr>
<tr>
<td>System Output</td>
<td>Average system output—233,991 kWh/year—is key in revenue generation. Any decrease in system output will have a very significant impact on the profitability of electricity sale business model.</td>
<td>![Graph]</td>
</tr>
<tr>
<td>Grid Electricity Price</td>
<td>Beginning price level of grid electricity is $/kWh 0.21 and subsequently decreasing at 2% YOY – change in the pace of electricity price decline or in the beginning grid electricity tariff will significantly impact the financial performance of a solar installation.</td>
<td>![Graph]</td>
</tr>
<tr>
<td>Inflation</td>
<td>Assumed level of inflation 3.5% - change to inflation will have significant impact on equity returns.</td>
<td>![Graph]</td>
</tr>
<tr>
<td>Discount Rate</td>
<td>Assumed discount rate of 14% - any change to discount rate will impact NPV significantly.</td>
<td>![Graph]</td>
</tr>
<tr>
<td>Margins</td>
<td>Solar tariff discount vs. grid tariff and sales margins are assumed to be $0.02 and 12% respectively. Markup on O&amp;M service fee of 15% was assumed – changes to markups impact profitability of the model significantly</td>
<td>![Graph]</td>
</tr>
<tr>
<td>Timing</td>
<td>Timing of entry into solar market in Cambodia will have significant impact on profitability of electricity sales given the assumption that electricity price will continue to decrease YOY until it reaches its sustainable level of $/kWh 0.10.</td>
<td>![Graph]</td>
</tr>
</tbody>
</table>

In considering scalability of electricity and system sales to clients, we modeled the business on 25 years of operations in Cambodia. The model assumes a total of 200 industrial solar system installations sold (150 direct system sales and 50 customers buying solar electricity output for 24 years of operation). The returns on the overall business yield $3.2 million dollars risk adjusted and an IRR of ~22% with a 12-year payback period. The below graph presents discounted cash flows from the analysis of this business model.
It is important to consider the potential for return variability of the electricity sale model based on the grid tariff prices at the time of system’s installation and the investor’s cost of capital. Sensitivity results show that a mere $/kWh 0.01 change in the grid tariff has a potential to either significantly increase or decrease the risk adjusted value of returns. Our base case, yielding an NPV of $65,000 and a 19% IRR per installed system, assumes a grid tariff of $/kWh 0.21 and a cost of capital of 14%. The best case generates an NPV of $139,000 and an IRR of 22% based on a cost of capital of 12% and a $/kWh 0.23 grid tariff price, while the worst case assumes a cost of capital at 16% and a grid tariff rate of $/kWh 0.17 grid tariff rate, yielding a negative NPV 19,000 and an IRR of 14%.

6. ALTERNATIVE BUSINESS MODELS

A range of other solar business models were also considered. Solar Home Systems and Solar Mini-grids are particularly common in many developing countries. However, for reasons discussed below, these models make a less convincing business case in the context of Cambodia.

6.1 Solar Home Systems

The value proposition for solar home systems (SHSs) in off-grid areas of Cambodia is strong and their potential social impact is clear. However, this market is less attractive to investors due to unsolved
challenges around logistics, consumer perceptions, and lack of scale. Taken together, these litany of factors introduce significant risks with limited upside returns.

Existing Landscape
A number of for-profit SHS companies are already operating in Cambodia, although their long-term financial viability was uncertain at the time of writing. Most of them are based in Phnom Penh with sales offices in one or two provinces and are not directly competing with one another. They have faced an uphill battle because poor consumers tend to be risk-averse and unwilling or unable to make the upfront investment for a SHS. Profit margins on systems sales are also slim. Increases in rural income and future regulatory changes could make this a more attractive market in the future, but at this point in time the business model's risks appear to outweigh its potential returns.

Market Size
We estimate the addressable market for solar home systems to be about $500-$750 million, based on the size of the market currently served by battery charging stations.40

SWOT Analysis

Strengths

- **Strong value proposition**: SHS give households access to electricity at a lower cost and greater convenience than the most common alternative, car batteries. Rural households spend between $150 and $300 per year on car batteries, not counting the opportunity cost of having to carry batteries to the charging station every couple of days. High quality SHS cost between $400 and $600, including several appliances such as light bulbs, fans, and even TVs. These types of systems have payback periods of 1-2 years.41
- **Clear social and environmental impact**: SHS generate fiscal savings for households, as well as reduce diesel consumption (battery charging stations powered by fossil fuels) and toxic waste (frequent battery disposal).

Weaknesses

- **Logistical**: Off-grid customers are hard to reach, increasing the costs of sales, distribution, and maintenance, and reducing economies of scale.
- **Financial**: Inventory costs can be high and difficult to manage. The upfront cost is unaffordable to most off-grid households. Numerous SHS businesses interviewed reported access to finance as a major barrier to success.
- **Reputational**: The poor performance of existing solar products caused by the sale of low quality solar panels that were not paired with appropriate batteries, maintenance, and / or other necessary components has given solar PV a negative reputation among many rural households. As a result of SHS’ damaged reputation, solar companies described having to invest heavily into awareness and education campaigns to rehabilitate solar’s image and stimulate demand.

Opportunities

- **Economies of Scale**: Unlocking economies of scale in assembly and distribution could make SHS companies more affordable to their target market and improve profit margins.
Consumer Finance: Partnering with microfinance institutions, as several companies already have, can help customers overcome the initial investment barrier.

Donor Support: NGOs, multi-, and bilateral donors could help reduce the cost of SHS for customers. The French AFD and Dutch SNV are currently implementing a program to provide up to $6 million in concessionary loans and $2 million in grants to MFIs to make SHS financing more affordable.

Advertising: Building a trusted brand through advertising and word of mouth could help overcome reputational problems in the medium term. Several companies recently made a step in this direction by establishing the Solar Energy Association of Cambodia, whose goals include addressing the issues of quality and reputation.

Threats

Grid Expansion: Uncertainty about the government’s grid-expansion plans may make rural households hesitant to invest in SHS, which, at about $0.66/kWh, is significantly more expensive than power provided through the grid.

6.2 Mini-Grids

There are many diesel mini-grids run by IPPs operating profitably in areas not yet connected to the grid. However, due to prohibitive government regulation and barriers to scale, solar mini-grids are a less attractive business model compared with other models, such as system sales to industrial clients. The EAC is no longer granting new IPP licenses, without which, it is not possible to sell electricity. Additionally, with Cambodia’s sparse population distribution, it would be difficult to reach the necessary scale to become commercially viable. Under certain scenarios it would be possible to distribute and sell power from a solar mini-grid, such as contracting under an existing IPP. However it would be difficult to rely solely on this model as a standalone business alone without a broad capital base and other revenue streams.

Existing Landscape

To our knowledge, there are no operating solar mini-grids in Cambodia. In at least one case, a solar mini-grid was established; however, the national grid expanded into the community and now provides electricity without the use of solar.

Strengths

- **Economic:** Offers a cheaper alternative to diesel mini-grids, with potential for high operating margins.
- **Financial:** Potential for auxiliary revenue streams (mini-grids can power SMEs, refrigeration, etc.)
- **Clear social and environmental impact:** The social impact lies in the ability to provide off-grid customers with affordable electricity. The environmental impact lies in a cleaner alternative to diesel generation.

Weaknesses

- **Regulatory:** Selling electricity in Cambodia requires a government-issued IPP license which must be applied for and approved by the EAC. However, as of January 2015 the EAC is no longer issuing any new IPP licenses. Therefore, it would be very difficult for a new player to enter this market.
Scalability: Given Cambodia’s low population density, it would be difficult to scale a mini-grid operator. Mini-grids would only be feasible in rural areas where the grid is not expected to arrive in the near future, and these areas tend to be sparsely populated. For reference, one successful and growing solar mini-grid business is Mero Gao Power operating in Uttar Pradesh, India. The population density of Uttar Pradesh is 828 person/km², while in Cambodia population density is only 84 person/km², and <1 person/km² in rural areas.  

Financial: High CAPEX and OPEX (staff, maintenance, payment collection) requirements.  

Logistical: Billing and payment requires usage measurement, payment collection and enforcement. Prepaid and pay-as-you-go meters are expensive. This can be a challenge given staff costs and the unstable cash flows of rural customers.

Opportunities

- **Mini-grid as a component of larger business model:** A company with other, similar business lines (i.e. SHS retailers, solar developers, etc) that could leverage existing assets, relationships, and other resources could potentially operate solar mini-grids profitably as an extension into a space adjacent to their existing business.  
- **Contract under existing IPP:** In order to eliminate the need to obtain their own IPP license, a mini-grid operator could negotiate directly with an existing IPP license holder to obtain the rights to distribute and sell power under the existing license. This would require creating a financial incentive for the license holder to enter a partnership.  
- **Buy existing IPP license:** It is legally possible to buy an existing IPP’s license from them (i.e. a license transfer), however this would need to be approved by the EAC, and would be prohibitively expensive.

Threats

- **Grid expansion:** Uncertainty over the government’s grid expansion plans may deter investors and customers alike from pursuing solar mini-grids. Because net metering is not available, once the grid arrives, mini-grids would not be allowed to sell excess energy back into the grid. In this situation, the mini-grids could use their existing transmission infrastructure to distribute electricity, however, the tariff would be dictated by EAC regulation, and any solar equipment would likely be rendered useless.  
- **Financial:** On-going costs (staff, maintenance, payment collection) require predictable and stable cash-flows to de-risk the investment. In rural areas, customers would largely be BoP customers with limited ability to pay.

7. **NEXT STEPS**

For entrepreneurs looking to move into the Cambodian solar PV space, we recommend taking the following steps:  

1. **Update the assessment of Cambodia’s macroeconomic, political, and electricity infrastructure considerations as necessary.** In particular, the entrepreneur should consider factory construction in and outside of the SEZs, as well as new grid tariffs in areas of factory construction.  
2. **Identify input suppliers, including possible savings through bulk purchases.** Most high-quality, cost-competitive producers are currently in China, but domestic Cambodian and regional production in ASEAN is likely to expand in coming years.
3. Due to tight and complex electricity regulation, it is important to validate the legal aspects of any proposed business model.
4. Consider financing requirements, including any subsidies available for renewables from philanthropic or government sources.
5. Define contract templates and standard terms for both the power purchase and sales models.
6. Identify primary target clients and initiate contact with industry associations, such as the Garment Manufacturers Association of Cambodia.

8. **CONCLUSION**

High grid tariffs, low grid reliability, and high solar irradiation make Cambodia an attractive location for private investment into the solar PV market. Entrepreneurs who act quickly, before new hydropower generation and grid expansion lowers grid prices, can expect significant returns. In particular, the growth of industrial facilities and other large commercial buildings presents a significant opportunity for investments. These investments have the potential to bring a range of benefits including profits for the project developer, lower energy costs for customers, and less GHG emissions for society more broadly due to fossil fuel displacement.

However, several factors pose significant risks to the feasibility and expected returns of the proposed investment, including uncertain grid expansion and tariffs, political risks, contract enforcement, among others. It is important to note that there are also other investment opportunities in renewable energy in Cambodia which may be worth investigating, such as biomass and hydropower. Here we have presented what we consider to be the most attractive model for a commercially viable investment for solar PV in Cambodia. Furthermore, future policy changes from the Cambodian government, in particular the removal of licensing requirements for electricity distribution sales and allowing net metering, could greatly catalyze the solar PV market.
9. ANNEX

Annex I: Population Density Map


Annex 2: Map of Special Economic Zones in Cambodia

Source: Open Development Cambodia. http://www.opendevelopmentcambodia.net/

Annex 3: Solar Irradiation Map of Cambodia
Annex 4: Map of Phnom Penh Special Economic Zone

Annex 5: NPV Sensitivity (Single & Multi System Electricity Sale) for Change in Cost of Equity and BoP Grid Tariff
### NPV Sensitivity Analysis (Single System)

<table>
<thead>
<tr>
<th>CF Discount Rate</th>
<th>5%</th>
<th>10%</th>
<th>15%</th>
<th>20%</th>
<th>25%</th>
<th>30%</th>
<th>35%</th>
<th>40%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Savings</td>
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<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Cost of Equity</td>
<td>1.00</td>
<td>0.81</td>
<td>0.63</td>
<td>0.45</td>
<td>0.27</td>
<td>0.09</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Discount on Solar Tariff to Client</td>
<td>1.00</td>
<td>0.71</td>
<td>0.41</td>
<td>0.10</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

### NPV Sensitivity Analysis (Multi System)

<table>
<thead>
<tr>
<th>CF Discount Rate</th>
<th>5%</th>
<th>10%</th>
<th>15%</th>
<th>20%</th>
<th>25%</th>
<th>30%</th>
<th>35%</th>
<th>40%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Savings</td>
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</tr>
</tbody>
</table>

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**Annex 6: NPV Sensitivity (Single & Multi System Electricity Sale) for Changes in Cost of Equity and Discount on Solar Tariff to Client**

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2 CIA World Factbook.
9 KPMG Investing in Cambodia, 2012.
11 Cambodia Article IV Consultation, IMF 2013.
12 Cambodia Article IV Consultation, IMF 2013.
17 World Bank. 2013. “World Development Indicators.” Accessed April 19, 2015, at data.worldbank.org/data-catalog/world-development-indicators. Cambodia number reflects the electrified population only, the countrywide average is 164 kWh per capita.
20 Electricity Generating Authority of Thailand. www.egat.co.th
21 Electricity Authority of Cambodia. www.eac.gov.kh
24 Authors’ calculations based on information from International Energy Agency
25 Interviews with public and private stakeholders
26 We expect the total number of factories in the country by 2025 to be roughly 2,200, 15% of which are currently operating, 60% of which will be operating by 2020, and 100% of which will be operating by 2025. The mean base load demand for factories in the Phnom Penh SEZ is 179 kW, so we have assumed a mean
installation capacity of 165 kw. Using 100% market penetration, we expect roughly $300,000-$350,000 in present value revenue for 2015 per facility.

27 Electricity Authority of Cambodia. www.eac.gov.kh

28 Here we only discuss the power purchasing agreement variant of the third party ownership model. The economics and benefits and drawbacks of the leasing variant are very similar.

29 This type of transaction represents a legal grey area. The input of local legal experts is required to ensure that it is in line with current regulation. In order to avoid regulatory delays, this model could also be structured as a lease agreement as part of which the customer makes a monthly lease payment that is determined based on the anticipated system output and grid tariff pricing.


34 List of garment factories can be accessed at: http://www.sithi.org/temp.php?url=bhr/bhr_list.php&lg=

35 Estimation provided by Chief Operating Officer of Phnom Penh Special Economic Zone, January 2015.


38 List of registered SEZs can be accessed via the government website at: http://www.cambodiainvestment.gov.kh/list-of-sez.html


40 3.34 million households * 65% electrification rate * 60% usage of car batteries * $400 - $500 retail price of SHS

41 Another way to demonstrate this is to compare cost per kWh, which is around $0.66 for SHS (assuming battery life of 3 years and system life of 5 years) and $1.6 – $2.40 for an equivalently sized battery


43 A list of Special Economic Zones can be found at http://www.cambodiainvestment.gov.kh/list-of-sez.html and a list of garment and shoe factories at http://www.sithi.org/temp.php?url=bhr/bhr_list.php&lg=

44 The GMAC can be contacted at www.gmac-cambodia.org