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Detroit Solar Financial Models Report

Our Team

THIS TOOLKIT IS SUPPORTED BY A TEAM LEAD BY ELEVATE ENERGY WITH PARTNERS DETROIT COLLABORATIVE DESIGN CENTER, DATA DRIVEN DETROIT, ECOWORKS, GREAT LAKES ENVIRONMENTAL LAW CENTER, MICHIGAN ENERGY OPTIONS, AND THE NATIONAL RENEWABLES ENERGY LABORATORY.

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Introduction

The City of Detroit conducted a Citywide Solar Feasibility Assessment to investigate and determine the potential for solar energy generation at different scales in Detroit. The study aimed to gather insight and recommendations from the greater community associated with or currently working toward solar energy deployment. Upon completion, the DSF has produced the following five items as a foundation of work. This foundation is a set of solar photovoltaic (PV) deployment tools to be utilized by all parties undertaking the equitable deployment of solar energy as a path to a more sustainable future for residents of Detroit.

- Online Solar Map: Geographically assesses areas in Detroit that are suitable for solar energy generation.
- Solar Policy Deployment Guides: Analyzes the current legal and regulatory framework governing solar energy at the state and city level.
- Solar Design Guidelines: Makes recommendations for the design and siting of solar energy projects in Detroit neighborhoods.
- Detroit Citizen Solar Toolkit Guide: Makes recommendations for potential co-benefits of solar energy with a focus on community benefits.
- Detroit Solar Project Leaders Toolkit
- Detroit Solar Financial Model Report : Details financial feasibility and operating models for solar development.

Background

The study completed for the City of Detroit was completed in phases to gather insight and recommendations from the greater community associated with or currently working toward solar energy deployment The World Café Format, a round table discussion on specific topics, enabled participants to contribute on different themes and listen, speak, or write down thoughts. This format was chosen to allow participants a full spectrum of contribution opportunities while encouraging a dynamic discussion that could build on the feedback of prior participating groups. Throughout the Detroit Solar Feasibility Assessment there were two sessions hosted in World Café Format, and two additional breakout sessions were held at Office of Sustainability (OoS) Action Agenda Forums as part of a resource-sharing strategy to gather input from Detroit residents. Members of the DSF team attended the other sessions hosted by the OoS to support the Action Agenda engagement process.

This Financial Model Report for the City of Detroit includes public input from the activities mentioned above and input from the City of Detroit's solar interdepartmental work group. Energy audits for select City-owned facilities were reviewed to identify the best candidates for solar based on the Solar Design Guidelines and poorly performing buildings that could benefit from solar offsetting high utility costs.

Deciding if a Project is a Good Investment

This Detroit Solar Financial Model Report is meant to provide high-level guidance in considering whether or not a solar project is a good investment. It covers the two main categories of questions to ask to decide if a project is feasible. These two categories of questions are related to technical and financial considerations.

First, there are technical issues such as the "siting" of an array on the property. Questions include, is there room for solar panels? Is the property or building roof oriented in the right direction to get the most sunlight possible? Solar power needs an unobstructed orientation to the south and/or southwest to produce its maximum output. It is true that solar applications can face east and west (not north), but the efficiency is greatly reduced while pointed in these directions.

A U.S. Department of Energy Study found that more than 40% of commercial rooftops are not good candidates for solar because of their orientation, structural integrity, and ownership (i.e. the building is rental space).[1]

Second, there are financial decisions to make as it relates to array ownership and operation. The property owner can purchase and own all the equipment and operate the system themselves. Or, they can enter into a "Power Purchase Agreement" (PPA) with a third-party developer. In PPAs, the property owner leases the space to the solar array owner and purchases power from the array from the developer at a lower cost than the local utility provides. The solar array owner can take advantage of federal tax credits the city cannot utilize. Other financial considerations are the local cost of energy and the amount of energy used at a facility. A related question considers building use. Is this building, among a portfolio of properties, likely to still be in operation 25 years from now, which is the industry's estimated lifespan for a solar array?

Timing of capital improvements for a building also needs to be factored into a solar decision. Is the roof scheduled for replacement soon? Is the roof itself structurally sound to handle the additional loading of the PV system?

Solar Decision Trees

For a solar project to be a good investment, it needs to be both technically and financially feasible. Decision trees can help in thinking through the considerations discussed here. The solar decision tree created by the U.S. Environmental Protection Agency and the National Renewable Energy Laboratory is one good and thorough example of a highly technical solar decision tree.[2] For this project we have created a Solar Decision Tree included in the Appendix to guide the City of Detroit's decision making process in evaluating the Solar Opportunity Spreadsheets provided to the city.

The tools presented in this assessment, and named in the Introduction, will allow the City to determine whether a solar project is viable or not. Appendix A explains in more detail how to use the Solar Opportunity Spreadsheets including inputs, adjusting optional parameters, and other features. Spreadsheet tools for select facilities within the City are included in the Appendix. The tools are intended to be included as interactive spreadsheets.

Solar Generation Potential in Michigan

Throughout Detroit, southeast Michigan, and the state, the sun shines in roughly equal amounts. The average "annual solar radiation value" for Detroit is 4.26 kilowatt hours per square meter per day (kWh/m2/day).

To provide some context, this is 14% more than a city in the state of Washington and 35% less than a city in Nevada. The solar radiation value tells you how efficient or productive solar energy will be based on your location. To elaborate on this, solar panels have a "capacity factor" of around 15% in Michigan. This means a solar installation is producing electricity about 15% of the time. This makes sense since half of the time we're experiencing night. Even at a maximum, solar could produce only 50% of the time. From here, the percentage drops for a number of

1 https://www.nrel.gov/docs/fy15osti/63892.pdf

2 http://resources.cleanenergyroadmap.com/Source_EPA-Solar-Decision-Tree.pdf

factors including weather and latitude. Michigan can be cloudy and overcast. The highest performing solar states are California, Arizona, and Nevada, which have capacity factors over 25%. In other words, of the potential daylight every day, roughly half of it comes as sunshine in these places. Michigan is 10% below that in solar performance—but still high enough to make it worthwhile to invest in solar systems. Although Michigan is cloudier than places like Arizona or New Mexico, it still has solar potential. Germany invested heavily in solar and now provides almost 7% percent of the country's energy needs, and Michigan has even more sun than Germany.[3]

Choosing a Location for Solar in Detroit

Where to locate a solar array in an urban environment like Detroit requires careful consideration. While the sun may shine equally across the city, all potential locations for solar are not equal.

Whether a solar installation is on a rooftop, built into a canopy over a parking lot, or constructed on an open space like a vacant lot or brownfield site, it is important to think about potential future redevelopment of neighboring properties. Solar access is an emerging issue and refers to the risk that something could physically block the sun from shining on an array in the future. As part of this study we have prepared a local city policy guide discussing specific zoning changes that can address these issues.

Additional trending issues for urban solar include locating an array on a brownfield and whether that constitutes the most economically productive adaptive reuse of that site. Most solar installations are constructed to be in place for at least 25 years, if not longer. Another issue is the state of the existing electricity distribution grid and how new solar installations could interact with the current grid in the city. The Detroit City Solar Map prepared as part of this study can help identify where solar is feasible; however, interconnection to the grid and other utility requirements dictate consultation with DTE. Finally, another growing issue has to do with proximity to populations and the lack of open space to place solar. This clean, renewable, and local energy resource has a "land-use footprint" that is not insubstantial, especially if located on the ground and not on roofs or as parking lot canopies. For example, 1,000 panels require two acres of space and will house 350 kilowatts of power, which is enough to provide electricity to 60 homes. A typical city block is approximately 2.25 acres.

Today, in Michigan "solar penetration" (how much of the energy market is comprised of solar energy) represents only about one percent of the overall utility fuel mix (coal, natural gas, wind) and this percentage comes primarily from large solar installations located in rural areas. Smaller solar arrays, such as rooftops, account for just 0.02% of the market. By conservative estimates, solar is going to grow significantly in the state in the years ahead as solar costs come down, utilities retire aging coal plants and switch to renewable energy, and communities and businesses desire to adopt more solar locating or "siting" solar will increasingly become a land use consideration for local governments.[4]

3 https://solarenergylocal.com/states/michigan/detroit/

4 https://www.michigan.gov/documents/mpsc/2019_Feb_15_Report_PA_295_Renewable_Energy_646445_7.pdf

Focusing on Energy Efficiency is Crucial

Solar generation is most effective on buildings that are already energy efficient. The combination of an energy efficient building, or ongoing energy efficient upgrades, followed by onsite solar is the best "clean energy" investment a building owner can make for an existing building because the solar panels generate a larger portion of the buildings' energy use. However, the order can vary. For example, a building owner could have a budgeting mechanism for solar (like a Power Purchase Agreement) that would allow moving forward immediately on onsite solar. But there is no comparable budget for energy efficiency. In this case, the building owner might move forward with the solar first with a plan to make energy efficiency improvements as funding becomes available. Nevertheless, energy efficiency is the most cost-effective investment. A report from the Michigan Public Service Commission found that $1 invested in energy efficiency returned more than $4 in avoided future energy costs.[5]

A technical energy audit is needed to understand how energy efficient or inefficient a building is. "An American Society of Heating, Refrigerating and Air-Conditioning Engineers) Level Two" (ASHRAE II) audit is a type of energy audit that includes utility bill analysis and a physical assessment of the building's lighting, cooling, heating, and other systems. This audit provides the building owner an "Energy Use Intensity" or EUI. The EUI tells how efficiently energy is being used per square foot of building and compares its performance against similar buildings in a national database. For a building to be a good candidate for solar, its EUI should be comparable to or lower than national averages. Solar also may be more appropriate for a building that has a relative "constant load," which means it uses energy at roughly the same rate daily and operates ideally as much as seven days a week all year. Finally, another consideration is to size an array so the power is consumed onsite or "behind the meter" instead of overproducing and sending surplus power to the electric grid.

While solar energy is becoming more affordable, it still represents a cost per unit of energy that is higher than many energy efficiency investments, such as replacing old lighting with new LEDs, or adding variable speed drives to motors, or changing a building energy management system schedule to match the site operational hours. If it is not possible to address all possible energy efficiency improvements prior to installing solar, it is important to continue to make these improvements. The upfront energy cost savings from installing solar can be set aside as a fund to do even more energy upgrades. Energy efficiency is an ongoing maintenance operation, especially as new and more innovative technical solutions come into the market.

5 https://www.michigan.gov/mpsc/0,4639,7-159-16400_17280-460305--,00.html

Case Studies

Choosing Case Study Locations

One goal of the Citywide Solar Feasibility Assessment was to identify city-owned properties that were good candidates for installing solar. There were many criteria used to choose which properties to study in this Opportunity Assessment. Summaries of each of the Case Study spreadsheets is included in the Appendix. Analyses were completed utilizing calculations and spreadsheets designed specifically for the City of Detroit including solar capacity, costs, and financial payback to help prioritize investments in solar development.

Reducing operating costs, and saving tax payer dollars was flagged as a high priority. That led to the decision to look first at active government facilities. A building Typology Matrix is is included in the Appendix to provide information on the opportunity for various typologies for solar in Detroit. Additionally, a Solar Financing Typology Matrix is included in the Appendix to help identify different financing options for various typologies. In accordance with the Detroit City Decision Tree it is extremely important to address energy efficiency before or during a solar installation, as such the decision was made to look first at the active City facilities that had recently had a technical energy audit. Opportunities for energy efficiency and solar from select City recreation centers and police precincts are shown in Figure 1. The work had already been done to identify ways to reduce the energy usage of these buildings, so there was a clear understanding of efficiency projects that could be included with a solar installation. Based on the Typology Matrix the team analyzed the opportunity for solar on a recreation center, police precinct, and a proposed nonprofit affordable housing project.

Public priorities gathered through outreach sessions described in the Background section of this document were then used to further narrow the list of properties. Residents and stakeholders had identified visibility, educational opportunities, and resiliency as important considerations. They wanted solar installations to be visible to building users and people passing by to send a message that the City government values renewable energy. They wanted the installations to be on places like recreation centers that have many daily visitors, especially children, because of the potential to use the arrays to educate people on solar. They also wanted to see solar on facilities in neighborhood structures that are critical in emergencies, like heating and cooling centers, because of the potential for solar to be utilized as backup power source with battery storage systems. Increasingly, solar developers and utilities are looking at combining solar arrays with large rechargeable batteries because of the ability to use power stored onsite when the sun is not shining. This is known as "solar plus storage." Argonne National Laboratory (ANL) is a partner of the City of Detroit and is currently analyzing solar plus storage modeling opportunities for the City of Detroit to evaluate along with this assessment.

Understanding the Financial Spreadsheet Tool

The spreadsheet tool in the Appendix is a dynamic spreadsheet that is designed to analyze the buildings identified in this project and can be used to analyze future projects. The "Net Metering Owned by the City of Detroit" column shows upfront costs. This is the cost to purchase and install a solar system whether it is on a roof top, on an awning in a parking lot, or is a ground mount on vacant land near a facility. The solar industry uses the "installed watt cost" to gauge the average price to develop solar. The installed watt cost varies by the size and type of installation. A "utility-scale" project that is in megawatts of solar located on open, flat land is cheaper per watt to build than a rooftop array that might be only a few kilowatts in size. The installed watt cost for rooftop solar as modeled, and for the other case studies, is about $2.28, which is a number estimated as average by the National Renewable Energy Laboratory.

The "average annual savings tab" indicates how much the city would save annually in utility costs. This figure is an average over the 25 years of the estimated life of the array and reflects the Payback Period in Years. The 25-Year Costs line item includes the expense to build the array and the estimated operations and maintenance (O and M) over the 25-year period. While solar is durable and has few moving parts, inverters (which are mechanical) often need to be replaced 10 to 15 years into the life of an array. Other routine maintenance includes the possibility of replacing a failed panel and upkeep on wiring and other components in the system. The 25-Year Revenues reflect the monetized value of the energy (kWh) the array would produce. Included in this calculation are the monetized kilowatt-hours savings, REC payments, interest on annual reserve, and capital costs, which as modeled here are 0.

The 25-Year Net Benefits is a financial calculation of the difference between 25-Year Net Revenues and 25-Year Costs. The 25-Year Net Present Value is positive, which signals a sound investment.

Financial Model Assumptions and Metrics

Excel-based financial models were created for each site. The models developed for this analysis include a number of inputs derived from industry averages that can be found in the individual models. A summary of key assumptions is listed here:

- 25-year system life
- Installed cost $2.28 - $2.90/watt depending on system type and size
- 14% capacity factor
- 0.50% annual derate (Calculation used to determine limitations to solar output based on clouds, angle to the sun, and dirt in the air specific to Detroit.)
- 2.5% annual energy cost increase
- Net Present Value discount rate of 3.0%
- No tax benefits for municipally-owned systems

The model creates individual pro forma for each of two different onsite deployment methods:

- Municipally Owned Distributed Generation: General Market
- Power Purchase Agreement (PPA): General Market

		Adams Butzel Complex	4th Precinct	Williams Center	Butzel Family Center	Lasky Center	Clemente Center	Total
Energy Assessement Summary	**Annual Electric Utility Costs**	$194,480	$149,706	$121,857	$102,844	$28,127	$34,297	$631,310
	Energy Uses Intensity (EUI)[1] (kBTU/F *2)	205.3	136.2	171	126.1	81.4	93.5	135.6
	Energy Efficiency (EE) Retrofit[1]	LED & Controls[2]	LED & Controls[2]	LED & Controls[2]	LED & Controls[2]	LED & Controls[2]	LED & Controls[2]	LED & Controls
	Retrofit Cost[1]	$176,840	$117,105	$140,364	$90,333	$80,212	$59,538	$664,392
	Annual Cost Savings[1]	$14,713	$24,099	$23,357	$7,557	$5,363	$6,014	$81,103
	Utility Cost Percent Savings	8%	16%	19%	7%	19%	18%	14%
	Payback Years	12 .0	4.9	6	12	15	9.9	9.9
Solar Analysis[3]	**Solar Array kW**	273.1	371.1	273.1[4]	243.0[5]	30.1[6]	30.1[6]	1,221
	Solar Installation Cost	$656,501	$933,771	$656,501	$567,405	$89,096	$89,096	$2,992,370
	Annual Solar Utility Cost Savings	$47,735	$68,158	$47,735	$41,416	$6,319	$6,319	$217,683
	Total Annual Utlity % Savings	25%	46%	39%	40%	22%	18%	32%
	Payback Years	13.8	13.7	13.8	13.7	14.1	14.1	13.9
Total Project City Financed Solar & EE Retrofit	**Upfront Cost**	$833,341	$1,050,876	$796,865	$657,738	$169,308	$148,634	$3,656,762
	Total Annual Savings	$62,448	$92,257	$71,092	$48,973	$11,682	$12,333	$298,786
	Total Annual Utility % Savings	32%	62%	58%	48%	42%	36%	46%
	Payback Years	13.3	11.4	11.2	13.4	14.5	12.1	12.7
Total Project PPA & EE Retrofit	**Upfront Cost**	$176,840	$117,105	$140,364	$90,333	$80,212	$59,538	$664,392
	Total Annual Savings	$20,292	$31,680	$28,936	$12,521	$7,980	$8,631	$110,040
	Total Annual Utility % Savings	10%	21%	24%	12%	28%	25%	20%
	Payback Years	8.7	3.7	4.9	7.2	10.1	6.9	6.9

1 = National Median for similar buildings is approximately EUI 46 kBTU/F2.
2 = Data collected from the City Wide Audit Project completed by SEEL.
3 = Includes Rooftop and Parking Lot Awning Solar Systems.
4 = Utilized solar rooftop and awning analysis from Adams Butzel Center recommend site specific analyses.
5 = Utilized solar rooftop analysis from Adams Butzel Center recommend site specific analyses.
6 = Utilized solar awning analysis from Adams Butzel Center recommend site specific analyses.
7. = Solar percent savings and payback are based on pre-energy efficiency improvements.

Figure 1 *Energy Efficiency Plus Solar Financing Assessment*

Adam Butzel – Ownership Model

The Adam Butzel Recreation Center emerged as a strong candidate for solar as it includes several unique characteristics that make it a good choice for solar: a sizeable, consistent, utility energy load with ample space for panels on the roof as well as in the parking lot and elsewhere on the property. While solar is ideally introduced to an energy efficient building, the opportunity to combine energy efficiency plus solar create a powerful opportunity to create large energy savings. The Detroit City Solar Decision Tree follows this path identifying City buildings that have high energy consumption to analyze energy efficiency and solar savings that can create large benefits for City budgets. The national average EUI for a recreational facility is 46. Butzel is 126, or, 174% higher. This brings about an interesting possibility when considering the financial payback of energy efficiency plus solar. Figure 1 shows energy efficiency lighting upgrades producing 8% savings coupledwith 25% savings from a solar system could save the city over 30% in utility costs. For most nonprofits, including the government, owning solar generation can be problematic because those entities cannot qualify for the federal Investment Tax Credit (ITC), which is currently at 30%. Similarly, these entities cannot realize the accelerated depreciation of the solar equipment. Both of these financial incentives are reserved for for-profit companies. The typical capital stack for solar development today includes a "tax equity investor," in which the return on investment comes as forgiveness of taxes owed and accelerated depreciation of the solar assets. This structure has the effect of a return on investment for a solar project in the range of six or seven years. Without the ITC, solar projects have a payback of 12 to 14 years, on average. On May 9, 2019, DTE rates are set to increase by up to 8.69% for residential customers and up to 4.34% for commercial/municipal customers. Locking in a rate with a solar PPA provides resilience to ongoing price increases. Rates have steadily increased since the 1990s with residential customers paying 80% more in 2019 and commerical/municipal costs are almost 30% higher.

Further, a a building owner could "reduce" the payback on a solar project by combining it with other energy efficient upgrades and treating the ROI as a combined number. In other words, a lighting upgrade, which Adam Butzel Recreation Center needs, could have an ROI of less than one year. Other improvements would also have relatively short paybacks. Add the solar financing into this overall mix, and the blended payback for all of these clean energy improvements would be less than the solar alone.

However, this assumes that the City would want to own the solar array at Adam Butzel Recreation Center or at any of the buildings highlighted in these case studies. Ownership is one option but it comes at a higher price for a nonprofit than a for-profit. The common alternative in the industry is for a third party, sometimes referred to as a Special Purpose Entity (SPE), which is a for-profit company, to own and operate the solar array and to sell the power to another entity—a City, for example—through a Power Purchase Agreement (PPA).

The Power Purchase Agreement financial model eliminates the upfront cost of installing solar and instead negotiates a kilowatt-hour price for the solar energy generated from a solar developer. Typically, the price is at or near what the building owner is currently paying the utility for energy from the grid. This price is either fixed for the term of a contract, typically 25 years, or has an escalator that parallels the rising rate of utility electricity. This known cost for a portion of energy usage at a building becomes, in effect, a hedge against the unknown: the rising rates of utility-generated electricity. A 2018 news article found that Consumers Energy and DTE Energy received a total of 15 rate increases since 2003.[6] Electricity rate—though not as ironclad as death and taxes—are all but certain to increase in the years ahead.

A PPA project differs from one the City would own and operate in that the SPE would be responsible for the array producing electricity, which includes maintaining its performance. Warranties for solar equipment and service vary but are typically relatively long-term at ten years or more. Furthermore, PPAs that include solar performance contracts are becoming more commonplace in the state, and, as such, are increasingly providing conditions favorable to municipalities. While energy efficiency performance contracts for buildings can be complex affairs, solar PPAs, in comparison, are more straightforward and easier to execute for cities.

The Financial Analysis Spreadsheet in the Appendix for Adam Butzel Recreation Center, and all of the case studies in this report, provide for the following two options: the solar generation is owned and operated by the City or by a Special Purpose Entity (SPE). The Summary Tab of the Adam Butzel Recreations Center spreadsheet illustrates the essential differences between the two. Further, the analysis includes solar rooftop ("RT"), ground mount ("GM") and awning or carports.

The rooftop Adam Butzel Recreation Center Summary Tab illustrates the comparison between owning versus

6 https://www.michigancapitolconfidential.com/michigan-electricity-rates-since-2003-15-increases-1-cut

purchasing the energy from a third party. First, given the roof's size, the capacity limit for panels is 694, which is the equivalent of 243 kilowatts. This size of a system would produce enough annual energy to offset the facility utility usage by 21%. Whether owned or with a PPA, the capacity and production from the rooftop onsite solar is the same. The finances, however, are not.

Net Metering Owned by the City of Detroit

In the Adam Butzel Recreation Center Financial Analysis Spreadsheet the Net Metering Owned by the City of Detroit column has an upfront cost of $567,405. This is the cost to purchase and install the 243 kilowatts of solar on the roof. The installed watt cost for rooftop solar at Adam Butzel Recreation Center, as modeled, and for the other case studies, is $2.28, which is a number estimated as average by the National Renewable Energy Laboratory.

The average annual savings is $22,701. This figure is an average over the 25 years of the estimated life of the array. Because of the upfront construction costs with Payback Period Years estimated to be 13.7, ROI may actually be negative until the project is paid off.

The 25-Year Costs line item includes the expense to build the array ($567,405) and the estimated operations and maintenance (O and M) over the 25-year period, which is $128,340. While solar is durable and has few moving parts, inverters (which are mechanical) often need to be replaced 10 to 15 years into the life of an array. Other routine maintenance includes the possibility of replacing a failed panel and upkeep on wiring and other components in the system.

The 25-Year Revenues reflect the monetized value of the energy (kWh) the array would produce, which is estimated to be $1,263,280. Included in this calculation are the monetized kilowatt-hours savings, REC payments and interest on annual reserve and capital costs, which are modeled here are 0.

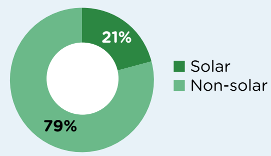
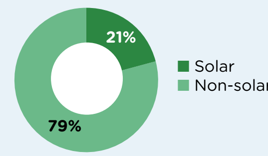
	Net Metering Owned by City of Detroit Voluntary REC Market	Power Purchase Agreement
System Size in kW	**243**	**243**
# Panels	694	694
Energy Offset:	**20.9%**  	**20.9%** 
Average Annual Savings:	**$22,701**	**$4,964**
Average Annual Savings: Subscriber	NA	NA
25-Year Costs:	($695,746)	($1,116,812)
25-Year Revenues:	$1,263,280	$1,240,902
25-Year Net Benefits:	$567,534	$124,090
25-Year Net Present Value (NPV):	$204,749	$84,538
Return on Investment (ROI) %:	181.6%	111.1%
Internal Rate of Return (IRR) %:	5.8%	NA
Upfront Costs	($567,405)	$0
Payback Period: years	13.7	0.0

Figure 2 *Adam Butzel Recreations Center Financial Model Summary Spreadsheet*

The 25-Year Net Benefits of $567,534 is a financial calculation of the difference between 25-Year Net Revenues and 25-Year Costs. The 25-Year Net Present Value is positive, which signals a sound investment.

The Return on Investment (ROI) percentage for the ownership model shows a 181% ROI, meaning that for every $1.00 invested, $1.80 is returned after the cost of the installation is recovered. Spreadsheet tools for select City facilities are included as an Appendix. The tools are intended to be included as interactive spreadsheets.

The Internal Rate of Return (IRR) can only be calculated for the ownership model with an upfront investment in the solar system. Similarly, to the payback, the IRR is relatively low at 5.8 % (desirable investments generally look to be greater than 10%) as the City of Detroit cannot take advantage of ITC tax credits that private investors utilize to improve the financial performance of the project. The low IRR does make the PPA model look more attractive; however, if other funding such as grants can be utilized, the IRR would improve based on reduced investment on the upfront costs.

The Payback Period Years of 13.7 is often what gets the attention of facilities departments in cities because that timeframe is outside of policy, which might consider a building improvement that has a payback of several years as maximum. If the City were to incur financing charges for the project capital to build and own a solar system, the payback would potential be even further out.

For a summary of energy efficiency and solar benefits Figure 1 tabulates scenarios for savings if the City invested in energy efficiency and solar combined or participating in a PPA along with energy efficiency upgrades. Various incentives and grants are available for lighting upgrades making those changes financially attractive along with a PPA.

Adam Butzel – Power Purchase Agreement

As shown in the Appendix the Adam Butzel Power Purchase Agreement Summary represents a solar financing option with no upfront costs. Returning to the Summary Tab, the Power Purchase Agreement column has several notable differences from the owned option. Most significantly there are no upfront costs. The 25-Year Costs of $1,140,902 are what the City will pay the SPE for the solar energy as part of the PPA. The 25-Year Revenues at $1,140,902 reflect the value of electricity produced which would benefit the City finances as avoided electricity costs.

The PPA is a way to reduce operational expenses (utility costs) for the City; it is not an investment, and thus the ROI isn't the appropriate financial metric. The PPA is best thought of as a way to achieve operational savings. The appeal of the PPA is that there is no upfront capital investment needed. The PPA gives the city electricity at a 10% savings compared to DTE utility supplied rate. Using a PPA with no up front cost the opportunities to deploy solar on City owned rooftop is available now. Adding 150KW or 250KW systems on high energy consuming buildings or using the economy of scale for lumping multiple building projects together, the City could add 2MW to 10 MW of solar in a matter of years. Washington D.C. recently completed a 10MW solar PPA installation on 35 municipal buildings anticipated to save tax payers $25million over the lifetime of the system.

In addition to rooftop solar, the Butzel site has the opportunity for solar awning or parking lot solar canopies. Solar canopies are increasingly appearing in the Midwest. Adaptive reuse of "non-productive land" (i.e., parking lots) allows for more solar generation at government facilities. Additionally, solar canopies can host electric vehicle charging stations and capture rainwater for reuse for landscaping. In terms of the installed watt price, solar canopies are more expensive than ground-mounted solar, but are increasingly becoming competitive with rooftop prices. In some applications, solar parking lot canopies can actually be less expensive than rooftop systems. In the case of the Adam Butzel Recreation Center property, solar canopies would add another 30 kilowatts of power on site.

Ground-mounted solar could also be installed at the Adam Butzel Recreation Center with an estimated of eight kilowatts possible. While ground-mounted solar is the least expensive to install and is typical of large "utility-scale" solar projects, urban and exurban property availability can be an issue. Issues around security and safety are also present, often necessitating ground-mounted solar to be encircled by fencing.

There is one advantage that solar parking lot canopies and ground-mounted solar have over rooftop solar: they are visible and signal to people visiting the property that clean energy is being generated here. An alternative to this if only rooftop solar is present is to include educational signage on the outside and inside of the building telling people about the clean energy being produced above their heads.

The introduction of solar, coupled with greater energy efficiency of the building, checks many boxes in a resiliency strategy for City operations. Solar and energy efficiency hedge against utility price volatility, improve energy security, mitigate onsite and at-source greenhouse gases, and improve air quality, among other benefits.

A final variation on a theme for solar at the Adam Butzel Recreation Center is "solar plus storage." Storage batteries would allow the facility to operate if it had the proper disconnect agreement with DTE in the event of a power outage. The Adam Butzel Recreation Center is designated as an emergency heating and cooling center, and, as such, makes the case for siting solar here stronger, despite its high energy consumption.

4th Precinct Police Station

s shown in the Appendix the 4th Precinct Summaries analyzes solar options on a representative police facility. Similar opportunities on other police precincts are available throughout the City. The amount of PV panels that can fit on the roof of the 4th Precinct Police Station happens to be the same as Butzel: 694. Thus, the system would be 243 kilowatts and the financials would track as they did for the recreational center. A difference between the two is that the solar would provide for 27% of energy usage at the police station, where the same solar would provide 21% of energy usage at the recreational center. If solar were added at the parking lot and on the ground at the station, 46% of the station's energy load could be met onsite.

"Critical services" (police, fire, medical) in cities often have back-up diesel generation in the event of power outages. Increasingly, these facilities are adding solar and onsite storage for greater resiliency. One benefit of onsite solar over diesel is that this energy production can be utilized when the facility is not in back-up mode. If a weather event is predicted, for example, the facility can instead direct the solar power to storage.[7]

7 https://www.cleanegroup.org/ceg-projects/energy-storage/resilient-power/

Again, as denoted in Figure 1 and the 4th Precinct Summary Tab spreadsheet in the Appendix, approaching the building holistically—making energy efficiency improvements at the front end—provides the best project payback. The payback for the City to own the array drops from 13.7 years to 11.4 years if bundled with recommended energy efficiency upgrades. Further, if the City were to take the PPA path, the overall clean energy payback drops to just 3.7 years. Of course, The energy efficiency improvements represent a capital outlay. While payback is a consideration in determining solar investment, the other important metric is knowing the rate for at least some of the needed energy because this is negotiated upfront as part of the PPA. No utility is going to negotiate with a customer today the future rate that customer will pay for energy over the next 25 years.

The Coleman A. Young Municipal Center

The Coleman A. Young Municipal Center (CAYMC) is an iconic building in the city and it is also one of the most energy efficient among government facilities. The high energy performance and desire of the building operators to have onsite solar made CAYMC an early contender in the feasibility analysis.

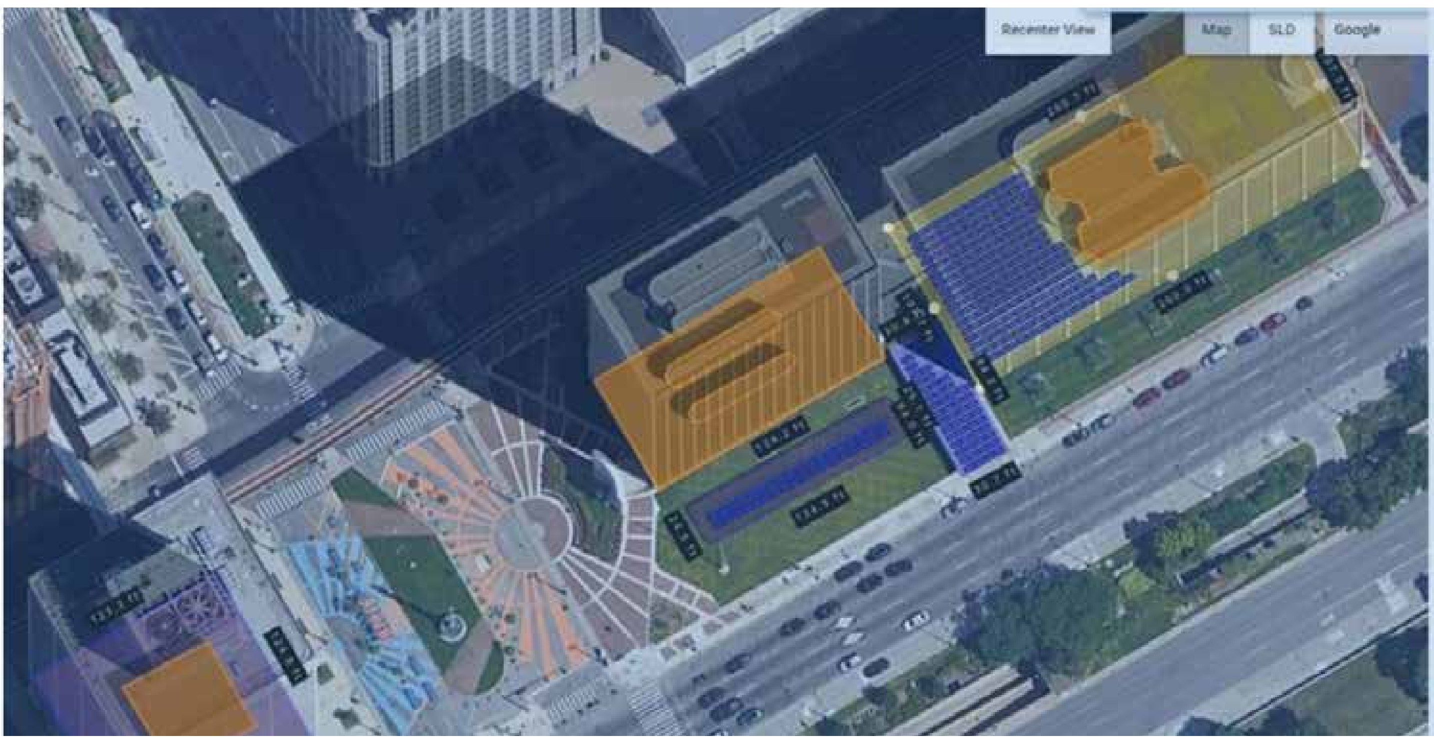


Figure 3 *Coleman A Young Shading*

However, when our team modeled the technical feasibility of introducing solar at CAYMC, we encountered challenges often common in urban environments. These challenges included shading, small roof footprint on which to locate panels, potential for high wind loading, difficult roof access, and less than ideal alternatives at ground level. Shading is a challenge to solar development on the Coleman A. Young Municipal Center as shown on Figure 3 , from a solar modeling software program called Helioscope. While the amount of solar on the roof to the right looks substantial (blue), the problem is the taller tower immediately to its southwest. That tower will shade the array significantly over the course of a day. Similarly, ground-mounted solar and solar on an entrance awning would also be significantly shaded by this building—as much as 24%. The tolerance standard for shading in the industry is 10%. Beyond this, a project becomes financially problematic. Additionally, given the orientation to the river, which is known to be a corridor for high winds, rooftop solar at CAYMC could face significant integrity issues. Gaining access to the roof on either tower requires walking up two stories since no elevators go that high. Thus, the installation of panels would be cumbersome and would add to the cost.

Lastly, solar located on the ground in front of CAYMC would likely require a fence, which could be an aesthetically unpleasant addition to this mid-century International Style gem. Despite the promise of locating solar at CAYMC, the assessment concluded that developing a highly visible project on this site would not be practical because of the poor solar performance and associated financials.

The Riviera Cooperative

The Riviera Cooperative will be a transitional affordable housing community sponsored by Nardin Park Non-Profit Housing and Community Development. The property will cover 10 vacant city parcels and will have 50 residential units, community spaces, a fitness center, and coworking space on the ground floor. The property will have many “green” features including onsite stormwater management and energy efficient design, as well as ample daylighting and onsite solar power. The five-story building has room on its roof for 50 kilowatts of solar power. Because Riviera will be new construction, solar can be integrated more thoroughly into the planning and building. In designing for integrated solar, architects often consider locating heating, ventilation, and cooling systems elsewhere than the roof to maximize room for solar panels. Relatedly, electrical connections are weather-sealed and solar panel racking is designed with minimal—if any—penetrations into the roof so as not to compromise a roof’s integrity or warranty. Designing and constructing a solar-ready roof represents marginal costs in the overall capital stack to finance a new construction building. Similarly, introducing solar at the outset of a new building coming online represents a reduction of long-term operating costs and modest additions to the build budget, often less than 10 percent.

As shown in the Appendix the the Rivieria Summary shows the opportunity for solar on an affordable housing cooperative in the City. The addition of solar at Riviera looks to offset its energy consumption from the grid by 82.6%--an impressive savings. Again, the question of whether to own or have a PPA will be a decision the cooperative partners will need to consider. As a nonprofit, the 30% tax break available through the ITC will not be available to the solar project. Thus, the anticipated payback is 14.4 years. As mentioned before, payback is typically measured against a 25-year-long operational period for the solar array. This period is codified as well in PPAs that typically are for the same amount of time. But solar, if maintained, can be productive beyond 25 years (30 to 40 years is not uncommon). In many places, systems that were installed in the 1980s and 1990s are still in operation. Given the quality and durability of building materials proposed for Riviera, solar would make an excellent addition to its green characters.

Ground-Mounted Solar on Brownfields

Underutilized land such as landbank properties, brownfields, and closed landfills present a win-win opportunity for introducing solar into urban and exurban environments in which land is at a premium for redevelopment options or as open space. For a number of years, the U.S. Environmental Protection Agency has led an effort to provide technical expertise to communities interested in locating solar on contaminated lands.[8]

The State of Michigan Department of Environmental Quality has also been working in this space as have individual communities, nonprofits such as Michigan Energy Options, brownfield authorities, and waste management companies. Through community engagement in various neighborhoods throughout the city, residents clearly stated that they would like to have solar located where they live. This includes rooftop but also solar parks where currently blighted land exists.

An innovative project in Detroit is demonstrating the synergy between affordable housing and solar energy. Cass Community Social Services is a Detroit-based agency with a person-centered philosophy, dedicated to providing food, housing, health services, and job programs. Among their affordable housing efforts have been the construction of six "tiny homes" (with more in the works) in a formerly vacant lot. Each house has onsite ground-mounted solar attached to it to provide for the majority of its electricity needs.

A variation on this model—in which each house has its own solar generation plugging directly into its electrical panel—could be located a solar array that is shared by the surrounding community. At present, the energy regulatory framework does not exist in Detroit for this to be possible. A described in the Detroit City Solar Decision Tree the City would have to negotiate directly with DTE for solar projects on vacant land. But other places in Michigan have adopted this "community solar" model in which residents and business lease a share in the solar generation and receive an on-bill credit for their portion from the utility. Community solar has been gaining adoption in states, notably Minnesota and soon Illinois with enabling legislation, as an alternative to rooftop solar.

Construction cost of a community solar park will be less than the cost per installed watt of rooftop solar and it includes an operations and maintenance agreement that requires the owner of the array to ensure it is functioning properly so that participants are realizing their estimated returns.

As part of this study we prepared a Detroit Solar Design Guidelines document that discussed best practices for solar design. For code reasons, a community solar park in a neighborhood will likely require fencing. However, with setbacks and landscaping, the somewhat industrial appearance of rows of solar panels can be softened. Moreover, many such solar parks are also adding native pollinator wildflowers and grasses that have the added benefit of providing food for bees, butterflies, and birds.

8 https://www.epa.gov/re-powering

Detroit As a Solar Standard

Detroit is in a unique position compared to other large American cities in that it has significant open land. This includes legacy industrial sites, vacant residential lots, and city-owned properties where solar could be located. Detroit has ample commercial and institutional flat roofs. It also is home to many residents who have expressed interest in having rooftop solar on their homes.

Might Detroit become one day a standard for solar among U.S. cities and the world?

Detroit's first substantive solar installation is at O'Shea Park. The installation is two megawatts located on 10-acres, incorporated into recreational facilities, such as outdoor basketball courts.

This Detroit Solar Feasibility Assessment is intended to provide the necessary data and information for City and community leaders, businesses, residents, and other stakeholders to understand solar energy and what role it could play in the future of this great city. A Building Typology Matrix and Finance Typology Matrix located in the Appendix help identify opportunities for solar throughout the City. Specific spreadsheet summaries of solar deployment are also included in the Appendix to show the various possibilities for different types of projects.

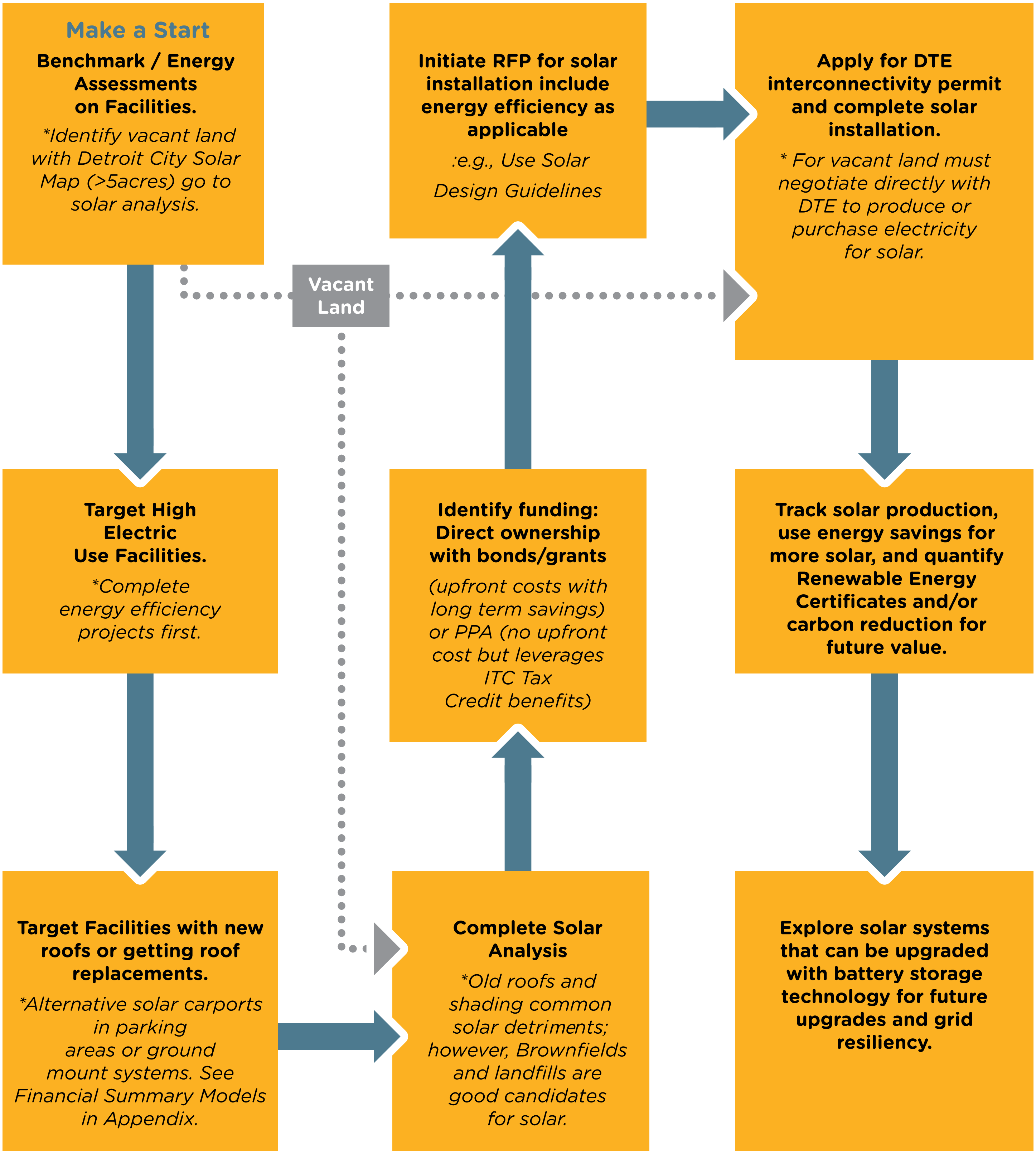
Municipalities across the world are now planning and adapting to the impacts that climate change is bringing, which includes increased and severe flooding, as Detroit experienced in 2014. Some of the federal funding Detroit received to deal with the aftermath of that flooding and make the city more resilient to future extreme weather events, has been directed to support this feasibility study.

Solar is one integrative solution that cities can put into motion today. Detroit currently has approximately 3.3MW of solar within the City limits, a goal of doubling this solar capacity in 5 years, and achieving 10MW of solar is feasible. The technology exists, the price point is becoming increasingly affordable, solar has near parity to the cost of fossil fuels, and it provides multipliers—financial, social, and environmental—to the places where it is built. Starting with solar PPAs on institutional rooftops and open space for more projects like O'Shea Park, Detroit can be a leader in solar production.

Solar works. Let the sun shine.

Appendices

Appendix 1: Detroit City Solar Decision Tree



Appendix 2: Building Typology Matrix

Typology Matrix Solar	Feasibility	Opportunity	Scale	Barriers/ Risk	Benefits	Job/Work Force Development	Community Input	Design Opportunities
Single Family Housing	Net Metering/ Inflow-Outflow model functional, but limited. ITC credit only incentive.	Strong, barriers can be overcome relatively quickly, straight forward installation, only need better payback and incentives. Projects can be completed immediately.	Limited, likely small projects completed one at a time.	Low housing values, old roofs, limited single family housing resources, utility power lines need upgrades, limited incentives.	Direct energy savings benefits to residents, resiliency through solar plus storage models.	Less immediate impact, but long term small solar installation firm jobs.	Townhall Meetings/ Charrettes	Generic typical single family home.
Multifamily Housing	Net Metering/ Inflow-Outflow model functional, but limited. ITC credit only incentive.	Strong, barriers can be overcome relatively quickly, straight forward installation, only need better payback and incentives. Projects can be completed immediately.	Moderate larger buildings can produce larger impact.	Low housing values, old roofs, limited single family housing resources, utility power lines need upgrades, limited incentives.	Direct energy savings benefits to tenants and/ or affordable housing owners, preserving affordable housing, resiliency through solar plus storage models.	Less immediate impact, but long term small solar installation firm jobs.	City of Detroit Internal Work Group/ Townhall Meetings/ Charrettes	Detroit Housing Commission Properties, nonprofit affordable housing owners (e.g., Develop Detroit)
City Owned Facilities/ Office Space/Parks	Net Metering/ Inflow-Outflow model functional, but limited. ITC credit only incentive.	Strong, barriers can be overcome relatively quickly, straight forward installation, only need better payback and incentives. Projects can be completed immediately.	Moderate, can deploy solar portfolio wide making large impact.	Limited city resources, utility power lines need upgrades, limited incentives.	Direct energy savings benefits to city, resiliency through solar plus storage models.	Less immediate impact, but long term small solar installation firm jobs.	City of Detroit Internal Work Group	Detroit Animal Care, 7401 Chrysler DPD Fleet and Com., 13131 Lyndon DPD 4th Precinct, 4700 W. Fort Adam-Butzel Rec Center 10500 Lyndon
Open Space Industrial	If parcels do not have electric meter must use PURPA/ Utility Scale models. DTE owned systems most feasible. Limited open space large enough for utility scale.	Moderate, placing large solar systems on open space near large industrial energy users allow energy to be sold across property lines.	Strong, single projects can increase overall city solar production dramatically.	Lack of adjacent open space, utility power lines need upgrades, limited incentives.	Opportunities for Community Solar assuming utility support or State Energy Policy support.* Activiates underutilized blighted property producing revenue for city.	Large one time solar installation jobs, likely installation completed by large potentially out of state solar firms.	City of Detroit Internal Work Group/ DFC Open Space Work Group	City owned industrial property. E.g., City Airport

Appendix 2: Building Typology Matrix, *continued*

Typology Matrix Solar	Feasibility	Opportunity	Scale	Barriers/ Risk	Benefits	Job/Work Force Development	Community Input	Design Opportunities
Open Space Commercial/ Residential	If parcels do not have electric meter must use PURPA/ Utility Scale models. DTE owned systems most feasible. Limited open space large enough for utility scale.	Limited due to lack of large tracks of adjacent open space and long planning to get approvals. Small neighborhood block open space limited opportunities.	Strong, single projects can increase overall city solar production dramatically.	Lack of adjacent open space, utility power lines need upgrades, limited incentives.	Hold land in a solar trust to prevent gentrification. Opportunities for Community Solar assuming utility support or State Energy Policy support.*	Large one time solar installation jobs, likely installation completed by large potentially out of state solar firms.	Internal Work Group/ DFC Open Space Work Group/ Townhall Meetings/ Charrettes	Michigan State Fair Grounds, Mt. Elliot
Nonprofit/ Faith Based/ Other Commericial Facilities	Net Metering/ Inflow-Outflow model functional, but limited. ITC credit not applicable unless third party involved.	Strong, barriers can be overcome relatively quickly, straight forward installation, only need better payback and incentives. Projects can be completed immediately.	Moderate larger buildings can produce larger impact.	Low property values, old roofs, limited resources, utility power lines need upgrades, limited incentives.	Direct energy savings benefits to organizations, resiliency through solar plus storage models.	Less immediate impact, but long term small solar installation firm jobs.	Townhall Meetings/ Charrettes	N/A
Accessory Use	Net Metering/ Inflow-Outflow model functional, but limited. ITC credit only incentive.	Limited due to due to zoning requirements minimizing size and location.	Limited, likely small projects completed one at a time.	Barriers and risk associated with limited accessory use types.	Opportunities to provide clean energy to property owners for urban farming, small businesses, and single family housing who lack roof space.	Less immediate impact, but long term small solar installation firm jobs.	Townhall Meetings/ Charrettes	N/A
Notes	Large scale solar adoption in any typology limited due to State of Michigan Solar Energy Policy.	Need large tracks of open space land to be adjacent. Small amounts of open space parcels have limited options for solar.	Large scale solar projects must involve community input, benefits to nearby neighborhoods, along with meeting energy policy requirements	Large scale solar adoption in any typology limited due to State of Michigan Solar Energy Policy.	Innovative community benefit models feasible only with direct support from utility or State Energy Policy.	Employer led solar job programs are recommended.	—	See Detroit Solar Feasibility Assessment Design Guide.

Appendix 3: Detroit City Solar Finance Typology Matrix

Typology Matrix Solar Financing	Tax Incentives	Property Accessed Clean Energy (PACE)	Michigan Saves	Lease Agreements/ Power Purchase Agreement (PPA)	Other Loan Products (e.g., bonds, mortgages, etc.)
Single Family Housing	**Yes** Solar Investment Tax Credit	No PACE for single family residential is not available in Michigan	Yes	Yes	Detroit 0% Home Repair Loan, SunPower, Green Sky Credit, Medallion Bank, EnerBank, Admirals Bank, Home Loan Investment Bank, Lighstream
Multifamily Housing	**Yes** Solar Investment Tax Credit New Market Tax Credits Opportunity Zones	Yes	Yes	Yes	Fannie Mae Green Financing Freddie Mac Green Advantage
City Owned Facilities/ Office Space/ Parks	**No**	No	Yes	Yes	Bonds
Open Space Industrial	**Yes** Solar Investment Tax Credit New Market Tax Credits Opportunity Zones	Yes	Yes	Yes	SunPower, Green Sky Credit, Medallion Bank, EnerBank, Admirals Bank, Home Loan Investment Bank, Lighstream
Open Space Commercial/ Residential	**Yes** Solar Investment Tax Credit New Market Tax Credits Opportunity Zones	Yes	Yes	Yes	SunPower, Green Sky Credit, Medallion Bank, EnerBank, Admirals Bank, Home Loan Investment Bank, Lighstream
Nonprofit/ Faith Based/ Other Commericial Facilities	**Yes** Tax credits require syndication for **No**nprofits and faith based organizations	Yes PACE financing deals require special structures for nonprofit/ faith based organizations who don't pay property taxes	Yes	Yes	SunPower, Green Sky Credit, Medallion Bank, EnerBank, Admirals Bank, Home Loan Investment Bank, Lighstream
Accessory Use	**Yes** Solar Investment Tax Credit New Market Tax Credits Opportunity Zones	Yes	Yes	Yes	SunPower, Green Sky Credit, Medallion Bank, EnerBank, Admirals Bank, Home Loan Investment Bank, Lighstream
Information	1. Solar Investment Tax Credit 2. New Market Tax Credit 3. Opportunity Zone	PACE	Michigan Saves	Lease Agreement/PPA	1. City of Detroit Home Loan 2. Fannie Mae Green Financing 3. Freddie Mac Green Advantage