Team Millennial Makers

PROPOSAL

Welcome Home to Savings

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Table of Contents

0 **Executive Summary**
1 **Introduction** 1
2 **Background** 1
2.1 Distributed Generation
2.2 Islanding
2.3 Multifamily Affordable Solar Housing (MASH) Incentive Program
3 **Proposed Solution** 2
3.1 Multifamily Affordable Distributed Energy (MADE) Program
3.1.1 MADE Tax Credit Based on NPV
3.1.2 Revenue Sharing
3.1.3 Multiple Forms of Distributed Generation across All States
3.1.4 Partnering with State and Local Incentive Programs
3.1.5 Financing
3.1.5 No Upfront Cost to HUD
3.2 Comparative Case Studies
3.2.1 Case Study for A Solar Installation in California
3.2.2 Adaptability of the solution to other states and technologies
4 **Implementation** 7
4.1 Selection of Priority Sites
4.2 One Hundred MW of Distributed Generation
5 **Owner Financing** 8
6 **Utility Allowance Coordination** 9
7 **Communication Plan** 10
8 **Conclusion** 10
9 **References** 11
10 **Appendices** 13
10.1 *Appendix A*
10.2 Appendix B - Calculations
10.3 Appendix C

0 Executive Summary

This proposal is prepared for the Department of Energy 2014 Better Buildings Case Competition and recommends the implementation of the Multifamily Affordable Distributed Energy (MADE) program to increase adoption of distributed generation (DG) at private-owned multifamily affordable housing sites across the United States. Successful implementation of MADE will result in 100 MW of distributed renewable energy generation with a net present value of $94 million for the U.S. Department of Housing and Urban Development.

First, the proposal highlights the current state of DG and highlights a successful solar incentive program for affordable housing in California. Next, the proposal describes the terms of MADE in detail including program requirements and benefits to stakeholders. The proposal highlights the practical implications of the program by presenting theoretical examples of several DG projects in California and North Carolina. The proposal also details where the selection of priority sites should occur and implications for the program to reach a goal of 100 MW. Finally, the proposal explains options for owner financing and highlights a communication plan to disseminate relevant information to stakeholders.

1 Introduction

In June 2013, President Obama released his Climate Action Plan (CAP) including strategies to mitigate the effects of climate change. One objective of the CAP is to achieve 100 MW of renewable energy capacity installed at federally subsidized housing by 2020. In addition to increasing capacity for renewable generation, CAP identifies the need for infrastructure resiliency in the aftermath of disasters such as Hurricane Sandy. The U.S. Department of Housing and Urban Development (HUD) seeks a plan to implement these goals as well as create more sustainable communities and quality homes. The following report develops an action plan for recommending the selection of priority sites, creating a replicable process for executing individual projects, identifying actions that they may take to accelerate renewable generation capacity, and promoting a strategy to motivate key stakeholders.

2 Background

2.1 Distributed Generation

Distributed generation (DG) refers to the generation of electricity near the site of consumption, usually from small sources of energy. Traditionally power is generated at large central power plants and then dispatched through high voltage transmission lines to customers hundreds of miles away.

DG benefits the grid in three ways. First, by reducing the load demand from large power plants, DG allows utilities to match demand with supply more easily. This improves the reliability of the grid during peak load hours. Second, DG allows customers to supply power to the grid if they produce more power than they consume. This both improves grid reliability and enables customers to reduce their utility bill. Third, DG reduces the amount of electricity to be transmitted over long distances. This reduces the need for utility companies to pay for expensive upgrades of high voltage transmission lines in order to carry additional power downstream as demand increases. DG is a flexible resource capable of improving power quality, providing both baseload power and peak power, and serving as a backup power source. Both commercial and residential customers, motivated by the desire to reduce their carbon footprint, are increasingly drawn to the energy security offered by smaller distributed sources of power.

Although currently popular, DG is not a new concept. For the past several decades, diesel-reciprocating generators have provided electricity (in addition to noise and harmful pollution) during power outages. Today clean sources of energy like solar, wind and fuel cells supply small-scale power typically between 1kW and 3 MW. The popularity of these clean sources come from improved reliability and reduced carbon emissions. Several innovative technologies have come to the forefront in the last few years to prove that DG is a powerful resource - fuel cells, combined heat and power systems (CHP), solar photovoltaics and small wind turbines. Bloom Energy's solid fuel oxide cells called Bloom Energy Servers are capable of providing 200kW of power using natural gas. These servers are currently powering the office buildings of industries such as Google, Amazon, and eBay. However, fuel cells like Bloom Energy Servers are relatively expensive. Mature technologies like solar photovoltaics (PV) are the preferred choice for DG. Solar PVs easily install on building rooftops and produce a significant amount of power to meet the electricity demand of the building. Any excess electricity can be sold to the grid for a fixed price.

2.2 Islanding

Another special characteristic of DG is that it is capable of producing power and feeding it into a circuit even if there is no power being supplied from the grid. This is known as Islanding. Power from the grid may be cut off in the case of a blackout due to a storm, overloading or routine maintenance operations. The fact that Distributed Generation systems are capable of producing power regardless of whether the grid is operational or not, makes them even more attractive from an energy security standpoint.

Islanding, however, poses an immense threat to workers who work to repair lines during power outages since DG systems keep feeding power into lines which are assumed to be "offline". As a result, it is important and necessary for DG systems to detect loss of power from the grid, and shut off in order to stop supplying power to utility lines. This can be achieved by employing the use of a grid-tie inverter with an anti-islanding function along with the DG system. The anti-islanding system detects when the grid goes down, shut itself off and stops producing power. This means that under current setups and mandates, distributed generation systems cannot operate during grid blackouts. A solution consists of coupling a DG system with a battery storage to continue to generate power and store it for use once the grid is functional again. However, battery storage is expensive and is accompanied by a loss in efficiency due to storing and discharging power.

2.3 The Multifamily Affordable Solar Housing (MASH) Solar Incentive Program

The California Public Utility Commission began the MASH program in 2007 to incentivize solar panel installation costs for affordable housing. The program will run through 2016 or until the $108 million fund is depleted. The main feature of the program is an fixed one time rebate dependent on system capacity. The rebate is dependent on what area the DG offsets; Common Area Load is offset at $1.90 per watt and Tenant Area Load is offset at $2.80 per watt. As of March 2013, MASH had completed 287 projects for a total of 18.4 MW capacity with 83 more projects and 11.3 MW of capacity on track for completion.

A 2013 assessment by the California Solar Initiative (CSI) highlights several emerging trends since the program's beginning. The most common participants are non-profits who partnered with solar integrators such as Solar City or Sunrun offering a power-purchase agreement (PPA). Large host customers dominate participation. Originally the program offered a second track with the opportunity to compete for higher incentives through a grant program, but this option was eliminated because it was less effective and difficult to manage. CSI's future recommendations including additional education for property owners, to establish a stable policy environment for investors, to increase the price differential between common area and tenant area to further benefit tenants, and to keep incentive levels consistent with the time of enrollment. MASH is an example of a successful incentive program for affordable housing solar generation. Many of the principles of MASH can be adopted or borrowed for an incentive program at the federal level.

3 Proposed Solution

3.1 Multifamily Affordable Distributed Energy (MADE) Program

The Multifamily Affordable Distributed Energy (MADE) program exists to invest in DG for affordable housing across the United States. The MADE program:

- Provides a 10-year DG tax credit to building owners equal to
  - The net present value of the distributed generation system total cost after federal

tax incentives *plus*
    - An additional 10% of the net present value of HUD's 25 year energy savings
- Accounts for multiple forms of Distributed Generation and across all states
- Complements state and local incentives
- Helps owners navigate the complicated financing mechanisms of affordable housing
- Requires no upfront investment from HUD

3.1.1 MADE Tax Credit Based on NPV

MADE utilizes a net present value tax credit to provide maximum flexibility. Tax credit is flexible and can be transferred between owner and a private investor (see section 5). As the tax credit is calculated to be equal to a net present value of investment plus shared profits, it could easily be modified to be distributed to owners over less or more than 10 years depending on HUD's budget timeline.

3.1.2 Revenue Sharing

MADE uses a 10% revenue sharing model between HUD and building owners to overcome the split incentive challenge. For commercial building owners, DG reduces utility bills to offset the price of the system and bring financial return. For multifamily affordable housing, the owner pays utility bills for common areas, but HUD pays the utility bills of tenants through a Utility Allowance. The Utility Allowance calculation varies depending on how the electricity is metered (at the building or apartment level) and is often based on an average regional consumption for all buildings of the same age and types. This leads to a poor knowledge of the building's actual consumption and does not incentivize investment in DG by tenant or building owner. However, because of increasing utility costs, HUD has significant financial incentive for multifamily housing owners to invest in DG.

3.1.3 Multiple Forms of Distributed Generation across All States

MADE uses similar calculations for several types of DG systems and for every state to allow owners freedom to find the best system. The attractiveness of installing renewable DG varies by location. Return on investment is a function of climate conditions, state and local rebate programs, and the local price of energy. Solar energy programs will not be financially viable in states with fewer sun hours per day or with utility rates significantly lower than the country average. MADE will use the same formula and rules for all states and for different types of distributed generation technologies, with only regional and technology parameters being changed.

3.1.4 Partnering with State and Local Incentive Programs

MADE calculates net present value using state utility rates to accurately forecast project returns. In order to be successful, MADE must support financially-viable projects to avoid encouraging the installation of systems that end up increasing the overall amount of money that HUD spends on utilities. In cases where the entire project is not beneficial after 25 years, the tax credit is calculated so that HUD savings cover tax credit payments. This means that the NPV of HUD's savings on utility bills over 25 years will equal HUD's payments to the owner over 10 years. The owner would bear the additional cost of the project. Therefore without any other incentives, the investor would not see a payback over 25 years. However, some of these low-return states have enacted additional incentive programs to the Federal Tax Credit. The MADE tax credit only takes into account federal incentives, but can be added to other state, federal or

local incentives to provide a significant return on investment. MADE will work with state and local agencies to coordinate the tax credit with complementary programs.

3.1.5 Financing

MADE provides a guaranteed tax credit to give owners assurance and flexibility when navigating the complicated lending structures of affordable housing. Most owners cannot finance the high upfront costs of DG systems. Owners seeking DG funds have two options. They can either apply for money from HUD's capital improvement fund (which often prioritizes immediate needs over long term projected savings), or obtain a private loan (which outside of a refinancing round can prove challenging). Without guarantee of the funding necessary to invest in building renovation or addition, many owners may not even look at federal and state incentives. MADE provides this guarantee so building owners can assure private investors to fund the project. In addition, several DG companies are emerging to help owners finance and install renewable generation-through Power Purchase Agreements (PPA). PPAs are an attractive alternative funding model because they allow owners to avoid convincing banks for funding and keep HUD's capital improvement fund free for more urgent common repairs as needed. MADE's tax credit can be applicable to alternative financing and ownership models, such as PPAs and utility owned systems. MADE will guarantee yearly payments with a return on investment equal to 10% of the expected project savings over 25 years. This provides investors a positive return on investment with low risk (see section 5 for investor advantages, section 8 for communicating with potential investors).

3.1.5 No Upfront Cost to HUD

MADE uses an annual tax credit to avoid prohibitively high initial investments. The total estimated present cost of the tax credit to provide DG for 100 MW is $540 million[1], which if implemented in one year time equals 8% of HUDs seven billion dollar capital costs budget. This is comparable to HUD investments in similar programs such as Partnership for Advancing Technology (HUD 2013). Instead of offering a one-time rebate like the MASH program, MADE spreads this cost over 10 years. This will allow HUD financial flexibility for more sustainable long-term operation beyond 100 MW, as opposed to a one-time lump sum program.

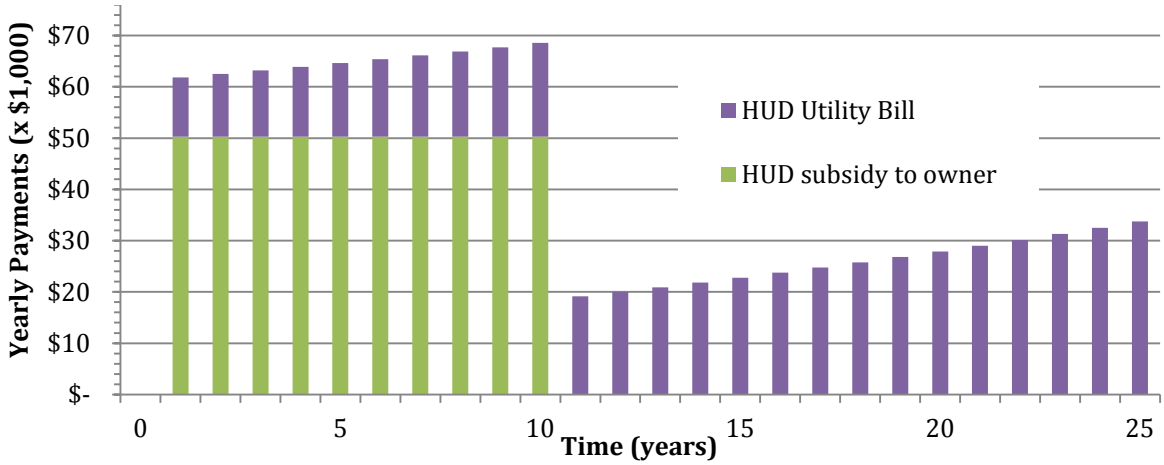
3.2 Comparative Case Studies

A 40-unit multifamily residential building consumes an estimated 292,000 kWh per year. When implementing MADE, the total utility savings depends on the price of electricity (which appreciates at 2.18% over time) (EIA, 2013), the production of the system (which depreciates about 20% over twenty years), and the future cost of money (which uses Treasury Bonds at 3.7% as the discount rate). Total value of the project is computed using the Net Present Value (NPV) of the project over 25 years. The NPV varies with the system capacity, the utility rate, the sun hours and the value of money (See Appendix B for complete calculations for each state). The MADE tax credit is calculated similar to a loan payment, with the principal being the cost of installation plus 10% of the NPV of the entire project.

3.2.1 Case Study for a Solar Installation in California

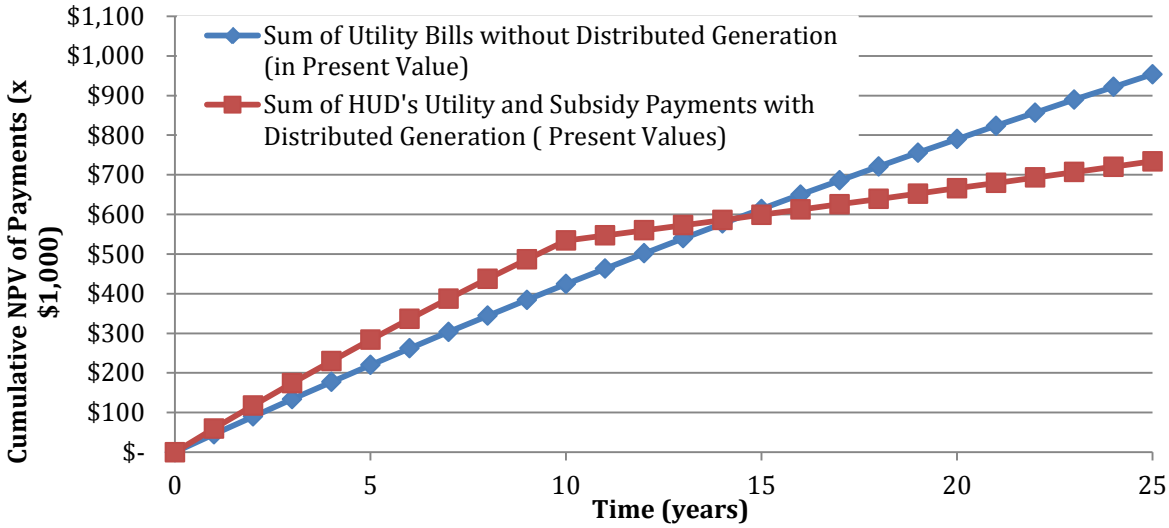
Using incentives given by MADE, an affordable housing complex in California wants to provide

Figure 1: HUD yearly payments for solar installation in California



75% of their energy from solar DG. For assumptions and complete results of the study, refer to the first column of Table 2. The MADE program provides a tax credit of $40,000 per year for ten years and HUD now pays a reduced utility bill for 25 years (see Figure 1). When compared to HUD's typical utility costs for this building, the California project has a payback period of 15 years (See Figure 2).

Figure 2 - Sum of HUD Utility Payments (cumulative) with and without Solar Panels over 25 years in CA



Without taking into account any state or regional incentive programs, the owner receives a 5.0% internal rate of return and a gains $24,413 in NPV after 10 years. HUD receives an internal rate of return of 13.6% with gains $220,000 in NPV after 25 years. Figure 3 shows the NPV for project and investor cash flows.

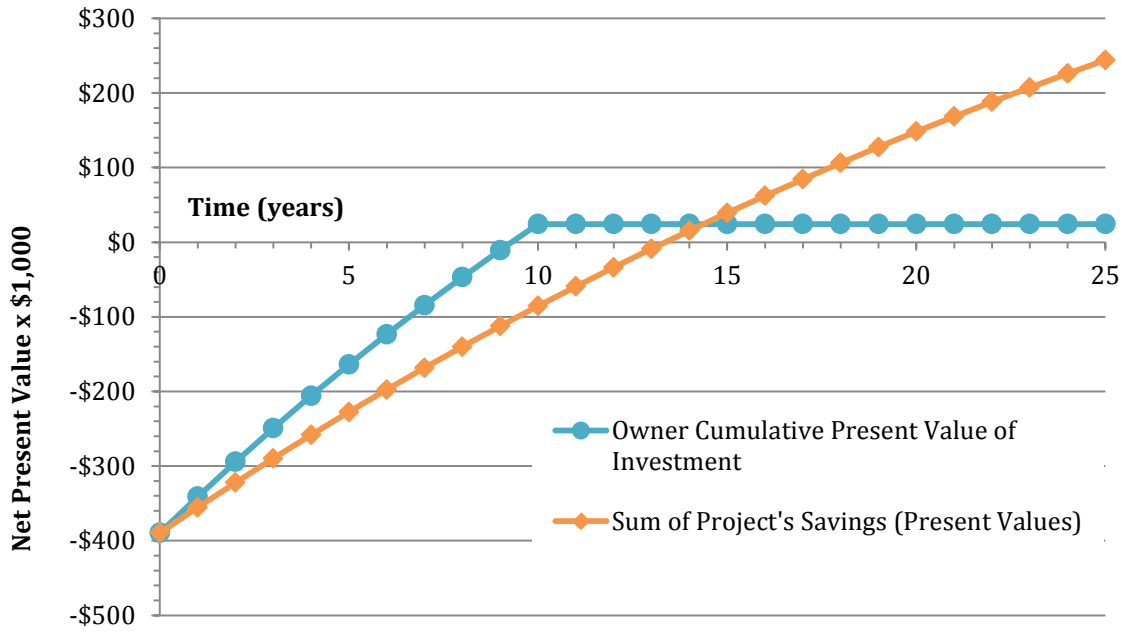


Figure 3 - Net Present Value of the Project's and Investor's Cash Flows for a Solar Installation in California

3.2.2 Adaptability of the solution to other states and technologies

Using the MADE financial model for the 40-unit complex, simulations are run for solar installations in 47 states using the average state sun hours and electricity prices (See appendix A). For 27 out of 47 states, implementation of solar DG is not financially profitable for HUD. For example, a solar project in North Carolina is not profitable to HUD when considering the MADE tax credit and the 30% federal rebate. The North Carolina project will receive a 10 year tax credit equal to the NPV of HUD's utility savings over 25 years (see Table 2, column 2). This project has a negative NPV of $13,000 and is not profitable to the building owner. However, if we assume that a local incentive can give an additional rebate of 10% on the initial cost of the system, the project now becomes financially profitable for both HUD and the owner (see Table 2, column 3).

Using the same incentive calculation, the model can be adapted to several other technologies using natural gas. Table 2 shows Fuel Cells and Combined Heat and Power System (CHP) as two alternatives to solar energy generation. The main difference with the solar generation model is that we include the cost of natural gas in the bill once the new system is installed, we assume a 100% generation of electricity by the new system and production during 8 hours for all systems.

The fuel cells technology is not profitable considering the national average of 12 cents per kWh of electricity (EIA, 2013). However, it is profitable when the electricity rate is higher, as it is the case in California, and is therefore an option for some states. The combined heat and power system (CHP) is a very efficient alternative to boilers. It does not use renewable energy and does not contribute to the presidential goal of installing 100MW of renewable energy production, but is a cost and energy efficient solution that could contribute to protecting buildings from electricity cuts in case of extreme climate events. Table 2 shows that the CHP option is extremely profitable with the national average utility rates. For comparison purposes, we considered only the electricity production of the CHP and not the heating potential, meaning that the overall savings would likely be even higher.

	Solar Panels			Fuel Cells		Combined Heat and Power System
	California	North Carolina	North Carolina + incentive	National Average	California	National Average
Electricity Rate ($/kWH)	$0.16	$0.11	$0.11	$0.12	$0.16	$0.12
Natural Gas Rate ($/MMBtu)				$0.10	$0.10	$0.10
Yearly usage (kWh)	292,000	292,000	292,000	292,000	292,000	292,000
System Capacity (kW)	105	120	120	100	100	100
Cost to Install System	$556,500	$636,000	$636,000	$1,200,000	$1,200,000	$329,300
Federal + State Tax Credits	$166,950	$190,800	$254,400	$610,000	$610,000	$72,900
Net Cost to Install System	$389,550	$445,200	$381,600	$590,000	$590,000	$256,400
Production Hours	5.74	5.01	5.01	8	8	8
Yearly DG Generation (kWh)	220,000	219,000	219,000	292,000	292,000	292,000
% electricity from DG (t=0)	75%	75%	75%	100	100	100
% electricity from the Grid (t=0)	25%	25%	25%	0	0	0
Project NPV	$244,133	$(12,977)	$50,623	$(51,970)	$148,452	$235,788
Project IRR	8.6%	3.4%	4.8%	5%	7.6%	12.0%
Project Payback	14 years	None	22 years	23 years	16 years	10 years
HUD NPV	$219,720	$(0)	$45,560	$5,445	$136,085	$208,169
HUD IRR	13.6%	3.7%	5.6%	7.0%	11.2%	26.0%
HUD Payback	15 years	None	22 years	20 years	16 years	11 years
Owner NPV	$24,413	$(12,977)	$5,062	$(57,415)	$12,366	$27,619
Owner IRR	4.9%	3.1%	4.0%	1.7%	4.1%	6.0%
Owner Payback	10 years	None	10 years	None	10 years	9 years

Table 2 – Stakeholder Value comparison across location and DG technology

4 Implementation

4.1 Selection of Priority Sites

As explained in 3.3.2, renewable energy generation, notably solar photovoltaic generation, is profitable only in certain locations. Figure 4 shows which states have positive net present values for our sample project over 20 and 25 years. These states should be targeted in priority to incentivize the installation of solar as a renewable distributed energy generation solution.

A second criteria should be placed with high risk of extreme climate events, high population density and high risk of electricity cuts. The coast of the Atlantic and of the Gulf of Mexico are particularly at risk, and could benefit from the proposed subsidy to install solar or other types of

distributed generation, among which we identified combined heat and power systems as possible ones. A key issue would be to work with local utilities to make islanding possible in case of extreme situations with reliable systems to island the properties from the grid and avoid to endanger workers repairing the lines.

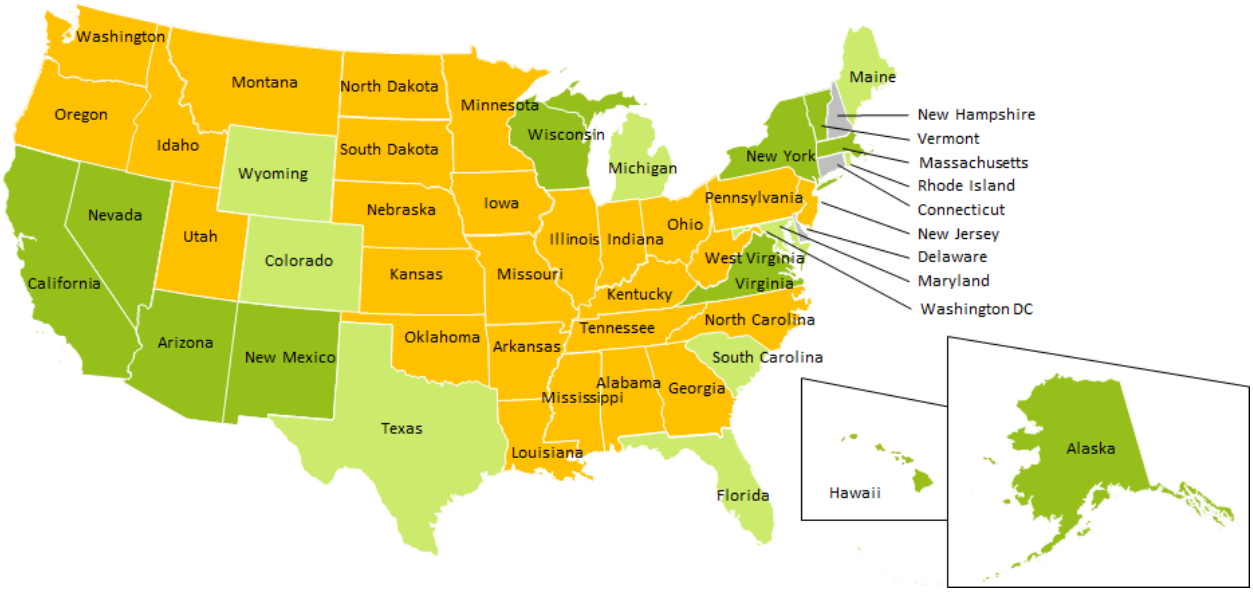


Figure 4 – Map of priority sites by state. Dark green indicates profitable states over 20 and 25 years Net Present Value (NPV) calculations, light green indicates profitable states over 25 years but not over 20 years NPV calculations, and orange indicates non profitable states under 20 years.

4.2 One Hundred MW of Distributed Generation

Our case studies looked at relatively small multi-family housing of 40 units, and had solar installations ranging from 89 to 160 kW with an average of 121.8 kW in states where photovoltaic installation was profitable. With these types of buildings, it would take about 820 projects to reach the goal of 100 MW. However if projects were equally distributed among all profitable states (see Appendix A), they offer HUD a net present value of $94.3 million over 25 years to HUD and $10 million over 10 years to building owners. Assuming apartments of 80 units and of average system size of 250 kW, it would take 400 projects to achieve the presidential goal.

5 Owner Financing

It is unlikely that owners have the available time, knowledge, and finances needed to purchase and install DG systems. Two types of finance models are expected to compete for the MADE tax credit: Private investors and DG companies using PPAs, and Utility Ownership. Similar to MASH projects in California, potential MADE projects will be popular targets of PPAs. PPAs allow the building owner to contract with a third party to finance the capital costs in exchange for the MADE tax credit. This is especially attractive to non-profit affordable housing organizations, who do not need tax credit. Private investors with access to capital might see opportunity to partner with local contractors to bring high returns. More likely, vertically integrated DG companies such as SolarCity or Sunrun can efficiently combine finance with control of the system installation cost. Utility companies, especially those under renewable energy requirements, are increasingly interested in solar DG on client property to reduce the cost of land purchase for solar farms. Typically a utility ownership model enables the utility to

provide upfront capital, installation and maintenance in exchange for a higher electricity rate on the client reduced electricity bill. Under the MADE program, the utility would receive the tax credit benefit from HUD to pay for this additional cost of electricity to pay off the system.

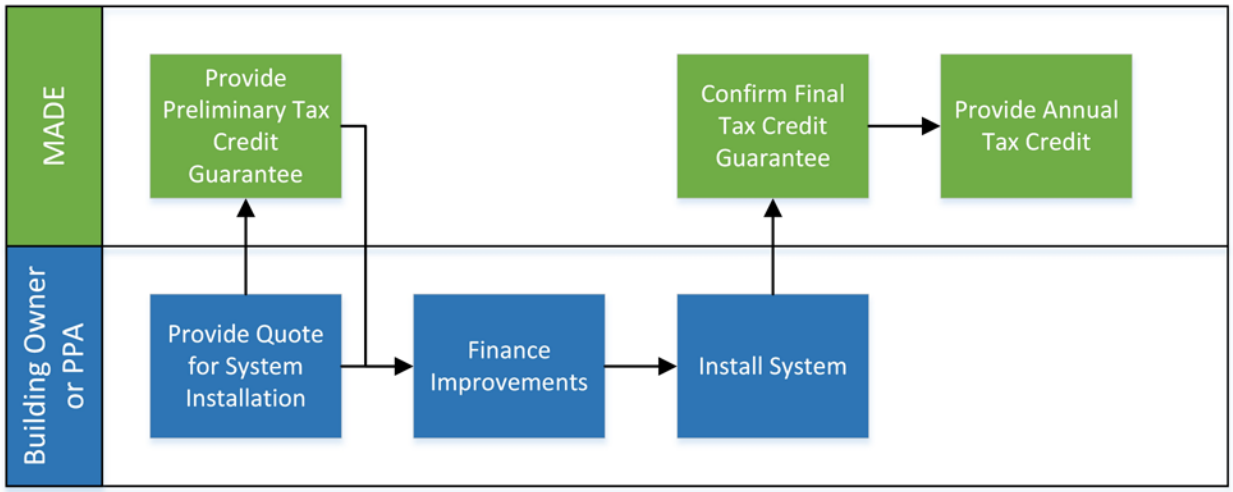


Figure 5 - Process flow for building owners & MADE

These alternative financing arrangements require certainty for investment. MADE uses a two-step process to provide certainty while ensuring return. First, MADE will provide a preliminary guarantee for the 10-year tax credit based on an installation quote for the system cost. This preliminary guarantee assures that for a system installed for the given price, MADE will offer a subsidy to cover the cost of installation plus 10% of HUD's 25-year savings. This guarantee assures an investor, DG company, or bank that HUD backs the project. Using this guarantee, the owner can obtain financing and install the DG system. At this point, MADE will conduct an audit to confirm the installation cost, and will adjust the tax credit for any differences from the original quote. The MADE programs guaranteed annual tax credit considerably lowers the risk that banks, PPA companies, and utilities will take on while still ensuring that projects provide a payback to HUD.

6 Utility Allowance Coordination

HUD provides a utility allowance to low income households in order to cover the resident's reasonable utility usage. Public Housing Authorities (PHAs) estimate the energy usage associated with heating, cooling, lighting, cooking and appliances and determine an allowance for residents that can range from a couple of dollars to a few hundred dollars per month, depending on the household size, geographical area etc. Utility allowances for multifamily housing units depend on the way the utility is metered. A utility can be metered in a few different ways: individual metering, sub-metering or master metering.

Individually metered utilities have a separate meter for each house and each house also has a separate account with the utility. In such cases, utility allowances are easy to distribute and are usually in the form of reduced monthly rent for the household. Master metered utilities have only one meter that measures energy usage of a building as a whole, not individual units. In such cases, residents do not see the utility allowance. Instead, PHAs usually include a portion of utility costs into the rent paid by each household and pays the rest to the utility.

In order to get around master metering, some PHAs install sub-meters to measure energy consumption of each unit. In such cases, units are allowed to consume electricity for no charge up to a certain level and are then charged a surcharge for any usage above the limit. Only houses that are sub-metered or individually metered are eligible for utility allowances since it is difficult to estimate energy usage for each household in buildings that are master metered.

MADE recognizes that utility allowance coordination is a complex challenge facing multifamily affordable housing improvements. See Appendix C for assumptions made regarding the utility allowance.

7 Communication Plan

A major barrier to implementation of DG is the complexity to locate reliable information. The main form of communication for MADE is the comprehensive program website. The website serves three stakeholders: building owners, state and local agencies, and private third-party investors. Similar to the *DSIRESOLAR* (DSIRE, 2013) site, the MADE website provides stakeholders with access to programs in their state, region, and city that incentivize DG. A key element of the website is the estimated savings calculator. Once stakeholders input information about site location, energy usage, and potential DG system sizes, the savings calculator estimates the payback period and return on investment. The website includes case study breakdowns to provide examples of the program's viability. The website will also include webinar trainings to help stakeholders navigate the complexities of DG financing for affordable housing.

8 Conclusion

The Multifamily Affordable Distributed Energy Program (MADE) presented in this report proposes a comprehensive program to support the installation of renewable and distributed energy generation in all states. It does not require upfront investment from HUD but relies on a flexible tax credit over ten years to reimburse the cost of the installation plus 10% of HUD savings. Calculation for tax credit ensures HUD does not invest in unprofitable projects. The MADE tax credit incentivizes building owners to choose the most appropriate system for their location and is additive with local and state programs. The calculation of the tax credit is straightforward and a savings calculator will be available on the MADE website for potential project candidates. MADE is attractive to third parties such as system installers, utility companies, and banks or other private investors interested in programs with stable investment returns and/or projects to expand their DG portfolio.

Successful implementation of MADE will control and reduce HUD's ever-growing utility cost. For an estimated budget of $540 million in tax credit spread over several years, HUD will earn a 17% return on investment thanks to reduction in its electricity bills over 25 years.

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Interviews

Ali Moazed, Manager, Distributed Generation Strategy, PG&E, and Elliana Spiegel, Program Manager, PG&E (2014, February 14). Telephone interview.

Georgina Mascarenhas (2014, January 22). Personal interview.

Joe Nation, Professor of the Practice of Public Policy and Director of Graduate Practicum, Stanford Public Policy Program, Stanford University (2014, February 4). Personal interview.

Gilbert Masters, Professor Emeritus, Civil and Environmental Engineering, Stanford University (2014, January). Personal Interview.

11 Appendices

1.1 Appendix A

State	Avg Sun Hrs	Utility Rate	System Capacity (kW)	% DG	Project NPV 20 years	Project NPV 25 years	HUD NPV 25 years	HUD IRR	Owner NPV 25 years	Owner IRR	Tax Credit	Electricity use (kWh/yr)	Profitable?
AK	3.77	$0.18	159	75%	$19,673.20	$128,229.70	$115,406.73	6.9%	$12,822.97	4.1%	30%	292,000	Y
AL	4.23	$0.11	141	75%	$(167,408.46)	$(104,061.93)	$-	3.7%	$(104,062)	0.0%	30%	292,000	N
AR	4.25	$0.10	141	75%	$(201,631.21)	$(144,379.38)	$-	3.7%	$(144,380)	0.0%	30%	292,000	N
AZ	6.50	$0.11	92	75%	$25,790.47	$91,168.81	$82,051.93	7.6%	$9,116.88	4.2%	30%	292,000	Y
CA	5.74	$0.16	105	75%	$148,340.84	$244,133.28	$313,885.65	13.6%	$24,413.33	4.9%	30%	292,000	Y
CO	5.37	$0.12	111	75%	$(26,382.11)	$42,258.35	$38,032.52	5.2%	$4,225.84	3.9%	30%	292,000	Y
DC	4.23	$0.13	141	75%	$(96,929.92)	$(21,031.94)	$-	3.7%	$(21,031.94)	0.0%	30%	292,000	N
FL	5.408	$0.12	111	75%	$(28,497.67)	$39,766.04	$35,789.43	5.1%	$3,976.60	3.9%	30%	292,000	Y
GA	4.865	$0.10	123	75%	$(108,419.89)	$(46,460.93)	$(0.00)	3.7%	$(46,460.93)	0.0%	30%	292,000	N
HI	6.02	$0.37	100	75%	$872,723.87	$1,094,217.40	$984,795.66	-	$109,421.74	9.2%	30%	292,000	Y
IA	4.4	$0.11	136	75%	$(143,367.87)	$(79,043.52)	$-	3.7%	$(79,043.52)	0.0%	30%	292,000	N
ID	4.81	$0.10	125	75%	$(145,534.55)	$(88,863.87)			$(88,863.87)		30%	292,000	N
IL	3.14	$0.10	190	75%	$(366,969.96)	$(306,788.34)			$(306,788.3)		30%	292,000	N
IN	4.21	$0.11	143	75%	$(161,802.94)	$(96,136.71)			$(96,136.71)		30%	292,000	N
KS	5.18	$0.11	116	75%	$(50,336.54)	$17,341.45	$15,607.31	4.3%	$1,734.15	3.8%	30%	292,000	Y
KY	4.94	$0.10	121	75%	$(130,562.56)	$(73,868.39)			$(73,868.39)		30%	292,000	N
LA	4.83	$0.09	125	75%	$(157,274.30)	$(102,694.35)			$(102,694)		30%	292,000	N
MA	3.95	$0.16	152	75%	$(28,773.00)	$66,530.79	$59,877.71	5.4%	$6,653.08	3.9%	30%	292,000	Y
MD	4.47	$0.13	135	75%	$(60,614.71)	$17,786.35	$16,007.71	4.2%	$1,778.63	3.8%	30%	292,000	Y
ME	4.35	$0.14	138	75%	$(32,746.75)	$52,599.42	$47,339.48	5.2%	$5,259.94	3.9%	30%	292,000	Y
MI	4.1	$0.15	146	75%	$(57,142.12)	$29,145.18	$26,230.67	4.5%	$2,914.52	3.8%	30%	292,000	Y
MN	4.53	$0.12	132	75%	$(103,581.67)	$(34,814.68)			$(34,814.68)		30%	292,000	N
MO	4.555	$0.10	132	75%	$(162,826.57)	$(104,610.45)			$(104,610)		30%	292,000	N
MS	4.43	$0.11	135	75%	$(125,270.63)	$(58,384.08)			$(58,384.08)		30%	292,000	N
MT	4.69	$0.10	128	75%	$(132,178.51)	$(71,147.15)			$(71,147.15)		30%	292,000	N
NM	6.77	$0.11	89	75%	$40,514.64	$106,533.06	$95,879.76	8.5%	$10,653.31	4.3%	30%	292,000	Y
NE	4.845	$0.10	124	75%	$(129,074.66)	$(70,133.37)			$(70,133.37)		30%	292,000	N
NC	5.01	$0.11	120	75%	$(80,650.14)	$(15,727.82)					30%	292,000	N

									$(15,727.82)				
ND	5.01	$0.09	120	75%	$(150,024.68)	$(97,457.20)			$(97,457.20)		30%	292,000	N
NJ	3.2	$0.15	188	75%	$(185,836.12)	$(94,717.97)			$(94,717.97)		30%	292,000	N
NV	5.31	$0.13	113	75%	$15,847.23	$93,329.70	$83,996.73	7.0%	$9,332.97	4.1%	30%	292,000	Y
NY	3.756	$0.18	160	75%	$22,520.04	$132,244.24	$119,019.82	7.0%	$13,224.42	4.1%	30%	292,000	Y
OH	4.045	$0.12	148	75%	$(154,518.70)	$(84,251.67)			$(84,251.67)		30%	292,000	N
OK	4.985	$0.10	120	75%	$(126,275.71)	$(69,478.80)			$(69,478.80)		30%	292,000	N
OR	3.86	$0.10	155	75%	$(243,414.05)	$(184,353.33)			$(184,353)		30%	292,000	N
PA	3.68	$0.13	162	75%	$(172,056.23)	$(95,662.50)			$(95,662.50)		30%	292,000	N
RI	4.23	$0.16	142	75%	$5,351.28	$100,125.13	$90,112.62	6.5%	$10,012.51	4.1%	30%	292,000	Y
SC	5.06	$0.12	119	75%	$(45,637.28)	$24,859.73	$22,373.76	4.5%	$2,485.97	3.8%	30%	292,000	Y
SD	4.56	$0.10	132	75%	$(153,785.54)	$(93,959.31)			$(93,959.31)		30%	292,000	N
TN	4.18	$0.10	143	75%	$(198,586.48)	$(139,470.99)			$(139,470)		30%	292,000	N
TX	5.00	$0.12	120	75%	$(56,412.85)	$12,825.86	$11,543.27	4.1%	$1,282.59	3.8%	30%	292,000	Y
UT	5.39	$0.10	111	75%	$(76,573.79)	$(16,871.91)			$(16,871.91)		30%	292,000	N
VA	6.72	$0.11	89	75%	$34,458.79	$99,398.73	$89,458.85	8.1%	$9,939.87	4.3%	30%	292,000	Y
WA	4.73	$0.09	127	75%	$(181,356.74)	$(129,744.19)			$(129,744)		30%	292,000	N
WI	4.29	$0.14	140	75%	$(65,916.74)	$14,843.64	$13,359.27	4.1%	$1,484.36	3.8%	30%	292,000	Y
WV	3.65	$0.09	164	75%	$(297,604.68)	$(242,248.33)			$(242,248)		30%	292,000	N
WY	6.06	$0.10	99	75%	$(26,469.60)	$34,226.76	$30,804.09	5.1%	$3,422.68	3.9%	30%	292,000	Y

Number of states where incentive should be adopted	**20**
Number of states studied	**47**

Total HUD NPV	**$2,291,573**
Average HUD IRR	**5.63%**

Total Owners NPV	**$244,156**
Average Owner NPV	**$12,208**
Average Owner IRR	**4.29%**

11.2 Appendix B - Calculations

Building energy usage
24.5 million BTU/house = 7209 kWh/house

= 20 kWh/house per day
= 800 - 1600 kWh/day for 40-80 unit home
= 292 MWh/house per year (for a 40 unit home)

Solar panel area requirement for 100kW system
assuming 10W/sq. ft → 10,000 sq. ft

Equation of the Net Present Value of the Project: NPV project

NPVproject (t) = -Io + SC . SH . 365 . UR . sum [(1-APS) . (1+APE) / (1+DR)] ^ t

where:

Io = system cost at t=0
SC = System Capacity in kW
SH = Sun Hours in hours per day
UR = Utility Rate at t=0 in $/kWh
APS = Loss rate of efficiency of the solar panels
APE = Increase in price of electricity per year, based upon Country increase over the last 10 years
DR = Discount Rate. We used the Treasury Bond value of 3.7%
t = Number of years of cash flows studied

Equation for the subsidy calculation:

If NPV project is positive:

S = CRF . (Io + NPV(t) . 10%)

where:

CRF = [DR . (1+DR) ^ n] / [(1+DR)^n – n]
n = Number of years during which the subsidy is given

If NPV project is negative:

S = CRF (Io + NPVproject (t))

11.3 Appendix C - Limits of the financial model and suggested improvements

The financial model we propose made some simplifications and assumptions that need to be

underlined here and could be improved based upon further discussion with HUD and industry stakeholders.

- First we assumed a time value of money equal to the Treasury Bonds (3.7%), and may have overlooked some risks. A higher value could be used, but will likely diminish the number of places where the investment is profitable if it goes above 5%. The IRR on table 2 and in appendix 1 is a good indication of the discount rate that would make projects unprofitable.
- Our approach is based on state average for a number of variables, which does not capture variations inside states. Therefore the map in figure 4 may show some states as unprofitable while they actually include some profitable locations. A more thorough study of the variables per main urban areas inside each state would need to be completed to refine the list of priority sites. Finally, some other variables may have to be corrected, such as the 8 hours of production for the fuel cells and HVC, which are likely to be higher.
- This model should be completed by further sensibility analysis to fully reflect the differences between states and technologies. The model is already adaptable to different cases and we would just need to enter a higher number of different variables to perform these analyses.
- We simplify the complex issue of Utility Allowance, to assume all utilities are paid by HUD. In reality, the building owner may pay the utilities on some common areas. In these cases, HUD would receive a slightly smaller payback and the owner would see a slightly larger payback. The MADE program will give priority to projects that offset tenant load as opposed to common load.

11.3 Appendix D – Existing HUD Programs

HUD has undertaken several initiatives to promote energy efficiency in affordable housing. These include PATH (Partnership for Advancing Technology in Housing) which is a public private partnership to promote energy efficiency. PATH conducts research on various technologies and issues including barriers to energy efficiency and makes information on best energy efficiency practices available to building owners, consumers and builders. Another initiative is the Public Housing Energy Conservation Clearinghouse which involves working with Public Housing Authorities (PHAs) to incentivize energy savings in homes, and finding innovative funding sources to reduce utility rates. However, as discussed in Section 3.1, in subsidized multi-family incentives for energy efficiency are misaligned which results in immense energy wastage. Our plan takes this problem into account and eliminates it by allowing HUD to share a part of its profits with building owners. As a result, building owners have a greater incentive to invest in DG and tenants do not bear any additional costs. We believe that a similar approach can be adopted by energy efficiency since there are various synergies between the DG and Energy Efficiency systems.

Endnotes

[1] Assuming an average subsidy of $658,000 per project and an equal distribution of 820 projects in the 20 profitable states. This is compa