



## Game Changer 2.0 Competitive Grants

# Final Report

## ConnectDER™ Project

Plug-and-Play Solar for Maryland Homes



Infinite Invention, LLC (DBA "ConnectDER, LLC")  
2761 January Court  
Falls Church, VA 22043  
207-202-6882  
[www.connectder.com](http://www.connectder.com)



# TABLE OF CONTENTS

1 - MEA PROJECT INFORMATION .....	4
2 - EXECUTIVE SUMMARY.....	5
3 - PRODUCT OVERVIEW .....	7
4 - EVIDENCE OF COMMISSIONING .....	8
5 - SUMMARY OF PROJECT SUCCESSES .....	9
PV SYSTEM OVERALL COST REDUCTION .....	9
STAKEHOLDER ACCEPTANCE .....	11
UTILITIES.....	11
THE AHJ .....	11
SOLAR PHOTOVOLTAIC (PV) INSTALLATION CONTRACTORS .....	11
HOMEOWNERS.....	12
INDEPENDENT ENGINEERING FIRM #1 .....	12
6 - LESSONS LEARNED.....	13
7 - PERFORMANCE DATA (THROUGH MARCH 2016) .....	14
7A - PERFORMANCE DATA (THROUGH MARCH 2017).....	15
8 - LIFE-CYCLE ANALYSIS/CONCLUSION .....	16
COST SAVINGS .....	16
SAFETY.....	16
CONVENIENCE .....	16
RELIABILITY.....	16
FUTURE OPPORTUNITIES.....	16
APPENDIX A – CONNECTDER SITE PHOTOS .....	17
SITE #1 .....	17
SITE #2 .....	18
SITE #3 .....	18
SITE #4 .....	19
SITE #5 .....	20
SITE #6 .....	21
SITE #7 .....	22

SITE #8 .....	23
SITE #9 .....	24
SITE #10 .....	25
APPENDIX B – EVIDENCE OF PV SYSTEM COSTS .....	26
SITE #1 .....	26
SITE #2 .....	27
SITE #3 .....	28
SITE #4 .....	29
SITE #5 .....	30
SITE #6 .....	31
SITE #7 .....	32
SITE #8 .....	33
SITE #9 .....	34
SITE #10 .....	35
APPENDIX C – INDEPENDENT ENGINEERING FIRM #1 EVALUATION REPORT .....	36

## 1 - MEA PROJECT INFORMATION

<b>1. Project Title:</b> ConnectDER Project: Plug-and-Play Solar for Maryland Homes		<b>2. Project Organization Name and Address:</b> Infinite Invention DBA "ConnectDER, LLC" 2761 January Court Falls Church, VA 22043	
<b>3. Reporting Period:</b> May 15, 2014 – March 12, 2017		<b>4. Total Grant Amount:</b> \$ 79,910	
<b>5. MEA Grant Number:</b> 2014-03-51951		<b>6. Invoice Number (if Applicable):</b> N/A	
<b>7. Project Organization DUNS:</b> 078482038		<b>8. Project Contractor DUNS:</b> PV Contractor #1 Electric Utility #1 Independent Engineering Firm #1 Videography Firm #1 PV Contractor #2 PV Contractor #3 PV Contractor #4 PV Contractor #5	
<b>9. Project Organization Federal Tax Identification Number:</b> 45-3754950		<b>10. Project Organization (and Project, if Different) County and Congressional District:</b> Fairfax County, CD #8 (Virginia)	
<b>11. Project Start Date:</b> May 15, 2014		<b>12. Scheduled Project Completion Date:</b> Extended to March 31, 2015 + 1 year of data for 5 of 10 systems. Remaining five extended for 1 year of data March 2016 to March 2017.	
<b>13. MBE:</b> N/A	<b>14. MBE Goal:</b> N/A	<b>15. MBE Commitment:</b> N/A	
<b>16. Project Manager Name and Contact Information:</b> Al Iaconangelo (703) 477-3401 <a href="mailto:aiaconangelo@connectder.com">aiaconangelo@connectder.com</a>			

## 2 - EXECUTIVE SUMMARY

Infinite Invention (DBA “ConnectDER, LLC”) recruited partners to install residential solar photovoltaic (PV) systems on ten residences in the state of Maryland using its “Simple” ConnectDER interconnection device. The original team consisted of:

- Infinite Invention (Grantee)
- Electric Utility #1 (Electric utility)
- PV Contractor #1 (PV installation contractor)
- Independent Engineering Firm #1 (Solar electric subject matter expert)
- Videography Firm #1 (Videographer)

ConnectDER personnel created project documents, marketing materials and legal documents related to this new and more efficient method to connect a residential solar PV system to the electric grid. Training sessions on the purpose, benefits and installation methods were conducted with:

- Electric Utility #1 in Rockville, MD
- PV Contractor #1 at their Maryland office
- Montgomery County permitting/inspection department in Rockville, MD
- Prince George’s County permitting/inspection department in Landover, MD

Other installer partners received training as they joined the team.

Electric Utility #1 received, tested and approved the ConnectDER after it was UL listed and before installing any units on customer homes.

The Game Changer Grant Agreement targeted ten ConnectDER units commissioned on all residences no later than September 30, 2014. The team experienced a number of challenges encompassing customer acquisition, utility commitments and permitting delays. ConnectDER requested (and was granted) two time extensions for this milestone, first to December 31, 2014 and subsequently to March 31, 2015.

The following partners were added to the team during the project lifecycle:

- PV Contractor #2
- PV Contractor #3
- PV Contractor #4
- PV Contractor #5

Ten ConnectDER units were installed on Maryland residences before March 31, 2015 meeting the MEA definition of “commissioned”. The PV systems lagged behind, and just eight customers proceeded with solar installations.

Homeowner recruitment and product development continued. A revised version of the Simple ConnectDER (unofficially dubbed “Version 2”, or “V2”) received its official Certificate of Compliance from UL on May 16, 2015. Notable changes included:

- Field wiring junction box was relocated from the bottom to the top of the unit
- Maximum integral circuit breaker increased from 60 amps to 80 amps
- Option for circuit breaker with 22,000 AIC rating.

Samples of the “V2” unit (which supersedes the original version) were provided to Electric Utility #1 for testing and evaluation.

Beta sample units of the “Smart” ConnectDER (which include revenue grade metering of the PV circuit, among other features) were also provided to the electric utility. Electric Utility #1 expressed a desire to finish out the pilot using one of each, pending UL listing on the Smart version and successful enlistment of two additional PV customers. UL issued the official Certificate of Compliance for the Smart ConnectDER on February 8, 2016.

The final two ConnectDER installs were performed on March 10, 2016 – one “V2” and one “Smart”. The PV interconnections were terminated and successfully tested the same day.

The Game Changer grant agreement stipulates that the grantee provides a report with one year of performance data. The ConnectDER must have a PV system attached to round out the full suite of data.

**The original “final” report included data from five of the ten PV systems with a minimum of one year of data, culminating in March, 2016. This revised version (2.0) includes data from the remaining five PV systems through March 10 - 12, 2017.**

Actual PV electricity generation data was collected for four of the first PV systems through March 25, 2016. One of those five systems does not have monitoring capability, so its production is estimated.

Cost savings and feedback from contractors and our subject matter expert were logged to provide data for this report. Video footage was collected during some of the installations and provided to the MEA.

The report shows that the ConnectDER is a market-ready solution to reduce costs for solar PV systems and utility operations.

### **3 - PRODUCT OVERVIEW**

The ConnectDER (DER stands for Distributed Energy Resources, such as solar photovoltaic systems) is a meter collar that mounts between an existing residential electric meter socket (back box) and the meter itself. It provides a safe, standardized, low-cost alternative connection point for solar PV systems over traditional wiring methods.

#### **TECHNICAL INFORMATION**

- Suitable for use with 4-terminal ringless and ring-type meter sockets, 1ph, 3 wire, rated up to 200 amps, 240VacRated 240Vac, 60Hz, 1ph, 3 wire, 64 continuous amps for the alternate energy input (supports PV installations of up to 15kW AC)
- Carries a short-circuit rating of 10 kA, 120/240V maximum
- Compatible with type 2S electric meters
- PV System Interface: Hard-wired via weatherproof junction box (included)
- Grounding and bonding compliant with NEC Article 250
- UL Listed (Meter Socket Accessory, File No. E361188)
- For use with grid-interactive PV systems with UL 1741-compliant inverters/micro-inverters

#### **BENEFITS**

- Drives down wiring costs, logistics headaches, and site inspection time
- Decreases BoS (Balance of System, i.e., everything besides the solar panels) costs by eliminating components and reducing need for premises wiring upgrades
- Integrated circuit breaker provides PV equipment protection and safe field connection to terminal block
- Direct utility grid connection option enables alternate PV asset ownership models

The ConnectDER is available with its integrated circuit breaker in standard size ratings from 15 through 80 amps to support a variety of PV system sizes. It is installed by the electric utility or utility-approved representative.

## 4 - EVIDENCE OF COMMISSIONING

Table 4.1 summarizes the PV deployed with the ConnectDER for the pilot. The ConnectDER units associated with the two cancelled PV systems are omitted, and are not considered part of the Game Changer pilot. Copies of county final inspections were previously transmitted to the MEA.

<b>TABLE 4.1 – Game Changer 2.0 ConnectDER units and PV systems</b>				
<b>Site #</b>	<b>Location</b>	<b>ConnectDER install (commissioning) date</b>	<b>PV system size (DC)</b>	<b>PV final inspection date</b>
1	Silver Spring, MD 20902	12/03/2014	8.715kW	12/19/2014
2	Silver Spring, MD 20901	12/03/2014 01/29/2015*	6.0kW	02/05/2015
3	Cheverly, MD 20785	12/03/2014	4.96kW	11/24/2014
4	Kensington, MD 20895	02/25/2015	11.07kW	02/06/2015
5	College Park, MD 20740	03/30/2015	14.75kW	03/10/2015
<b>Production data from the systems below are included in this revised final report.</b>				
6	Rockville, MD 20853	03/19/2015	8.12kW	05/11/2015
7	Upper Marlboro, MD 20744	03/30/2015 07/07/2015**	10.66kW	05/07/2015
8	Kensington, MD 20895	03/30/2015	7.15kW	06/29/2015
9	Takoma Park, MD 20912	03/10/2016	4.905kW	03/17/2016
10	Silver Spring, MD 20910	03/10/2016	6.867kW	02/19/2016

\* The homeowner invoked an option to upgrade the service entrance **after** the ConnectDER was installed on 12/03/2014. The ConnectDER was re-installed in the new meter socket on 01/29/2015.

\*\* The homeowner and contractor upgraded the PV system from 5.98kW to 10.66kW. The original 30amp ConnectDER installed was upgraded to a 60 amp ConnectDER on 07/07/2015.

Performance data includes total kW hours produced by the five PV systems that have been in operation a minimum of one year.

Photos of all ConnectDER units as they are installed and wired are provided in [Appendix A](#).

## 5 - SUMMARY OF PROJECT SUCCESSES

### PV SYSTEM OVERALL COST REDUCTION

Total generating capacity across the ten PV systems:	83.197kW
Average system size (kW):	8.3197kW
The total cost of PV systems ( <i>see Table 5.1</i> )	\$254,995.90
Total estimated savings:	\$5,267.50
Average cost per system:	\$25,499.59
Average cost savings per system:	\$526.75
Average cost % savings per system:	2.06%

<b>TABLE 5.1 – Total PV system costs and estimated cost savings using ConnectDER</b>		
<b>Site #</b>	<b>PV System Cost</b>	<b>Estimated Savings</b>
1	\$38,123.00	\$537.50
2	18,034.56	650.00
3	17,983.32	650.00
4	32,436.00	0 (due to customer preference)
5	26,000.00	500.00
6	27,202.00	615.00
7	21,000.00	540.00
8	28,242.00	615.00
9	26,095.01	607.50
10	19,880.01	552.50
<b>TOTAL</b>	<b>\$254,995.90</b>	<b>\$5,267.50</b>

Evidence of PV system cost information is provided in [Appendix B](#).

Estimated savings is based on feedback from the partners, discussions with county inspectors and the ConnectDER Project Manager’s experience as a master electrician.

2% savings based on *retail* costs for eight of the ten systems is a significant reduction in overall PV system costs. Indications that savings are (and will be in the future) higher:

- One homeowner opted for the inverters to be placed indoors making the savings zero. Averaging the savings across nine systems instead of ten results in a 2.36% savings.
- Two installs are homeowner-leased systems, meaning the PV system costs shown are contractor costs. Therefore, the percentage of savings to the *contractor* is higher. Assuming a 30% margin for overhead and profit for the eight systems, the average savings across all ten systems would be 2.73%
- One homeowner opted to proceed with an electrical service upgrade due to its poor condition. Otherwise the average savings across all ten systems would be approximately 2.79%.

Avoiding an electrical service upgrade (for example, where the existing service equipment is in good condition but too small to support the desired PV system) saves an average of \$2,500.00 to the PV contractor in the utility/Maryland market area. This is because the ConnectDER interconnects ahead of the main service disconnect, meaning code-required amperage limitations do not apply (when connecting to directly into the service panel).

Another method to avoid a service upgrade is called a “line-side tap” which is nearly as costly as a service upgrade. Neither of these high-impact scenarios were encountered during the pilot. However, Maryland contractors estimate they could avoid either a service upgrade or line-side tap for approximately ten percent of their residential installs rated 200 amps or less.

In summary, even the most conservative savings estimate is significant given the small sample size, the lower cost-impact conditions encountered and contractor learning curve. **Greater average savings are anticipated** if and when the electric utility makes the ConnectDER readily available to its customers.

Table 5.2 summarizes factors influencing cost reductions.

<b>TABLE 5.2 – Factors influencing cost reductions (Applicability is case-by-case)</b>	
<b>FACTOR</b>	<b>SAVINGS IMPACT</b>
Avoiding a service upgrade, line side tap, sub-panel, major alteration	\$1,000 - \$2,500
Avoiding penetration, cutting and patching inside the residence	\$500 - \$1,000+
Reduction of labor required	\$500 - \$1,000
Reduction of equipment (disconnects, sub-panels, breakers/wiring)	\$100 - \$500
Soft cost reductions (e.g., inspections, coordinating interior access)	\$400 - \$500

## **STAKEHOLDER ACCEPTANCE**

### **UTILITIES**

Utility acceptance is critical to initiate and maintain a market for the ConnectDER. The utility is the first entity required to grant permission to access the meter socket. The utility agreed to the field trial in part because it is evaluating other cutting-edge technologies. The utility is considering offering the current “Simple” product to PV contractors which will:

- Provide a source of revenue and
- Lower operating costs by avoiding the utility contribution to service upgrades.
  - When homeowners upgrade their electrical service up to the level of 200 amps, the utility will confirm the infrastructure is sufficient and coordinate a dispatch to cut power (allowing the upgrade to take place) and later dispatch a crew again to restore power. Surveys from Electric Utility #1 and other utilities indicate an average operating cost savings of \$1,000.00 for every service upgrade avoided.

Additionally the utility is reviewing a proposal to test the “Smart” version of the ConnectDER for the benefit of getting timely PV metering data. Verifying system performance and reliability will help forecast needs for other generation sources. The built-in revenue-grade metering can measure power out as well as power in. The utility is evaluating the Smart ConnectDER as a substitute for installing a costly 2<sup>nd</sup> electrical meter to support time-of-use rates for electric vehicle charging.

### **THE AHJ**

The permitting/inspection departments, (known as the Authority Having Jurisdiction, or AHJ) received the new technology well. Four training sessions were held, two each with Montgomery and Prince George’s counties. Representatives from the plan review and inspection departments were present at each session. Both jurisdictions expressed a willingness to accept the new product, either by accepting changes to existing permits (without starting the process over again) or by accepting the ConnectDER circuit breaker as the PV AC disconnect switch (reducing system components).

ConnectDER installations passed inspection in both Montgomery and Prince George’s County.

### **SOLAR PHOTOVOLTAIC (PV) INSTALLATION CONTRACTORS**

Installer acceptance was generally well received. Contractors realized they could save labor and materials on many of their projects, making them more competitive and possibly increasing their profit. The integrated circuit breaker allows them to terminate field wiring to de-energized terminals, vs. working in an energized service panel. They are eager to see the ConnectDER widely available and commonly deployed.

### **Quotes from our installation partners:**

*"I love the product and I'm looking forward using it on a lot of jobs going forward as a default tie in method. The majority of the cost savings is on the drywall repair and labor of install."*

*"Thanks again for having us in the program. We like the units and would be happy to see them deployed."*

*"We feel generally that if the inverter is to be mounted outside, near the meter, ConnectDER is a significant time and money saver."*

*"Look forward to promoting ConnectDER when I can."*

### **HOMEOWNERS**

Homeowners welcomed the ability to have their system installed without a contractor entering their home during the installation and inspection process. Market forces will drive the portion of the contractor's cost savings to be passed on to the homeowner in the form of overall lower PV system costs.

### **INDEPENDENT ENGINEERING FIRM #1**

A highly respected professional engineer in the PV industry was subcontracted on this project to become familiar with the ConnectDER, witness some installations in Maryland and provide a brief review of the product. He agrees that the ConnectDER provides a simple and compact means to terminate PV systems at the service entrance, and that utility acceptance is paramount.

The full report from Independent Engineering Firm #1 was transmitted to the MEA on April 24, 2015 and is included in [Appendix C](#).

## **6 - LESSONS LEARNED**

Only one installation partner was originally engaged to provide suitable PV systems for the ConnectDER. This partner provided a great value by introducing us directly to the AHJ representatives from Montgomery and Prince George's counties. They also permitted us to witness two PV installations in Maryland, while the ConnectDER was getting UL listed. One installation was relatively simple, and the other was more complex, invoking a "line side tap". Both the contractor and ConnectDER, LLC saw potential for cost savings in both situations.

The original partner had difficulty obtaining candidates in the utility's Maryland territory. New potential partners feared unknown delays waiting on ConnectDER installation. This is a normal and inherent in a pilot project. To rectify this, time commitments were secured from the utility to install the ConnectDER within three to five business days (weather permitting and assuming the existing meter socket was in suitable condition) after issuing their "approval to install" and the contractor had the necessary permits from the county. Additionally the utility committed to upgrade the customer's meter to the NEM (net energy meter) within three to five business days (again, weather permitting) following proof of final county inspection. These time commitments were valid only for the trial program, but were enough to persuade additional contractors to sign on as partners in the pilot.

In retrospect we would recruit multiple partners and secure a favorable service level agreement with the utility as early on as possible. We would also attempt to sign agreements with multiple utilities in Maryland.

We were not aware of the permit application/processing delays in Montgomery County, which routinely ran 4 weeks or more.

Contractors suggested a ConnectDER with a larger capacity than 200 amps would be useful. Homes with larger service entrance sizes make up a significant portion of their target market in Maryland. We've had this request before, but feel it will be difficult to pass the heat rise test required by UL. The homeowners with electrical services over 200 amps were disqualified as pilot participants.

Some homeowners prefer the string inverter(s) (if used vs. microinverters) to be placed indoors to preserve exterior aesthetics. The ConnectDER may still provide value in those cases, e.g., by potentially avoiding costly wiring upgrades.

Another contractor suggested a shorter form factor if possible, meaning the entire assembly and meter wouldn't protrude so far out from the meter socket. This is another request we've seen before, and we are considering alternative designs and feature sets which would permit a shorter form factor.

## 7 - PERFORMANCE DATA (THROUGH MARCH 2016)

Total DC kW of PV systems installed with the ConnectDER: **83.197**

Total DC kW of the five PV systems with minimum 1 year of data: **45.495**

Four of the five PV systems (with at least one year of data) have monitoring systems which log the PV power production. Electricity production for site #2 was estimated based the DC PV system size (6.0kW) and the average of the actual production of the other four systems. See Table 7.1 for details.

TABLE 7.1 - Photovoltaic (PV) electricity production data	
SITE #	TOTAL PRODUCTION (1-Year +) through March 25, 2016
1	8.073 MWh (megawatt hours)
2	5.000 MWh (ESTIMATED)
3	5.730 MWh
4	10.30 MWh
5	6.176 MWh

Total MWh (megawatt hours) produced: **35.279** **(35,279 kilowatt-hours)**

Total reported occurrences the ConnectDER circuit breaker tripped: 0

Total trouble calls reported relating to the ConnectDER: 0

Zero issues of any kind including safety and reliability were reported.

## 7A - PERFORMANCE DATA (THROUGH MARCH 2017)

Table 7.2 details the total production for:  
Systems #1 - #8 through March 10, 2017.  
Systems #9 - #10 through March 12, 2017.

Electricity production for site #2 was estimated based the DC PV system size (6.0kW) and the average of the actual production of the other nine systems.

TABLE 7.2 - Photovoltaic (PV) electricity production data		
SITE #	TOTAL PRODUCTION	# of days in service
1	15.395 MWh (megawatt hours)	812
2	11.425 MWh (ESTIMATED)	764
3	10.360 MWh	837
4	19.790 MWh	763
5	16.663 MWh	731
6	16.61 MWh	669
7	15.843 MWh	673
8	14.300MWh	620
9	4.85 MWh	367
10	7.458 MWh	367

**Total MWh (megawatt hours) produced: 130.734 (130,734 kilowatt-hours)**

Total reported occurrences the ConnectDER circuit breaker tripped: 0

Total trouble calls reported relating to the ConnectDER: 0

Zero issues of any kind including safety and reliability were reported.

## **8 - LIFE-CYCLE ANALYSIS/CONCLUSION**

The Maryland Game Changer 2.0 pilot has demonstrated benefits associated with cost savings, safety, convenience, reliability and future opportunities. Details for each of these benefits are listed below.

### **COST SAVINGS**

- Lower material and labor costs for PV systems (benefits contractors and homeowners).
  - Initial savings of over 2% to the retail price is significant.
- Lower operating costs for the utility.

The cost savings to all parties is expected to improve if the utility approves the ConnectDER for general use in its service territory and workflow becomes routine.

### **SAFETY**

- The integrated circuit breaker provides a safe termination point for field wiring.
- Lower operating costs for the utility from the reduction in service upgrades.

### **CONVENIENCE**

- No entry into the home is necessary to interconnect the PV system to the premises.
- No disruptions to the homeowner and simplified coordination for inspection activities.

### **RELIABILITY**

- Zero trouble calls reported.
- Over 2000 Simple ConnectDER units shipped to other areas of the country in 2015.

### **FUTURE OPPORTUNITIES**

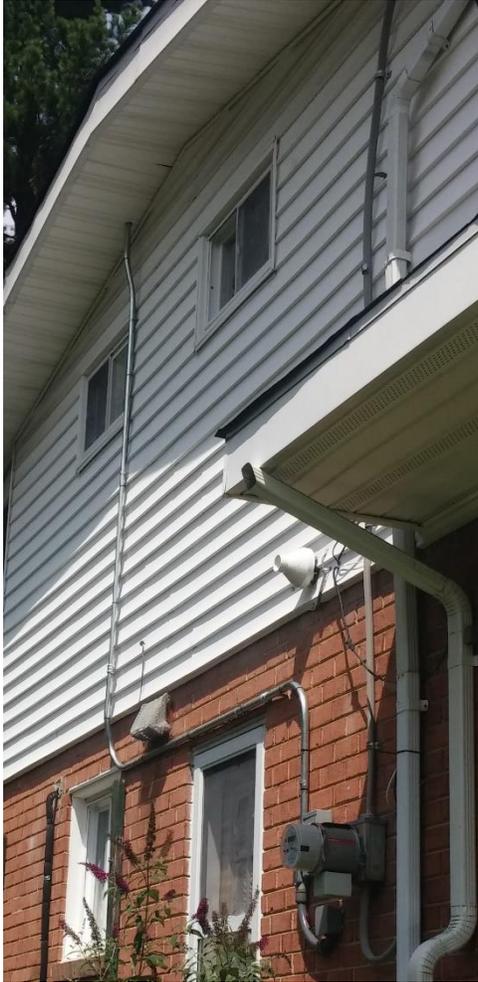
- Electric Utility #1 is considering:
  - Opening the Maryland market to general use of the Simple ConnectDER.
  - The ConnectDER for use in the District of Columbia.
  - The Smart ConnectDER for both solar PV and electric vehicle charging applications.

The assistance from the MEA demonstrates the ConnectDER is a market-ready solution to reduce the costs of traditional renewable energy deployments while driving other economic development opportunities.

## APPENDIX A – CONNECTDER SITE PHOTOS

### SITE #1

The inverters are on the opposite side of the house as the meter and ConnectDER.



**SITE #2**



**SITE #3**



SITE #3, continued:



**SITE #4**

Left: ConnectDER installed (winter)

Right: Shown w/PV connected (summer)

The inverters were placed indoors per the customer's preference.



**SITE #5**



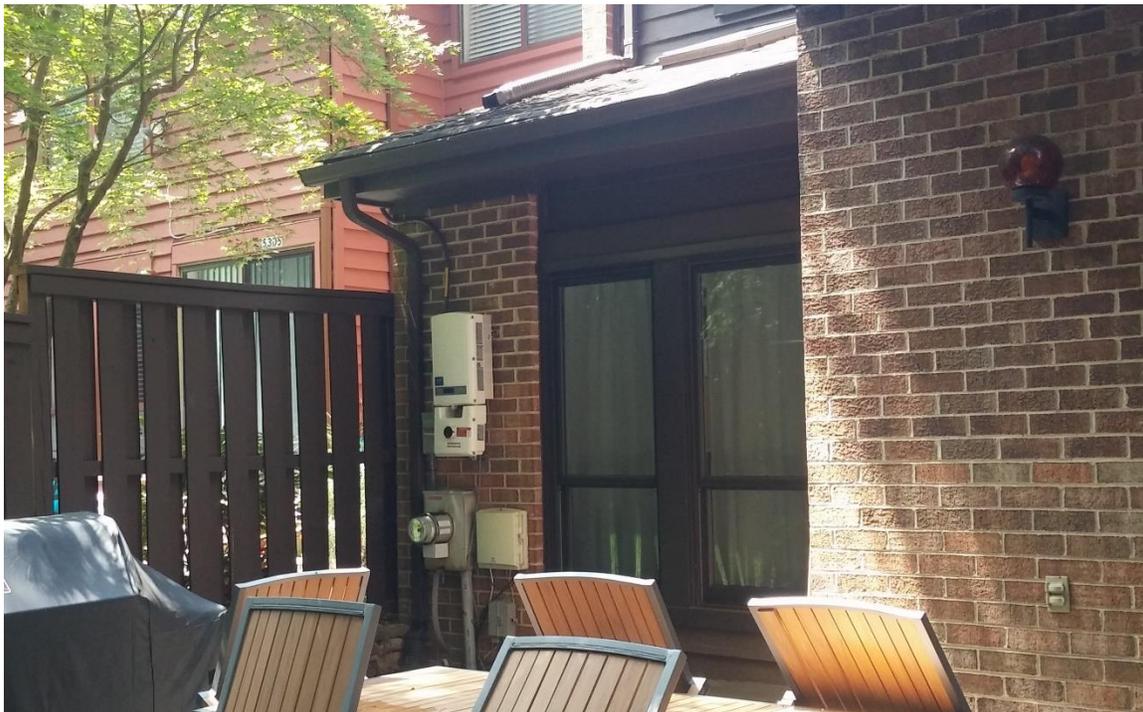
**SITE #6**



**SITE #7**



**SITE #8**



**SITE #9**



**SITE #10**



# APPENDIX B – EVIDENCE OF PV SYSTEM COSTS

**SITE #1**

<b>Invoice</b>											
						<b>PAID</b> 12/22/14					
Bill To  Silver Spring, MD 20902						Date 8/21/14		Invoice # 769PV			
						P.O. No.		Terms		Project	
Item	Description	Est Amt	Prior Amt	Prior %	Qty	Rate	Curr %	Total %	Amount		
Resident...	Initial deposit - upon contract signing				1	500.00			500.00		
Resident...	1st Enerbank SAC flex loan advance				1	5,998.00			5,998.00		
Resident...	2nd Enerbank SAC flex loan advance - upon materials order				1	5,998.00			5,998.00		
Resident...	Enerbank reduced interest loan disbursement, upon successful electrical inspection				1	25,627.00			25,627.00		
	Out-of-state sale, exempt from sales tax					0.00%			0.00		
						<b>Total</b>			<b>\$38,123.00</b>		
						<b>Payments/Credits</b>			-\$38,123.00		
						<b>Balance Due</b>			\$0.00		

**SITE #2**

		Date	<b>Invoice</b>	
		12/9/14		
		Due Date	Terms	Invoice #
		12/9/14	As Per Contract	2493
		Finance Charge		1.5%
<b>PAID</b> 12/12/14				
Bill To		Ship To		
Silver Spring, MD 20901		Silver Spring, MD 20901		
P.O. No.		Rep		
Completion		RS		
Item	Description	Proposal Amt	Current Amt	
PV Installation	Installation of a 6.0kW PhotoVoltaic System As Per Contract	18,034.56	5,410.00	
* A finance charge of 1.5% per month will be added to balances 30 days past due				
		<b>Total</b>		\$5,410.00
		<b>Payments/Credits</b>		-\$5,410.00
		<b>Balance Due</b>		\$0.00
Phone #		E-mail		
Web Site				

**SITE #3**

		Date	<b>Invoice</b>					
		12/19/14						
		Due Date	Terms	Invoice #				
		12/19/14	As Per Contract	2573				
		Finance Charge		5%				
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;"> <b>PAID</b>  <b>12/22/14</b> </div>								
<b>Bill To</b>  Cheverly, MD 20785		<b>Ship To</b>  Cheverly, MD 20785						
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%;">P.O. No.</td> <td style="width: 50%;">Rep</td> </tr> <tr> <td>Interconnection</td> <td>RS</td> </tr> </table>		P.O. No.	Rep	Interconnection	RS			
P.O. No.	Rep							
Interconnection	RS							
Item	Description	Proposal Amt	Current Amt					
PV Installation	Installation of a 4.96 kW Grid Tied PhotoVoltaic System As Per Contract	17,983.32	1,795.32					
* A finance charge of 1.5% per month will be added to balances 30 days past due								
		<b>Total</b>	\$1,795.32					
		<b>Payments/Credits</b>	-\$1,795.32					
		<b>Balance Due</b>	\$0.00					
<table style="width: 100%;"> <tr> <td style="width: 50%;">Phone #</td> <td style="width: 50%;">E-mail</td> </tr> </table>		Phone #	E-mail					
Phone #	E-mail							
Web Site								

**SITE #4**

**Invoice**

Date	Invoice #
10/24/14	683PV

**PAID**  
12/22/14

Bill To
Kensington, MD 20895

P.O. No.	Terms	Project

Item	Description	Est Amt	Prior Amt	Prior %	Qty	Rate	Curr %	Total %	Amount
Resident...	Initial deposit - upon contract signing				1	10,812.00			10,812.00
Resident...	Materials order - upon order of materials				1	10,812.00			10,812.00
Resident...	Electrical inspection - upon successful electrical inspection				1	10,812.00			10,812.00
	Out-of-state sale, exempt from sales tax					0.00%			0.00
						<b>Total</b>			<b>\$32,436.00</b>
						<b>Payments/Credits</b>			<b>-\$32,436.00</b>
						<b>Balance Due</b>			<b>\$0.00</b>

## SITE #5

**From:** [REDACTED]  
**Sent:** Friday, June 12, 2015 8:49 AM  
**To:** Al Iaconangelo <aiaconangelo@connectder.com>  
**Subject:** RE: [REDACTED] punch list

1. For [REDACTED]
  - a. We need approximate actual costs unless it's customer-owned and we'd need a copy of the final invoice to them. For [REDACTED] there's a cost of [REDACTED] I will go with that unless you tell me it's way off base. **That works**
  - b. What is "PTO"? Is the homeowner lacking documents....meaning is everything submitted to Pepco? **Permission to Operate waiting on utility**
  - c. Obviously we'll need the savings when it's completed. I think this one might have significant savings. **When this getting install I should be able to give that to you**
2. For [REDACTED] we need the cost as mentioned in #1. **13,000**
3. For [REDACTED] - cost, savings, what is "PTO"? Does Pepco have everything they need from you/the homeowner? **Still not installed yet**
4. For [REDACTED] - cost **26,000**

**SITE #6**

**Invoice**

Date	Invoice #
12/8/14	827PV

**PAID**  
03/22/15

Bill To
Rockville, MD 20853

P.O. No.	Terms	Project
	Due on receipt	

Item	Description	Est Amt	Prior Amt	Prior %	Qty	Rate	Curr %	Total %	Amount
Resident..	Initial deposit - upon contract signing				1	2,438.00			2,438.00
Resident..	Materials order - upon order of materials				1	14,988.00			14,988.00
Resident..	Electrical inspection - upon successful electrical inspection				1	4,888.00			4,888.00
Resident..	Utility interconnection - upon utility approval of interconnection				1	4,888.00			4,888.00
	Out-of-state sale, exempt from sales tax					0.00%			0.00
						<b>Total</b>			<b>\$27,202.00</b>
						<b>Payments/Credits</b>			<b>-\$27,202.00</b>
						<b>Balance Due</b>			<b>\$0.00</b>

## SITE #7

**From:** [REDACTED]  
**Sent:** Thursday, March 24, 2016 1:53 PM  
**To:** aiaconangelo@connectder.com  
**Subject:** RE: ConnectDER/MD Energy Admin punch list

Hey Al

Sorry about the late response but this month has been crazy due to the amount of work we are doing it is the end of the 1<sup>st</sup> quarter of the year so always a stressful time. I hope this is everything you were looking for if not let me know. As for the Nabcep conference I was thinking of going but I don't think I have the time I don't know if anyone locally [REDACTED] will be there or not to be honest I wish I could go I could use the continuing ed for renewing my Nabcep cert. Let me know if you need anything from my end and I can't wait until we can go for every job [REDACTED] with the Connectder. Any news on [REDACTED] or [REDACTED]

Thanks  
[REDACTED]

1. Updated cost info for [REDACTED] – you informed me \$13,000 when his system was 23 panels/5.98kW which works out to 260 watt panels. As you may recall, we had to change the 30 amp ConnectDER to a 60 amp – to accommodate 41 panels. Using the same formula (41 x 260 watt panels), that works out to 10.66kW. At the same \$ rate that works out to \$23,173.91. Can you please confirm the actual cost or that this is essentially correct? **Its actually slightly less around 21,000 but close enough**

2. You estimated \$500 savings when his system was 5.98kW. What is the estimated savings at 10.66kW? – I know it's not much (wire and fuse size increase, but we want the savings to be the maximum). **I would say roughly a 30-50 extra savings**

3. As of March 31st 2016 (or any day between now and then), I'd like to get the total kW hours produced by the [REDACTED] system - I assume that's available to you by logging in to it? **6175.540KWH as of today**

I have to wait another year to ask for a report on [REDACTED] data – I have to split the data into 5 systems that had final inspections by 3/31/2015 with the remaining 5. I'll take the data you have though if you look it up.

(Note, if there's a read-only login to these you can provide to me then I can get this on own if that's easier....and I won't have to ask for [REDACTED] data a year from now.). **sorry there is no outside log in to a single customers account unless you're the customer so I can get that for you next year as well**

4. Any report of the breaker tripping or other misc. info? (If so, any cause, consequence, etc.) **No problems at all to report which is awesome news**

5. A couple of sentences on your thoughts about reducing costs using a meter collar, cost savings, estimated % of installs (residential, 200 amp max) it might apply to, etc. if Pepco opens it up for general use in their territory. I love the product and I'm looking forward using it on a lot of jobs going forward as a default tie in method. The majority of the cost savings is on the drywall repair and labor of install. The next best step is if [REDACTED] would allow us to do the collar install that way the [REDACTED] crew could come back and install the net meter and inspect the work. That way we wouldn't have to come back to make our final connections. As for estimated number of installs if I gave you a number that could change next month but I would tell you we are installing [REDACTED] in Md this month residentially so I would say a majority of that would could have the Connectder on them.

**SITE #8**

**Invoice**

Date	Invoice #
11/11/14	704PV

Bill To
Kensington, MD 20895

**PAID**  
12-30-14

P.O. No.	Terms	Project

Item	Description	Est Amt	Prior Amt	Prior %	Qty	Rate	Curr %	Total %	Amount
Resident..	Initial deposit - upon contract signing				1	9,080.66			9,080.66
Resident..	Materials order - upon order of materials				1	9,080.67			9,080.67
Resident..	Electrical inspection - upon successful electrical inspection				1	9,080.67			9,080.67
Resident..	Utility interconnection - upon approved utility interconnection				1	1,000.00			1,000.00
	Sales Tax					5.75%			0.00

<b>Total</b>	<b>\$28,342.00</b>
<b>Payments/Credits</b>	<b>-\$28,342.00</b>
<b>Balance Due</b>	<b>\$0.00</b>

**SITE #9**

**Invoice**

Rep	Date	Invoice #
JD	2/9/2016	8010

Bill To	
	Silver Spring, MD 20910

Terms

Item	Description	Rate	Amount
43 - Solar PV	SOLAR PV RENEWABLE ENERGY SYSTEM Design, Engineer, Permit, and Install NEW 6.87 kW Solar PV system	1.80006	26,095.01

		<b>Total</b>	<b>526,095.01</b>
		<b>Payments/Credits</b>	<b>-513,047.50</b>
		<b>Balance Due</b>	<b>513,047.51</b>

By signing below, the customer certifies all the above work has been satisfactorily completed.

Date: \_\_\_\_\_

**SITE #10**

**Invoice**

Rep	Date	Invoice #
JD	3/10/2016	7447

<b>Bill To</b>	
	Takoma Park, MD 20912

<b>Terms</b>

Item	Description	Rate	Amount
	NEW SOLAR PV RENEWABLE ENERGY SYSTEM	0.00	0.00
45 - Solar PV	Design, Engineer, Permit, and Install new 4.9 kW Solar PV system	4.05301	19,880.01

<b>Total</b>	519,880.01
<b>Payments/Credits</b>	-59,940.00
<b>Balance Due</b>	59,940.01

By signing below, the customer certifies all the above work has been satisfactorily completed.  
 \_\_\_\_\_ Date: \_\_\_\_\_

**APPENDIX C – INDEPENDENT ENGINEERING FIRM #1 EVALUATION  
REPORT**

**ConnectDER Meter Base Parallel  
Generator Connection Device:  
A Review of the Value and Viability of the Product  
for the Utility and Solar Industries**

*Prepared for:*

**ConnectDER**

*Prepared by:*

Independent Engineering Firm #1

Version 1.0

April 22, 2015

## Table of Contents

- 1 Introduction
- 2 Review of the ConnectDER Product
- 3 Advantages of Supply Side Connections with ConnectDER
- 4 Viability of the ConnectDER Product
- 5 Summary

## **1 Introduction**

Making electrical connections of a solar photovoltaic (PV) system to a building electrical system can often be one of the more challenging aspects of a PV installation. The National Electrical Code (NEC) has detailed information on how to perform load side connections in 705.12(D). Significant size restriction exist with load side connections so it is common for larger PV systems to be installed on the line side of the service disconnecting means. Line side connections are covered briefly in 705.12(A), but little detail is provided on these connections. The primary requirement is that a parallel generator be no larger than the service entrance conductors.

General requirements for any electrical equipment installed in accordance with the NEC is that electrical products be tested by a recognized testing laboratory [NEC 90.7] and that electrical products be installed in accordance with the manufacturer's instructions [NEC 110.3(B)]. Several challenges exist with making electrical connections to the line side of the service disconnecting means, not the least of which is finding certified equipment for the application. The ConnectDER product reviewed in this report provides a somewhat unique approach to making a line side service connection that will be described in this report. Since the product is installed in the utility meter socket, approval from the serving utility is necessary in addition to approval from the local jurisdiction charged with enforcing the electrical code. The value and viability of this product is discussed as it relates to enabling the electrical connections for PV systems to residences.

## 2 Review of the ConnectDER Product

The ConnectDER product reviewed in this report provides a somewhat unique approach to making a line side service connection in that it interconnects the parallel generator on the immediate load side of the utility meter. For net metering solar PV system installations, the PV system must be connected on the load side of the utility meter to properly monetize the benefits of the PV system. A supply side parallel generator connection can be made at any point from the load side of the utility meter to the line side of the service disconnecting means.

Since most residential electrical services require a self-contained electrical meter through which all the power to the residence must pass, an electrical connection at the utility meter is a logical place for a net metered PV system interconnection. The ConnectDER product is configured as a meter collar intended to be installed on the existing meter base. The ConnectDER meter collar is installed by removing the existing utility meter from the meter base, installing the ConnectDER meter collar on the meter base, and then reinstalling the utility meter on the ConnectDER meter socket. The ConnectDER meter collar includes a neutral conductor that must be terminated in the existing meter base to properly establish the system bonding of the parallel generator and to provide the neutral reference so that the meter can properly measure energy flows.

The ConnectDER meter collar includes a circuit breaker and electrical termination box so that the parallel generator can easily make the necessary electrical connections and have the NEC required disconnect and overcurrent device at the point of connection. This means that none of the field wiring connected to the parallel generator is unprotected as all wiring is downstream of the ConnectDER circuit breaker. The ConnectDER product can be ordered with either a 60-amp or a 40-amp, 240-Volt ac circuit breaker. This will allow up to an 11.5 kW PV system to be installed on as small as a 60-amp service while still meeting NEC requirements. As PV systems continue to get cheaper and more efficient, the size of PV systems will continue to grow. Even with the growth in the size of PV systems on residential construction, only a small percentage of systems will exceed 10 kW. This is further constrained by the fact that many utilities and jurisdictional authorities have special interconnection and permitting processes that give preference to systems no larger than 10 kW. Currently, average PV system sizes remain around 5 kW.

### **3 Advantages of Supply Side Connections with ConnectDER**

There are several advantages to supply side service connections at the utility meter location as provided by the ConnectDER device. One advantage is that it allows electrical connections to be made on the exterior of the house. While some distribution panels are located on the exterior of houses, most panelboards are located within the house requiring contractor access to the house during the PV installation. The more work that can be done from the exterior of the house, the more flexible the installation timing can be for the contractor and the homeowner. Also, there is less disruption for the homeowner and their home, which is always an important consideration for good customer relations.

Another advantage of a supply side connection at the utility meter is avoiding connecting to the customer's distribution panel. There are several reasons why avoiding a distribution panel may be beneficial. One reason is the need for two branch circuit breaker spaces in the existing distribution panel for the residence. Often, houses in subdivisions are designed with few, if any spare breaker spaces. This lack of breaker spaces can even necessitate installing a larger distribution panel which can be costly and time-consuming. Additionally, any time a contractor adds equipment to an existing service panel, there is a possibility of damage to the panel or the wiring if the panel is old or has little room for additional circuits. Lastly, working in an existing panel can open the homeowner's distribution panel to code compliance scrutiny. A field inspector that sees an obvious code violation during an inspection, even though it has nothing to do with the PV installation, may be obligated to flag the violation and require that the violation be fixed prior to signing off on the PV installation.

Finally, the advantage of a supply side connection is to allow a larger-sized PV systems than allowed with load-side connections. The NEC limits load-side connections in panelboards 705.12(D)(2)(3)(b) based on the sum of the supply sources to the panelboard. The sum of supply breakers can be no more than 120% of the service panelboard busbar rating. If the service panelboard has a busbar with a 100-amp rating, and the utility supply breaker is rated at 100-amps, the largest PV system is limited to a 20-amp circuit breaker (3840 Watts maximum continuous output). A 200-amp busbar with a 200-amp supply breaker would limit the PV system to 7680 Watts (40-amp circuit breaker). Many 100-amp panels exist throughout the United States presenting a real limitation to PV systems connected to the load side of the service disconnect. The ConnectDER product alleviates this limitation.

#### **4 Viability of the ConnectDER Product**

The NEC compliance of the ConnectDER product is clear based on listing of the device and the rules related to parallel generation equipment installed on the supply side of the service disconnecting means. While NEC compliance is extremely important, approval from the serving utility company is equally important. Since the ConnectDER device is installed in the utility meter socket and mounts the utility meter, installation approval for the device also falls under the jurisdiction of the utility company. To date, several utility companies have approved the ConnectDER device for use with their utility meters. This early utility acceptance of the product proves that there are no technical concerns from a utility point of view. Also, the size and form factor of the residential utility service meter is one of the most standardized pieces of equipment in the electric industry.

The fact that several utilities have approved the product is key to general utility approval. However, there is still much to be done to get to the point where most utilities will accept the device in their service territories. The positive experiences that utilities are having with the device need to be leveraged so that other utilities approve the device. Success within the utility industry is closely related testimonials from fellow utility companies rather than by solar industry testimonials. There are also regional entities within the utility industry that are key to approving products for service entrances. In the western United States, an influential organization for service entrance equipment is the Electric Utility Service Equipment Requirements Committee (EUSERC). This organization is made up of meter technicians, local building department representatives, and electrical equipment manufacturers. Participants in this group review designs of service equipment, set standards for service equipment, and develop lists of equipment that are approved by EUSERC. Most utilities in the western United States will approve the installation of service equipment that has been approved by EUSERC.

It is recommended that ConnectDER work to get the approval of EUSERC and other similar organizations across the country. While obtaining approval from these types of groups will take strategy and time, it is the best way to get the widest acceptance of the product in the shortest amount of time. For ConnectDER to be truly viable on a national scale the approval of these key utility organizations cannot be underestimated.

## **5 Summary**

In summary, products that allow simple connection of PV systems at the service entrance equipment are key to the widespread use of solar energy in the United States. The ConnectDER product provides a simple and compact means to accomplish this connection that meets NEC requirements and has proven acceptability with utility companies. While the ConnectDER product still has a ways to go before it enjoys broad utility acceptance, the proper steps are being taken to prove itself to the utility industry. As this utility acceptance spreads through influential utility organizations, the benefits of simple PV system connections will be realized throughout the United States. Products like the ConnectDER device are an important connection option that needs to be available to customers looking for simple PV system connection options that do not require a connection inside the service panelboard.

This concludes the Independent Engineering Firm #1 assessment of the value and viability of the ConnectDER device.