



Cogeneration and Solar Photovoltaic Characteristics

PURPA Technical Advisory Committee

Michigan Public Service Commission

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COGENERATION

QF Characteristics

Cogeneration facilities are not subject to a size limit under PURPA

Cogeneration facilities may use any fuel

There is considerable technology variation

Cogeneration must produce useful and used heat in addition to electricity

- Most cogeneration provides either industrial process heat or large facility or campus heating/cooling
- Most cogeneration uses heat “left over” after power generation but power generation can be done using waste heat recovery

Existing Cogeneration Facilities

Organization Name	Facility Name	Application	SIC4	NAIC S	Op Year	Capacity (KW)	Prime Mover	Fuel Class
Dow Corning Corporation	Fairgrove Farms	Agriculture	100	111	1981	80	Reciprocating Engine	BIOMASS
Andersons Albion Ethanol LLC	Pulp And Paper Mill	Pulp and Paper	2621	322121	1985	28000	Boiler/Steam Turbine	BIOMASS
Hardy Salt Company/Akco Company	All-Wood, Inc.	Wood Products	2421	321113	1985	150	Reciprocating Engine	BIOMASS
Morton Salt Company	Waste Energy Services Inc	Utilities	4939	221112	1986	1400	Reciprocating Engine	BIOMASS
Cargill, Inc.	Adrian Landfill	Solid Waste Facilities	4953	562212	1994	2400	Reciprocating Engine	BIOMASS
Michigan State University	Citizens Disposal Landfill	Solid Waste Facilities	4953	562212	1994	4000	Reciprocating Engine	BIOMASS
Northern Michigan University	Peoples / Citizens Disposal	Other/Unknown	9900	999	1995	3200	Reciprocating Engine	BIOMASS
Viking Energy Of Lincoln	Scenic View Dairy	Agriculture	241	11212	2007	800	Reciprocating Engine	BIOMASS
General Foods Corporation	den Dulk Dairy	Agriculture	241	11212	2007	30	Reciprocating Engine	BIOMASS
Michigan Sugar Company	Geerlings Hillside Farms Overisel Hog Facility	Agriculture	241	11212	2008	500	Reciprocating Engine	BIOMASS
Herman Miller, Inc.	Delhi Wastewater Treatment Plant	Wastewater Treatment	4952	22132	2009	60	Microturbine	BIOMASS
Department of Veterans Affairs	Landfill	Solid Waste Facilities	4953	562212	2011	1600	Reciprocating Engine	BIOMASS
County Of Jackson	Facilities / Heating Plant	Colleges/Univ.	8221	613111	2013	645	Boiler/Steam Turbine	BIOMASS
Robbins, Inc.	Battle Creek VA Medical Center	Hospitals/Healthcare	8062	62211	2014	2000	Boiler/Steam Turbine	BIOMASS
Detroit Steel Company	Lowell Waste-to Energy Facility	Solid Waste Facilities	4953	562212	2014	800	Boiler/Steam Turbine	BIOMASS
Neenah Paper	BFI Lyons - Landfill Gas	Solid Waste Facilities	4953	562212		1000	Reciprocating Engine	BIOMASS
Sappi / S.D. Warren/Scott Paper Company	BFI Marshall - Landfill Gas	Solid Waste Facilities	4953	652212		1000	Reciprocating Engine	BIOMASS
Pulp And Paper Mill	Munising Mill	Pulp and Paper	2621	322121	1940	6200	Boiler/Steam Turbine	COAL
T.E.S. Filer City Station LP	Hardy Salt Company	Chemicals	2899	325998	1946	1500	Boiler/Steam Turbine	COAL
Domtar Industries, Inc.	Michigan Sugar Company	Food Processing	2063	311313	1949	3000	Boiler/Steam Turbine	COAL
Graphic Packaging Corp	Menominee Paper Company	Pulp and Paper	2631	32213	1951	2500	Boiler/Steam Turbine	COAL
Escanaba Paper	Morton Salt International	Chemicals	2899	325998	1957	5000	Boiler/Steam Turbine	COAL
Mead Corporation	Louisiana Pacific Corp	Wood Products	2421	321113	1957	6200	Boiler/Steam Turbine	COAL
Waldorf Corporation	Smurfit Stone Container Corp	Pulp and Paper	2631	32213	1966	14800	Boiler/Steam Turbine	COAL
Cellu Tissue Holdings, Inc.	Cargill Salt Inc.	Chemicals	2899	325998	1968	2000	Boiler/Steam Turbine	COAL
Smurfit Stone Container Corporation	Eddy Specialty Papers Facility	Pulp and Paper	2621	322121	1969	7000	Boiler/Steam Turbine	COAL
Greater Detroit Resource Recovery	Power Plant 65-Utilities Service Dept and South Campus Anaerobic Digester	Colleges/Univ.	8221	61131	1974	71450	Boiler/Steam Turbine	COAL
Kent County	Muskegon Pulp Paper Mill	Pulp and Paper	2621	322121	1985	29000	Boiler/Steam Turbine	COAL
2G CENERGY	Packing Corp.Of Amer/Filer Cty.Paper Mil	Pulp and Paper	2621	322121	1990	65000	Boiler/Steam Turbine	COAL
General Motors Corp-WFGPontiac	General Motors Corp-WFGPontiac	Transportation Equipment	3711	336111	2007	25000	Boiler/Steam Turbine	COAL

Existing Cogeneration Facilities

Organization Name	Facility Name	Application	SIC4	NAICS	Op Year	Capacity (KW)	Prime Mover	Fuel Class
Marquette Fabricators, Inc.	Mead Corporation	Pulp and Paper	2631	32213	1940	7000	Boiler/Steam Turbine	NG
Beaver Michigan Associates L.P.	Detroit Steel Company	Primary Metals	3312	331111	1954	5000	Boiler/Steam Turbine	NG
Louisiana Pacific Co / Decorative Panels International	Waldorf Corporation	Pulp and Paper	2631	32213	1955	2500	Boiler/Steam Turbine	NG
Core Energy	Graphic Packaging Corporation	Pulp and Paper	2621	322121	1959	11800	Boiler/Steam Turbine	NG
General Motors	Kraft Foods Inc.	Food Processing	2043	31123	1965	9000	Boiler/Steam Turbine	NG
Michigan Power, L.P.	Central Power Plant	Colleges/Univ.	8221	61131	1975	45200	Combined Cycle	NG
ADA Cogeneration	Northwood Institute	Colleges/Univ.	8221	61131	1983	180	Reciprocating Engine	NG
Swedish company EQT Infrastructure and American partner Fortistar	Country Fresh Dairy Inc	Agriculture	241	11212	1984	500	Reciprocating Engine	NG
University Of Michigan	Albion College	Colleges/Univ.	8221	61131	1984	360	Reciprocating Engine	NG
Central Michigan University	James River Paper-Packaging Papers Mill	Pulp and Paper	2631	32213	1985	15000	Combustion Turbine	NG
Deanborn Industrial Gen Inc.	Parke-Davis	Chemicals	2834	325412	1986	2800	Combustion Turbine	NG
Lansing Board of Water and Light	Rawsonville Plant	Transportation Equipment	3711	336111	1986	4500	Combustion Turbine	NG
IMC Kalium Chemical	Southeastern Michigan Gas Company	Utilities	4924	22121	1987	60	Reciprocating Engine	NG
Parkdale Pharmaceutical Inc.	Eastern Michigan Univ	Colleges/Univ.	8221	61131	1988	3500	Combustion Turbine	NG
Warner-Lambert Company	Hutzel Hospital	Hospitals/Healthcare	8062	62211	1988	1600	Combustion Turbine	NG
Dow Chemical USA.	General Motors Corp-Warren	Transportation Equipment	3711	336111	1988	4000	Combustion Turbine	NG
Eastern Michigan University	Clarion Inn Hotel	Hotels	7011	72111	1988	125	Reciprocating Engine	NG
Ferris State College	Warner-Lambert Company	Chemicals	2834	325412	1989	2800	Combustion Turbine	NG
Western Michigan University	Allied Finishing, Inc.	Fabricated Metals	3400	332	1989	800	Reciprocating Engine	NG
State of Michigan Secondary Complex	Oakwood Hospital	Hospitals/Healthcare	8062	62211	1989	1350	Reciprocating Engine	NG
Spectrum Health Partners Butterworth Hospital	Amway Corporation	Chemicals	2841	325611	1990	29400	Combined Cycle	NG
Hutzel Hospital	Dow Chemical Company	Chemicals	2869	325199	1990	1633000	Combined Cycle	NG
Domtar Paper	FSU Central Heating/Air Conditioning	Colleges/Univ.	8221	61131	1990	1100	Combustion Turbine	NG
Dunn/Seco Partners	Ajax Metal Processing	Fabricated Metals	3400	332	1990	500	Reciprocating Engine	NG
United States Gypsum / Menasha Packaging Co LLC / Otsego Paper Inc.	Lorin Industries	Primary Metals	3341	331314	1990	3200	Reciprocating Engine	NG
Ford Motor Company	Central Michigan University	Colleges/Univ.	8221	61131	1991	4400	Combined Cycle	NG
Powertrain Warren GMC	Vossilantz	Fabricated Metals	3400	332	1991	1000	Reciprocating Engine	NG
Fairgrove Farms	Voss Steel Project	Primary Metals	3312	331111	1991	1000	Reciprocating Engine	NG

Existing Cogeneration Facilities

Organization Name	Facility Name	Application	SIC4	NAICS	Op Year	Capacity (KW)	Prime Mover	Fuel Class
On Site/ Enegrid Ltd.	Butterworth Hospital	Hospitals/Healthcare	8062	62211	1993	3800	Combustion Turbine	NG
Scenic View Dairy	Metty Drive Project	Misc. Services	8900	514199	1994	350	Reciprocating Engine	NG
den Dulk Dairy / Grand Valley State University (Dr. Imad Mahawill); Entect Biogas GmbH of Austria	Dow Chemical Plant	Chemicals	2821	325211	1995	128000	Combined Cycle	NG
Geerlings Hillside Farms Overisel Hog Facility	USG Paper Mill / Paperboard Division Power Plant	Pulp and Paper	2631	32213	1995	10600	Combustion Turbine	NG
Detroit Metropolitan Airport	Western Michigan University	Colleges/Univ.	8221	61131	1997	10583	Combustion Turbine	NG
Decker Energy International, Inc.	Ford & Rouge Steel Company - Severstall	Transportation Equipment	3711	336111	1999	760000	Combined Cycle	NG
Decker Energy International, Inc.	IMC Kalium Chemical	Chemicals	2800	325	1999	6170	Combustion Turbine	NG
University of Detroit Mercy	Dow Agro Science	Chemicals	2870	325998	1999	7030	Combustion Turbine	NG
Michigan Automotive Research Corporation	Dorntar Paper	Pulp and Paper	2621	322121	1999	1210	Combustion Turbine	NG
Voss Industries Aka Mmc Metals	CRM Inc.	Fabricated Metals	3400	332	2000	450	Reciprocating Engine	NG
Ajax Metal Processing, Inc./Hale Enginee	Botsford Kidney Center	Hospitals/Healthcare	8062	62211	2000	75	Reciprocating Engine	NG
Allied Finishing, Inc.	Detroit Metropolitan Airport	Air Transportation	4581	488119	2001	17200	Reciprocating Engine	NG
CRM Inc.	Michigan Alternative and Renewable Energy Center (MAREC)	Colleges/Univ.	8221	61131	2003	330	Fuel Cell	NG
Oakwood Hospital Corporation	Henry Ford Community College	Colleges/Univ.	8222	61121	2003	70	Other	NG
William Beaumont Hospital	Anderson Albion Ethanol	Chemicals	2869	325193	2006	2000	Boiler/Steam Turbine	NG
Botsford Kidney Center	Detroit Arsenal	Military/National Security	9711	92811	2010	334	Reciprocating Engine	NG
Royce Ventures	State of Michigan Secondary Complex	General Gov't.	9100	92119	2012	3400	Combustion Turbine	NG
Detroit Arsenal	Veterans Affairs Hospital	Hospitals/Healthcare	8062	62211	2012	1000	Microturbine	NG
Focus Hope Technical School	REO Town Plant (Moores Park replacement)	Utilities	4939	221112	2013	100000	Combined Cycle	NG
Stirling Thermal Motors, Inc.	Washtenaw Community College - United Association Great Lakes Regional Training Center	Colleges/Univ.	8221	61131	2014	130	Microturbine	NG
North American Natural Res	University of Detroit Mercy	Colleges/Univ.	8221	61131		450	Reciprocating Engine	NG
Voss Industries Aka Mmc Metals	Focus Hope Technical School	Misc. Education	8299	61111		1500	Reciprocating Engine	NG
Lorin Industries	Michigan Automotive Research Corporation	Energy Management Services	8731	54171	1990	1600	Reciprocating Engine	OIL
DTE Biomass Energy/Landfill Energy Systems	William Beaumont Hospital	Hospitals/Healthcare	8062	62211	1992	3800	Reciprocating Engine	OIL
TOTAL						3,452,946		

Existing Cogeneration Facilities

Organization Name	Facility Name	Application	SIC4	NAICS	Op Year	Capacity (KW)	Prime Mover	Fuel Class
BFI Lyons	Lafarge Corp Alpena	Stone/Clay/Glass	3200	327	1952	47200	Steam Rankine Cycle	WAST
BFI Marshall	Mead Paper Subsidiary	Pulp and Paper	2621	322121	1969	100000	Boiler/Steam Turbine	WAST
Landfill	State Prison Of Southern Michigan	Justice/Public Order	9223	92214	1987	3700	Boiler/Steam Turbine	WAST
Citizens Disposal Landfill	Greater Detroit Resource Recovery	Solid Waste Facilities	4953	562212	1989	68000	Boiler/Steam Turbine	WAST
Decker Energy International, Inc.	Kent County Waste to Energy / Covanta	Solid Waste Facilities	4953	562212	1989	18000	Boiler/Steam Turbine	WAST
Eq-Waste Energy Services Inc	Co-Generation	Warehouses	4226	49319	1990	75	Reciprocating Engine	WAST
Co-Generation	GM Lansing	Transportation Equipment	3711	336111	2002	1800	Backpressure Steam Turbine	WAST
All-Wood, Inc.	Core Energy	Oil/Gas Extraction	1381	21111	2008	509	Backpressure Steam Turbine	WAST
Wayne State University	Herman Miller, Inc.	Furniture	2500	311999	1980	500	Boiler/Steam Turbine	WOOD
Grand Valley State Univ	Seco Plant	Chemicals	2869	325199	1982	22400	Boiler/Steam Turbine	WOOD
Henry Ford Community College	Marquette Fabricators, Inc.	Wood Products	2400	321	1987	175	Boiler/Steam Turbine	WOOD
Macomb Community College	Furman Foods	Food Processing	2000	311	1989	18000	Boiler/Steam Turbine	WOOD
GEM Energy	Robbins Woodburning Cogeneration Project	Misc. Manufacturing	3900	339999	1992	500	Boiler/Steam Turbine	WOOD
GEM Energy	Cadillac Renewable Energy	Wood Products	2421	321113	1993	34000	Boiler/Steam Turbine	WOOD
Delhi Charter Township	College of Engineering	Colleges/Univ.	8221	61131	2003	5	Fuel Cell	zOTR
Lafarge Corp	Henry Ford Community College	Colleges/Univ.	8222	61121	2003	5	Fuel Cell	zOTR
Henry Ford Community College	M-TEC Facility	Colleges/Univ.	8222	61121	2003	5	Fuel Cell	zOTR

Ancillary benefits

- Environmental
 - Carbon mitigation (for some fuels)
 - Greater fuel efficiency
 - Waste management (for some fuels)
- Social
 - Local jobs, local resource
 - Tax base, property value



Energy value

Compared to separate heat and power generation,

- Reduced carbon = Sec. 111(d) / CPP credits
- Reduced air emissions

Schedule is predictable,

- Usually driven by host facility need for heat
- Highly correlated with host need for power
- Effectively load-following

System benefits

- Source diversification
 - By fuel
 - By ownership
- Capacity
 - Grid reliability
 - Voltage support
 - VARs
 - Minimize impact of transmission outages
 - Distributed generation
 - Load-Related





SOLAR PHOTOVOLTAIC

QF Characteristics

Standard Offer Required <100 kW

Standard Offer Allowed >100 kW but <20 MW

Michigan offers customers with behind-the-meter solar, without formal QF registration

- True Net Metering for systems < 20 kW
- Modified Net Metering for systems > 20 kW

Michigan does not have standard offer for solar that is not behind-the meter

- Consumers FIT would satisfy this requirement

Existing QFs

None registered in Michigan (to my knowledge)

All existing solar systems potentially qualify

- Planned GroSolar system for LBWL >20 MW
- All other non-utility systems are <20 MW
- Solar is rapidly approaching competitiveness with avoided cost

Ancillary benefits

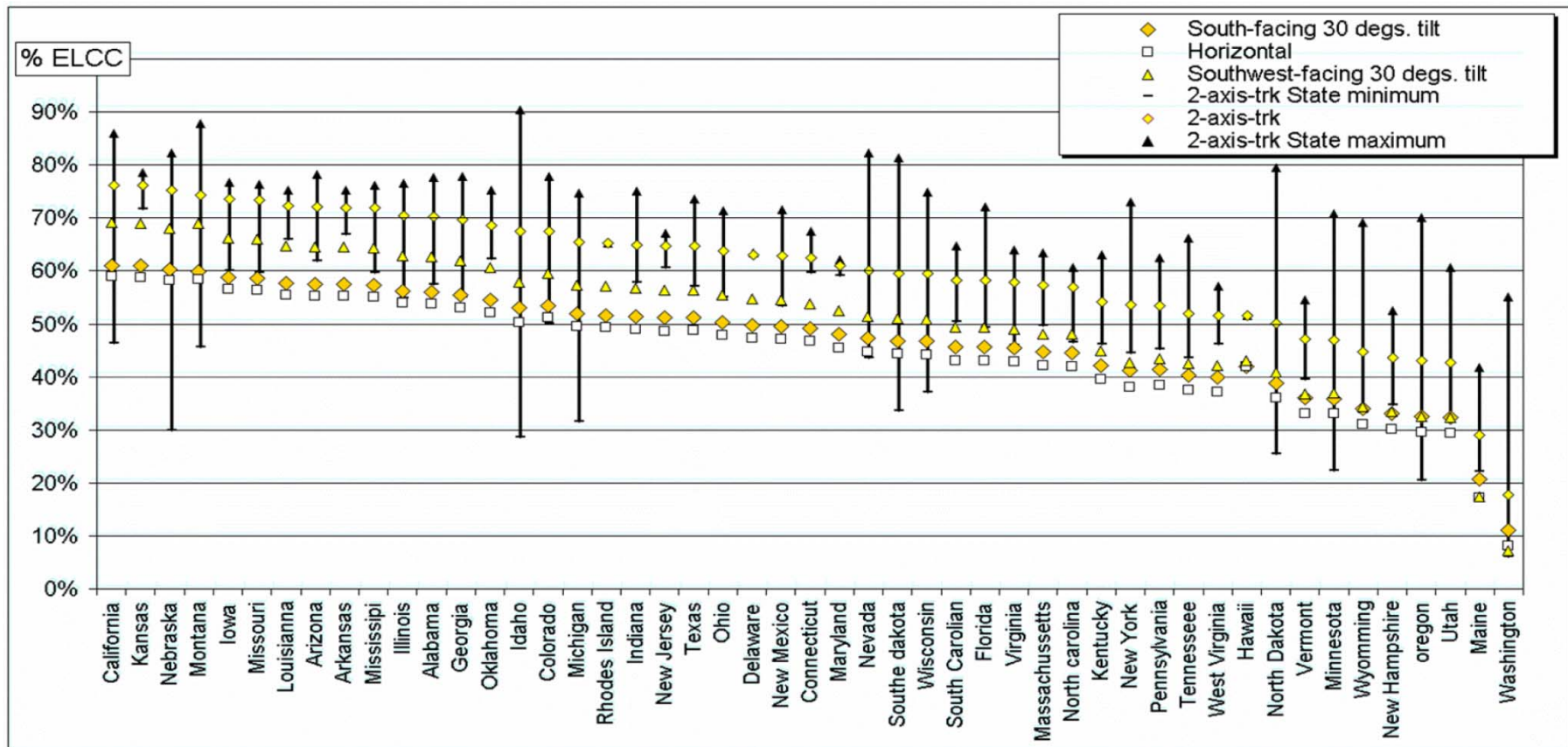
- Environmental
 - No direct emissions
 - Essentially tied with wind for lowest environmental harm amongst power generation technologies
 - Can use land that has limited other value (e.g., brownfields)
- Michigan-made energy
 - Built & operated
 - Local labor

Energy value

- Michigan RPS & CPP qualified
- Generates when sun shines, strongly correlated with load
- Correlation is more than season and time of day – about 25% of air conditioning load is directly due to sunlight on buildings
- Individual solar system output is variable in short term, aggregate of distributed systems is fairly steady in short term and as or more predictable than load
- Fuel Price Hedge (reduces costs associated with volatility) of about \$25/MWh Solar Generation

Capacity value

- Not at nameplate, but can be evaluated at Effective Load Carrying Capacity (ELCC)
- Depends on tracking, positioning, etc.

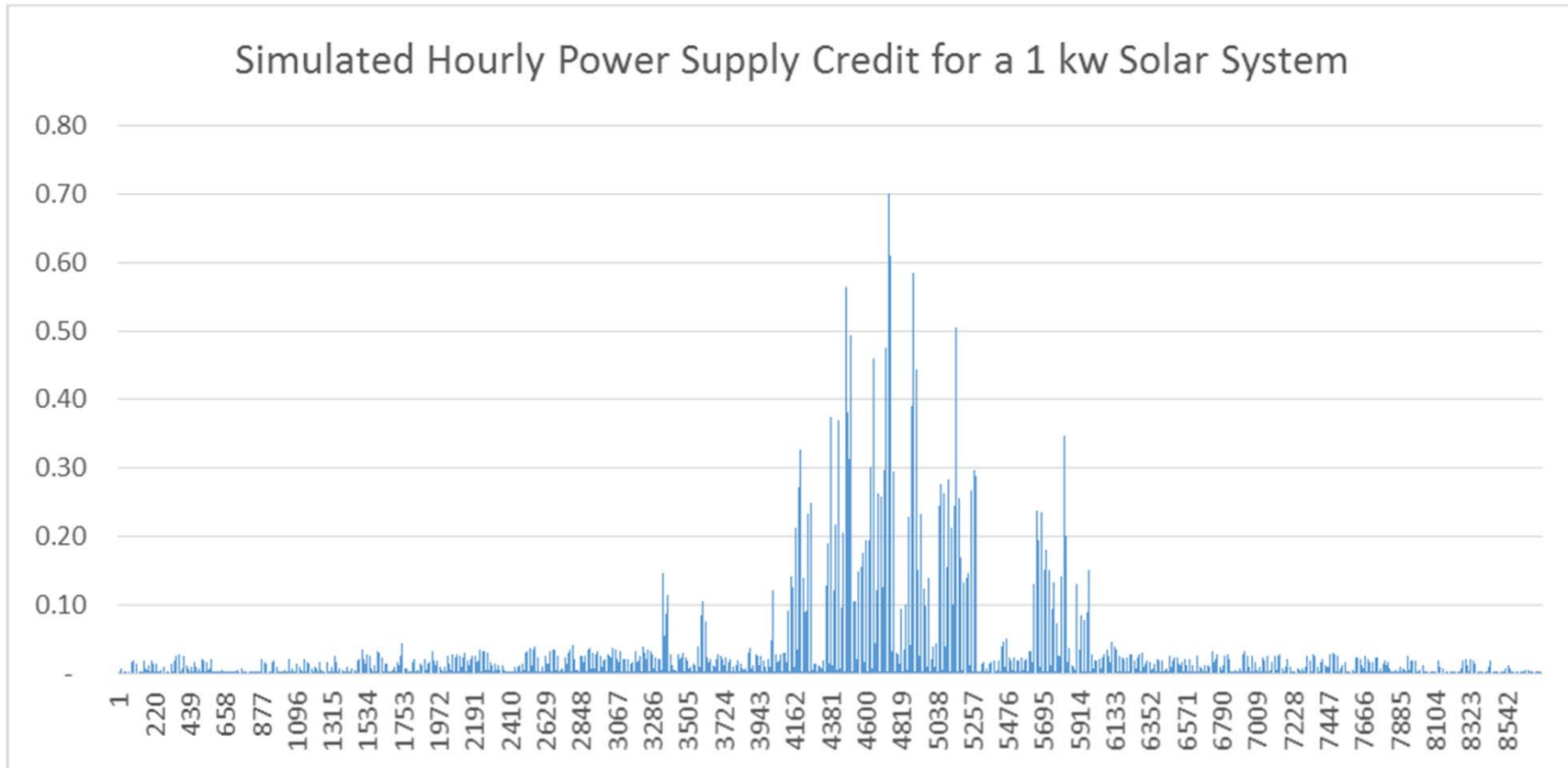


Capacity value

- Very high ratio of capacity contribution to energy compared to other PURPA technologies
- Can be compared to CCGT with care but also can be compared to CT peaker on net CONE (capacity cost less energy value) per ELCC
- Forecast below is based on 4% per year cost decline, current law for investment tax credit

Build Yr	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Net CONE/ELCC \$	85,902 \$	77,620 \$	69,551 \$	61,682 \$	54,000 \$	46,494 \$	46,049 \$	45,203 \$	56,692 \$	48,497

Solar Power Value through the Year



System benefits

- Fuel diversification
- No dependency on fuel delivery
- Load correlated
- Volt-VAR dispatchable
- Distributed generation
 - Supports LDC with VARs
 - Transmission cost and capacity avoidance
 - Line loss reduction (I^2)
 - Distribution capacity avoidance
 - Reduced voltage drop



Conclusions

- A capacity component in Avoided Cost is appropriate, reasonable and prudent
- A capacity component in Avoided Cost is essential to reflect the system benefits of load-correlated generation
- Avoided cost should be based on next build
 - Combined cycle natural gas for cogeneration
 - Net CONE plus energy, perhaps CCGT for solar
- Avoided cost must be long term