SOLAR ENERGY TECHNOLOGIES OFFICE
U.S. Department Of Energy

Keystone Solar Future Project

PPL Electric Utilities Corporation

Modeling Inverter Capabilities in DERMS

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PPL Electric Utilities

Objectives

The Keystone Project is an innovative program to develop and evaluate a technology platform to manage and monitor DER, and improve the interconnection process.

Interconnection Web Portal

Eligible residential customers approval in less than 24 hours

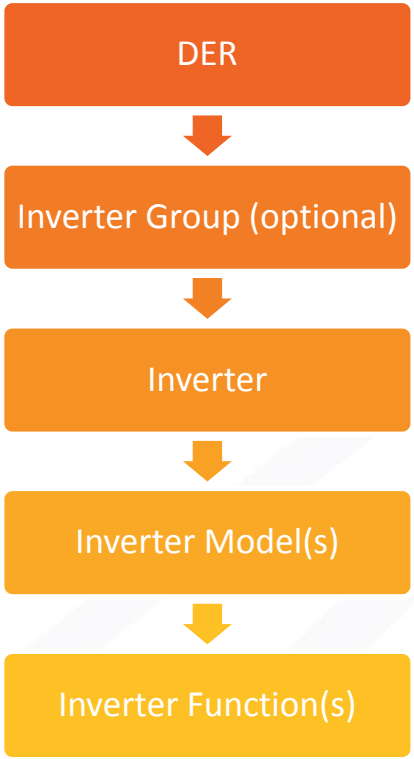
DERMS

Central platform with Distributed Energy Resource-aware algorithms for monitoring and

Proof of Scalability

DERMS Pilot technology demonstration high penetration simulation

DER Modeling Reference



Example:

1 Solar Site → 5 Inverters → Vol/VAR Curve 1 Enabled on 1 Inverter

DER Modeling

Analyst Attributes - DMSENERGYRES

Identifiers		
Name	DER_SP_XFR386186	
ID	DER_SP_XFR386186	
Address		
Service Center		
Permission Area	QUARVILL	
Normal Station and Feeder	QVIL 65604	
Normally De-energized	False	
Advanced Applications Eligibility Override	True	
Constructed Phase(s)	C	
Future Phase(s)		
Node	N_XFR386186_L	
Regulation Node	N_XFR386186_L	
Ownership	Unknown	
Device Type	Solar	
Connectivity Data (Real Time)		
Station and Feeder	QVIL 65604	
Status	Connected	
Last Disconnection Time	--	
Last Disconnect Reason	Low Voltage Out of Range	
Inverter ID	INV_SP_XFR386186	

DER System Output

Engineering Data		
Nominal Voltage	0.21 kV LL / 0.12 kV LG	
Energy Resource Model Name	ER10	
kVA size	10.00	
Voltage Schedule Name	--	
Real Power Schedule Name	PVPOWER_10	
Reactive Power Schedule Name	PQReactivePower	
Slack Bus	False	
Type	PQ	
Primary Source	False	
Wye Connected	True	
Grounded	True	
Contributes To Fault Current	True	
Voltage Target (%)	--	
Voltage Regulation is Line to Line	False	
Control Capability		
Excitation Mode	Constant Voltage	
Connection Type	Induction	
Real Power Target (kW)	1.00	
Reactive Power Target (kVAR)	2.00	
Phase(s) Measured	C	
High Disconnect Voltage Limit	126.00 kV	
Low Disconnect Voltage Limit	114.00 kV	
LVM Control Type	VAR Control	
Maximum Voltage Before Separation From the Network (Per unit)	1.050000	
Minimum Voltage Before Separation From the Network (Per unit)	0.950000	
Maximum Frequency Before Separation From the Network (Hz)	63.000000	
Minimum Frequency Before Separation From the Network (Hz)	56.000000	
	Maximum	Minimum
Real Power Output (kW)	10.00	1.00
Reactive Power Output (kVAR)	6.00	-5.00

DER Modeling

Analyst Output - DMSENERGYRES

Identifiers				
Name	DER_SP_XFR386412			
ID	DER_SP_XFR386412			
Address				
Constructed Phase(s)	C			
Network Application Results				
Distribution Power Flow (DPF) Solution Time	05/11/2019 02:40:00 AM			
Distribution Power Flow (DPF) Solution Status	Solved / BLA Converged			
	Phase A	Phase B	Phase C	ABC
Total Real Power (kW)	--	--	-0.00	-0.00
Total Reactive Power (kVAR)	--	--	1.99	1.99
Total Apparent Power (kVA)	--	--	1.99	1.99
Voltage (LL)	--	--	--	
Voltage (LG)	--	--	116.02 V 87.53 Deg LG	
Current (Amps)	--	--	17.50 Amp -3.50 Deg	
Engineering Data				
Nominal Voltage	0.207846 kV LL / 0.120000 kV LG			
	Maximum	Minimum		
Real Power Output (kW)	10.00	1.00		
Reactive Power Output (kVAR)	6.00	-5.00		

DER System Output

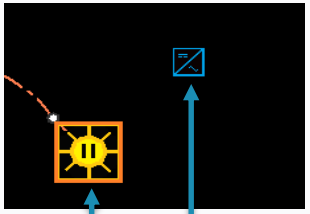
DER Limits

Inverter Modeling

- Geographic/Static Modeling
  - Nameplate
  - Lat/Lon
  - Manufacturer
- Capability Modeling
- Setting Modeling
- SCADA/DERMS Modeling

Analyst Attributes - DMSINVERTER

Identifiers	
ID	INV_SP_XFR386412
Name	INV_SP_XFR386412
Attributes	
Inverter Size (kVA)	10.000000
Inverter Phases	C
Inverter Node	N_XFR386412_L
Model Attributes	
Model Name	IG PLUS A 10.00
Max Real Power Deliverable (kW)	19.50
Max Apparent Power Deliverable (kVA)	29.50
Max Reactive Power Deliverable (VAR)	39.50
Max Real Power Absorbable (W)	49.50
Max Apparent Power Absorbable (VA)	59.50
Max Reactive Power Absorbable (kVAR)	69.50
Peak Power Limit	50.00
Amperage Rating (Amps)	20.00
Short Circuit Rating (Amps)	10.00
Normal Operating Voltage (V)	115.00
Voltage Offset (V)	5.00
Disconnect Expiration Timeout (sec)	60
Setting Limit Time Window (sec)	30
Power Factor Reversion Timeout (sec)	60
Disconnect Capability Type	
Power Factor Type	1



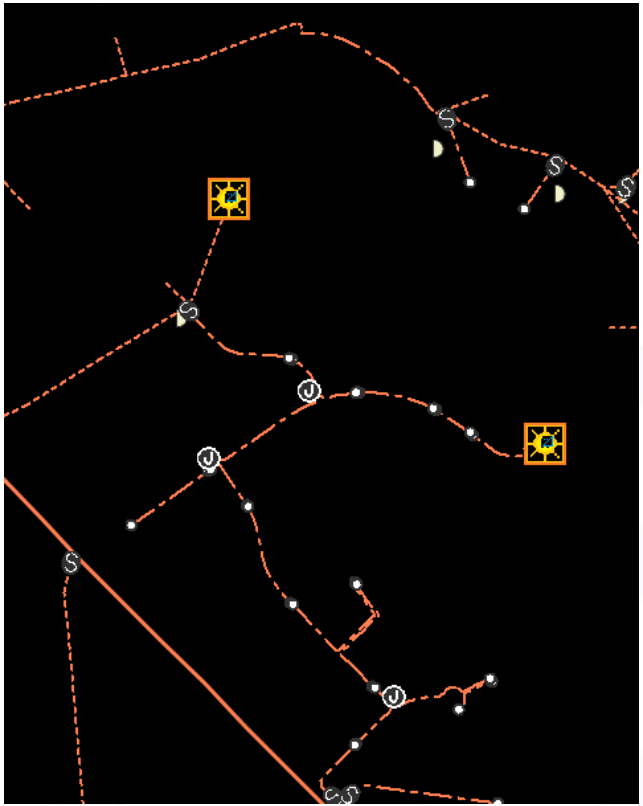
Inverter

Energy Resource

Inverter Model

Inverter Operation Data

Inverter Modeling – Attributes/DERMS



Connectivity Data (Real Time)	
Station and Feeder	QVIL 65604
Status	Disconnected
Last Disconnection Time	04/05/2019 11:04:58 AM
Last Disconnect Reason	Low Voltage Out of Range
Inverter ID	INV_SP_XFR386985
Engineering Data	
Nominal Voltage	0.21 kV LL / 0.12 kV LG
Energy Resource Model Name	ER5
kVA size	5.00
Voltage Schedule Name	--
Real Power Schedule Name	PVPOWER_5
Reactive Power Schedule Name	PQReactivePower
Slack Bus	False
Type	PQ

Inverter Status

Connectivity History

Inverter Power Schedule

Inverter Control Type

Inverter Modeling – SCADA/DERMS

Current Output

AC Voltages

Watt Output

Inverter Freq

VA Output

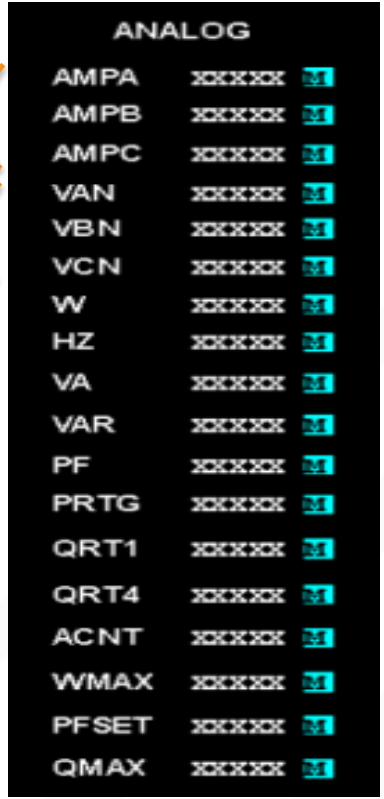
VAR Output

Power factor

Inverter Rating

Max W Output

Max VAR Output

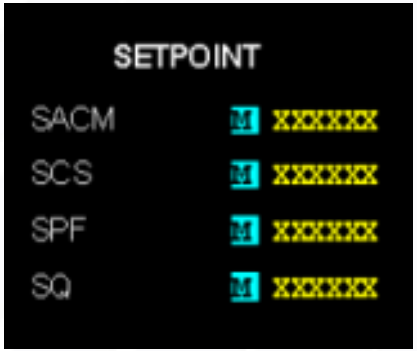


Set control mode

Set connection status

Set power factor

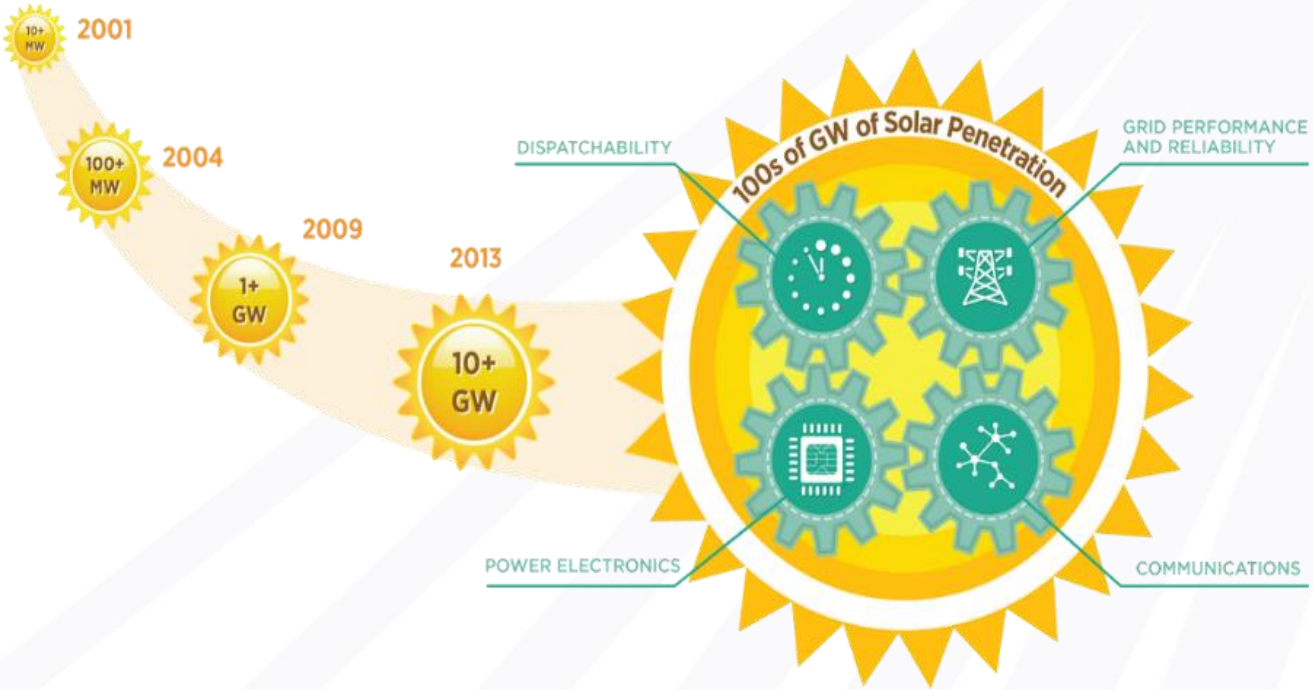
Set kVAR



Challenges

- Register Mapping is not standardized across inverters
- IEEE 1547-2018 capabilities are not fully reflected
- Practical Challenges of implementing the settings

Questions?


10+ MW
2001
100+ MW
2004
1+ GW
2009
10+ GW
2013
100s of GW of Solar Penetration
DISPATCHABILITY
GRID PERFORMANCE AND RELIABILITY
POWER ELECTRONICS
COMMUNICATIONS