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The Need for PV Output Data

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❖What is the Need?

- There is still much to be learned about large scale penetration of PV into the utility grid.
- There is **fear** among utility leadership that variability will cause problems including:

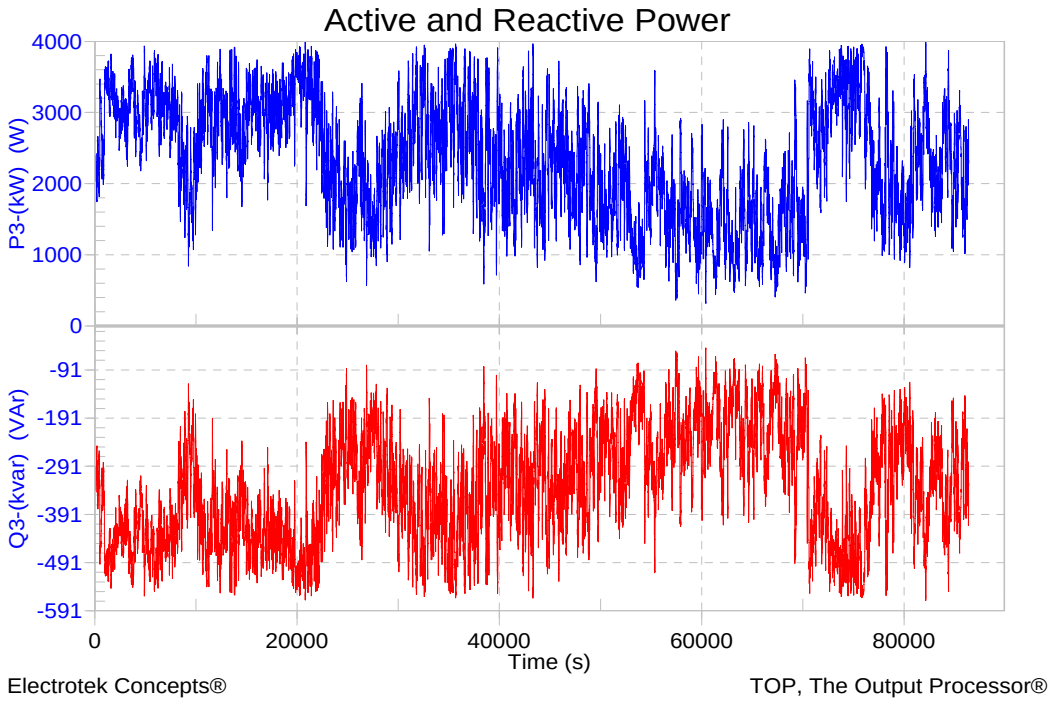
  System Stability, Flicker, Voltage Regulation, CPS2 (ACE) Violations, Possible Increase in Required Reserves

- These fears must be addressed to remove **arbitrary caps** on PV deployment.
- How can we address the fear?
- We need DATA!

FEAR!

❖What Type of Data is Needed?

- ❖ Frequency (for high penetration systems)
- ❖ Irradiance (to understand ramp rates & variability issue)
- ❖ **Watts**
- ❖ **Vars**
- ❖ Voltage



❖What Resolution is Needed?

- ❖ 1 second data is best
- ❖ 5 second data is good
- ❖ Dead-band settings can limit file size and still provide adequate resolution
- ❖ Interval can be a function of array size (large arrays respond more slowly than small arrays)

❖What are we Willing to Share?

- PV Variability Ad Hoc Group Developed a Metadata Standard
- Standard addressed “metadata” of PV sites more than the actual “data”
- Standard was divided into 3 groups of metadata:
- **1) Public Data**
  - DC Plant Rating (STC DC Rating)
  - Type (if various technology, specify splits - mono-crystalline, thin film, etc.)
  - Rating of panels
  - Number of inverters
  - Location (latitude, longitude, and elevation) of site
  - Sampling rate & recording rate
  - Irradiance sensor type, orientation, and number
  - Power system voltage at point of delivery (or interconnection)

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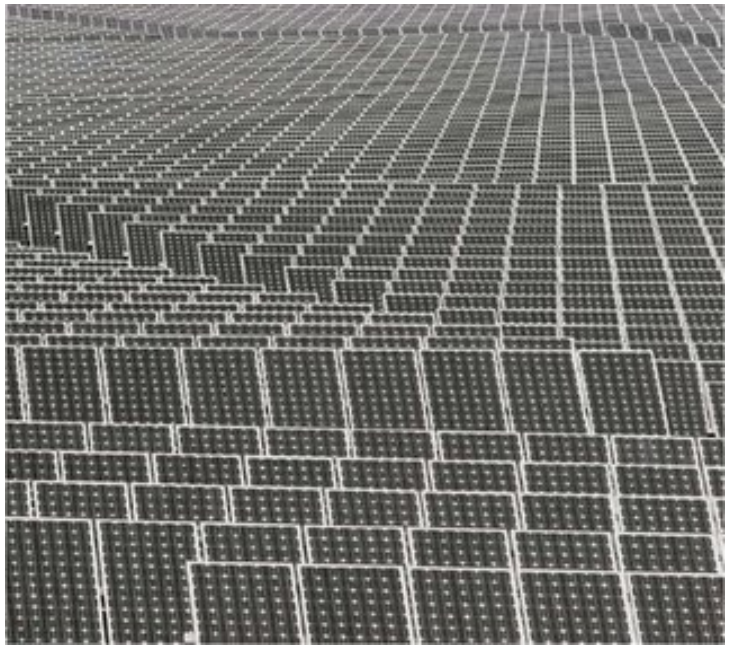
❖What are we Willing to Share?

- PV Variability Ad Hoc Group Developed a Metadata Standard
- Standard addressed “metadata” of PV sites more than the actual “data”
- Standard was divided into 3 groups of metadata:
- **2) Optional Public Data**
  - Array tilt angle and azimuth
  - Spacing of module rows
  - Tracking characteristics of array



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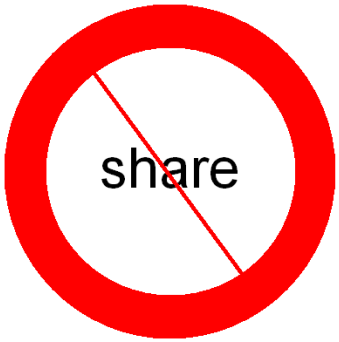
What are we Willing to Share?

- PV Variability Ad Hoc Group Developed a Metadata Standard
- Standard addressed “metadata” of PV sites more than the actual “data”
- Standard was divided into 3 groups of metadata:
- **3) Private Data (never shared)**
  - Inverter logic/control/programming
  - Design specifics (wire size, structure type, civil design)
  - Levelized cost of energy (LCOE)
  - Name of site owner
  - Street address of project
  - Cost of system components
  - Manufacturer
  - Date of installation
  - Price of installation



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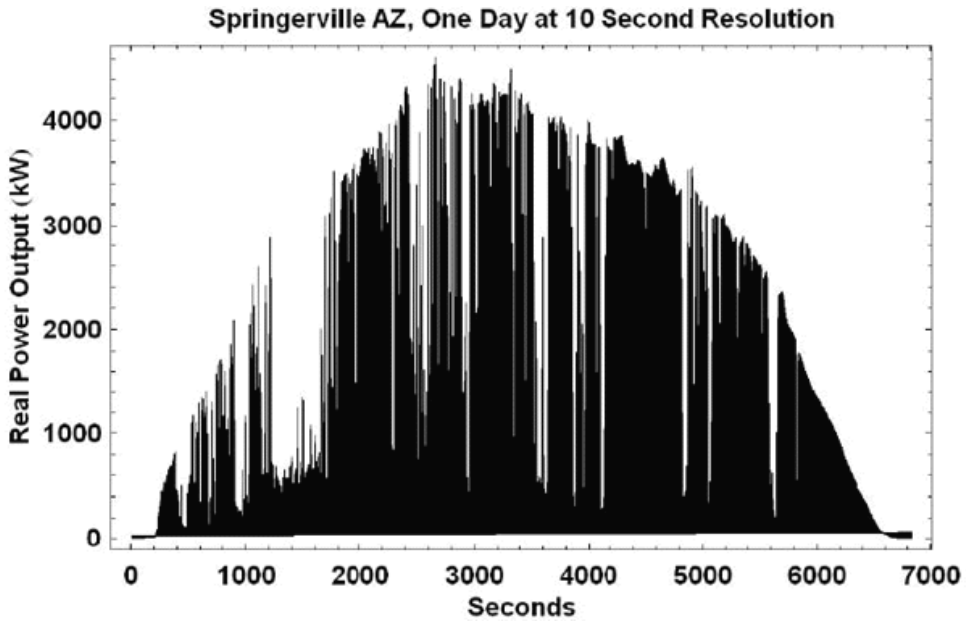
❖What are we Willing to Share?

- **What Was Missing? Data!!**

  - Watts
  - Vars
  - Irradiance
  - Frequency
  - Voltage



- The standard simply addressed that this data is considered confidential and may be addressed on a case by case basis.
- **It <u>also states</u> "sharing monitored data with third parties, such as national laboratories, research organizations, and industry partners, may result in benefits that accrue to the industry as a whole."**

❖Who Will Use the Data?

- ❖ Utilities only?
- ❖ Industry?
- ❖ National Labs?
- ❖ Industry Partner?

Sandia National Laboratories

NREL National Renewable Energy Laboratory
Innovation for Our Future

EPRI Electric Power Research Institute

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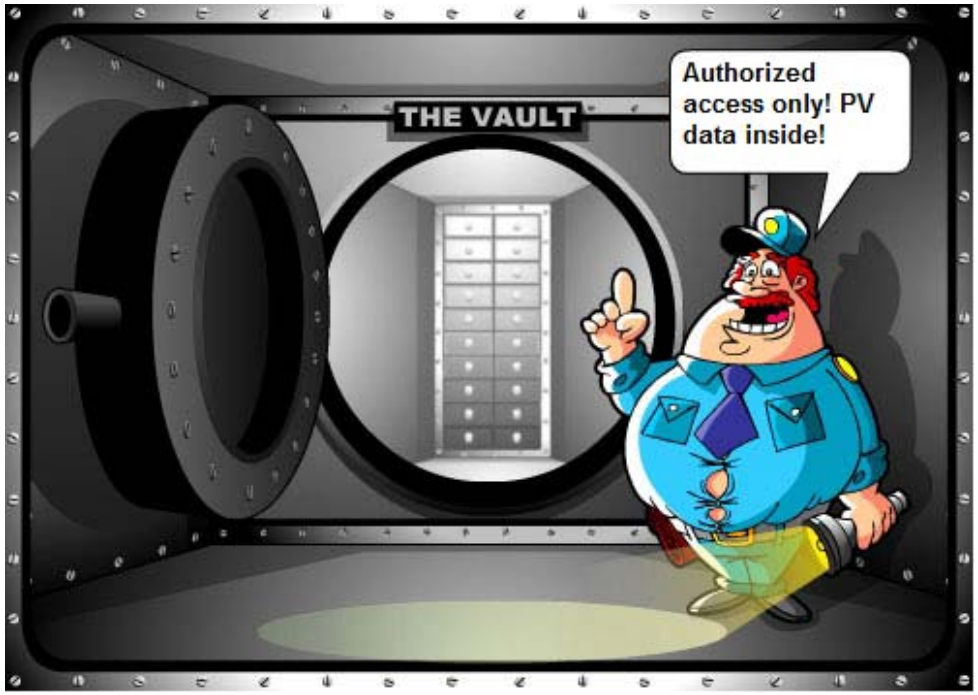
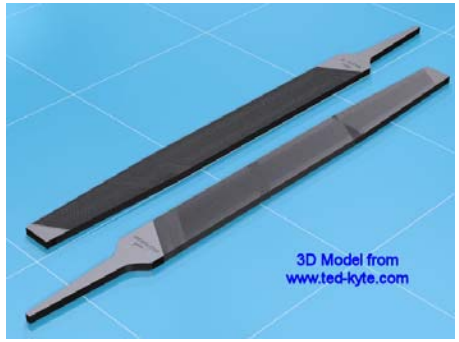
❖Where Should the Data Reside?

- Secure site?
- Data warehouse?
  - NDA required?
  - Other conditions?



❖Data Set

- ❖ Flat ASCII file (comma delimiter, etc.)
- ❖ Excel not really a good option
- ❖ Files should be daily – one day per file.
- ❖ Time zone issues – need proper time stamp (GMT offset required)



Less desirable flat file formats.

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❖Data Set

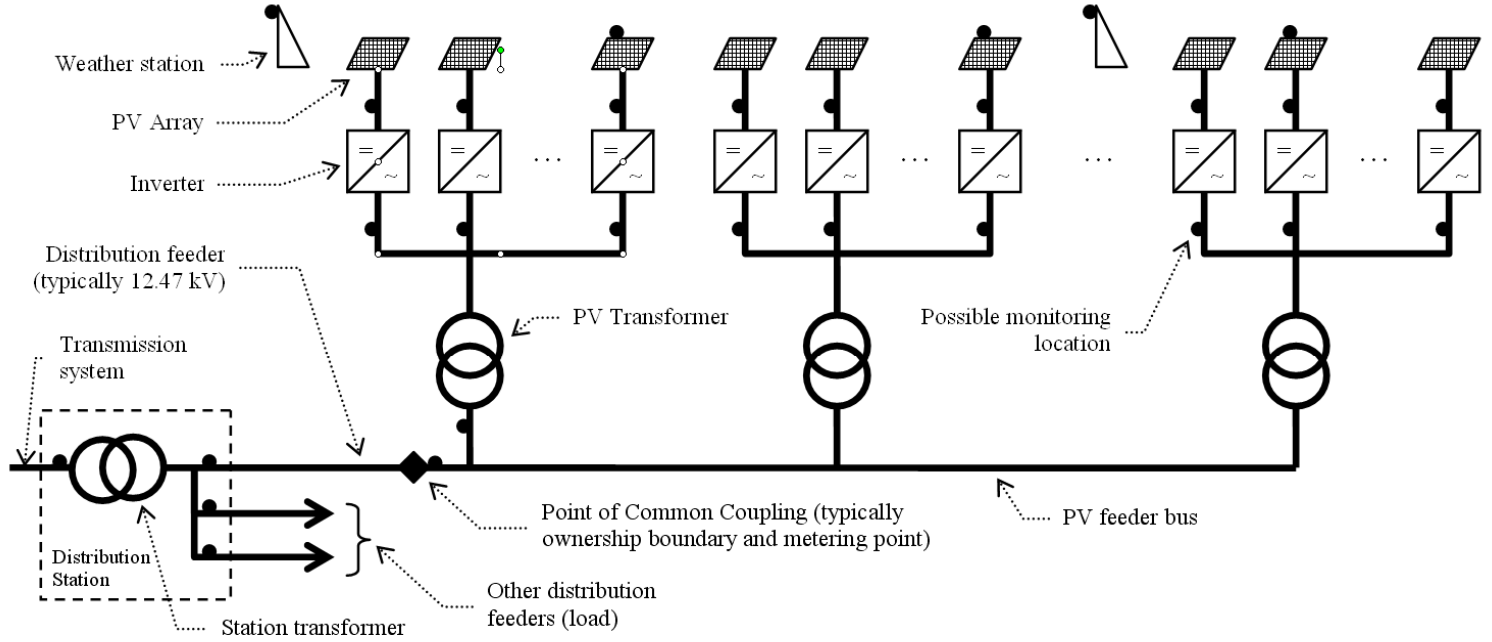

Figure 1 – Distribution-connected utility-scale PV system

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
1	YYYY	MM	DD	HH	MM	SS	Freq_Hz	PCC_Kw	PCC_Kvar	Inv1T1_KW	Inv1T1_kVar	Inv2T1_KW	Inv2T1_kVar	Inv2T3_kV	Inv3T3_KW		PCCVa_kV	PCCVb_kV	PCCVc_kV	POAeast_Wm2	POAWest_wm2	POANortht_wm2	POASouth_	GHEast_V	DifEast_Wm2	
2	2009	7	4	0	0	1	60	9.391	9.437	6.037	3.462	9.347	7.797	8.159	1.146		7.2	7.2	7.2	100	200	300	500	600	50	
3	2009	7	4	0	0	2	59.999	4.809	5.235	4.921	4.04	7.765	0.827	3.253	0.008		7.204	7.198	7.196	100	200	300	500	600	50	
4	2009	7	4	0	0	3	59.994	9.934	0.553	2.579	7.61	8.269	2.785	1.63	1.062		7.205	7.202	7.193	100	200	300	500	600	50	
5	2009	7	4	0	0	4	59.993	7.424	4.061	3.272	3.905	2.503	6.17	8.96	6.863		7.203	7.198	7.189	100	200	300	500	600	50	
6	2009	7	4	0	0	5	59.989	7.385	0.66	4.462	1.941	6.623	2.849	0.857	8.814		7.198	7.195	7.188	100	200	300	500	600	50	
7	2009	7	4	0	0	6	59.989	7.26	0.319	4.701	5.891	9.646	9.189	6.13	6.847		7.203	7.193	7.189	100	200	300	500	600	50	
8	2009	7	4	0	0	7	59.984	6.793	9.991	5.184	8.787	7.472	7.075	3.332	8.777		7.206	7.191	7.193	100	200	300	500	600	50	
9	2009	7	4	0	0	8	59.984	3.89	1.935	4.301	2.009	5.728	9.853	2.267	1.555		7.205	7.193	7.192	100	200	300	500	600	50	
10	2009	7	4	0	0	9	59.987	9.515	4.208	3.743	6.239	8.481	2.659	9.717	1.688		7.201	7.196	7.192	100	200	300	500	600	50	
11	2009	7	4	0	0	10	59.991	8.772	9.409	1.956	2.441	7.44	3.433	4.208	1.45		7.201	7.196	7.193	100	200	300	500	600	50	
12	2009	7	4	0	0	11	59.986	3.987	4.962	0.085	2.021	5.028	3.433	2.186	2.111		7.204	7.193	7.195	100	200	300	500	600	50	
13	2009	7	4	0	0	12	59.988	6.481	7.773	2.812	9.801	6.261	7.271	7.122	1.379		7.202	7.194	7.193	100	200	300	500	600	50	
14	2009	7	4	0	0	13	59.993	3.371	0.103	4.792	0.536	2.848	8.302	3.408	8.985		7.203	7.193	7.194	100	200	300	500	600	50	
15	2009	7	4	0	0	14	59.989	3.93	5.665	9.178	2.638	7.157	8.255	3.602	4.49		7.204	7.194	7.198	100	200	300	500	600	50	
16	2009	7	4	0	0	15	59.992	4.209	1.732	4.561	9.343	6.921	4.613	4.852	9.637		7.204	7.19	7.199	100	200	300	500	600	50	

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❖Data Set

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
1	YYYY	MM	DD	HH	MM	SS	Freq_Hz	PCC_Kw	PCC_Kvar	Inv1T1_KW	Inv1T1_kVar	Inv2T1_KW	Inv2T1_kVar	Inv2T3_kV	Inv3T3_KW		PCCVa_kV	PCCVb_kV	PCCVc_kV	POAeast_Wm2	POAWest_wm2	POANortht_wm2	POASouth_	GHEast_V	DifEast_Wm2	
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- **Column headers** (first row only), each string 12 characters or less.
- **Timestamp** format: YYYY, MM, DD, HH, MM, SS
- **Frequency**
- **Real and reactive power** (kW and KVar, 3 phase)
  - Total for the entire PV plant, and
  - At each inverter (desirable for selected large systems)
- For distribution-connected systems, **RMS voltage** (line-line or line-neutral, each phase)
  - At PCC or other PV feeder bus location (best), or
  - At terminals of two PV inverters connected to different transformers
- For transmission-connected systems, **RMS voltage** (line-line, positive sequence)
  - **At POI or high side of station transformer, and**
  - **At terminals of electrically closest and farthest inverter in the PV plant (desirable)**
- **Irradiance** - Plane of Array (POA) and Global Horizontal (GH) irradiance captured by each reference cell and pyranometer in the PV system. Column header (and possibly metadata as well) should indicate approximate location of sensors with respect to the PV array

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❖What Mechanism Will Make it Happen?

- How do we get there?
  - Need to finalize a “data” standard (quickly)
  - Should be assigned, not ad hoc group (too slow)
  - Needs to be compatible with PI Historian and other data historian software (flat file should be)

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❖What Mechanism Will Make it Happen?

- **Discussion:**
  - What model of data sharing is acceptable to manufacturers?
  - What is the preferred method for the labs?
  - What do utilities prefer?

- **Action Items:**
  - Close meeting with volunteer to set final format of data
  - Seek agreement between PV manufacturers to supply data to _____.

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