

### Monitoring Health and Performance of MW Scale Battery Installations Using OSIsoft's Connected Services

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- About UET
- Remote Monitoring: Health and Performance
- Use Case Description: Weekly Health Reports for Service Monitoring
- Expected Savings in Time and Money
- Summary and Questions

## About UET



#### UniEnergy Technologies

- Large Scale Energy Storage
- Founded in 2012 by Gary Yang and Liyu Li
- Based in Mukilteo, WA
- Molecules to MW (2012-2014):
  - Licensed Advanced Vanadium
    Electrolyte from PNNL
  - Developed Energy Dense, Continerized Flow Battery with Advanced Stack and Electrolyte Technology
  - Manufactured and Deployed the First 1MW System in Q1 2015





Power/Source Load

#### Uni.System – 4 Hour Integrated AC Battery

- Energy Battery with Power Battery Capabilities
- Prime Applications
  - Micro-Grids especially for renewable integration
  - Transmission or Generation Deferral
  - Peak Shaving
  - Layered Applications
    - Backup Power
    - Frequency Regulation





#### **Uni.System Basics**



1 MW installation in Pullman, WA for Avista



## **Remote Monitoring**



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#### **Tiered Response**





#### **PI Data and OSI Applications**

Data: Process Data State Data Operational Data Applications: 16 PI Coresight Displays 6 Weekly Health Reports Notifications Outcomes: Quality Control Service Operation Optimization



# Use Case Description: Service Monitoring



#### Data Flow



- New data points feed directly to AF
- Freedom to specify PI Points (edges for events, smooth for integration)
- AF performs simple calculations, creates Event Frames needed for PI DataLink, and sends Notifications
- PI Applications
  - PI Coresight references AF for HTML coding
  - PI DataLink References AF to include Event Frames and calculations, for ease of replication

#### **Health Reports**

- 1 page weekly summary per 0.5 MW battery string
- Subsystem analysis calculated and compared to known failure or low performance parameters
  - Cooling System
  - Pump
  - Stacks (2 page report)
  - Gas Management
  - Matching
  - PCS

#### Health Report: Cooling System

н	EX/Radiator S	System -	Health Re	port (8/1	17/14 to 8	3/23/14)		On	ie w	ora				Anolyte Te	mp-Cath	olyte Temp			
Site	Johnny Cash	Ĺ.			Checks for	1) Usage devia	ət	C	mm	201			Start	30 min	1 hr	2 hr	3 hr		
Ctring	String1		Overall Ac	coccmont	above/belov	<i>» av</i> erage usa	ag	30		dly	<u>/1</u>		0.1	0.7	1.2	1.5	1.6		OK
String	Sungr		Overall As	sessment	draws during	) on/off steps	an anaoluta	bad	Come		p2		0.2	0.8	1.3	1.6	1.6		OK
Week Begin	8/17/2014		0	к	Catholute T	emperatures :	after the HE	X	Separ	ation	Battery3		0.0	0.6	1.1	1.4	1.4		OK
Week End	8/24/2014		Ŭ		turns on 4) (	Conductivity a	above 100 5)	) Life								1.6	1.2		OK
			This wk	last wk	2 wks	Life Use	FI	ags	Cycle	Circ		т:		: <b> </b> + ~ ~		· <b></b>			
	Time Dischargi	ng	22%	19%	19%			_	55	Sin	npie		ne-F	litere	a			120	
HFX/	Avg. Ambient T	Temp	18	19	19								-+-					- 100	
Badiator	Total Discharge	e (KWh)	13812	12000	-12000								dld			_		- 80	
Radiator	Battery1	%Time On	27%	29%	29%	22 hr		JK	50									- 60	
System	Battery2	%Time On	29%	30%	30%	22 hr		ОК					1 T I					- 40	
Usage	Battery3	%Time On	24%	25%	25%	22 hr	0	ОК	45					20				- 20	
	Battery4	%Time On	23%	26%	26%	22 hr	0	DК	2							9393	9 9 9	9	
									51	Π		Tuia						120	
		Ste	p On	Ste	p Off				50	EV	ent	TIC	jger,	EXCE			<u> </u>	- 100	
		Avg $\Delta P$		Avg $\Delta P$		Conduct-			49									- 10	
Power Usage		(kW)	Count	(kW)	Count	ivity			48		FILE	31, F	Avero	lye				- 60	
&	Battery1	0.71	3	-1.23	6	40		СК	47									- 40	
Conductivity	Battery2	1.21	3	-1.25	6	29		DK	46				<b>1</b> -1 1	20				- 2	Anolyte
	Battery3	1.32	2	-1.27	5	39	0	DK	45					a 45					- Catholyte
	Battery4	1.25	4	-1.24	5	38	0	DK	8 <sup>9</sup> -9 <sup>7</sup>	11 <sup>19</sup> 11 <sup>19</sup> 1)	y" y" y"	\$° \$° \$	9 . 4 <sup>29</sup> . 4 <sup>29</sup>	59 50	\$ \$ .	1 1 1 1	2 2 2	÷" -	



#### Health Report: Cooling System

L	EV/Padiator	Sustom	Hoalth Po	nort (9/	17/14 +0 9	/22/1/		Anolyte			Anolyte Te	mp-Catho	lyte Temp		
Cite		System -	nearth Ne	port (o)	17/14 (0 8	23/14)	tions over 20%	Catholyte		Start	30 min	1 hr	2 hr	3 hr	
site	Jonnny Cas						ge 2) Power	Tomp	Battery1	0.1	0.7	1.2	1.5	1.6	OK
String	String1	<b>F</b>	Tui au				above 2 kW 3)	Temp	Battery2	0.2	0.8	1.3	1.6	1.6	OK
Week Begin	8/17/2014	Even	t i rigg	ger a	and E	xcei	n anaolyte and the HEX	Separation	Battery3	0.0	0.6	1.1	1.4	1.4	OK
Week End	8/24/2014			<u>с</u> с	<b></b> :		pove 100 5) Life	Stats	Battery4	0.2	0.8	1.3	1.6	1.2	OK
		anar	ysis o	t tuti	ure II	me	Flags	Cycle on graph	Cycle 2	Start	8/20 10:32	End:	******		
	Time Discha							55			120 55				120
HEX/	Avg. Ambient	Temp	18	19	19		T	Battery 1			100 Batte	ery 2			100
Padiator	Total Discharg	ge (KWh)	13812	12000	-12000				_		80				- 80
Naulator	Battery1						OK	50			60 50				60
System	Battery2						OK				40				- 40
Usage	Battery3		$\sim$ 1	<b>C</b> 1			OK				20				- 20
1	Battery4		Grapi	1 OT I	Event	S	OK	45		0 0 0	0 45	A D A	0.0.0	2.12.12	 
								8 9 9 4	4 4 4 4	\$~ \$~ \$~	\$ \$	\$ \$ \$	N N N	\$ \$ 1	F
								Battery 3	$\sim$		100 Battery	4			120
		AVE OF	1	AVE OF	I	Conquet-		40			200				- 100
Power Usage	•	(kW)	Count	(kW)	Count	ivity		48			60 50				
&	Battery1	0.70	3	-1.23	6	40	ОК	47			40				- 40
Conductivity	Battery2	1.21	3	-1.25	6	29	ОК	46			20				Anolyte
conductivity	Battery3	1.32	2	-1.27	5	39	OK	45			a 45				Catholyte
	Battery4	1.25	4	-1.24	5	38	OK	8 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4	1 <sup>9</sup> 1 <sup>9</sup> 1 <sup>9</sup> 1 <sup>9</sup>	13 <sup>19</sup> 14 <sup>19</sup> 14 <sup>19</sup>	59 50	\$ 4 4	1 1 1	5 5° 5°	Radiator



#### Health report: Pump

Time-filtered averages for current time period and for baseline time period

#### Current period graphs

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#### Electrolyte Pumps - Health Report (8/17/14 to 8/23/14)

Site      Johnny Cash      Overall Assessment:      Check sthat none of the average spread by more than 20x        Start      8/17/2014      Overall Assessment:      Check sthat none of the average spread by more than 20x        End      8/24/2014      OV      Presure devided from the baseline average for than average spread by more than 20x        Battery1      Anolyte      65%      55      Expected      Avg. Flow, Presure      Verage      Avg. Flow, Presure      Presure devided from the baseline average for than average spread by more than 20x        Battery2      Anolyte      65%      55      Expected      Avg. Avg. Flow, Presure      Verage      Avg. Flow, Presure      Presure devided from the baseline average for than average spread by more than 20x        Battery2      Anolyte      65%      55      Expected      Avg. Avg. Avg. Flow, Presure      Presure devided from the baseline average for than average spread by more than 20x        Battery2      Anolyte      65%      55      Expected      Avg. Avg. Avg. Avg. Avg. Avg. Avg. Avg.												
String      String1      Overall Assessment:      Checks that none of the averages (Flow, Power, Pressure) deviated from the baseline average for that average speed by more than 20x        Kind      8/12/2014      OK      Expected Avg, Flow      Avg, Pressure) deviated from the baseline average for that average speed by more than 20x        Battery1      Anolyte      65%      55      Avg, (kW)      Expected Avg, (kW)      Avg, (LPM)      Expected Flow (LPM)      Avg, Pressure) (psi)      Expected (days)      File (psi)      Expected (days)      File (psi)      Expected (days)      File (days)      File (days)      File (flow)      File (flow)      Expected (flow)      Avg, (flow)      Expected (flow)      File (flow)      File (flow)      File (flow)      Expected (flow)      Avg, (flow)      Expected (flow)      Expected (flow)      Expected (flow) </td <td>Site</td> <td>Johnny</td> <td>/ Cash</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>	Site	Johnny	/ Cash									
Start      8/17/2014      OK      Pressure deviated from the baseline average to that average speeds more than 20:        End      8/24/2014      OK      Pressure deviated from the baseline average to that average speeds more than 20:        % Time      Speed      Average      Aver	String	Stri	ng1		Overall A	ssessment		Checks that	none of the	aueranes (Flo		
End      8/24/2014      OK      average speedbymore than 20x        Battery1      Ang.      Average      Avg.	Start	8/17/	2014					Pressure) d	eviated from	the baseline a	average for	that
Avg.      Average      Expected      Avg.      Fine      Expected      Avg.      Fine      Expected      Avg.      Fine      Avg.      Fine      Fine </td <td>End</td> <td>8/24/</td> <td>2014</td> <td></td> <td></td> <td>OK</td> <td></td> <td>average spe</td> <td>ed by more t</td> <td>han 20%</td> <td>-</td> <td></td>	End	8/24/	2014			OK		average spe	ed by more t	han 20%	-	
Avg. % Time on (%)      Avg. (kW)      Expected Avg. (kW)      Avg. Flow (LPM)      Expected Avg. Flow (LPM)      Expected Avg. Pressure (LPM)      Expected (LPM)      Expected Avg. (ps)      Expected (days)        Battery1      Anolyte      65%      55      1      1      16.8      16.8      49        Battery2      Anolyte      65%      55      1      1      16.6      16.6      50      0        Battery2      Anolyte      65%      55      1      1      16.5      16.5      50      0        Battery3      Anolyte      65%      55      1      1      16.9      16.6      48      0        Battery2      Catholyte      65%      55      1      1      16.7      50      0        Battery3      Catholyte      65%      55      1      1      16.7      50      0        Battery4      Catholyte      55      1      1      1      10.7      50      0        Battery4      Catholyte      55      1      1      1      10.7	LIIG	0/24/	2014									
Expected with on      Average (%)      Average Power (%)      Average Power (%)      Expected Power (%)      Expected Power (%)      Expected Power (%)      Expected (%)      Expected (%)      Expected (%)      Expected (%)      Expected (%)      Expected (%)      Expected (%)      Expected (%)      Expected (%)      Average (%)      Average Power (%)      Average (%)      Averatheres (%)      Averatheres (%)						5		<b>F</b>		C		_
Avg.      Avg. <th< th=""><th></th><th></th><th></th><th></th><th></th><th>Expected</th><th></th><th>Expected</th><th></th><th>Expecte</th><th>Life-</th><th></th></th<>						Expected		Expected		Expecte	Life-	
% lime      speed      Power      Power      Power      Power      Power      Power      Power      Power      Pessure      Ose				Avg.	Average	Avg.	Avg.	Avg.	Avg.	a Avg.	time	
on      (%)      (KW)      (LPM)      (LPM)      (LPM)      (EB)      (DS)      (DS) <th< th=""><th></th><th></th><th>% lime</th><th>Speed</th><th>Power</th><th>Power</th><th>Flow</th><th>Flow</th><th>Pressur</th><th>Pressure</th><th>Use</th><th>-1</th></th<>			% lime	Speed	Power	Power	Flow	Flow	Pressur	Pressure	Use	-1
Battery1 Anolyte 65% 55 Battery2 Anolyte 65% 55 Battery1 Anolyte 65% 55 Battery1 Catholyte 65% 55 Battery1 Catholyte 65% 55 Battery2 Catholyte 70 Battery2 Catholyte 70 Batt			on	(%)	(KW)	(KW)	(LPIVI)	(LPIVI)	e (psi)	(psi)	(days)	Flag
Battery2 Anolyte 65% 55 Battery2 Anolyte 65% 55 Battery2 Anolyte 65% 55 Battery2 Anolyte 65% 55 Battery2 Catholyte 700 Battery2 Catholyte 700 Batte	Battery	Anolyte	65%	55					16.8	16.8	49	OK
Battery3 Anolyte 65% 55 Battery1 Catholyte 65% 55 Battery2 Catholyte 65% 55 Battery2 Catholyte 65% 55 Battery2 Catholyte 65% 55 Battery4 Catholyte 70 Battery4 Catholyte	Battery2	Anolyte	65%	55					16.6	16.6	50	OK
Battery4 Anolyte 65% 55 Battery2 Catholyte 70 Battery2 Catholyte 70 Batter	Battery3	Anolyte	65%	55		0.80	189		16.1	15.8	50	OK
Battery1 Catholyte      65%      55      16.9      16.6      48      0        Battery2 Catholyte      65%      55      16.6      16.6      16.3      50      0        Battery2 Catholyte      65%      55      16.6      16.3      50      0        Battery2 Catholyte      65%      55      16.6      16.3      50      0        Battery2 Catholyte      65%      55      16.6      16.7      50      0        Weekly Pump Power      60      50      50      40      50      50      40        Battery3 Catholyte      Battery3 Anolyte      Battery3 Anolyte      50      50      40      50	Battery4	Anolyte	65%	55	0.79	0.77	_ 215 _	212	16.5	16.5	50	ОК
Battery2      Catholyte      65%      55      17.0      16.7      50      0        Battery3      Catholyte      65%      55      16.6      16.3      50      0        Battery4      Catholyte      65%      55      16.7      50      0        Battery4      Catholyte      65%      55      16.7      50      0        Weekly Pump Power      0      0      50      0      0      0        Battery4 Anolyte      Battery4 Anolyte      0      0      0      0      0        Battery4 Anolyte      Battery4 Anolyte      0      0      0      0      0        Battery4 Anolyte      Battery4 Anolyte      0      0      0      0      0        Battery4 Catholyte      0      0      0      0      0      0      0        0      0      0      0      0      0      0      0      0        0      0      0      0      0      0      0      0      0      0	Battery1	Catholyte	65%	55		0.80	_ 178	181	16.9	16.6	48	OK
Battery3      Catholyte      65%      55      16.6      16.3      50      0        Battery4      Catholyte      65%      55      16.9      16.7      50      0        Weekly Pump Power      60      50      50      40      50      40        Battery4      Anolyte      Battery4 Anolyte      50      40      50      40        Battery4 Anolyte      Battery4 Anolyte      Battery4 Catholyte      50      40      50      50        Battery4 Catholyte      Battery4 Catholyte      0      0      50      40      50      50      40      50      50      40      50      50      40      50      50      40      50      50      40      50      50      40      50      50      40      50      50      40      50      50      40      50      50      40      50      50      40      50      50      40      50      50      40      50      50      40      50      50      50      50	Battery2	2 Catholyte	65%	55		0.74		175	17.0	16.7	50	OK
Battery4      Catholyte      65%      55      16.9      16.7      50      60        Weekly Pump Power      60      50      40      50      40      50      40        Battery2 Anolyte      Battery2 Anolyte      Battery2 Anolyte      60      50      40      50      50      40        Battery2 Anolyte      Battery2 Catholyte      Battery2 Catholyte      60      50      50      50      50      50      50      50      40      50 <td>Battery3</td> <td>3 Catholyte</td> <td>65%</td> <td>55</td> <td></td> <td>0.79</td> <td></td> <td>179</td> <td>16.6</td> <td>16.3</td> <td>50</td> <td>OK</td>	Battery3	3 Catholyte	65%	55		0.79		179	16.6	16.3	50	OK
Weekly Pump Power Weekly Pump Power Battery1 Anolyte Battery2 Anolyte Battery2 Anolyte Battery2 Anolyte Battery2 Catholyte Battery2 Catholy	Battery4	Catholyte	65%	55	0.82	0.81	171	176	16.9	16.7	50	OK
Weekly Pump Flow Weekly Pump Flow Battery2 Anolyte Battery2 Anolyte Battery2 Anolyte Battery2 (atholyte Battery2 (atholyte) Battery2 (atholyte) Batt	Pump Power (KW) , OC	Battery Battery Battery Battery Battery Battery OCV Speed	1 Anolyte 2 Anolyte 3 Anolyte 4 Anolyte 1 Catholyte 2 Catholyte 3 Catholyte 4 Catholyte	137 AUS	-B <sup>1</sup>	,ub	21.4.96	2. <sup>Au®</sup>	1	A.Mb	24.64%	40 30 20 40 30 20 10 0
I.5 Battery2 Anolyte Battery2 Anolyte Battery2 Anolyte Battery2 (Atholyte Battery2 (Athol	300				Wee	ekly Pum	p Flow					
ت مۇر مۇر مۇر مۇر مۇر مۇر مۇر مۇر	Flowrate (LPM) , Speed (%)	Batter Batter Batter Batter Batter Batter Batter Speed OCV	y1 Anolyte y2 Anolyte y3 Anolyte y4 Anolyte y1 Catholyte y2 Catholyte y3 Catholyte y3 Catholyte									1.5 1 § 00 0.5
10 10 DC DC DC DC DC	84.0	,	BUB	BUB		de	BUB	BUS		BUB	Read	

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#### Health Report: PCS

Messages with dates/times and code interpretation based on error codes

"Pivot" efficiencies using and AF calculation, ranges and averaging with a complex filtering statement for current period and baseline

Site	Johnny (	Cash		Overall As	sessment:						
String	String	1				OK Assessment indicates no PCS system Trips and efficiencies no less than 2% below baseline efficiency for					
Start	8/24/20	8/24/2014		Ľ	лк Л	that power vol 95% at 200-60	tage combination 0 kW power	or any efficiency	y below		
End	8/31/20	014									
System Trips:											
PCS Trips:											
Details of PCS											
warnings and											
Trips:											
PCS Temp											
deratings:											
Charging											
Throughput		This week (kWh		24,757	Lifetime (MWh):		256	95%	BL		
Time		This w	eek (h):	80 Lifetime (days):			22	Flag	Flag		
Efficience	Averages		Chi	arging Pow	er (+/- 10	kW)					
Efficiency	Averages.	100 kW	200 kW	300 kW	400 kW	500 kW	600 kW				
	800V - 850V								OK		
DC Voltage	850V - 900V	93.4%	95.8%					OK	OK		
range	900V - 950V			96.1%	95.9%			OK	ОК		
	950V - 1000V		95.9%	95.8%	96.4%			OK	ОК		
D:	_										
Discharging	3	-1.				10 00 01 1					
Throu	ughput	This we	ek (kWh):	16,041	Lifetime	(MWh):	165				
_		_									
Time		This w	eek (h):	41 Lifetime (day		e (days):	11				
Efficiency	Averages:		Disc	harging Po	wer (+/- 1	DkW)					
	-	100 kW	200 kW	300 kW	400 kW	500 kW	600 kW				
	550V - 600V			98.0%	98.4%		98.4%	OK	OK		
DC Voltage	600V - 650V			97.9%	98.2%		98.2%	OK	OK		
DC Voltage				97.7%	98.1%		98.1%	OK	OK		
range	650V - 700V										
range	650V - 700V 700V - 750V			97.8%	97.9%			OK	OK		

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#### Health Report: Stack

- Automatically Generate PI Coresight HTML for in-depth study on a cell by cell basis
- Key health parameters:
  - Max CV Min CV
  - Resistance
- More multi-parameter filtering with various summary statistics reported (average, max)
- Event triggers to watch for outlying cells or BOC/EOC specific parameters

# Expected Savings in Time and Money



#### **Using Health Reports**

- Implementation
  - Automated 7 page report generation for each string
  - Human review
  - Where possible create notifications from insight gained through reports and experience



#### **Benefits**

- Automate to the extent reasonable
- Create visuals and summary KPIs that allow quick review and interpretation
- Reduce service visits through predictive maintenance
- Feedback to reduce service
  - Improve maintenance Schedules
  - Improve design
  - Create operation- specific design

# Summary



#### **UET UniEnergy Technologies**

#### UniEnergy Technologies: Actionable Health and Performance Parameters

#### **Business Challenges**

- A. Remote monitoring for long-term health and performance
- B. Minimize service costs by predicting service needs
- C. Ensure contractual performance compliance
- D. Design, operations, and marketing direction

#### Solution

- A. Implement PI System Notifications and PI DataLink reports for automated alerts to low, medium, and high priority issues
- B. Automate monitoring and response
- C. Automate asset utilization and performance reports.
- D. Facilitate management feedback



#### **Results and Benefits**

- A. Publish six weekly health reports for each 0.5MW/ 2MWh battery, and issue alerts for higher priority items
- B. Offer 12 PI Coresight displays for in-depth analysis for efficient in-depth study
- C. Improved service results at a lower cost



#### Becca.Gillespie@uetechnologies.com

**Applications Manager** 

UniEnergy Technologies



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## Questions

Please wait for the **microphone** before asking your questions

State your name & company





# ΗΑΝΚ Y()|]

And remember to "Go with the Flow"