## From Historical to Actionable:

**ERCOT's Changing Use of the OSIsoft Ecosystem** 







## **Agenda**

- ERCOT overview
- Review PI System usage
  - Asset Framework buildout
  - Data integration
  - Prototyping
  - Control room visualizations and tools
- Questions



#### The ERCOT Region

# The interconnected electrical system serving most of Texas, with limited external connections

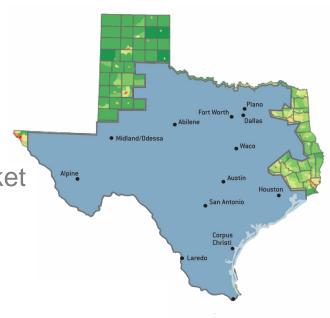
- 90% of Texas electric load
- 75% of Texas land
- 71,110 MW peak, August 11, 2016
- >46,500 miles of transmission lines
- 570+ generation units

NPCC MRO WECC SERC FRCC Western between regions/balancing SPP Interconnection Eastern Includes El Paso and 820 MW Interconnection Far West Texas and the Panhandle region TRE **ERCOT** Interconnection **CFE** 430 MW

ERCOT connections to other grids are limited to ~1,250 MW of direct current (DC) ties, which allow control over flow of electricity

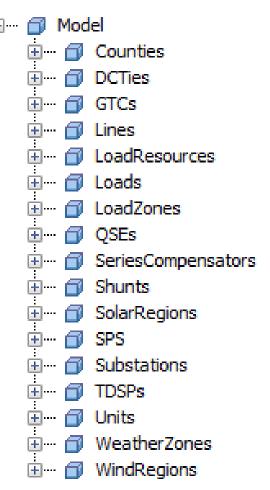
## So What Exactly Are ERCOT's Goals?

- Maintain a reliable power grid for the ERCOT interconnection
  - Coordinate planned and unplanned outages
  - Ensure the balance between load and generation
- Provide a competitive wholesale and retail market
  - Allow for retail switching (pick your power provider)
  - Dispatch generation at the least cost while accounting for transmission and temporal constraints

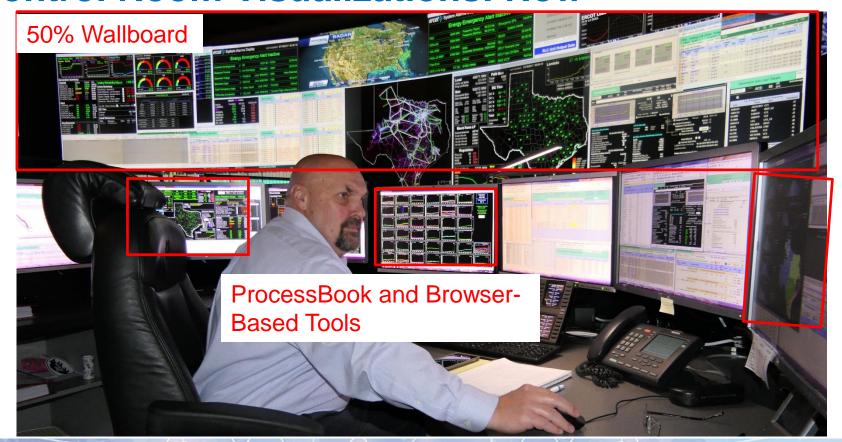


## **ERCOT PI System Metrics**

- Started using PI in 2004
- ~ 530k tags
- ~ 40k assets modeled
  - Units, loads, lines, shunts
- Update tags and AF model on a weekly basis
- Multiple production environments
  - Secure and corporate



#### **Control Room Visualizations: Now**

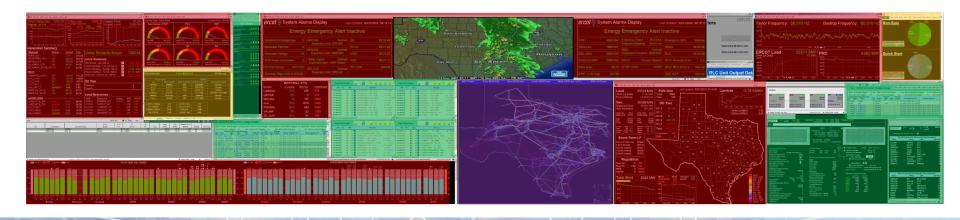


#### **ERCOT Control Room Wallboard**

Display data sources include...

- Excel
- EMS displays
- Macomber Map
- ProcessBook displays

Roughly 50% of the wallboard real estate is ProcessBook



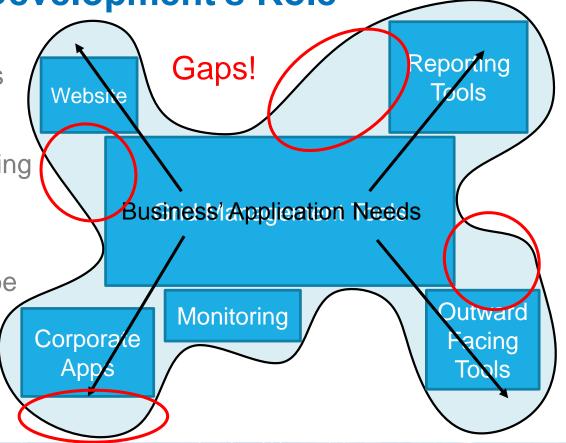
## **Ownership Change**

**Grid Application Development's Role** 

Business requires a wide variety of tools and services to effectively do their job

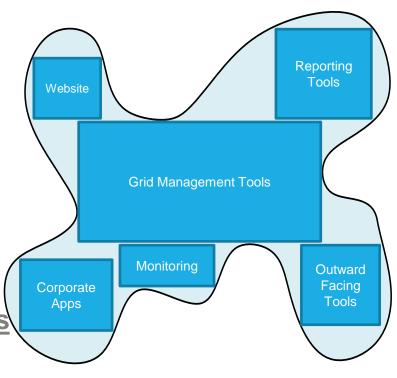
IT does a good job of creating applications and groups to fulfill these requirements

However there will always be gaps in what is needed and what is delivered



#### **GAD Works To Fulfill The Remaining Needs**

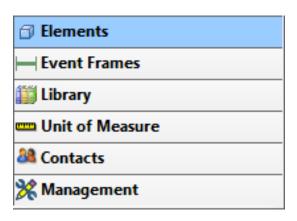
- Grid Applications Development (GAD) reports to Business as opposed to IT
- 4.5 person group
- Work directly with engineers and operators
- Iterative approach to deliveries
- Example tools
  - Report (Excel) management
  - User-developed-application monitoring
  - And now, OSIsoft-related applications



## **Asset Framework**

### **Developing Asset Framework: Foundational Work**

A <u>well-crafted</u> and <u>accurate</u> Asset Framework model is key to ERCOT's current and future successes.





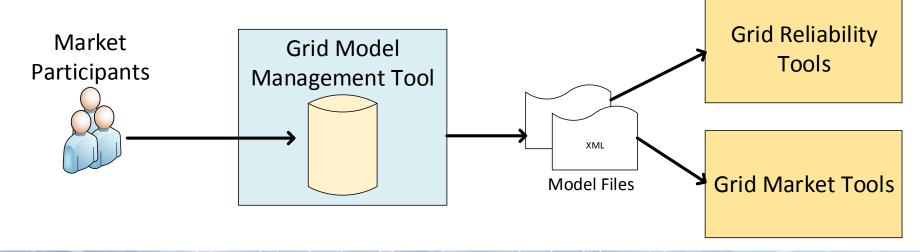
#### **Initial Asset Framework Buildout**

- ERCOT began working on the Asset Framework model in 2015
- First activities were to attend the "Building PI System Assets and Analytics" training in Houston
- Had to design model which "fit" into existing PI tag structure
  - Not all devices had the same tags
  - Creating template hierarchies was key to future success

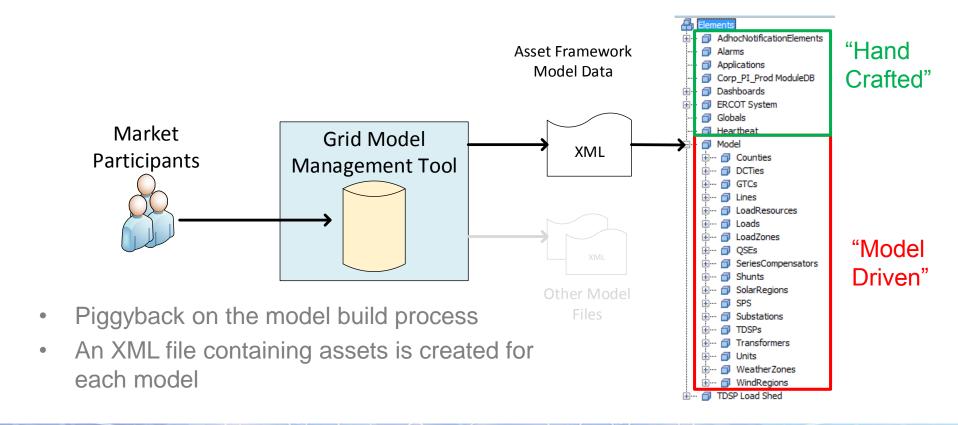
## **Creating the Power Systems Model**

- ERCOT's grid model is maintained by the "Market Participants"
- Changes are submitted with an effective date

A new model is created every week

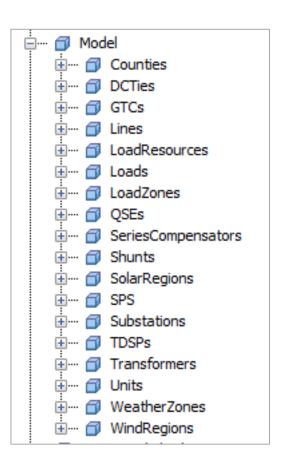


#### AF Data Is Created In The Weekly Model Build Process



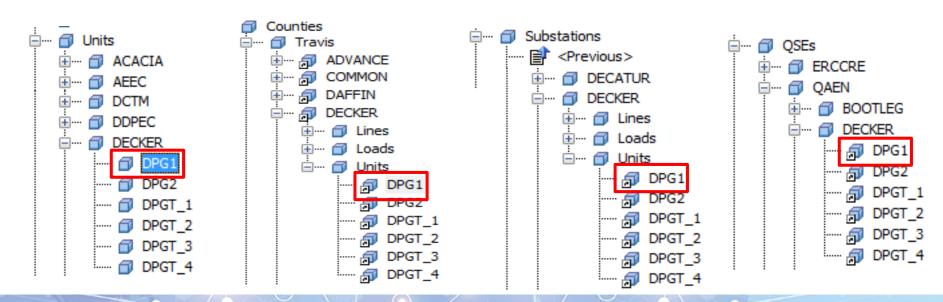
#### Loading "Model-Driven" Assets

- Removing and then importing the "Model" section takes too long
  - Calculations are down during this time
- Developed scripts to create an incremental AF model file
- Utilize Extended Properties to capture renames
- AF model "guaranteed" to match source systems
  - Calculations and displays driven by these assets stay up-to-date



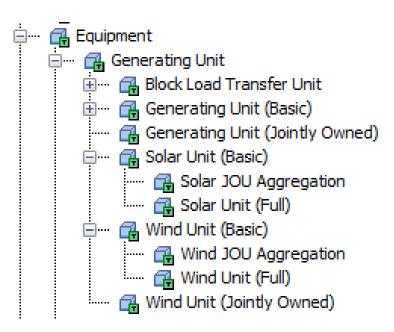
#### Same Element Is Accessible Through Multiple Hierarchies

- Allows for easier user navigation
- Key to providing new aggregate calculations
- Allows displays to be "model driven" by different hierarchies

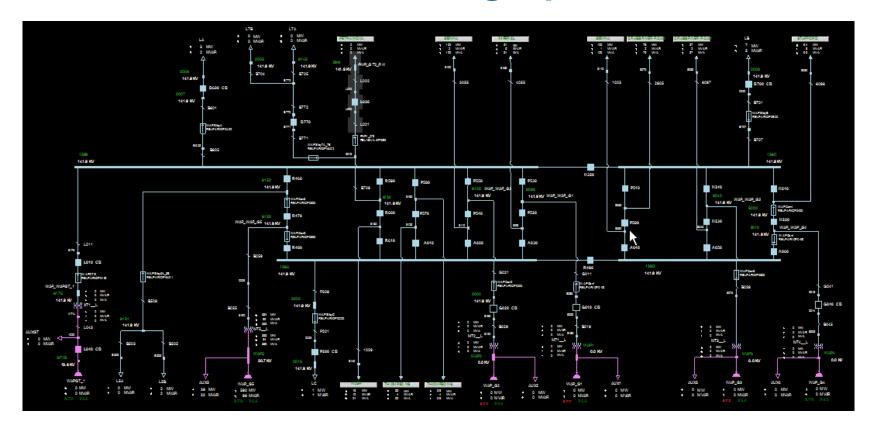


#### **Asset Framework – ERCOT Takeaways**

- Invest the time to carefully design your templates, analyses, and hierarchies.
- A programmatic approach to maintaining the AF model is a must
- Take advantage of existing modeling tools wherever possible

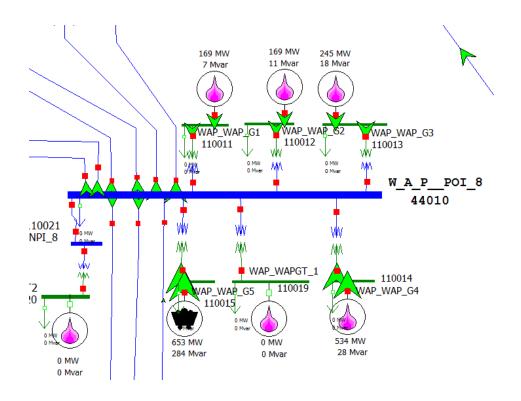


#### Future AF Plans: Converting Operations...



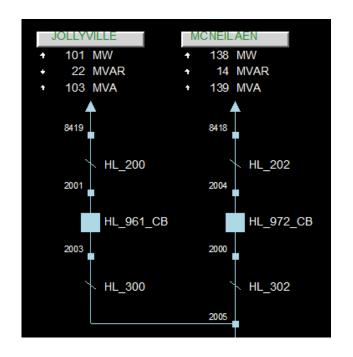
#### ...To Planning

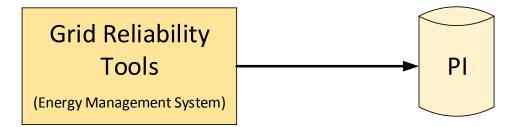
- Familiar naming conventions
- Aggregate load and unit values
- More customers!



## **Data Integration**

#### Original Data Source: Energy Management System

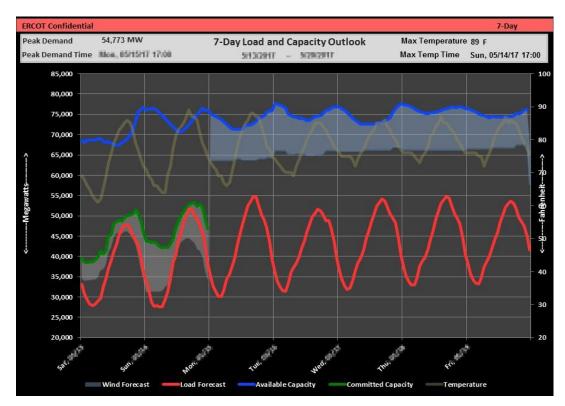




- Flows from Units, Transformers, Lines, etc.
- Status of breakers and switches
- Field telemetry updating every 4-10 seconds
- Estimator values updating every 5 minutes
- Tools could only show EMS data

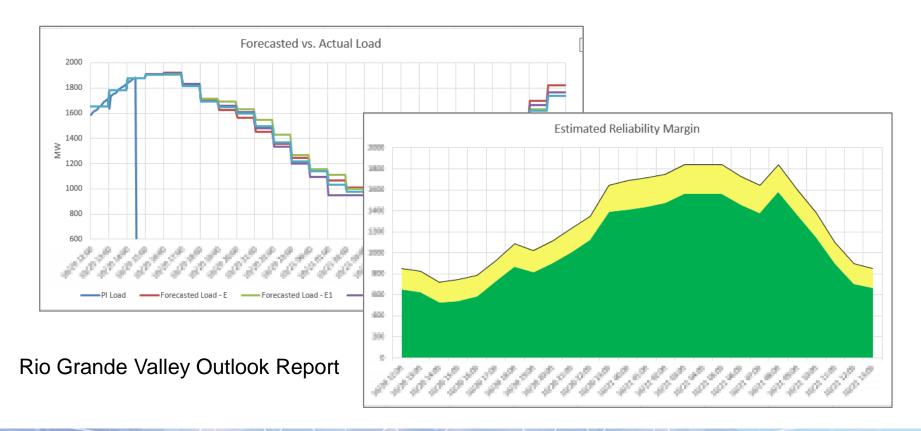
#### If the Report Needs More Than Pl...

- Excel spreadsheets!
  - Combines Oracle and PI data
  - Ugly
- IT reporting tools?
  - Potential for ~8 hour lag
  - Unacceptable staleness



7-Day Outlook Report

#### **There are More**



#### ...and More

ercot 🢝			<b>ERCOT</b>				
		Reliability					
,		Itemability	10/20/2017	or itepor	. •		
Weather Information:							
	Austin	Brownsville	Corpus Christi	Dallas	Houston	Midland/Odessa	San Antonio
High:	80	83	81	81	77	79	81
Low:	43	57	49	45	46	45	48
Conditions:	Sunny	Partly Cloudy	Partly Cloudy	Sunny	Partly Cloudy	Sunny	Partly Cloudy
RCOT RC Footprint Load Data	:						
All-Time Summer Peak MW - 08/11/16		1187					
All-Time Winter Peak MW - 01/06/17		940					
Fall Seasonal Peak MW							
Projected Peak MW		0.00					
Projected Peak Hour		1					
Previous Day Actual MW		0.00					
Peak Hour	eak Hour Da	ata:					
Interchange MW		esc.					
ERCOT RC Transmission Line C	Outages:						
		(Line Segments)					
ERCOT Footprint Generation M							
Scheduled Outage (MW Total)		2000					
Forced Outage (MW Total)		MA.					
Total MW	1	5.000					
ERCOT Projected MW Reserves	Data:						
Required MW		100					
Projected MW		650					
Meet Requirement	_	Tee					

#### ...and More

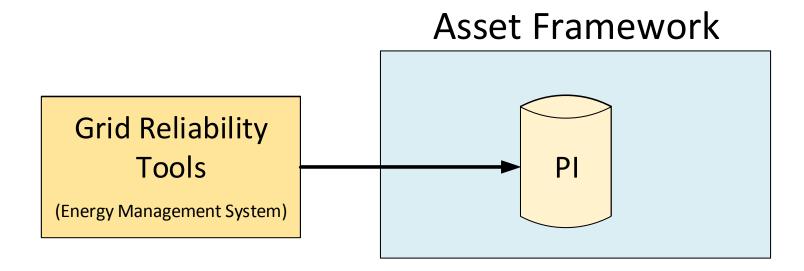
DAY	HR	HIGHEST LF	ONLINE HSL	NET CHANGE HSL/ LOAD/DC	ONLINE HASL	ONLINE ROOM	NSPIN	DC TIE	WIND WGRPP FORECAST	ERCOT_I	ERCOT_A3	Areva_A6	ERCOT_E	ERCOT_E1	ERCOT_E2	ERCOT_E3
10/25/2017	1	1980	58.545		Section 1	1000	1000	100	7.754	28623	28850	20998	28617	28623	28582	28691
10/25/2017	2	379.00	3400	1994	20,000	1007	1000	7.9	1-679	27504	27678	27601	27475	27504	27075	27547
10/25/2017	3	1.5	20079	100	2000	100	608	- 0	4798	27149	27074	27141	27090	27149	27138	27150
10/25/2017	4	27967	35300	- 154	10000	900	1000	1.0	20.0	26969	27065	27123	26916	26969	27067	26987
10/25/2017	5	17950	100.00	685	100.00	7054	2000	100	7.004	27723	27850	27784	27675	27724	27776	27743
10/25/2017	6	10.00	380-0	404	36.00	40.00	1000	1.00	3000	29497	29722	30142	29445	29497	29056	29512
10/25/2017	7	3,000	10000	400	200	1000		100	344	32756	32902	33971	32783	32756	32650	32867
10/25/2017	8	1.000	1800	1000	20000	1404	1986	200	1 107	34455	34893	35415	34350	34455	34439	34446
10/25/2017	9	200	4867	-000	1800	4947	100	100	400	34097	34778	34957	34253	34097	35239	34331
10/25/2017	10	20020	40709	400	2007	375	199	100	3404	35069	34272	33652	35158	35070	34763	35220
10/25/2017	11	35000	28600	4000	2000	100.0		- 40	201	34968	34230	34179	35259	34968	34930	35342
10/25/2017	12	1000	3600	- 84	2660	100	1946	628	100	35139	35014	35033	35255	35139	35101	35334
10/25/2017	13	100.40	1994	1101	38.67%	25.57	1995	140	1718	35557	35710	35656	35340	35557	35477	35421
10/25/2017	14		1994	203		200	1940		Table 1	36410	36495	36495	36104	36410	36131	36186
10/25/2017	15	37780	400.75	- 646	26.00	080	100	100	1300	37452	37845	37667	37149	37452	36485	37263
10/25/2017	16	36044	10000	1084	2010	_	10.0	100	2304	38900	39054	38634	37981	38900	36835	38243
10/25/2017	17	4000	100	1986	19019		3500	100	2.004	40032	39958	39841	38528	40032	37580	39072
10/25/2017	18	\$100.0	40000	46	200.00	40.00	2000	4.0	1.00	39951	39483	39420	38513	39951	37804	39090
10/25/2017	19	30000	40,000	- 60	26.00		1000	400	3896	39068	38662	38866	37778	39068	37192	38571
10/25/2017	20	349.04	10410	403	2000		1000	- 0	800	39826	39033	39364	38672	39826	38090	38980
10/25/2017	21	1004	14.00	1400	1000	100	1000	100	100	39061	38171	38323	37940	39061	37618	38262
10/25/2017	22	1796	45.00	75.00	40000	346	1000	1.0	9000	37080	36330	38555	36213	37080	36159	36310
10/25/2017	23	3-04	38.00	100	2000	2000	1000	100	1000	34642	33620	33781	33511	34642	33559	33599
10/25/2017	24	1 100	26.00	2011	2000	10.04	100	1079	+083	31998	30964	31087	30869	31998	30896	30736
10/26/2017	1	200.87	16.00	1908	1666	7000	100	1 140	STATE	28868	28988	29084	28776	29687	28868	28424
10/26/2017	2	3874	20.000	14.1	(2004)	1000	100	500	10411	27787	27913	27918	27655	28764	27787	27326
10/26/2017	3	1000	1000						1,000	27609	27215	27258	26938	28332	27609	26744

## Replacing Excel in the Control Room

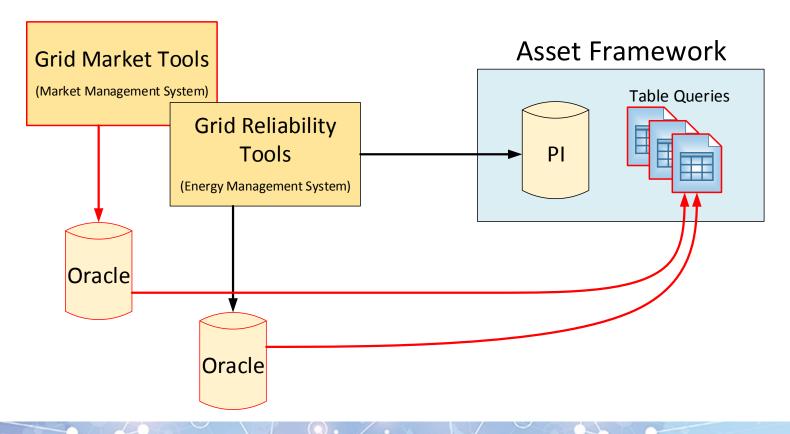
- 2018 goal is to reduce the amount of Excel in the Control Room
- To do so we need a tool which can:
  - Integrate disparate data sources
    - PI System data
    - Oracle data
    - Static data
  - Create decent charts and tables



#### First Step in Data Integration: Asset Framework

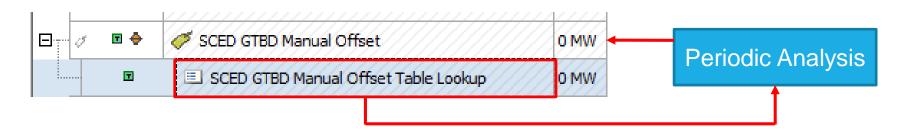


#### **New Data Sources: Oracle Data Via Table Queries**

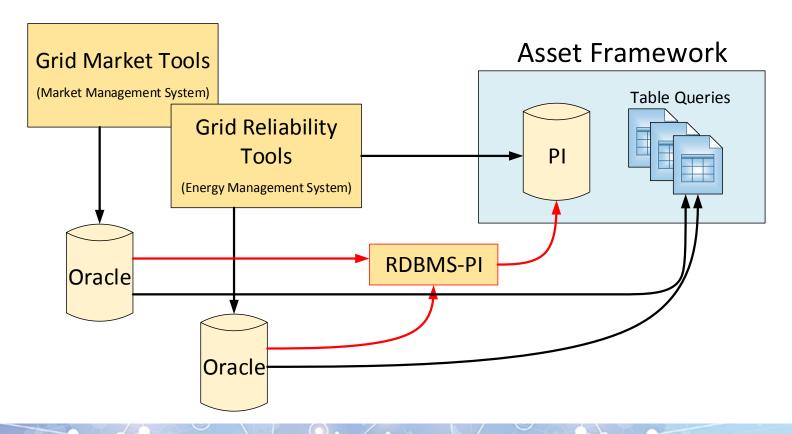


#### **Table Queries**

- Query source database at a regular interval
- Bring results into an Asset using table lookups
- Write results to a PI tag using analytics
- First time we were able to historize Market-sourced information in PI



## **New Data Sources: Oracle to PI Tag**

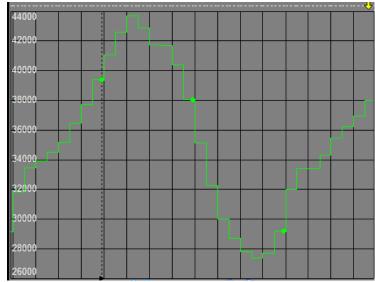


### **RDBMS-PI: Put Query Results into PI**

- Multiple values can be written to the same tag
- First time we introduced future data on a single tag

_				
	TAGTIME	TAGNAME	TAGVALUE	TAGSTATUS
١	10/23/2017 2:00:00 PM	1RDB.MTLF.ERCOT_A3	41048.796875	0
	10/23/2017 3:00:00 PM	1RDB.MTLF.ERCOT_A3	42597.29296875	0
	10/23/2017 4:00:00 PM	1RDB.MTLF.ERCOT_A3	43685.76171875	0
	10/23/2017 5:00:00 PM	1RDB.MTLF.ERCOT_A3	42881.88671875	0
	10/23/2017 6:00:00 PM	1RDB.MTLF.ERCOT_A3	41731.21875	0
	10/23/2017 7:00:00 PM	1RDB.MTLF.ERCOT_A3	41715.26953125	0
	10/23/2017 8:00:00 PM	1RDB.MTLF.ERCOT_A3	40378.53515625	0
	10/23/2017 9:00:00 PM	1RDB.MTLF.ERCOT_A3	38071.1484375	0
	10/23/2017 10:00:00 PM	1RDB.MTLF.ERCOT_A3	35148.26171875	0
	10/23/2017 11:00:00 PM	1RDB.MTLF.ERCOT_A3	32278.478515625	0
	10/24/2017	1RDB.MTLF.ERCOT_A3	30033.76953125	0
	10/24/2017 1:00:00 AM	1RDB.MTLF.ERCOT_A3	28763.546875	0
	10/24/2017 2:00:00 AM	1RDB.MTLF.ERCOT_A3	27814.41015625	0
	10/24/2017 3:00:00 AM	1RDB.MTLF.ERCOT_A3	27392.013671875	0
	10/24/2017 4:00:00 AM	1RDB.MTLF.ERCOT_A3	27734.06640625	0
	10/24/2017 5:00:00 AM	1RDB.MTLF.ERCOT_A3	29219.64453125	0

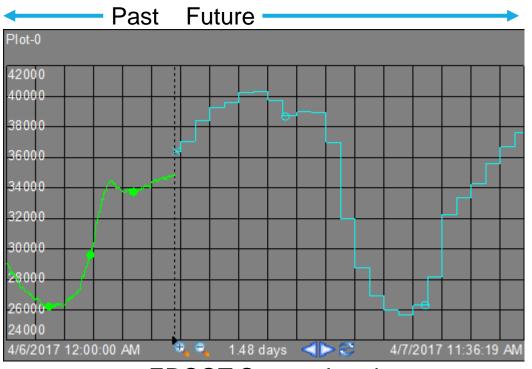




Query Results

Written to Tag

### **Combining Future and Historical Data**



**ERCOT System Load** 

#### Starting the Transition: Valley Outlook Replacement



## **Data Integration: ERCOT Takeaways**

- Integrating external data into the PI System is easy with Table Queries and RDBMS
- Table Queries are useful for lookup attributes or single values
- RDBMS is a great tool for incorporating future forecasts into PI



## (Fast) Prototyping

## **Custom Development In Core Applications**

- ERCOT creates custom code and calculations for the Reliability and Market applications
- 6 major releases a year
- Changes to these systems often have a lead time of 5-6 months
- Fixing oversights and tweaking calculations can extend projects/enhancements unnecessarily
- Missed requirements are not found until implementation starts

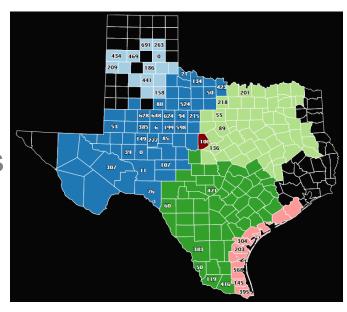


# **Asset Framework For Prototyping**

- Due to the carefully created AF structure we can very rapidly create analyses and prototype solutions
- GAD's changes do not have a long lead time like the core applications
  - AF model/calculations are updated weekly.
- Calculations "hide" is AF instead of the changing the core applications.
- AF is able to use and combine different data sources

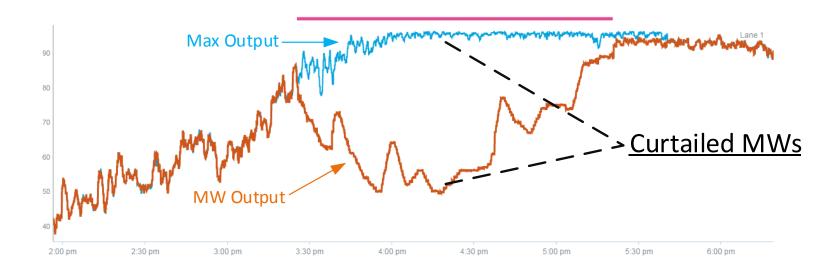
# **Prototyping New Tools: Reliability Risk Desk**

- In 2015 ERCOT determined a new desk, the Reliability Risk Desk, was needed
- Main goal is to manage moreinfrequent but potentially severe risks
  - Inertia, Renewable ramping events, forecast errors
- New desks require new tools!



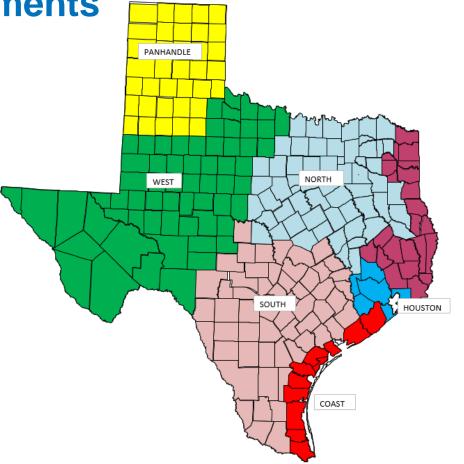
## **New Desk = New Requirements**

- New Calculations
  - Example: Curtailed MWs for Wind and Solar Units



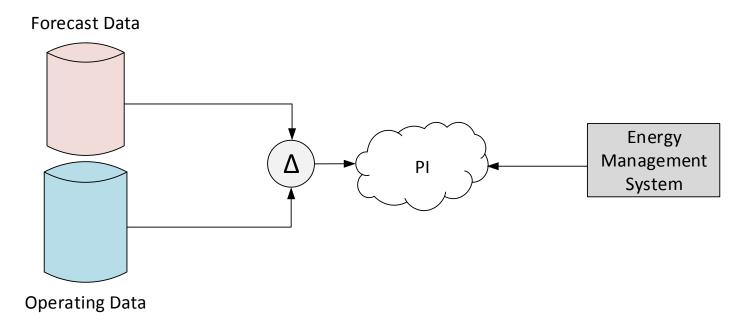
**New Desk = New Requirements** 

- New Wind Regions
  - Different geographical regions behave differently.
  - Need aggregated values for each region.



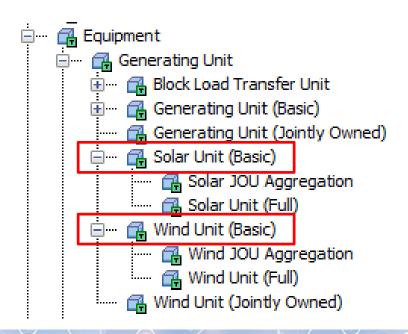
#### **New Desk = New Requirements**

- New Data Sources
  - Forecast and Future Operating Plans do not exist in EMS.



#### **Renewables Templates Allowed For Focused Implementation**

Fully modeled representation of Solar and Wind Units



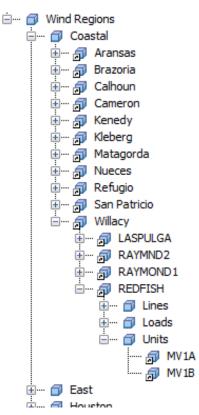
#### **New AF Calculations Only Applied to Desired Units**

- Generating unit assets define complex analyses
- Results are written to PI and rolled up for high-level view
- Example: curtailed generation calculates how much wind/solar was "held back" due to a constraint on the grid

Name	Expression	Value	Output Attribute
Curtailment	Max('HSL' - 'MW', 0)	0	Мар
LastSBBH	PrevVal('SBBH', '*-5m')	1	Мар
LastRST	PrevVal('RST', '*-5m')	ON	Мар
WasCurtailed	Not BadVal(LastSBBH) And Not BadVal(LastRST) And LastSBBH And LastRST <> "ONTEST"	True	Мар
IsCurtailed	Not BadVal('SBBH') And Not BadVal('RST') And 'SBBH' and 'RST' <> "ONTEST"	True	Мар
Result	If IsCurtailed Or WasCurtailed Then Curtailment Else 0	0	CurtailedMW

#### **New AF Hierarchies Modeled With AF**

- Texas counties grouped into "wind regions" with common meteorological characteristics
- Rollup analyses to county and wind levels for key quantities:
  - Wind/solar generation and HSL
  - Curtailed wind/solar generation
  - Number of turbines on

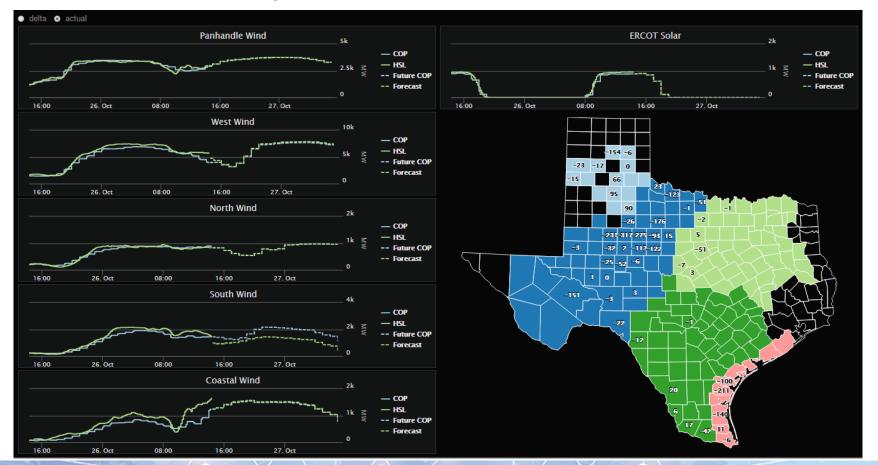


# Rollup Analyses with OLEDB Queries

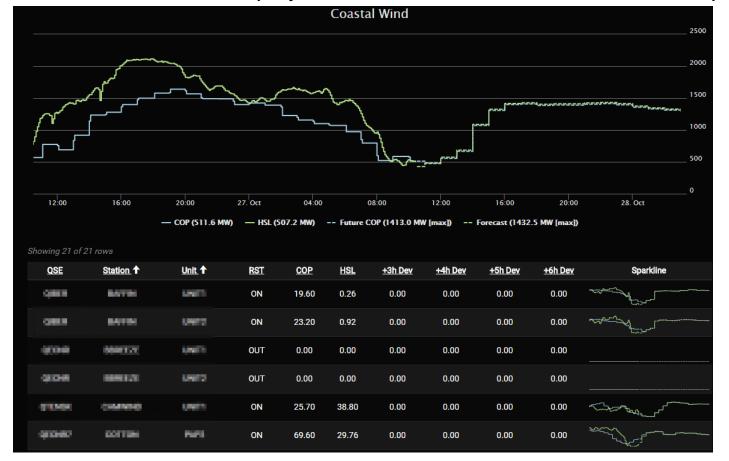
- OLEDB queries used for more complicated rollups
- Useful when history/backfilling is not needed
- Allows multi-level rollups with less "clutter"



#### Overview Page: Renewable Forecast vs. Planned Output

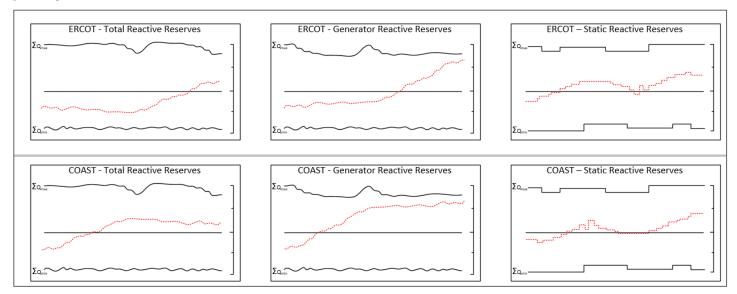


#### Coastal Wind Drill Down Display: Renewable Forecast vs. Planned Output



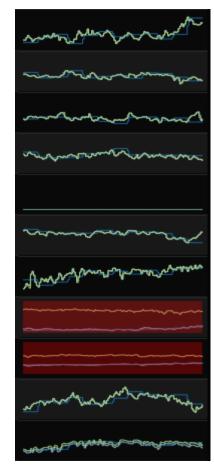
#### **Future Prototyping Plans: Reactive Power Displays**

In 2018 we will start work on Dynamic Reactive Power displays



# **Prototyping in AF: ERCOT Takeaways**

- Reduces implementation time in "core" systems
  - Less rework
  - Requirements are in the prototype
- Easier to integrate new data sources for new calculations
- Testing "core" deliverables easier against prototypes



# **Control Room Visualizations**

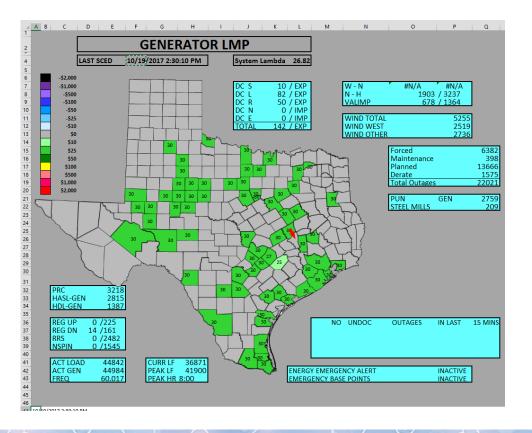
# Not Too Long Ago...Excel and EMS Displays



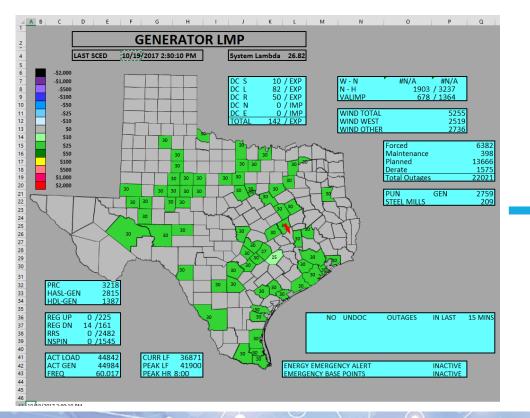
#### **Another View**

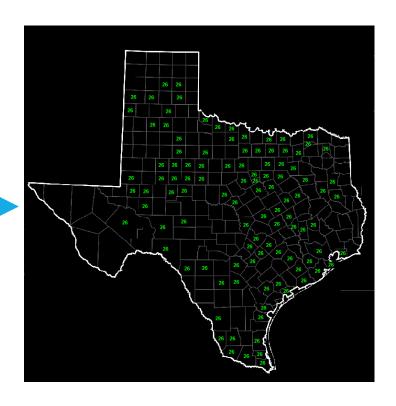


## **Pushing the Limits of Excel**



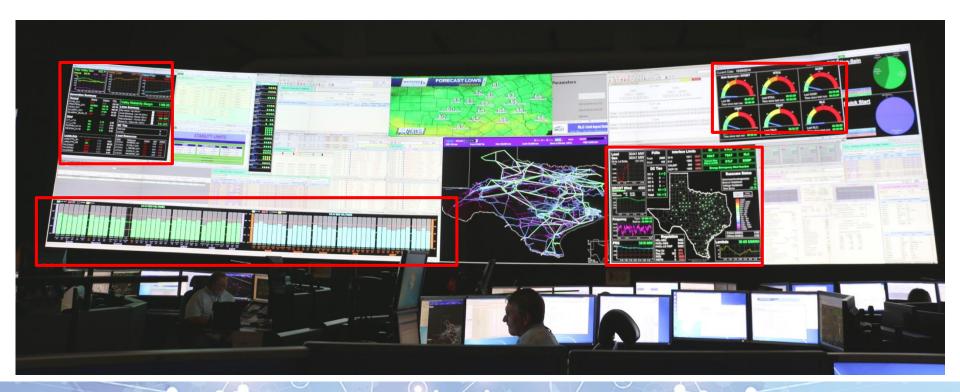
# **Slowly Removed Excel**





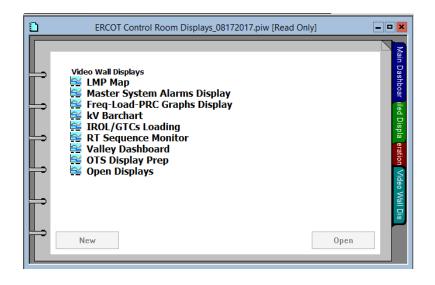
#### **Transitioned From Excel To ProcessBook**

The most visible use of the PI System in on the Control Room wallboard



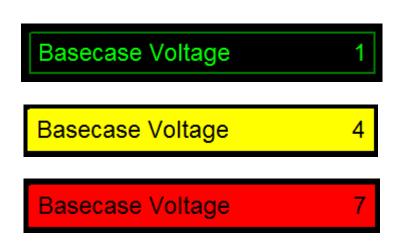
#### **Basic ProcessBook Framework**

- All displays are located within a single ProcessBook file
  - 60 MB file
  - 132 unique displays
  - Easy to share "global"
     Datasets between displays
- Operators "share" a read-only copy
- Same file can be used in the non-Secure network by using a Server Alias



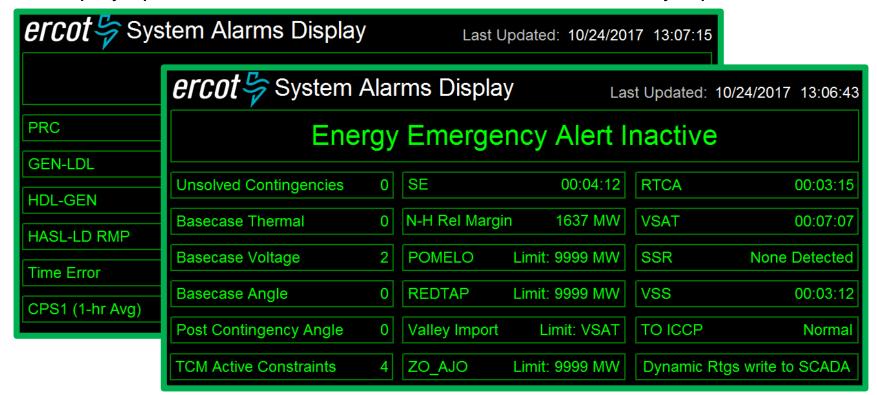
#### **Basic ProcessBook Framework**

- Displays use a combination of MultiState and VBA logic to highlight issues
- Significant amount of code used to keep text aligned
- Heavy use of error protection to handle failovers
- 37 separate "deployments" in 2017 (through October)

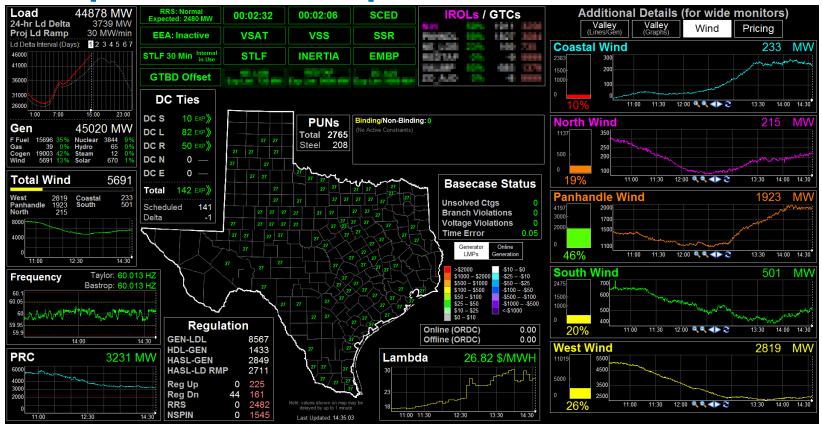


#### **Wallboard Display - Alarms**

Alarm display spans across middle of Wallboard and is divided by Operator role

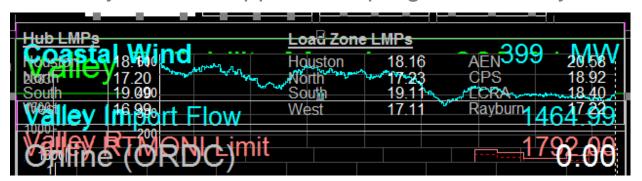


## **Desktop Tools: Main Operator Dashboard**

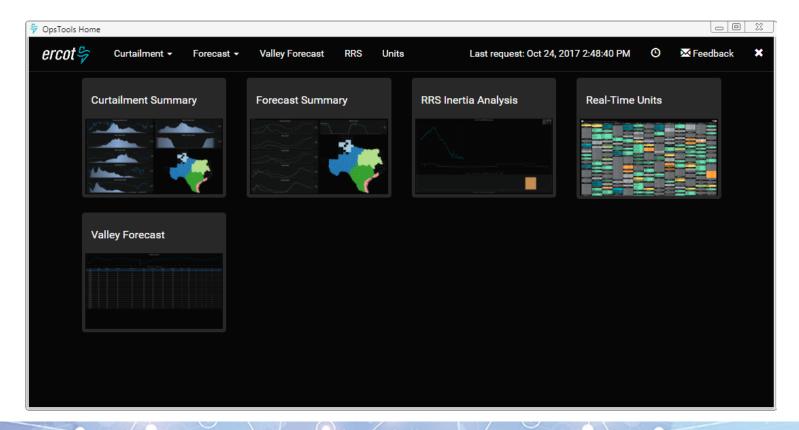


# **Next Steps: Transitioning Beyond ProcessBook**

- ProcessBook does not natively work with AF
- Cannot fully utilize the AF model
  - For example: Have to create a separate display for each County in the state.
- Maintenance is difficult
  - Source control is hard
  - Layout is done by hand as opposed to programmatically



# Transitioning to ERCOT's OpsTools Framework



# What is The OpsTools Framework

- Framework to:
  - Create browser-based dashboards
  - Use the PI WebAPI to access the AF model and PI data
  - Utilize the best-of-breed technologies
    - Angular
    - Highcharts
    - Bootstrap



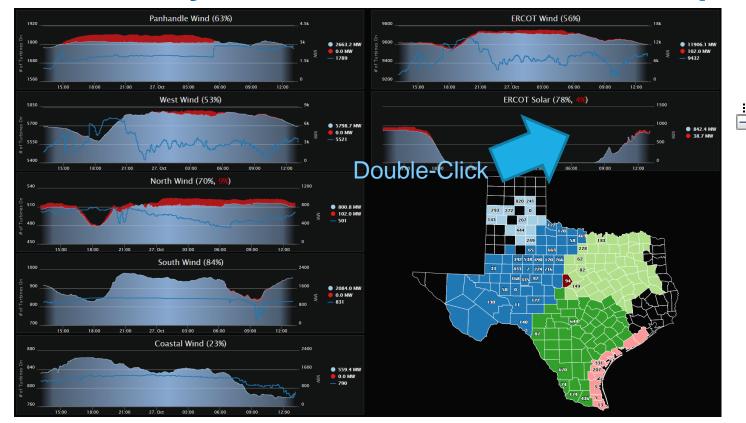


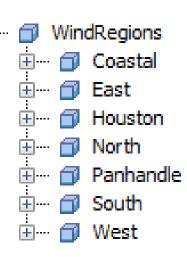


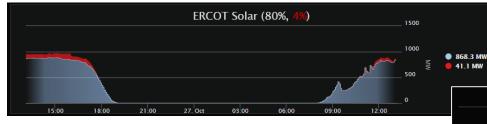
# **Benefits of The OpsTools Framework**

- Easier deployment
  - Everyone uses the same version
  - No software installs (besides the browser)
- More powerful presentation-layer capabilities
- PI Web API allows for "querying" of AF data
- The same display can be used for many different contexts
- Larger talent pool

# Reliability Risk Desk: Curtailment Display



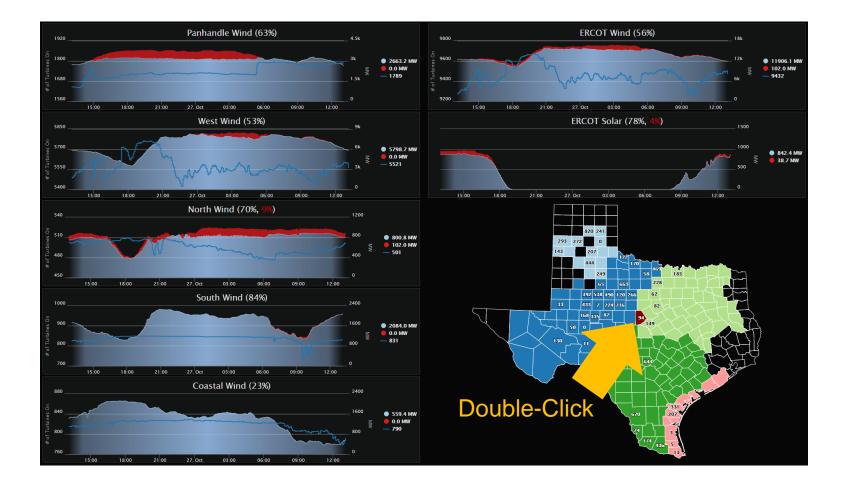


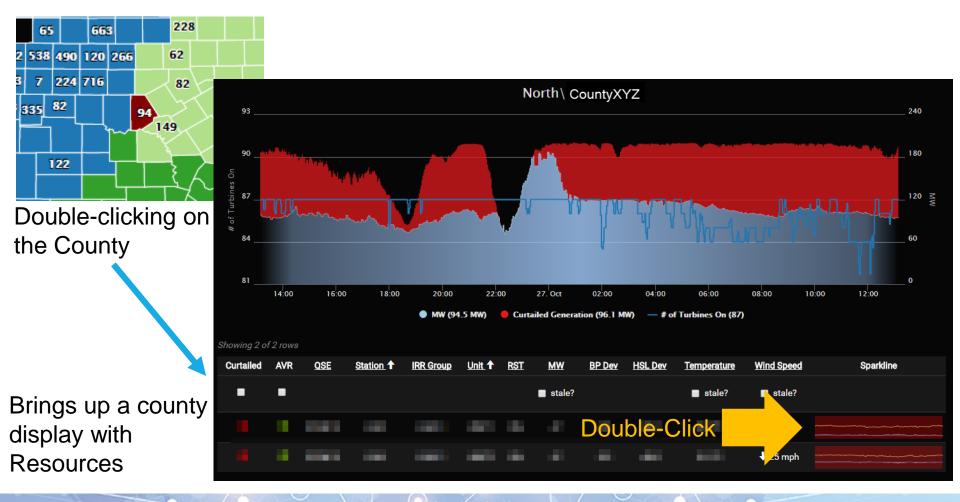


Double-clicking on the Solar chart

Takes you to a details page of Solar resources



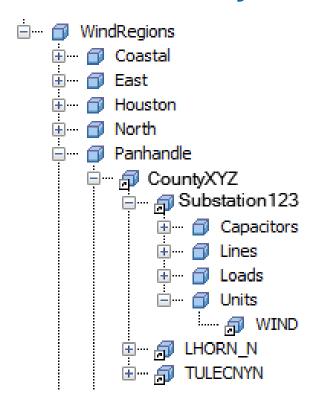






#### All Drill Down Capabilities Follow the AF Hierarchy





#### Longest Living Spreadsheet at ERCOT: Real Time Values

	_	- 10		rn Zone	-			Total generati		3736	-	GTC		0.9	Limit	Panhandle Wil	ND.	-		1413	-
					-		_		on												
OECCS_CT11		PBSES_CT1	0	MGSES_CT1		ECEC_G1	0	OKLA	0	Avail QSGen	910		321		9999			MIAM1_G1		LHORN_UNIT2	55
OECCS_CT12	147	PBSES_CT2	0	MGSES_CT2		ECEC_G2	0		0			N_TO_H	1189			BRISCOE	75	MIAM1_G2	23	MARIAH_NORTE1	40
OECCS_CT21		PBSES_CT3	0	MGSES_CT3	0		0					PNHNDL	1400			COTPLNS_COT			54	MARIAH_NORTE2	40
OECCS_CT22		PBSES_CT4	0	MGSES_CT4		SOLARA_UN1	105	CARBN	0			POMELO	6.1	0%	9999			HRFDWIND_V	73		
OECCS_UNIT1	158	PBSES_CT5	0	MGSES_CT5	0	LASSO	41	LMESASLR	85			REDTAP	25.4	0%	9999	GRAND COLA	15	HRFD_JRD1	74		
OECCS_UNIT2	157		0	MGSES_CT6	0	AEEC ANTLP_1	0	QALSW GT1	0	North DC Tie		VALIMP	114	10%	1127	GRAND COLB	16	HRFD_JRD2	80	PH1_UNIT1	9
	920	FLCNS_UT1	0		0	AEEC ANTLP_2	0	QALSW GT2	0	DCTMG1	0	ZO_AJO	34.1	0%	9999	GRAND GV1A	0	LHORN_UNIT1	55	PH1_UNIT2	12
BOOTLEG_UNIT1	0	FLCNS_UT2	0	WFCOGEN1	0	AEEC ANTLP_3	0	QALSW STG1	0							GRAND GV1B	0			PH2_UNIT1	9
HOVEY UNIT1	20	FLCNS UT3	0	WFCOGEN2	0	AEEC ELK 1	0	QALSW GT3	0											PH2_UNIT2	9
HOVEY UNIT2	6	_	0	WFCOGEN3	0	AEEC ELK_2	0	QALSW GT4	0					Western WIND (co	ont)					ROUTE 66	55
REROCK UNIT1	71	ACACIA_UNIT_	7	WFCOGEN4		AEEC ELK_3	0	QALSW STG2	0	Keo Sherbino2	58	LnCrk G83	21	Owf Owf	10	SRWE1	60	Sweetwn4 4B	20	SALTFORK_UNIT1	5
REROCK UNIT2	67	SIRIUS	157		0		0		0	Keo sm1	50	LnCrk G871	13	Pc north Pthr1			42	Sweetwn4 5	17	SALTFORK_UNIT2	9
				Western \	WIND		_		_	KING NE	13	LnCrk G872	9	Pc south Pthr2		SPTX12B	154		29	SPLAIN1 WIND1	49
Braz Wnd 1	42	Callahan 1	0	Elb Creek		H_Hollow 1	0	Indi Inadale2	24	KING NW	17	McDld FCW1	10	Pc south Pthr3		Stwf T1	19	Tkwsw1 Rosc	0	SPLAIN1 WIND2	47
Braz Wnd 2	20	Capridge 1	49			H Hollow2 1	0	Indi ESS	0	KING SE	7	McDld SBW1	22	Pyr Pyron1&2		Sw_Mesa	19	Trent	19	SPLAIN2 WIND21	72
Buff Gap 1	25	Capridge 1		Fluvanna 1		H Hollow3 1	0	INDNENR 1	32	KING SW	18	Mesacrk WND1	14	Pyr Pyron ESS		Swec 1	25	Ttwec G1	27	SPLAIN2 WIND22	70
Buff Gap 2 1	21	Capridge 3		Fluvanna 2		HICKMAN 1&2		INDNENR 2	34	LGD	22	Mesacrk WND2	9	RdCanyon 1		Sweetwnd 1	3	Vertigo	36	SSPURTWO	13
Buff Gap 2 2	21	Capridge 3	21	Goat Goatwind		HORSECRK UN1	0	INDNNWP	28	Lonewolf G1	11	Mozart Wind	6	Rsnake 1		Sweetwind 1	17	Wec WecG1	34	SS3WIND1	14
Buff Gap3	37	Csec 1	45	Goat Goatwind		HORSECRK UN1	24	INDIAMAN	20	Lonewolf G2	13	Mwec G1	62	Rsnake 2		Sweetwn2 24		Woodward 1	20	SS3WIND1	15
			41				0		_				3	Salvation 1&2				Woodward 2	19	WAKEWE G1	
Bullcrk 1	13	Csec 2		Gpasture		H_Hollow4 1			_	Lonewolf_G3	6	Nwf_nwf1				Sweetwn3 3A	6				76
Bullcrk 2	15	Dermott	161	Gunmtn	0	HWF_1	0			Lonewolf_G4	/	Nwf_nwf2	4	Signal Mt	6	Sweetwn3 3B		TOTAL West	WIND	WAKEWE G2	94
					_	Indi Inadale1	16					NBOHR	0			Sweetwn4 4A	23	2255	-		
			_		_			Southern	Zone		_		_		_		_	Total ger	neration	11095	
South Wind	359	South Wind		South West	_	Corpus		San Antonio		W Austin		E.Austin		Austin		Victoria	-	Victoria			
Anacacho	9	Sendero		EAGLE_HY1	5	INGL_CTG1	0			BUCHANG1	0	GIDEONG1	0	AUSTING1	0	VICTORG5	0	STP_G1	1315		
Baffin 1&2	10	TGW T1 & T2		EAGLE_HY2	0	INGL_CTG2	0	CALA_JKS1	318	BUCHANG2	0	GIDEONG2	0	AUSTING2	0	VICTORG6	0	STP_G2	1311		
BORDAS	0	White Tail	0	EAGLE_HY3	0	INGL_STG	0	CALA_JKS2	0	BUCHANG3	0	GIDEONG3	0		0		0		2626		
BORDAS2	0				5	Gregory/INGL	0	CALA_JTD1	168		0		0	S. Austin		FORMOSG1,2	0	CALHOUN 1	0	RAS Name	%Trip
Bbreeze 1&2	0			LAREDOG4	0			CALA_JTD2	136	WIRTZ_G1	0	WIPOPA_1	0	GUADG_G1	0	FORMOSG3,4	0	CALHOUN 2	0	ALLEN XF	40.7
Cameron Wind	18			LAREDOG5	0	OXY_CC	0	CALA_OWS1G1	0	WIRTZ_G2	0	WIPOPA_2	0	GUADG_G2	141	FORMOSG5,6	0		0	BDAVIS	24.9
Cedro Hill 1	0	RedGate_AGRA	0		0	VISTRON12	12	CALA_OWS1G2	0		0	WIPOPA_3	0	GUADG_G3	154	FORMOSG7,8	0			ESKOTA	23.2
Cedro Hill 2	0	RedGate_AGRE	0	ECLIPSE_UNIT1	34	LGE_LGE_GT1	0		622	MARSFOG1	0	WIPOPA_4	0	GUADG_G4	156	FORMOSG9,10	0			HHGT	25.2
Callahan	28	RedGate_AGR0	0	HELIOS	95	LGE_LGE_GT2	0	BRAUN_AVR1_CT1	122	MARSFOG2	0		0	GUADG_S5	78	FORMOSG11,12	2 0			MBDSW	30.0
Cotton	1	RedGate AGRE	0			LGE LGE STG	0	BRAUN AVR1 CT2	117	MARSFOG3	0	N.E. Austin		GUADG S6	166		0			MGSES 14030	1.4
H Hollow GT 1	55		0	FALCONG1	0	ICP	0	BRAUN AVR1 ST	145	i	0	SDSES 4	294		694	COLETOG1	626			MGSES 14035	1.4
H Hollow GT 2	31			FALCONG2	0	CCEC GP1	128	BRAUN VHB1	0	MARBFAG1	0	SD4SES 5	573	RIONOG CT1	91					MGSES 6474	12.0
H Hollow GT 3	57	Valley Area		FALCONG3	0	CCEC GP2	118	BRAUN VHB2	0	MARBFAG2	0	_	867	RIONOG CT2	90	RAYBURN G1.2	0 12			MGSES AXFMR3H	14.9
H Hollow GT 4	26	DUKE GT1	150		0	CCEC ST1	80	BRAUN VHB3	0		0	Austin		RIONOG CT3		RAYBURNG7	0	1		MNSESB	26.7
Los Vientos 1	26	DUKE GT2		FERMI	25		326	BRAUN VHB6CT5	0	INKS G1	0	SANHSYD 5A	99	RIONOG ST1		RAYBURNG8	0	1		PBSES 6550	41.2
Los Vientos 3	7	DUKE ST1	167			NUECESG7	115	BRAUN VHB6CT6	0		_	SANHSYD 5C	57			RAYBURNG9	0	1		PBSES 6545 A	35.0
Los Vientos 4	6	Hidalgo	471	S.San Anton		NUECESG8	66	BRAUN VHB6CT7	0	<del>                                     </del>	1	SANHSYD1	0	HAYSENG1	0	RAYBURNG10	0	Dynamic	1	SCSES 1255 B	30.5
Los Vientos 5	4	maaigo		PEARS A	0	NUECESG9	68	BRAUN VHB6CT8	0	E.Austin	_	SANHSYD2	0	HAYSENG2	0	TO CLEDINIO TO	0	RT Proc		SCSES 1820 A	5.0
MIRASOLE MIR1	0.3	NEDIN G1	222	PEARS B	0	HOLOLOGS	249	DKAON_VIIDOC 10	384	BASTENG1	0	SANHSYD3	0	HAYSENG3	0	S/HOUSTON	+ "	Complete	-	WIRTZ	0.0
MIRASOLE_MIR1		NEDIN_G1	206	PEARS_B	0	B DAVISG1	0	LEON CT1	0	BASTENG1 BASTENG2	0	SANHSYD4	0	HAYSENG4	163		40	Complete	DSA	WIRTZ	0.0
MIRASOLE_MIR1		NEDIN_G2 NEDIN G3		PEARS D		B_DAVISG1 B_DAVISG2	118	LEON_CT1	0	BASTENG2 BASTENG3	0	SANHSYD6	0	TIA FORION	163		42	20.04	DOM		
MIKASULE_MIK2				PEAKS_D						DASTENGS				CANDUDA				00.00	DTOA	1	
	5.5	MVEC	663		0	B_DAVISG3	65	LEON_CT3	0		0	SANHSYD7	0	CANYHY	0	SCLPC_3	40	23:30	RTCA	4	
PAP1_J01	0		_		_	B_DAVISG4	65	LEON_CT4	0	LOSTPGT1	0		156			SCLPC_4	0				
Pena 1	10	SILAS_6	0	SANMIGL G1	366		248		0	LOSTPGT2	0	DECKER_G1	0	WEBBER SOLAR	26		122				
Pena 2	8	SILAS_9	0			VALEROG1	0	OCI_Alamo	32	LOSTPST1	0	DECKER_G2	0			DUPV1_G1	0				
Pena 3	5	SILAS_10	0			VALEROG2	0				0	DPGT_1	0			1					
	31		0	1			0	1			T T	DPGT 2	0	1				1		Nuke Voltages	
IREDEISH 1 & 2																					
REDFISH 1 & 2			Ť				_				†	DECT 2	^	TOTAL OFNEDATIO	ONL	25042		landad annum annum a		CDCEC	254.7
REDFISH 1 & 2 Sanroman I Santacruz 1	17		Ť									DPGT_3 DPGT_4	0	TOTAL GENERATION EMS total GEN	NC	35843 35690	cons	traint responsive p	ower	CPSES STP	354.7 357.5

Displays generation output in a geographic manner

# Replacing In OpsTools Framework



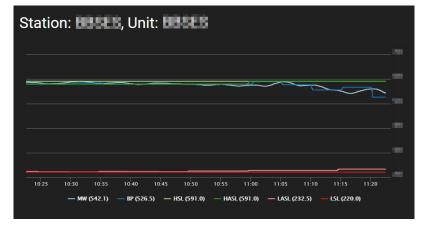
#### **Additional Data Available**

#### Hover for more details





#### Double-click for past data



#### Color Scheme Can Be Changed: Pricing



Fuel: WIND Select Search Fields ... Status Fields:

Filter on various attributes (contained in the AF model)

Wind Resources in **ERCOT** 

# **Visualizations: ERCOT Takeaways**

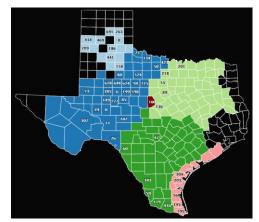
- ProcessBook can take you a long way
- Transition to browser-based displays to stay current
  - IE 11 is slow
  - Chrome is not
- AF provides a centralized location for all display data
- Utilize your AF hierarchy to allow for different data "slices"

# Using the PI System to monitor the ERCOT Interconnection

#### **COMPANY** and **GOAL**

ERCOT is using AF, ProcessBook, and the WebAPI to help Operators visualize and diagnose events on the electric grid







Data spread across different systems and technologies did not allow for a cohesive display approach

 Excel was constantly being used to "integrate" the different systems

#### SOLUTION

ERCOT integrated the different datasets using Asset Framework

- Market, Modeling, and EMS data located in a single system
- Used Table Queries, RDBMS-Int, and PI OLEDB to gather the data

#### **RESULTS**

ERCOT can replace old displays and tools with Asset Framework-driven displays

- Excel tools are being replaced and retired from the Control Room
- Higher quality displays have never been easier to create



#### **Contact Information**

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Development

**Electric Reliability Council of Texas** 

#### Questions

Please wait for the microphone before asking your questions

State your name & company

## Please don't forget to...

complete the Post Event Survey