

PXiSE Advanced Control Technology (ACT)

“Advanced Grid Control Success Story”

Presented by Chuck Wells, Chief Technology Architect - PXiSE
Patrick Lee, President - PXiSE

Agenda

- Introduction - PXiSE Energy Solutions
- Solving the Electric Grid Challenges of the Century
- Problems Identified
- Success Story
 - Summary of results and insights
 - Technology and Product Details
 - Implementation Details
 - Results Obtained and Business Impact
- Conclusion and Looking Ahead

PXiSE Advanced Control Technology (ACT): Joint technology development between Sempra Energy & OSIsoft



PXiSE Energy Solutions, LLC

A superior, innovative alternative to traditional power systems control

- The electric grid is transforming, thereby creating new and changing grid operation challenges which PXiSE ACT has been designed to solve
- PXiSE ACT, a high-speed and precision electric control solution, can stabilize the renewable-based grids, and improve efficiency of poorly coordinated energy resources, applicable from behind-the-meters, to utilities, and regional grids

PXiSE ACT is a software-based control solution, with 7 licensed and 4 pending patents, specifically designed to manage the increasingly variable, less predictable supply & demand dynamics of the modern & future electric grid

¹PXiSE is a wholly owned indirect subsidiary of Sempra Energy

Solving the electric grid challenges of the century

Mission

A solution is needed to offer the most advanced control for the modern power grid to improve operational efficiencies and enable additional intermittent generation resources to be added to the grid



Challenges

Traditional control technology is slow, coordinates resources poorly, and involves longer more complicated integration & maintenance

- Slow sampling rate
- Inadequate local “droop controls”
- Resources poorly coordinated
- Expensive proprietary hardware, complex and lengthy field integration & maintenance

Solutions

An advanced solution that uses readily available but underutilized high-speed phasor data and advanced control algorithms to effectively control energy resources

- Fast data from existing relays
- Adopted real-time advanced control technologies
- Built-in proven data platform
- Hardware agnostic, fast & simple integration & maintenance

Value Propositions

Such solution can offer tailored value proposition:

- **Owner operator / utility / ISO** – addresses challenges stemming from renewables/DERs penetration
- **Utility-scale renewables / large DERs** – the above, plus competitive price point and fast field integration to accelerate project implementation
- **Microgrids / end users** – coordinates many diverse resources to improve utilization and reliability

Existing island grid operation reached limits

Problem #1 (Sub-optimal Operating Efficiency of Energy Assets)

Problem #2 (Inability to integrate high % renewables and DERs)

Under-frequency load-shed events

Not able to achieve economic dispatch, and frequent wind energy curtailment at night

Transition to higher % renewable stalled

Successful outcome and summarized results



PXiSE ACT enabled integration of high percentage of renewables



Improved efficiency of generating resources and reliability of electric system



PMU-based control implemented quickly and cost effectively

Success factors in achieving objectives

1

- PXiSE breakthrough use of PMU data with advanced feedback control and system models

2

- High resolution grid visibility and precision control
- OSISOFT PI System Infrastructure enhances operability and flexibility

3

- Software - easy to implement and replicate
- Hardware - proven and commonly available

Insights from the successful implementation

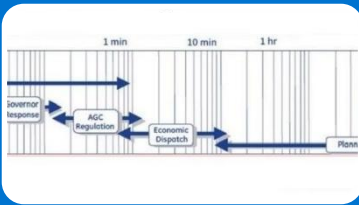


Validated ACT application in wind/solar farms and enabled broad applications from large to microgrids

A wind farm with energy storage and auxiliary load function like a microgrid

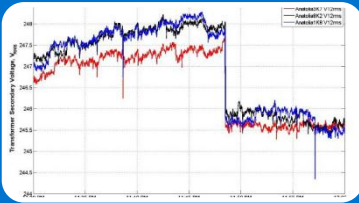
Speed and precision of control system is critical in managing performance of energy assets

PXiSE offers new control capabilities not possible before



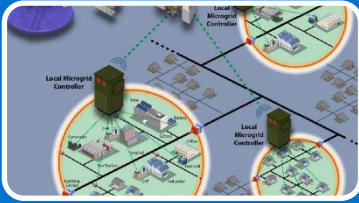
Advanced Frequency Control (real power)

- Stabilizes frequency to integrate high % of renewable
- Allows better economic generators dispatch according to heat rate



Advanced Volt. / Var Control (reactive power)

- Addresses intermittencies from renewables
- Mitigates fast voltage excursions from grid disturbances



Frequency-based and State-based Control Options

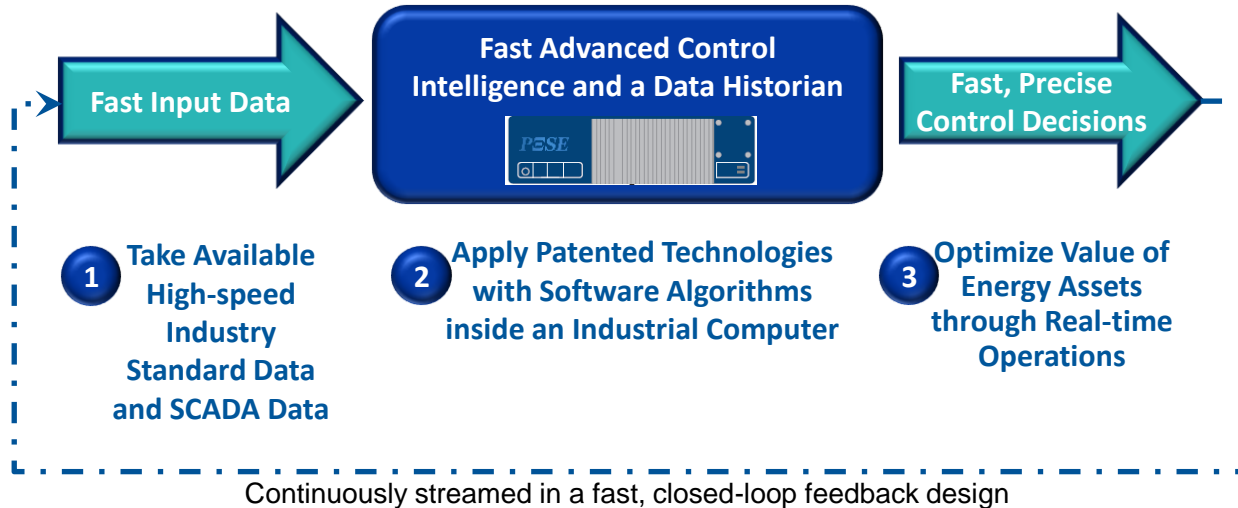
- Adapts to frequency-based control for grids with spinning generators
- Can switch to state-based control in low or no inertia grids

What is PXiSE (a software-based solution)

An Innovative Alternative to Traditional Power Control

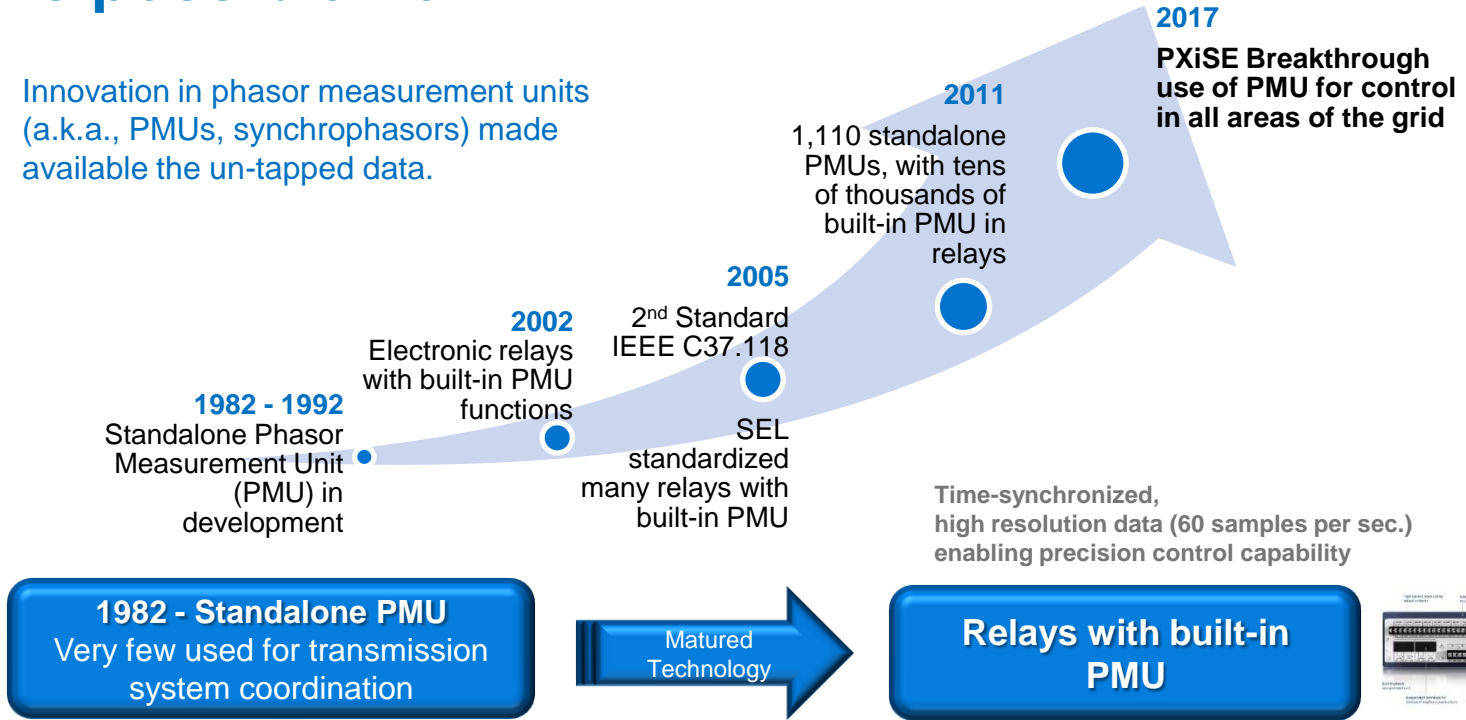
Unlock Efficiencies not Possible by Legacy Solutions

Enable Effective Integration of Very High % of Renewables in Modern Grids



Why it is possible now?

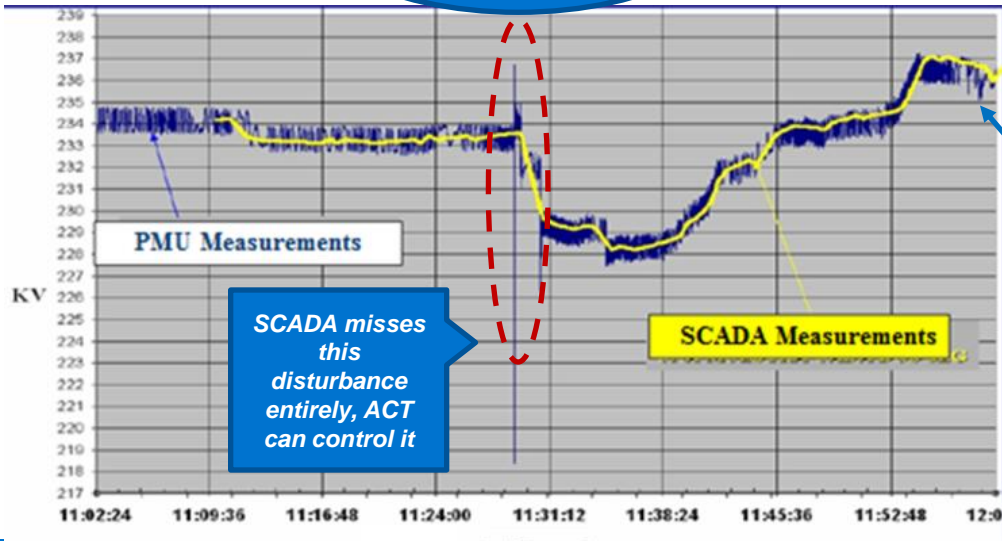
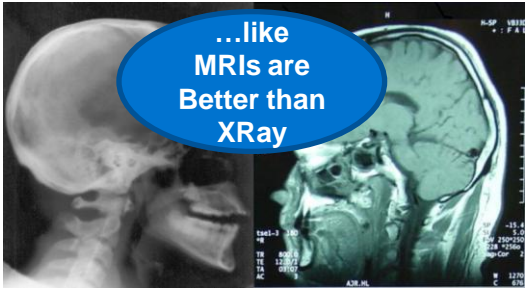
Innovation in phasor measurement units (a.k.a., PMUs, synchrophasors) made available the un-tapped data.



The breakthrough in synchrophasor-based technology for real-time control provides complete vision and peak performance to electric grid assets

High-resolution and high-speed data enable the control necessary for the modern, renewable, and DER-based grids

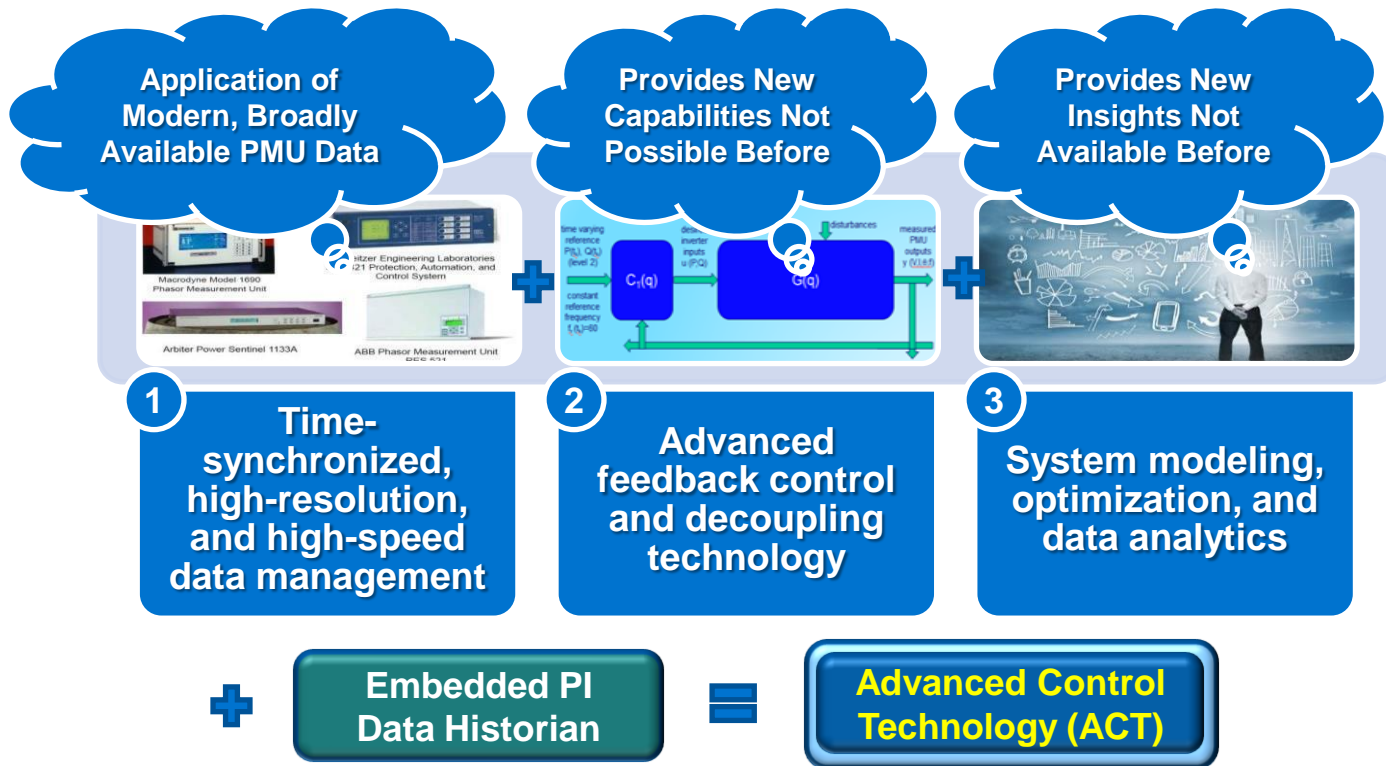
Phasor Measurements are Superior to SCADA...



You can't control what you can't measure

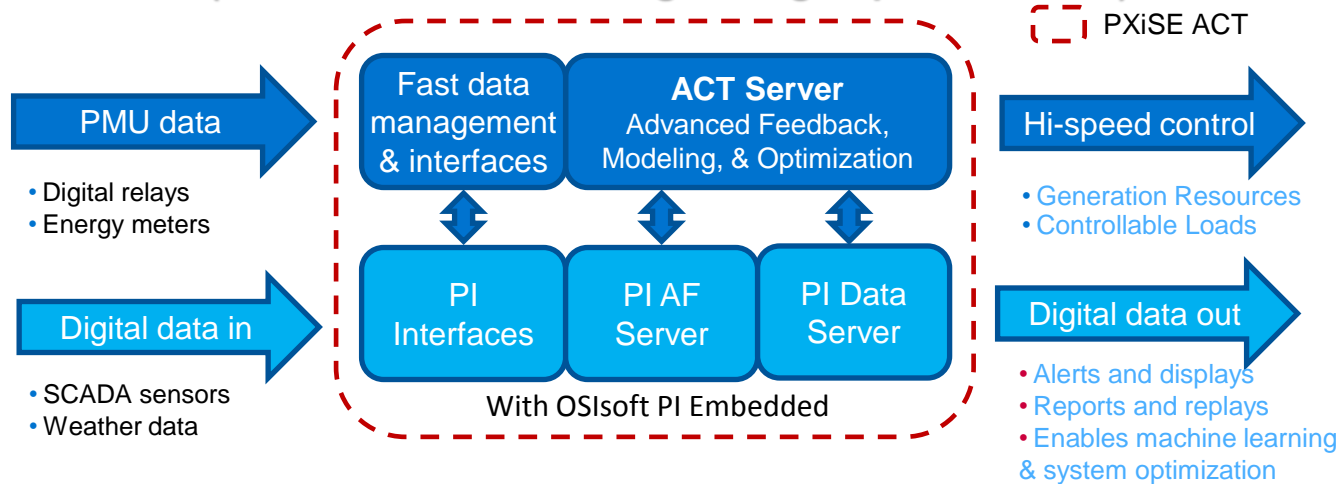
PXiSE integrating multiple enabling technologies into a solution

- created new control capabilities not possible before



What is PXiSE Advanced Control Technology (ACT)?

1. Integrated on a Proven Data Platform (Function Like an Intelligent High-speed SCADA)



2. Implemented on Field Proven Hardware



Example hardware:

- SEL 3355 (industrial computer)

3. Software Designed for Fast Field Implementation

Benefits of embedding a proven PI System data platform

PI Tools

Quick initial setup and configurations from system components to data structure

Data Services

Supports high-speed & big data management with events and control actions recording & analysis

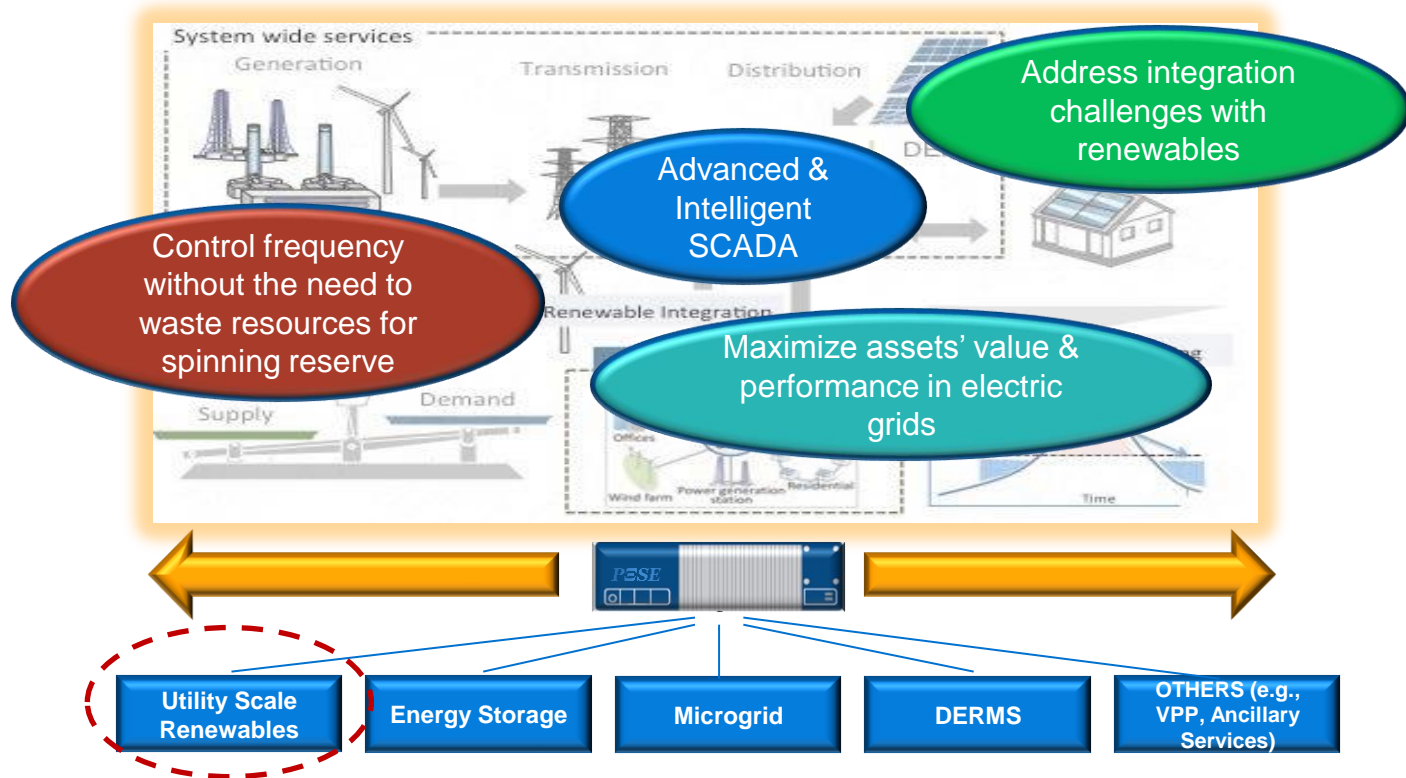
Asset Framework

Enables faster and easier implementation of similar applications supporting a diverse portfolio of energy assets

The screenshot displays the PI System Explorer interface. The top window shows a tree view of system elements, including categories like CONTROL_COMMANDS, CONTROL_INTERNAL, CONTROL_OUT_P, CONTROL_OUT_Q, INV_SHAREF, INV_ONLINE, PARAMETER_FILES, PHASORS, and BATT. The middle window shows the detailed view of the 'SEL_351A_69KV' element, with a table of data points categorized by Event Detection, Frequency, Neutral, and Phase A. The bottom window shows a data table for 'Elements' with columns for Selected, A, Parent, Name, Object Type, Version, Modify Date, Attribute Value, and Attribute Config.

Selected	A	Parent	Name	Object Type	Version	Modify Date	Attribute Value	Attribute Config
1			_CONFIG	Element		2/7/2017 9:48		
2	x	_CONFIG	ModbusByteOrder	Attribute				4321
3	x	_CONFIG	BAT_NUMBAT	Element		2/7/2017 10:12		
4	x	_CONFIG/BAT_NUMBAT	0	Attribute				\Vpk
5	x	_CONFIG/BAT_NUMBAT	1	Attribute				\Vpk
6	x	_CONFIG/BAT_NUMBAT	2	Attribute				\Vpk
7	x	_CONFIG/BAT_NUMBAT	3	Attribute				\Vpk
8	x	_CONFIG/BAT_NUMBAT	4	Attribute				\Vpk
9	x	_CONFIG/BAT_NUMBAT	5	Attribute				\Vpk
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13	x	_CONFIG/BAT_NUMBAT	Prefix	Attribute			AUW_OV	
14	x	_CONFIG/BAT_NUMBAT	Suffix	Attribute			BACKCONNECTED	
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PXiSE ACT has broad applications



ACT's software-based horizontal technology has applications across the full power grid and precisely automates and synchronizes the control of many energy assets

Fast 2-week implementation at Auwahi Wind Farm



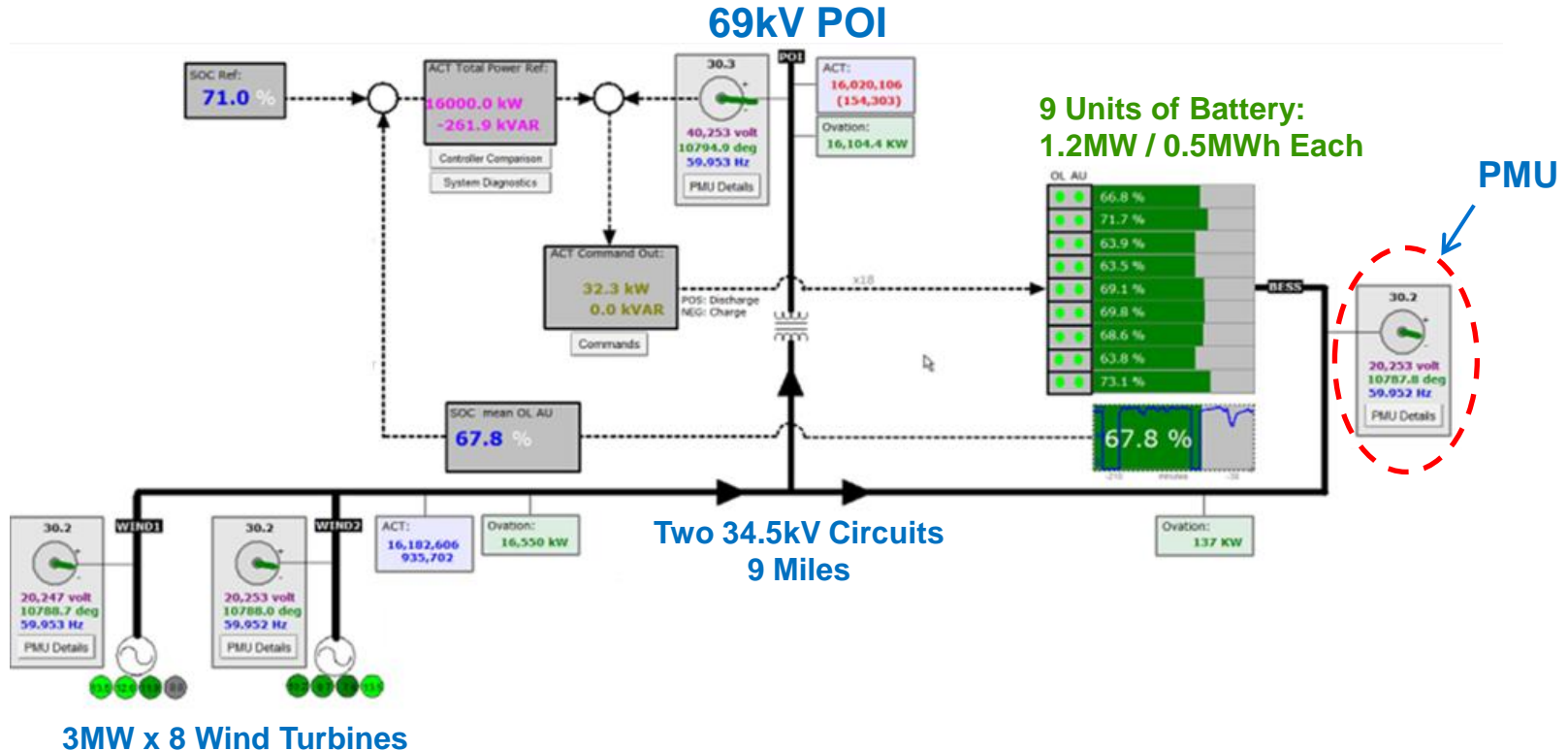
Wind Farm Commissioned in 2012

- 24 MW Wind Turbines (3MW x 8)
- 11MW / 4.4 MWh Li-ion Battery Storage
- Existing SEL Relays with built-in PMUs
- Hardware added 2017: PXiSE Computer & I/O Controller

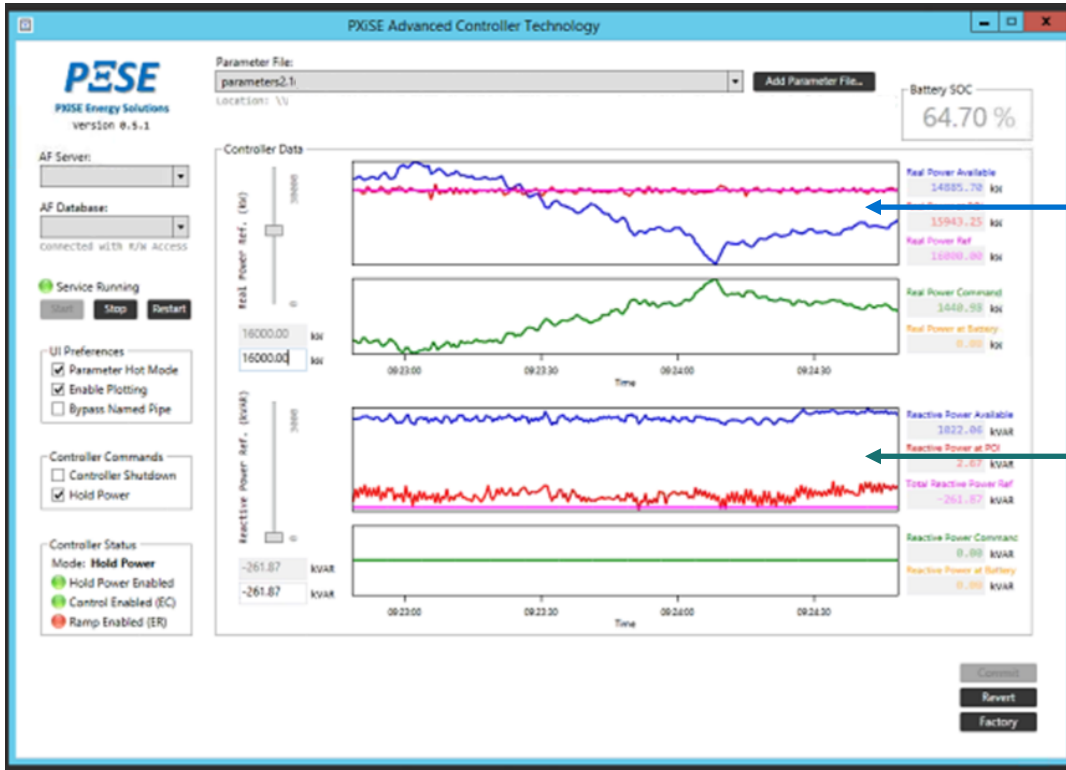
Control Capabilities

- Existing Controller (2012 - Industrial PLC/Computer):
 - Ramp Control of Real Power Only
- PXiSE ACT (2017):
 - Ramp Control of Real and Reactive Power
 - Advanced Frequency and Volt./Var Control

PXiSE PMU-based high-speed feedback control at Auwahi Wind Farm with battery storage



High-speed precision real and reactive power control



Real Power scheduling and curtailment management

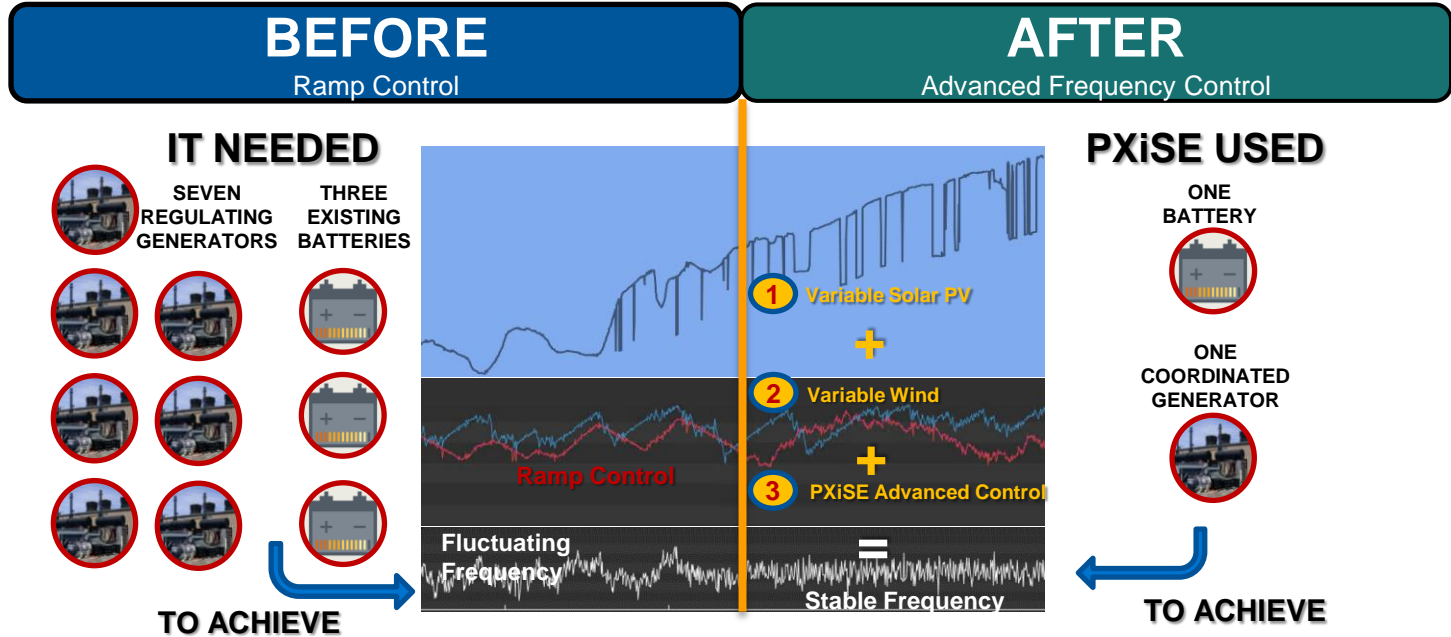
Reactive power volt. / var management

Paradigm shift needed – let each type of resource contribute according to its natural advantages & characteristics



1. Renewables produce power to the grid as available based on desirable mix
2. Use coordinated batteries as the primary tool to stabilize frequency (manage the dynamic changes from intermittency of renewables and variations in the grid as a single disturbance)
3. Enable large thermal generators to operate in a steady speed and dispatch in coordinated steps thus improving thermal efficiency (speed governor action avoided due to frequency changes addressed by ACT)

Demonstrated result: Operational value with ACT + battery

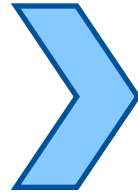


Value to an Asset Owners:

1. Reduce generator capital, O&M, and fuel costs
2. Enable further increase of renewable mix to lower energy cost

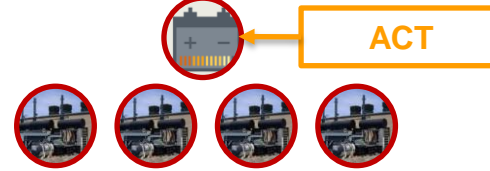
Business impacts: Utilization of electric grid energy assets can improve significantly with PXiSE ACT + battery

BEFORE
Traditional Control



AFTER
Advanced Frequency Control

Battery sized to cover for largest contingency



Fuel savings from heat rate improvements

Less renewable curtailment (less fuel use)

Maintenance savings from generators on standby

GHG benefits from fuel savings

Energy cost savings from additional renewables

Conclusion and implications



Successful implementation in an island demonstrated the benefit of an advanced PMU-based, high-speed, and precision control alternative to legacy controls



Such advanced control technology can improve efficiency and reliability of electric energy assets significantly

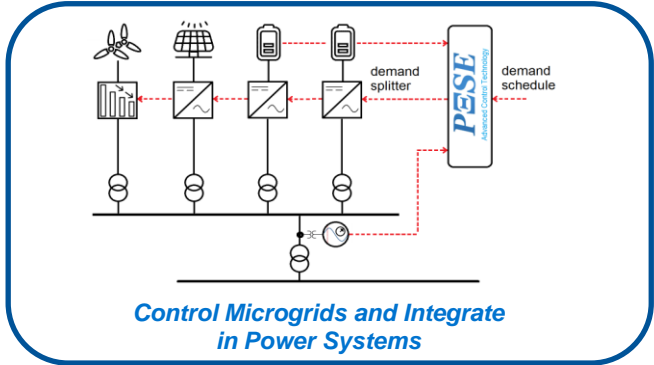


High % renewables integration can be achieved cost effectively and intermittencies can be addressed



PXiSE ACT enables new control capabilities with a huge potential to benefit large and small electric grids worldwide

PXiSE ACT has broad applications to ensure smooth, reliable, and cost-effective operations of energy assets in an modern grid



PESE
PXISE Advanced Controller

Energy Storage

Multi-objectives Energy Dispatch – Timed Demand & Flow Control

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Energy Storage + Gas Turbine

Enhanced Hybrid Turbine – Ramp & Frequency Control

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PXISE Advanced Controller

Wind Resources + Energy Storage

Intermittencies and Power Output Schedule Management

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Wind Resources + Solar Resources + Energy Storage + Thermal Generation

Optimal Control of All Resources – Improve Efficiency and Reliability

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Chief Technology Architect

PXiSe Energy Solutions

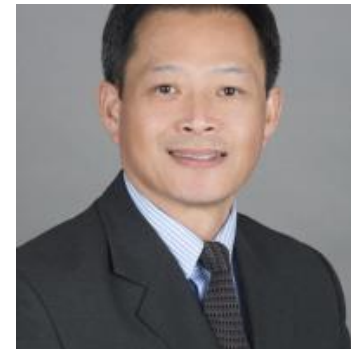


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Questions

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

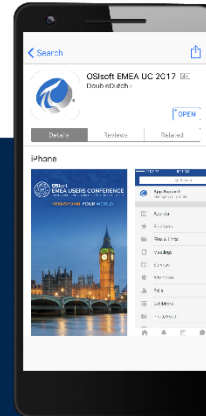


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감사합니다

Danke

谢谢

Merci

Gracias

Thank You

ありがとう

Спасибо

Obrigado