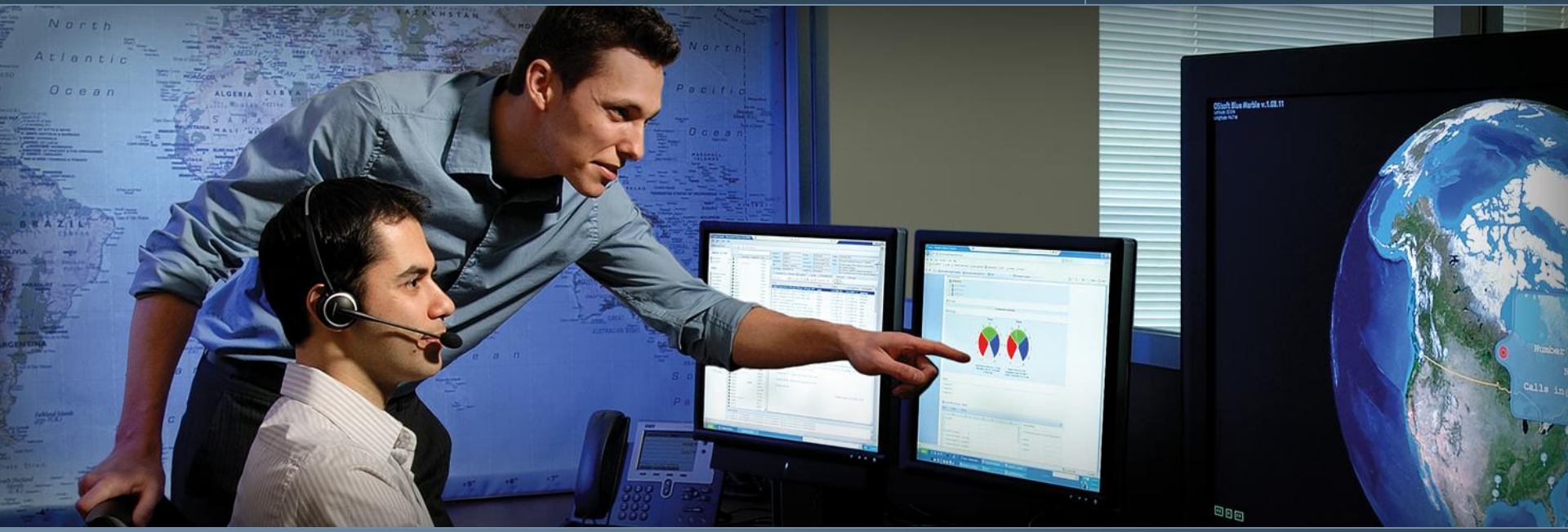

Leveraging Historical and Real-time Data to Meet the Challenges of Wind Power Generation

Value now, Value over time.

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The Primary Challenges

- Asset utilization
  - Availability
  - Efficiency
- Sell power at highest rates
  - Grid integration
  - Forecasting
  - Scheduling
  - Trading
- Warranty management

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Other Challenges and Opportunities

- Enterprise integration
  - Heterogeneous assets
- Security
  - NERC CIP
- Regulations and Compliance
  - Reporting

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About OSIsoft

- Established in 1980
- Founder - J. Patrick Kennedy
- Private & Profitable
- Headquarters - San Leandro, CA
- 660 + employees
- 225 + employees in product development
- PI Installed base
  - 14,000 + systems (excluding OEMs)
  - 110 + countries
  - 40% of Fortune 1 000 process & manufacturing companies
  - 65% of Global 500 process & manufacturing companies

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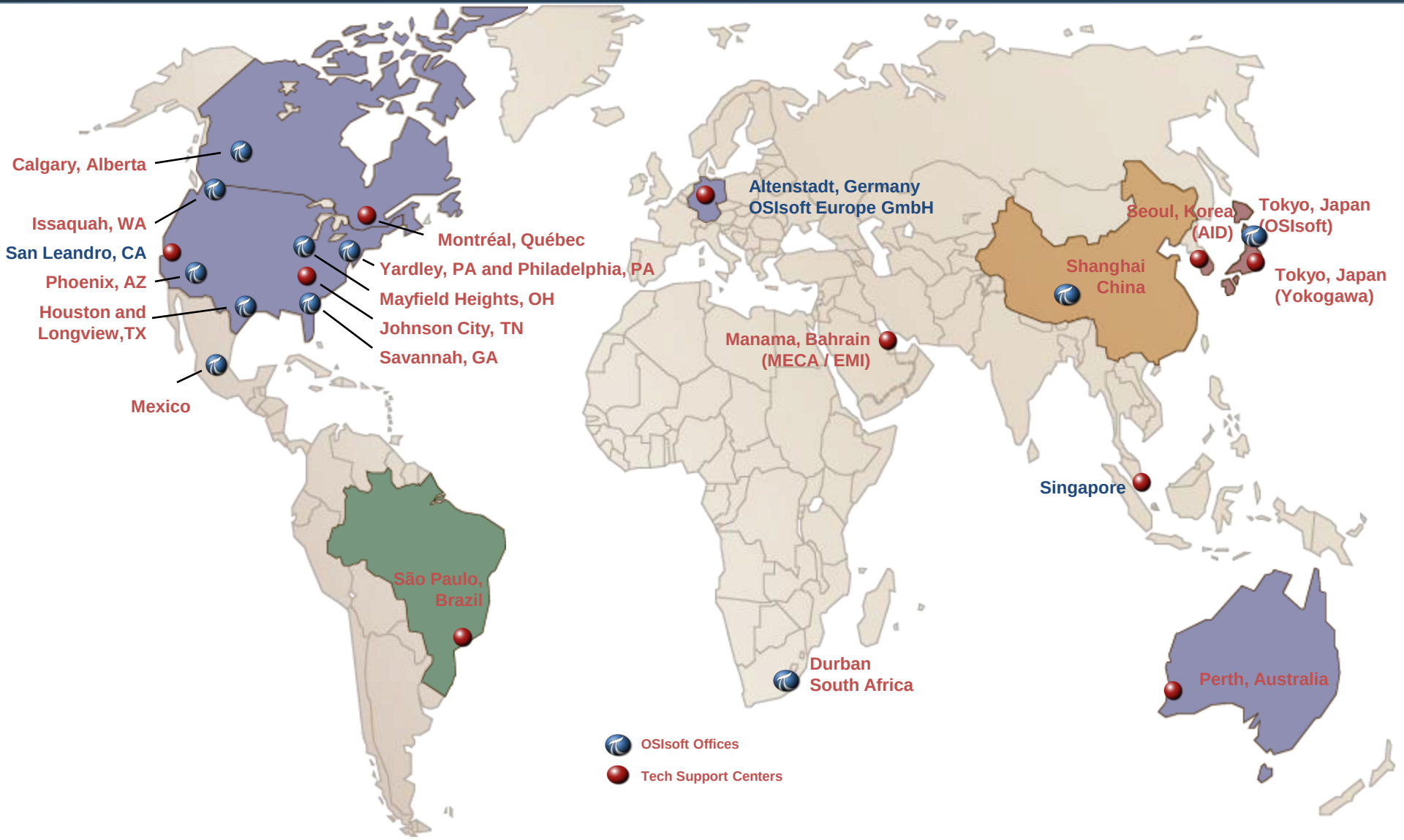
Where is OSIsoft in the world?



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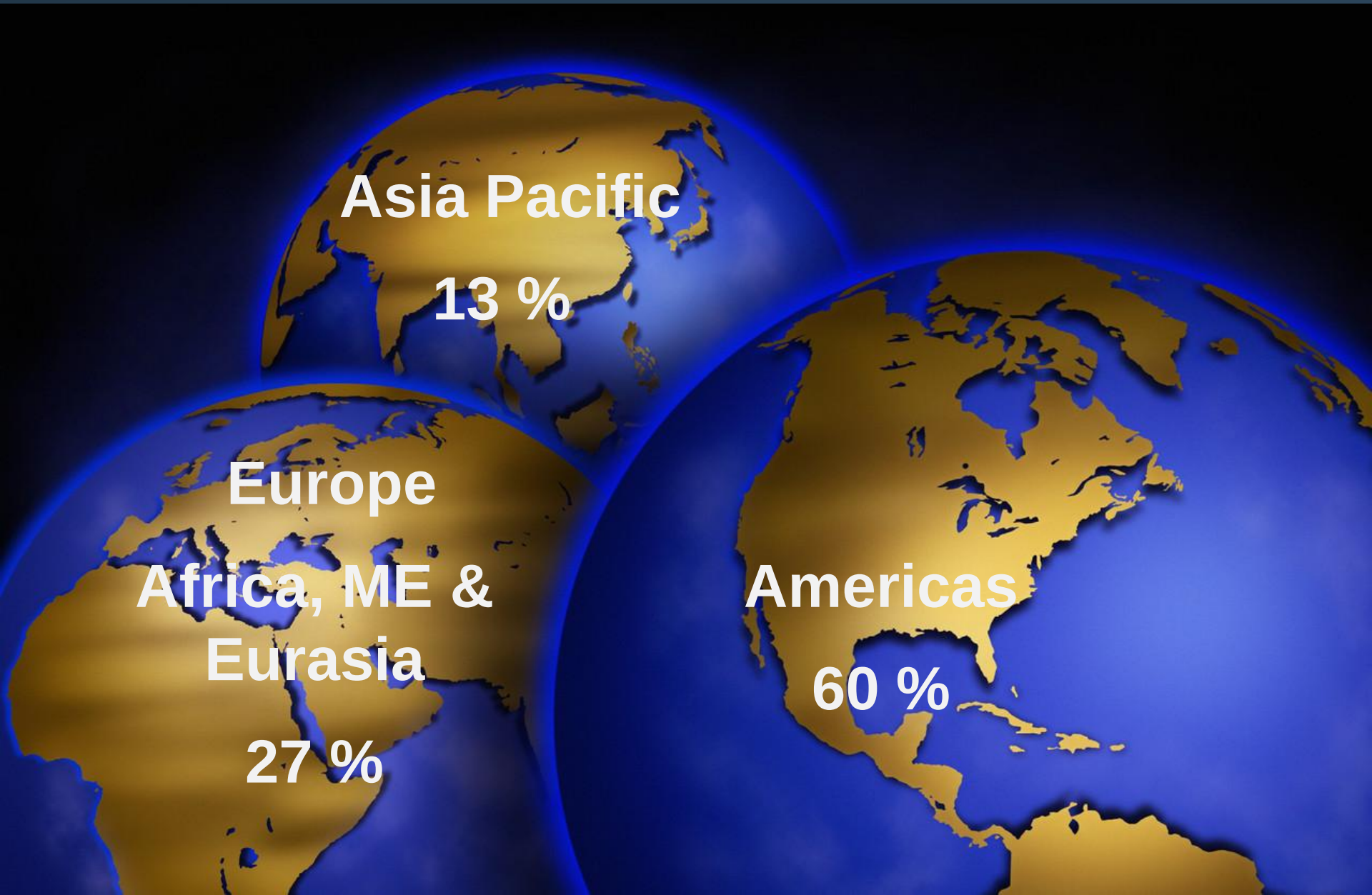
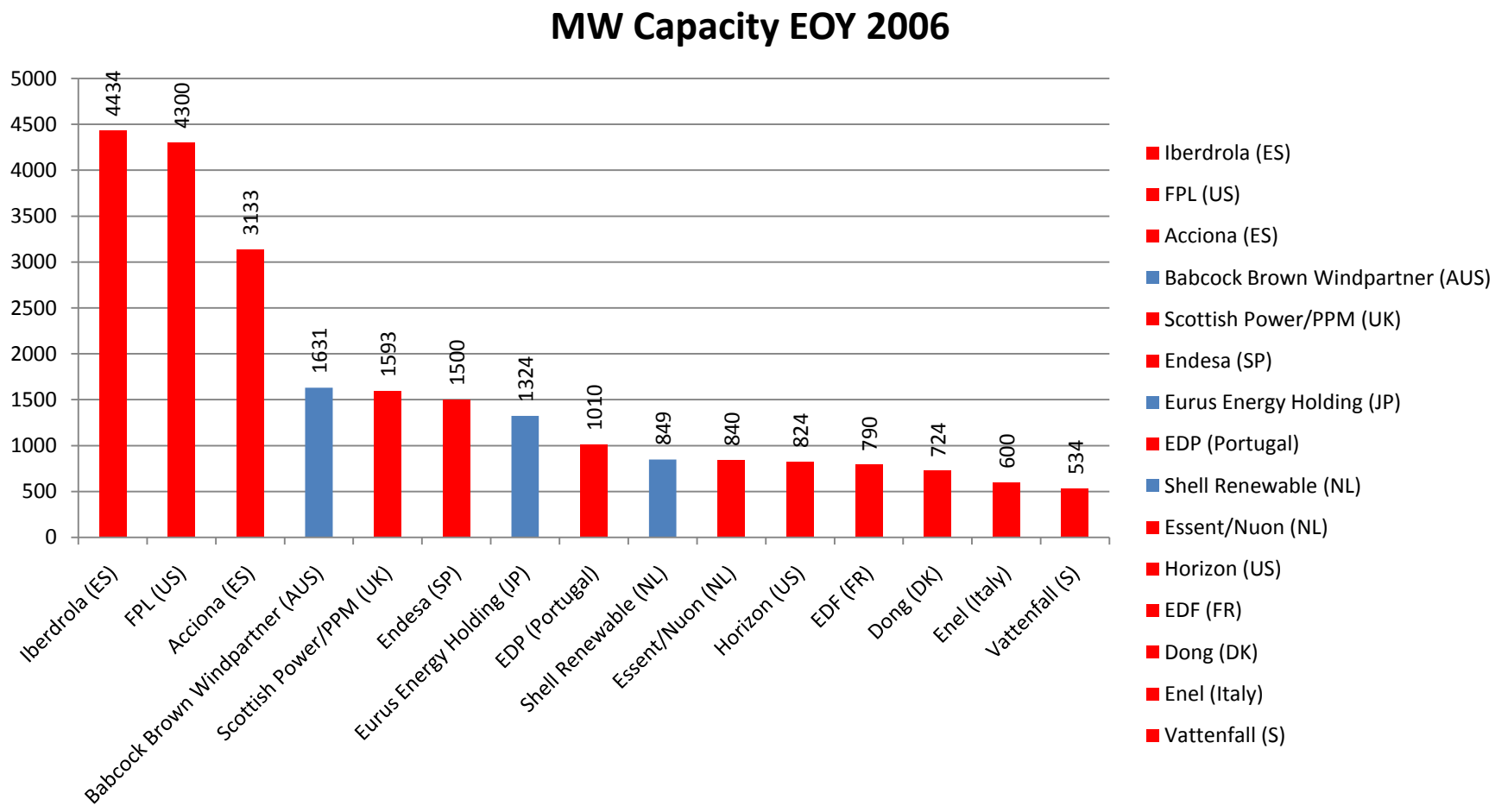
Primary market segmentation



President of Spain at RED Electrica

12 of Top 15 Owner/Operators use PI*



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Delivering Value to Wind Customers

- 7200MWs in single WindCORE – going global…
- Centralized M&D Center with Control – coordinated with Grid Operator – RED Electrica

- >5000MWs in Centralized M&D Center
- Distributed Control approach

- Enterprise Customer since 2007
- Developing Operations Center – Bezier, France.
- US Subsidiary – ENXCO – OCC Center - Minnesota

- Enterprise Customer since 2007/08
- Global Integration of NA, European, ME, Asian assets

- Enterprise Customer since 2007
- Distributed control, centralized monitoring & diagnostics

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Targeted Industries

Power & Utilities – 30 %

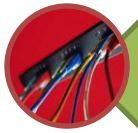
Oil & Gas – 20 %

Chemicals & Petrochemicals – 10 %

Mines, Metals, Metallurgy & Materials – 10 %

Pulp & Paper- 10 %

Pharma., Food & Life Sciences – 10 %



Data Centers, IT & Facilities (all industries)

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Omnipresent Challenges

- Quality
- Personnel
- Variable costs
  - Materials
  - Energy
- **Capital utilization**
- **Trading and markets**
- Regulations, compliance
- Environmental, Health, Safety
- Technology

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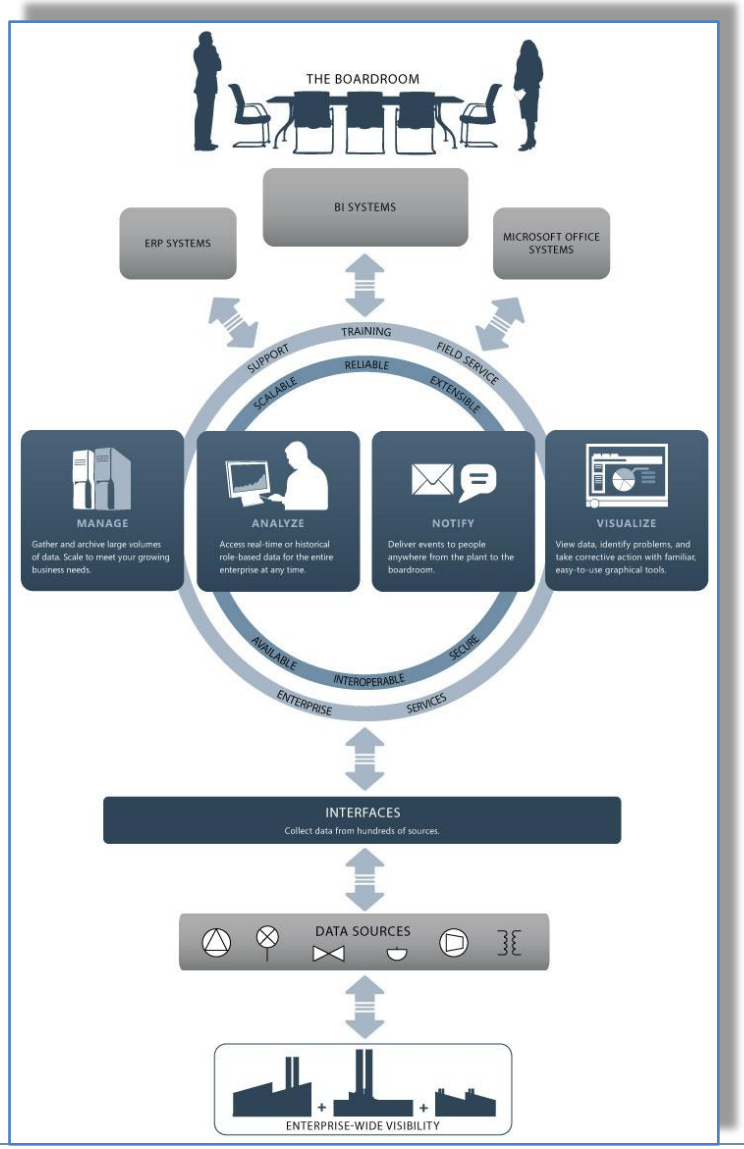
Quick PI System Overview



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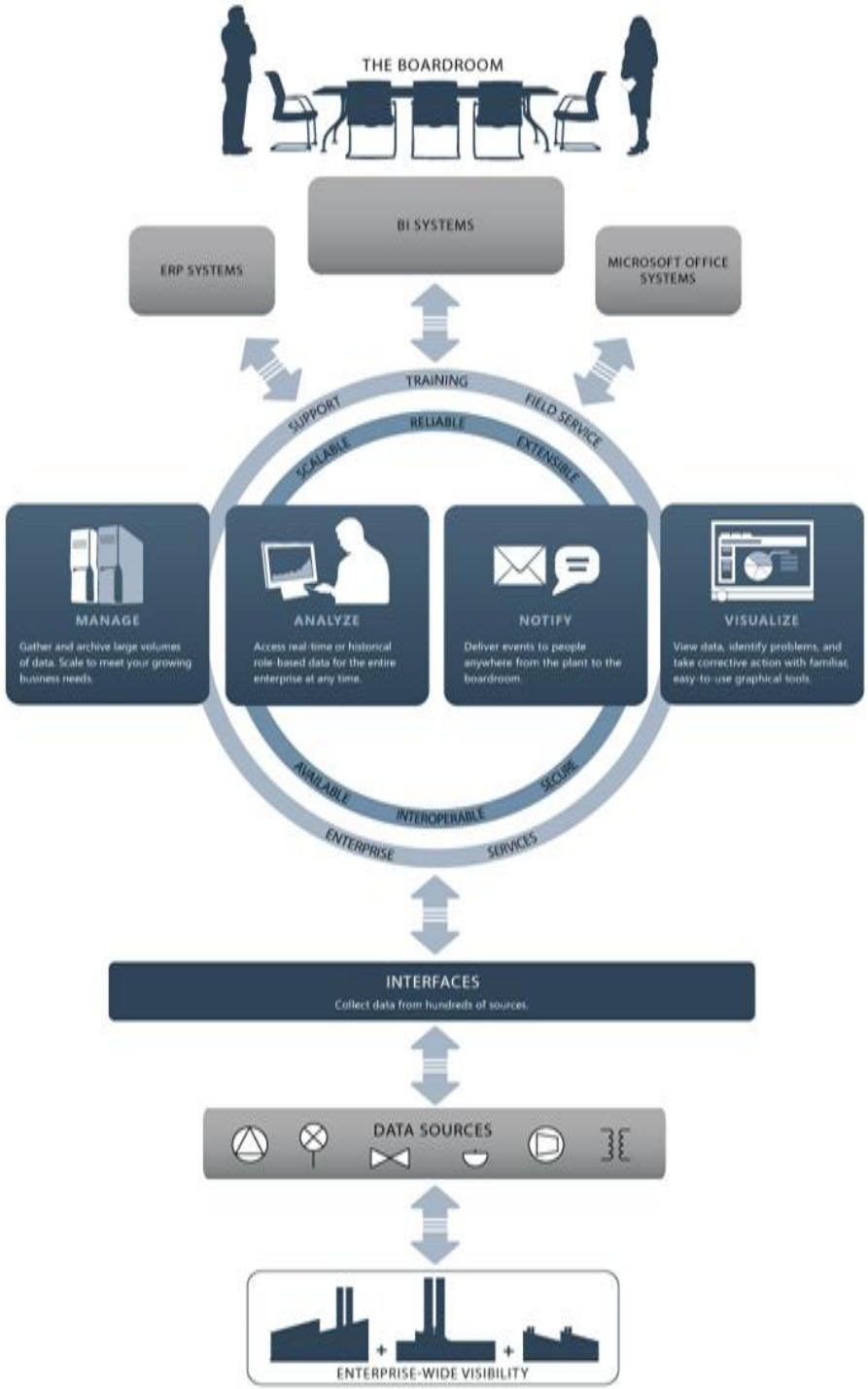
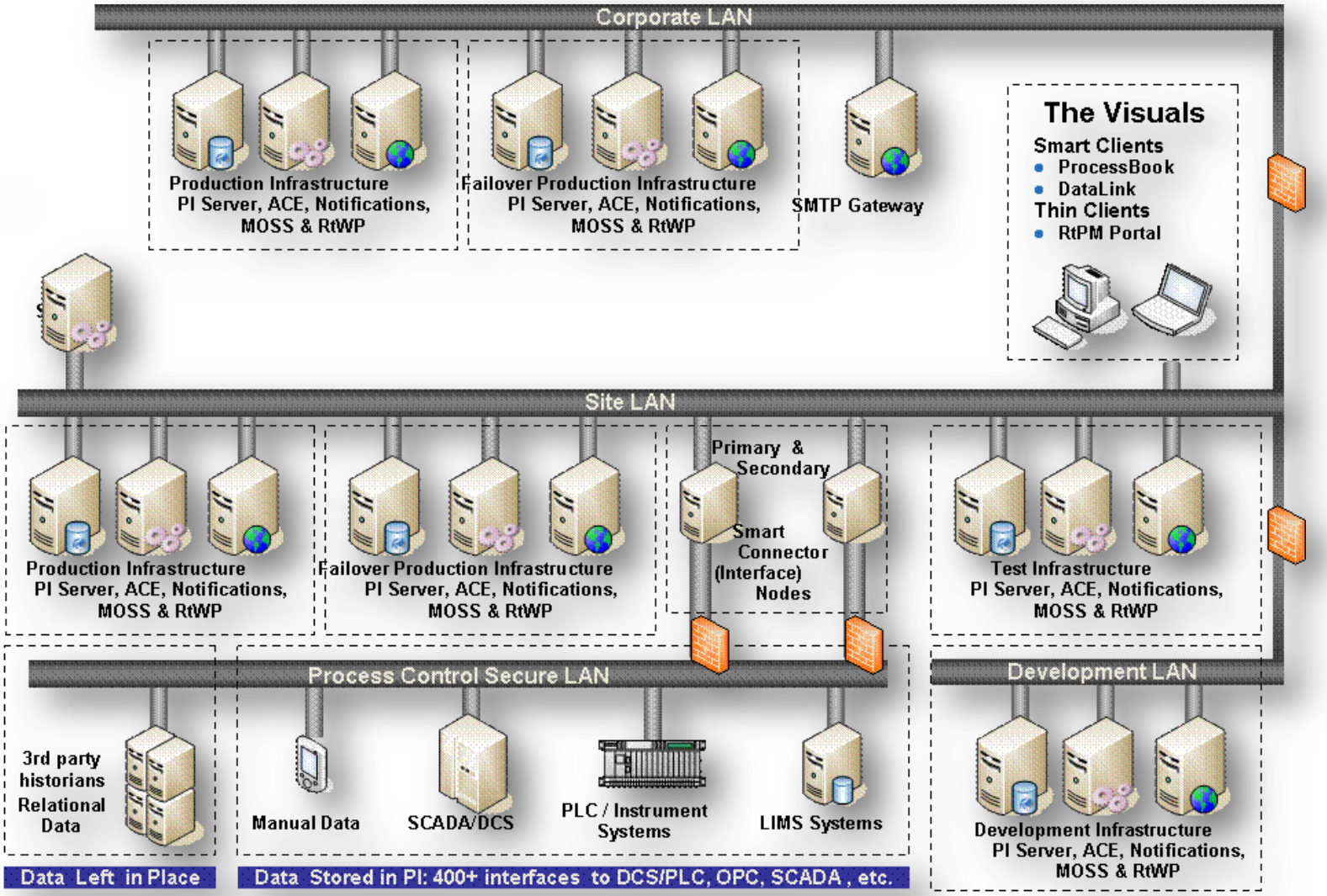

THE BOARDROOM
BI SYSTEMS
ERP SYSTEMS
MICROSOFT OFFICE SYSTEMS
TRAINING
FIELD SERVICE
EXTENSIBLE
RELIABLE
SCALABLE
SUPPORT
MANAGE
Gather and archive large volumes of data. Scale to meet your growing business needs.
ANALYZE
Access real-time or historical role-based data for the entire enterprise at any time.
NOTIFY
Deliver events to people anywhere from the plant to the boardroom.
VISUALIZE
View data, identify problems, and take corrective action with familiar, easy-to-use graphical tools.
AVAILABLE
INTEROPERABLE
SECURE
ENTERPRISE
SERVICES
INTERFACES
Collect data from hundreds of sources.
DATA SOURCES
ENTERPRISE-WIDE VISIBILITY

Enterprise Architecture



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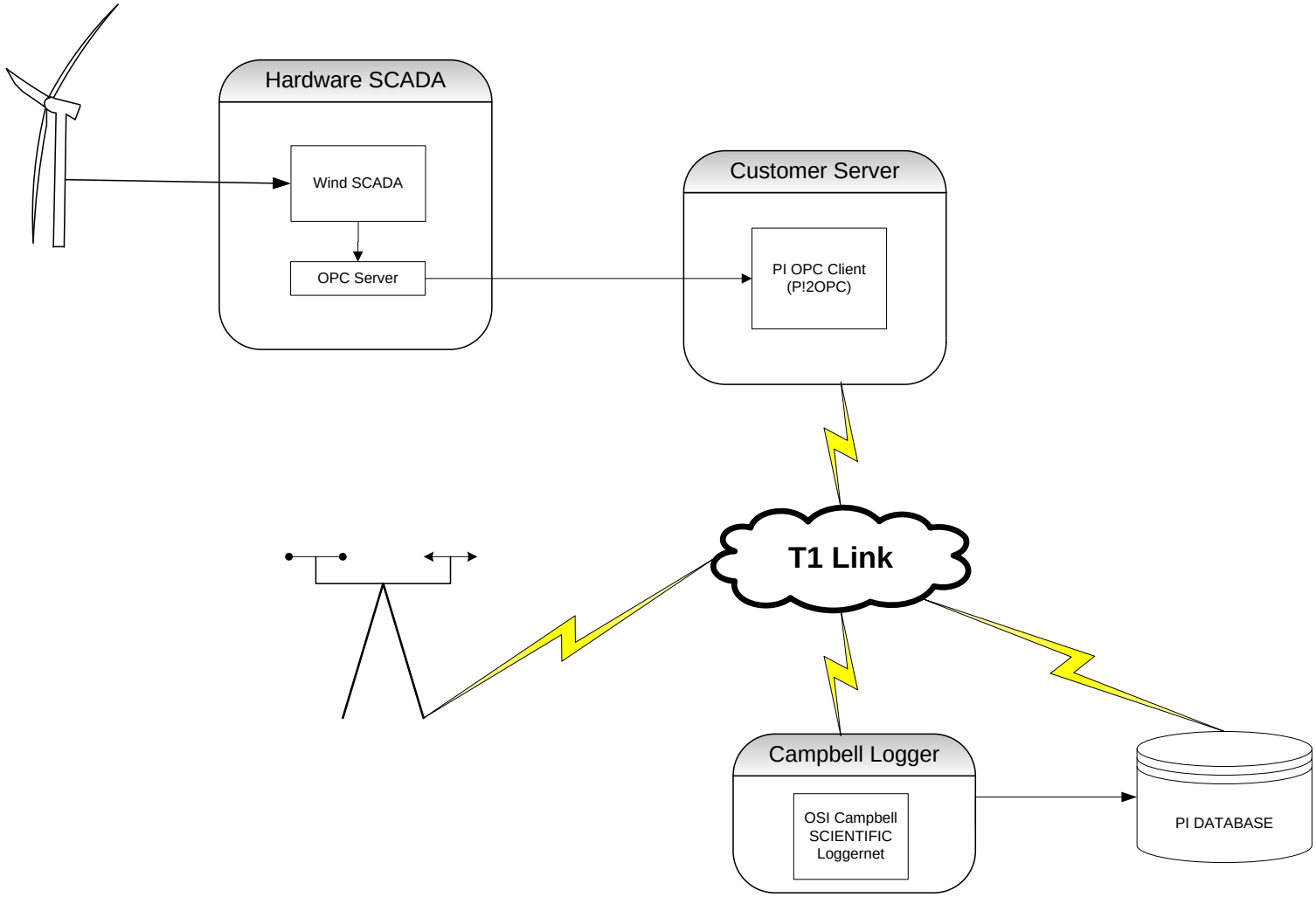
Basic Connectivity to Turbines



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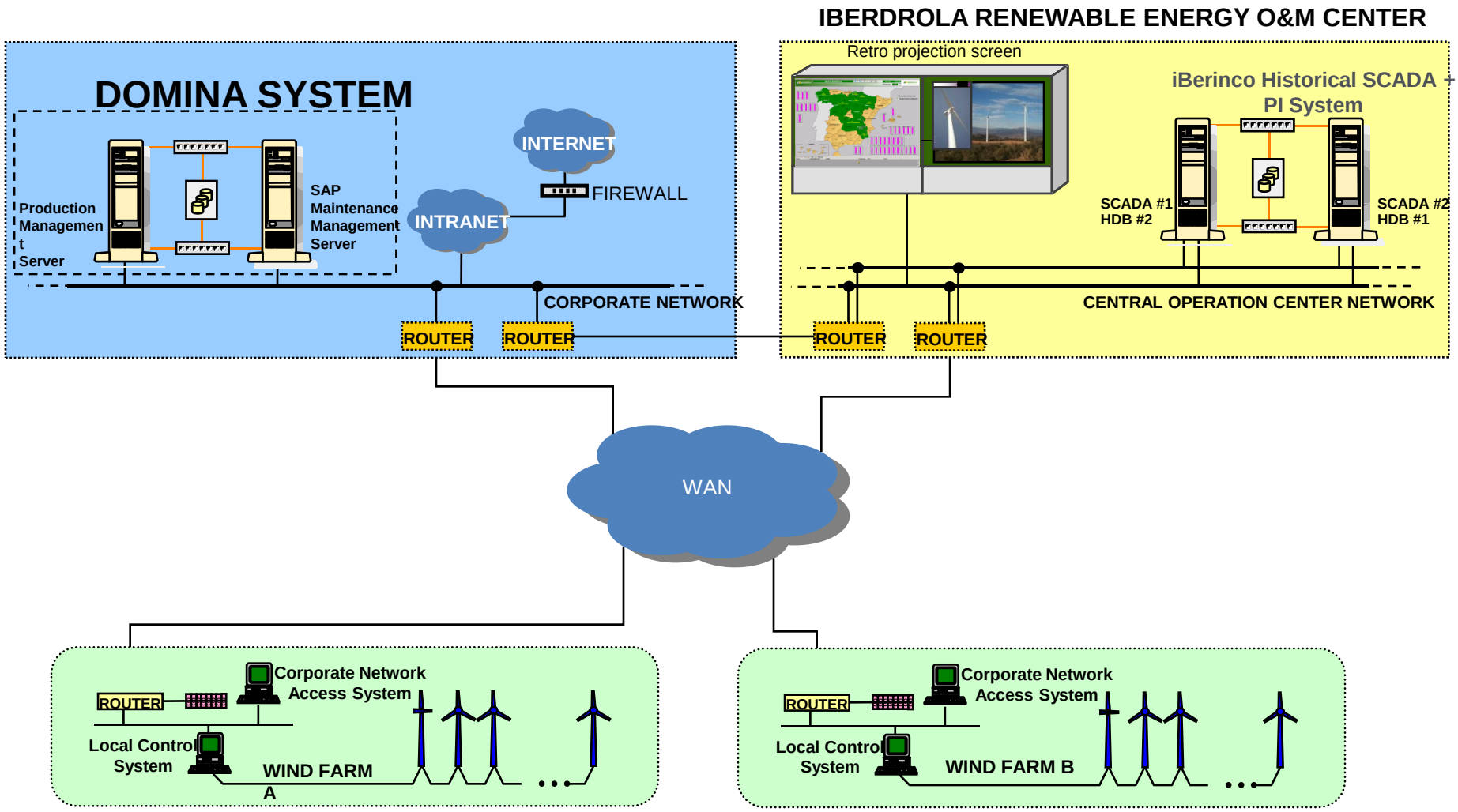
Customer Architecture--Iberdrola



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Challenge--Asset Utilization

- Availability
  - Is asset online?
- Efficiency
  - Is it performing to expected levels?

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What is Availability Worth?

Hours	TurbineClass (kW)	Capacity Factor	Availability	Annual Expected Output (kWh)*	Busbar Price /kWh	Annual Cash Flow per WTG
8760	600	33%	100%	1,734,480	0.0425	$ 73,715.40
8760	1000	33%	100%	2,890,800	0.0425	$ 122,859.00
8760	1500	33%	100%	4,336,200	0.0425	$ 184,288.50
8760	2000	33%	100%	5,781,600	0.0425	$ 245,718.00
8760	2500	33%	100%	7,227,000	0.0425	$ 307,147.50
8760	5000	33%	100%	14,454,000	0.0425	$ 614,295.00

**Formula = Hours * Generator Capacity * Capacity Factor * Availability*

- A typical utility scale wind farm may have 30 to 200 Turbines
- Large owners (e.g. Iberdrola – 3500MWs) may have thousands of turbines
- A single percentage point gain/loss of "in-market" availability (e.g. turbines available to operate when the wind is blowing) for
  - Iberdrola **Total Fleet** would result
    - in a 1st Year ROI/loss of **$4.3MUSD**.
    - NPV over 5 Years = **$13.5MUSD** @ 18% Discount Rate
    - Based on US prices, power rate in Spain is .07 to .10/kWh produced
  - For a **Single Wind Farm of 150MWs**:
    - In a 1st year ROI of $185,000
    - NPV over 5 years = $576,000 @ 18% Discount Rate

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Iberdrola WindCORE

- **Cost reduction in O&M**
  - By centralizing operation, resource optimization is achieved with a significant reduction of local staff
- **Reduction of unavailability costs**
  - Continuous monitoring and remote operation of wind farms
  - Remote pre-diagnosis and activation of local maintenance squads for the solution of failures
- **Implementation of energy control functions**
  - To meet new grid operation requirements based on high penetration rate of wind energy…
- **Centralized way to communicate with other energy management centres**

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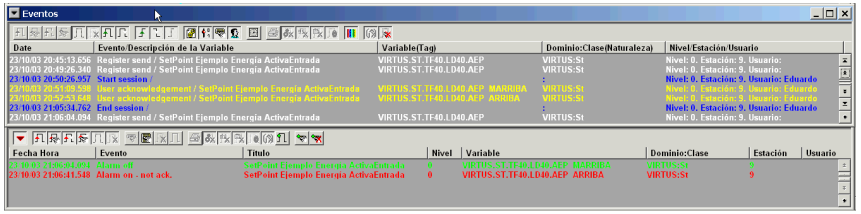
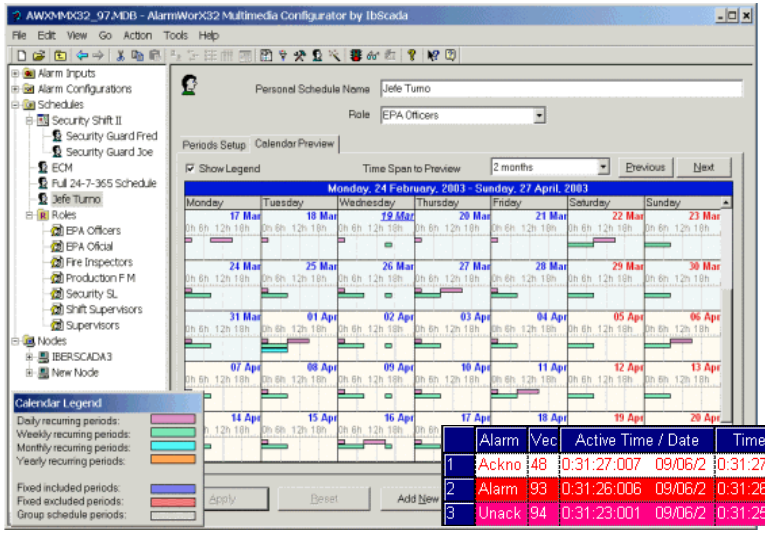
Iberdrola WindCORE

- Alarm Warnings and Events



- Advanced Alarm Manager (Multimedia and Squad Manager)



	Alarm	Vec	Active Time / Date	Time	Area/Node	Valor	Tag	Límite	Description	Type
1	Ackno	48	0:31:27:007 09/06/2	0:31:27:0	AreaParque1\AreaGrupo1	90.475938	Parque1.Grupo1.Potenc	92	Grupo1.Potencia--> Límite Bajo	LO
2	Alarm	93	0:31:26:006 09/06/2	0:31:26:0	AreaParque1	94.091685	Parque1.Potencia	95	Parque1.Potencia--> Límite Bajo	LO
3	Unack	94	0:31:23:001 09/06/2	0:31:25:0	AreaParque1\AreaGrupo1	50.498800	Parque1.Grupo1.Frecue	50.55	Grupo1.Frecuencia --> límite NORMAL	HI

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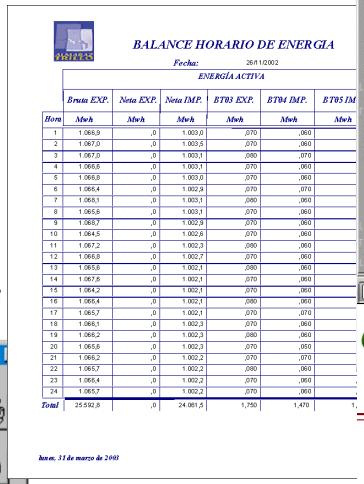
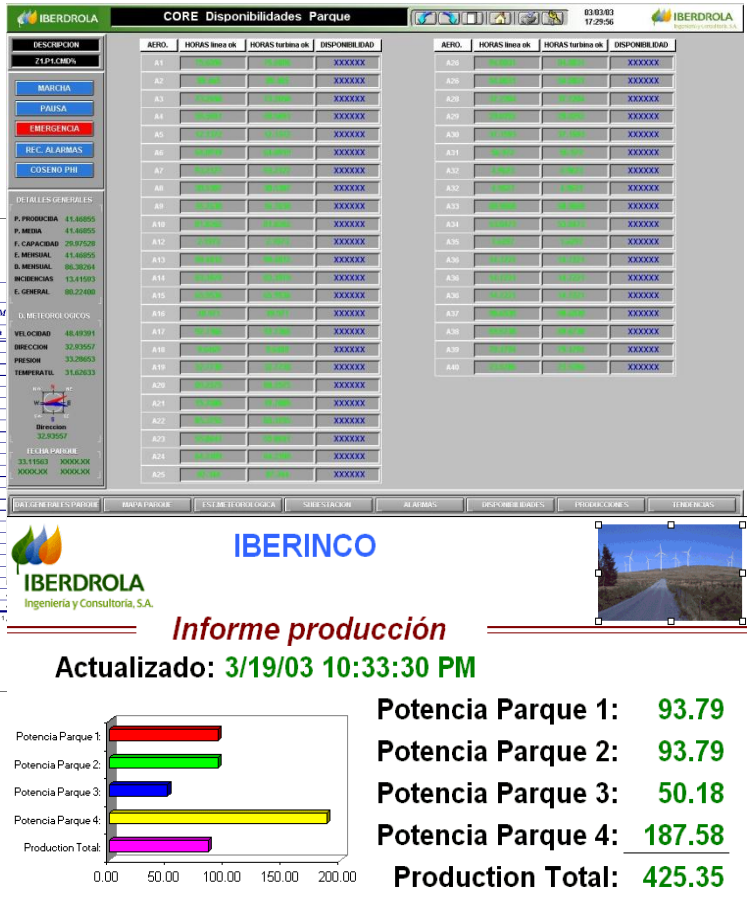
Iberdrola WindCORE

- Historic Data Storage
- Historic Reports
- Calculation
- Reports





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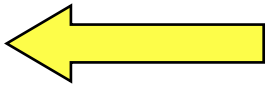
Iberdrola WindCORE

Benefit Received				
MW	**Capacity Factor**	**Availability**	**MWh Production**	
2000	27,5%	97%	4673460	
2000	27,5%	98%	4721640	
			48180	MWh Gain from Availability Improvemen
			$ 80,00	Feed In Tariff USD/MWh
			$ 3.854.400,00	

Cost Model for WindCORE					
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Total cost (infrastructure, system, labor, utilities, rent…)	$ 2.100.000	$ 600.000	$ 600.000	$ 600.000	$ 600.000
Net Present Value of Cost	$3.638.108				
Benefit	$ 3.854.400	$ 3.854.400,00	$ 3.854.400,00	$ 3.854.400,00	$ 3.854.400,00
Net Present Value of Benefit	$14.611.209				
Payout per Dollar Spent	**$ 4,02**				



Cost Assumptions: Number of Wind Farms

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Availability--Common Component Failures

- **Gearbox**
- Blades
- Drive train

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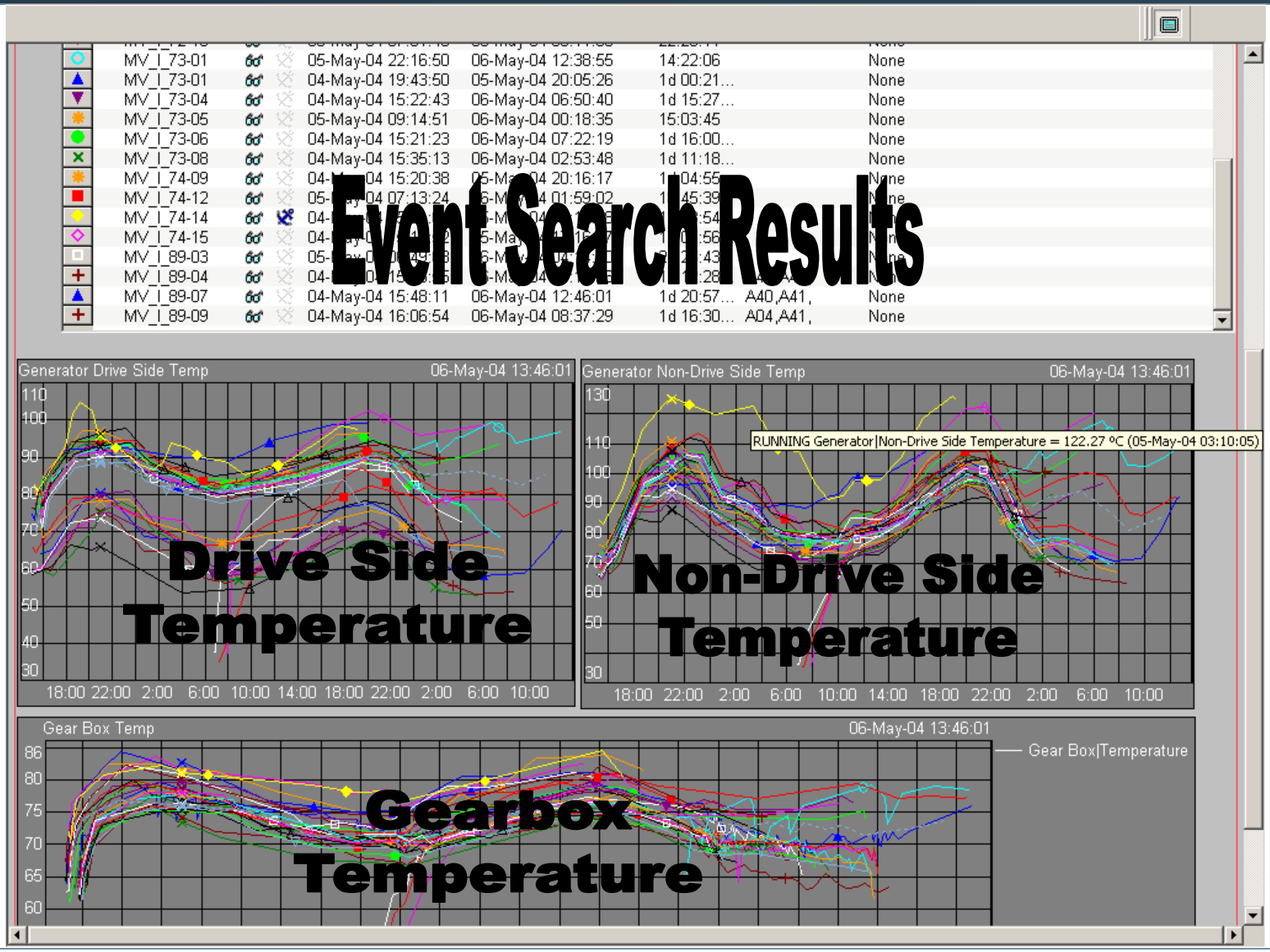
Gearbox Example



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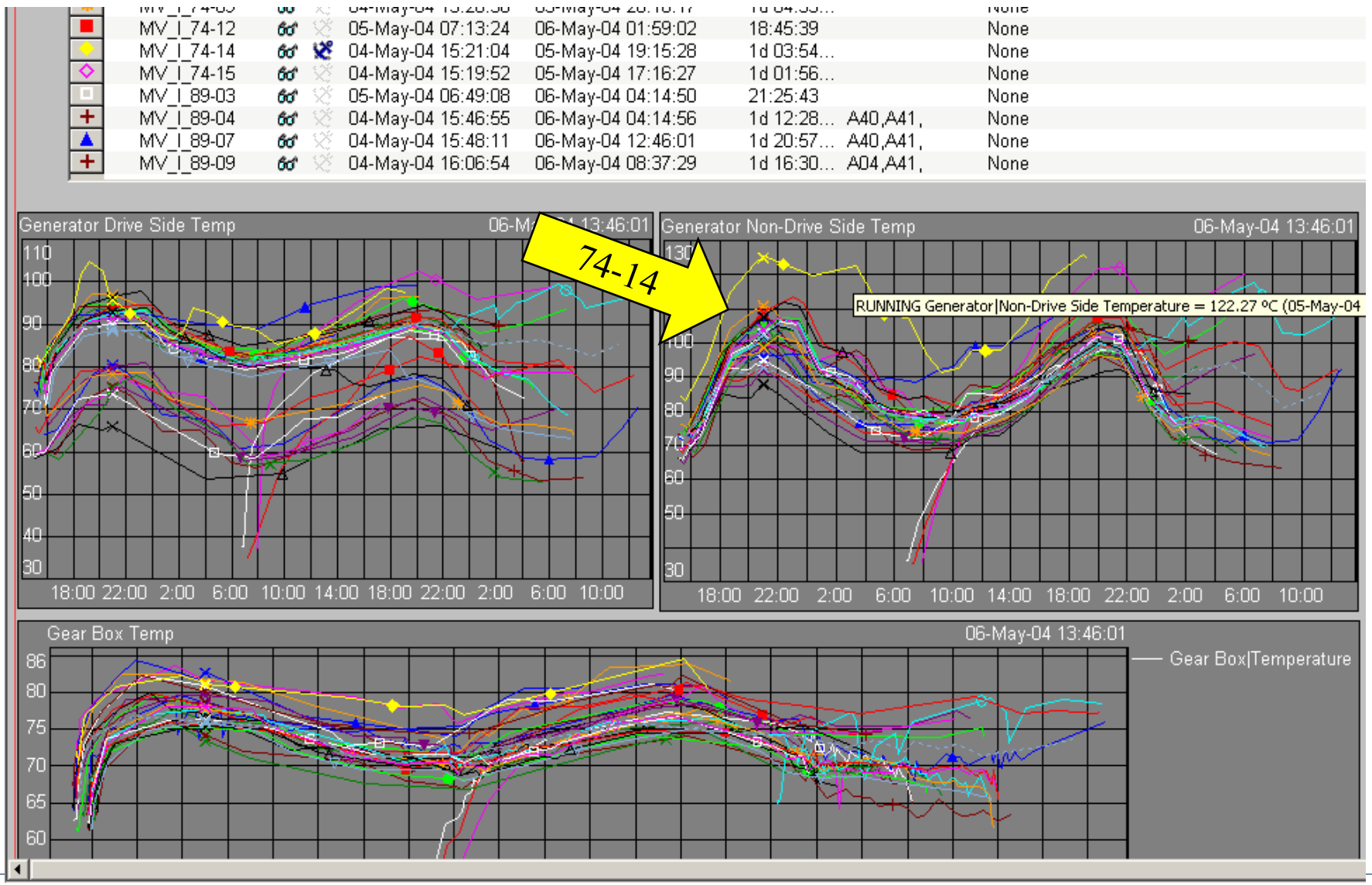
Gearbox Example

	MV_I_74-12	60'	05-May-04 07:13:24	06-May-04 01:59:02	18:45:39	None
	MV_I_74-14	60'	04-May-04 15:21:04	05-May-04 19:15:28	1d 03:54...	None
	MV_I_74-15	60'	04-May-04 15:19:52	05-May-04 17:16:27	1d 01:56...	None
	MV_I_89-03	60'	05-May-04 06:49:08	06-May-04 04:14:50	21:25:43	None
	MV_I_89-04	60'	04-May-04 15:46:55	06-May-04 04:14:56	1d 12:28... A40,A41,	None
	MV_I_89-07	60'	04-May-04 15:48:11	06-May-04 12:46:01	1d 20:57... A40,A41,	None
	MV_I_89-09	60'	04-May-04 16:06:54	06-May-04 08:37:29	1d 16:30... A04,A41,	None



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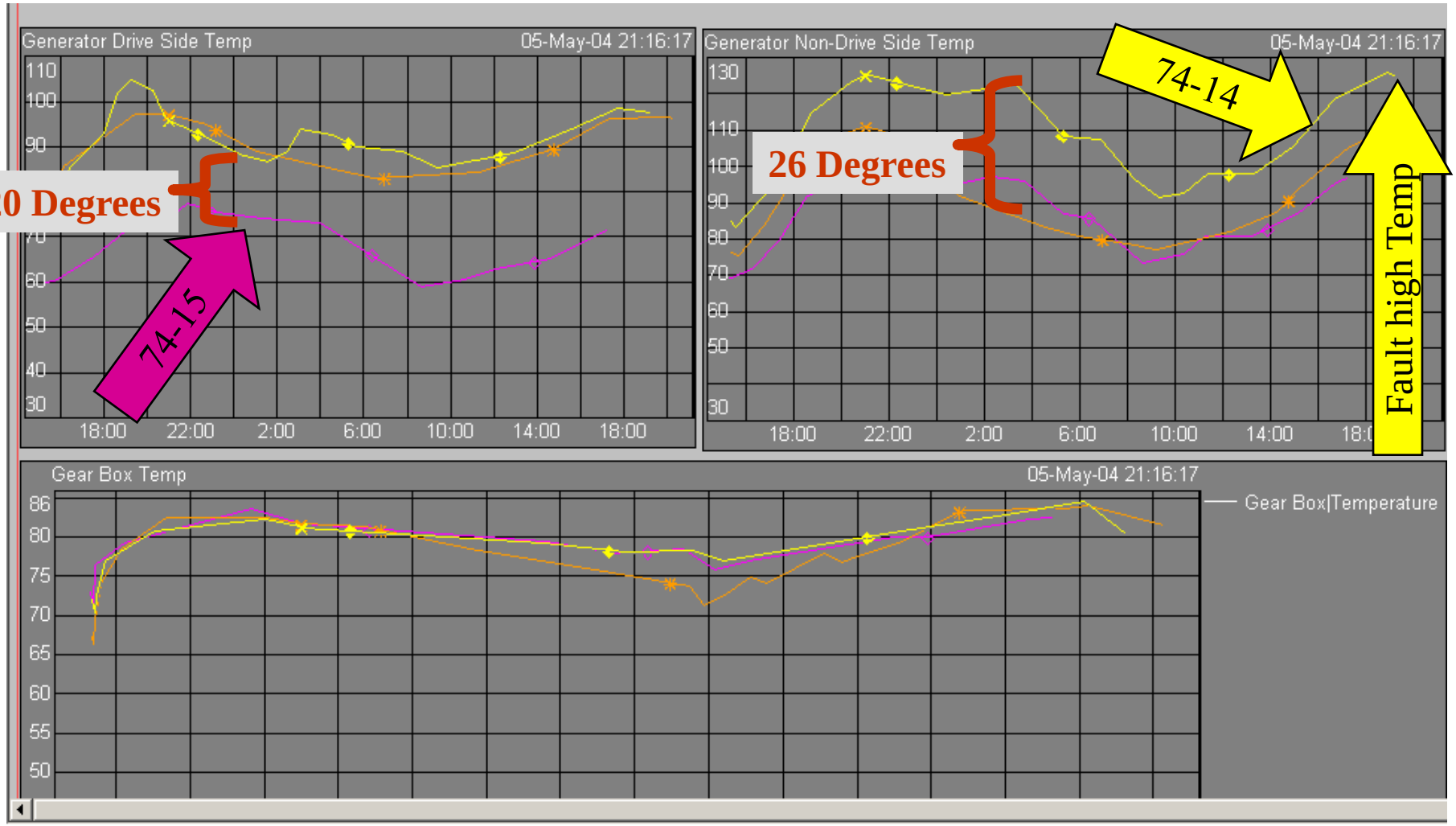
Gearbox Example



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Gearbox Example

Date	Time	Hours Lost	Production Lost	Fault
5/5/04	19:15	11.90	6,627	Gen Temp High
5/9/04	20:29	11.93	7,200	Gen Temp High
5/16/04	18:25	17.32	10,297	Gen Temp High
6/29/04	16:14	382.57	157,665	Generator R&R, Gen Alignment
7/16/04	6:43	1.05	700	Nacelle Reassembly after R&R Gen
Total		424.77	182,489	**$10,024 lost revenue from 1 turbine over 2 month period**

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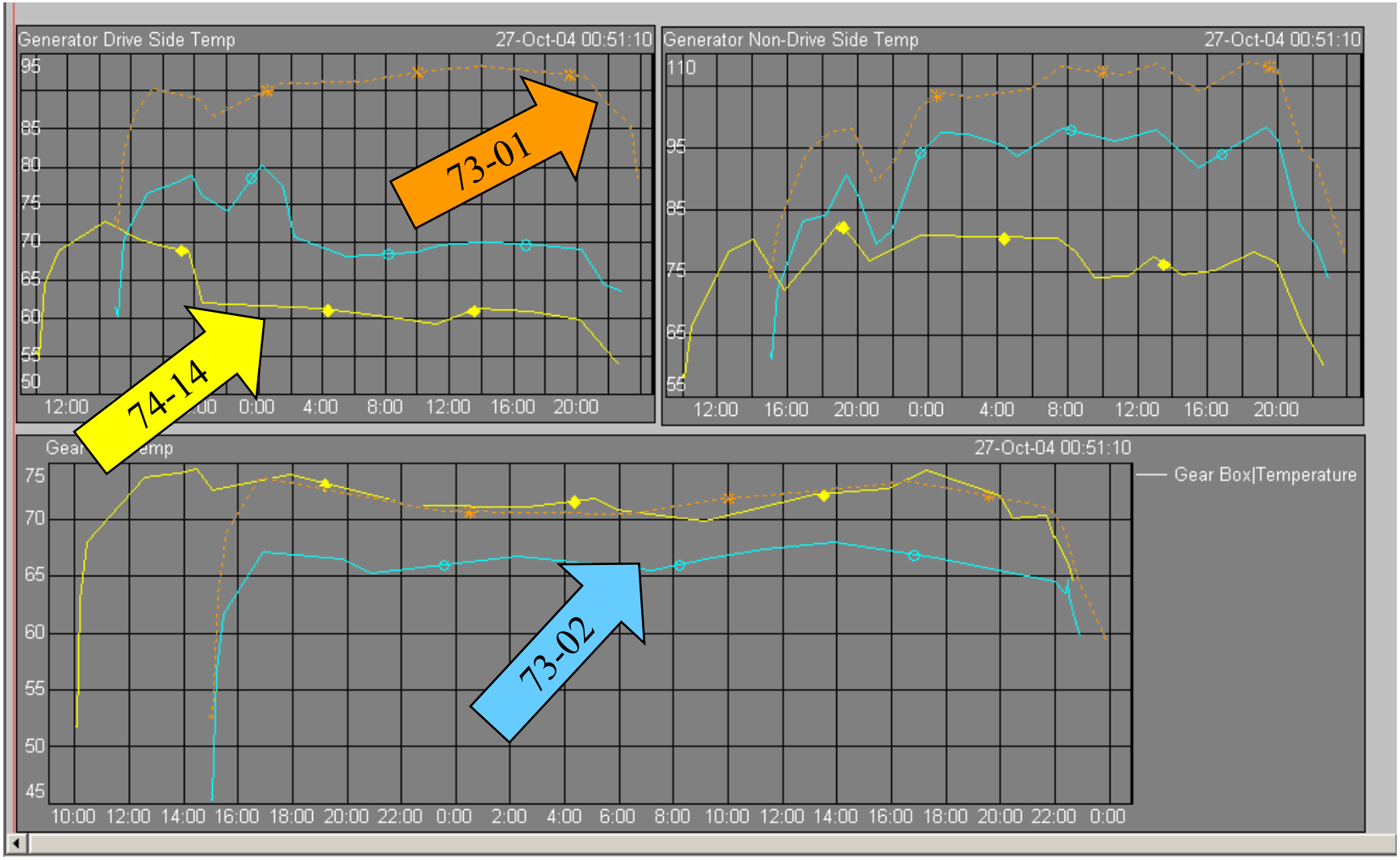
Gearbox Example



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Availability and Reporting

- Next examples are by one of our Engineers
  - Done on real customers systems
  - Example of getting visibility into what is going on

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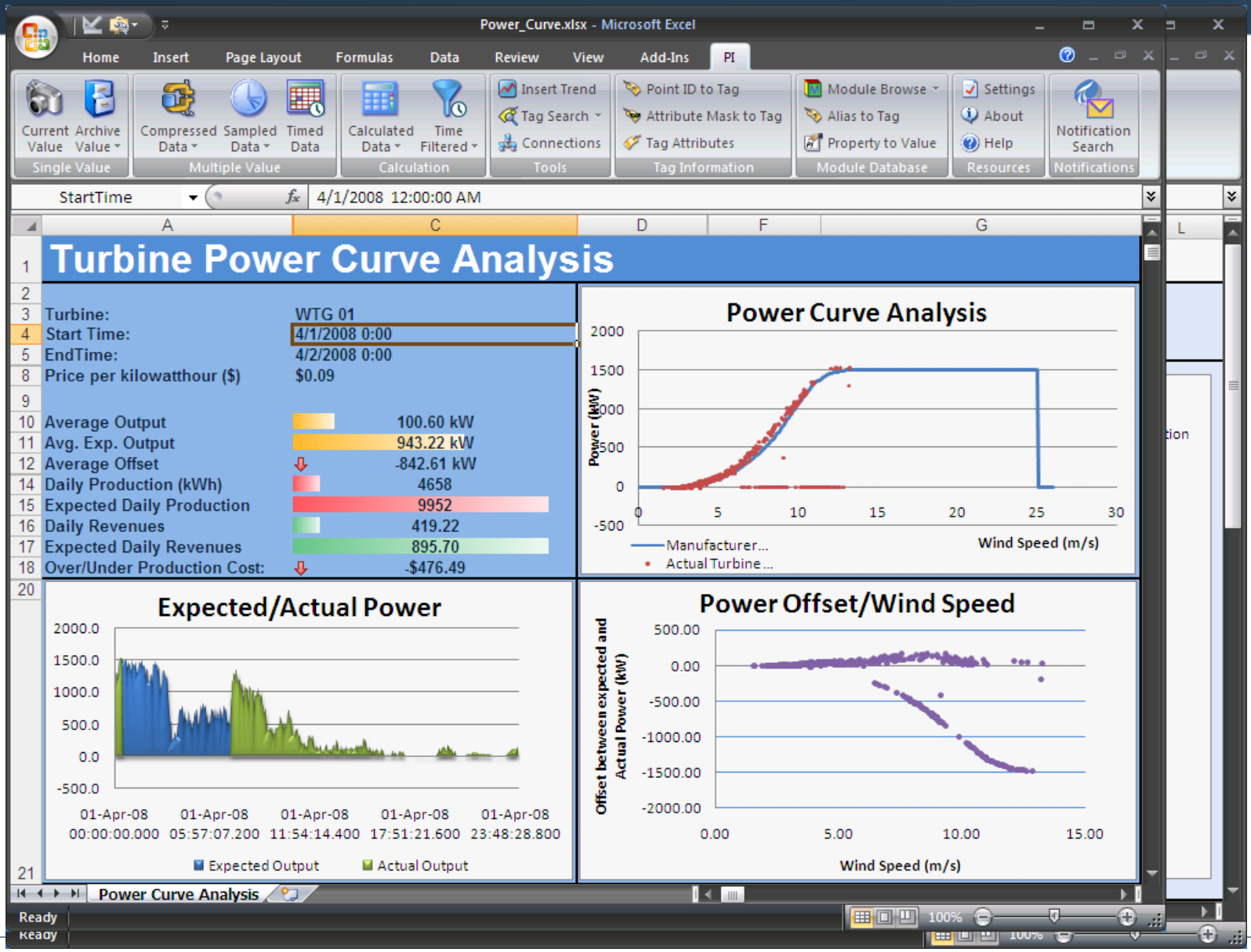
Availability and Efficiency Report



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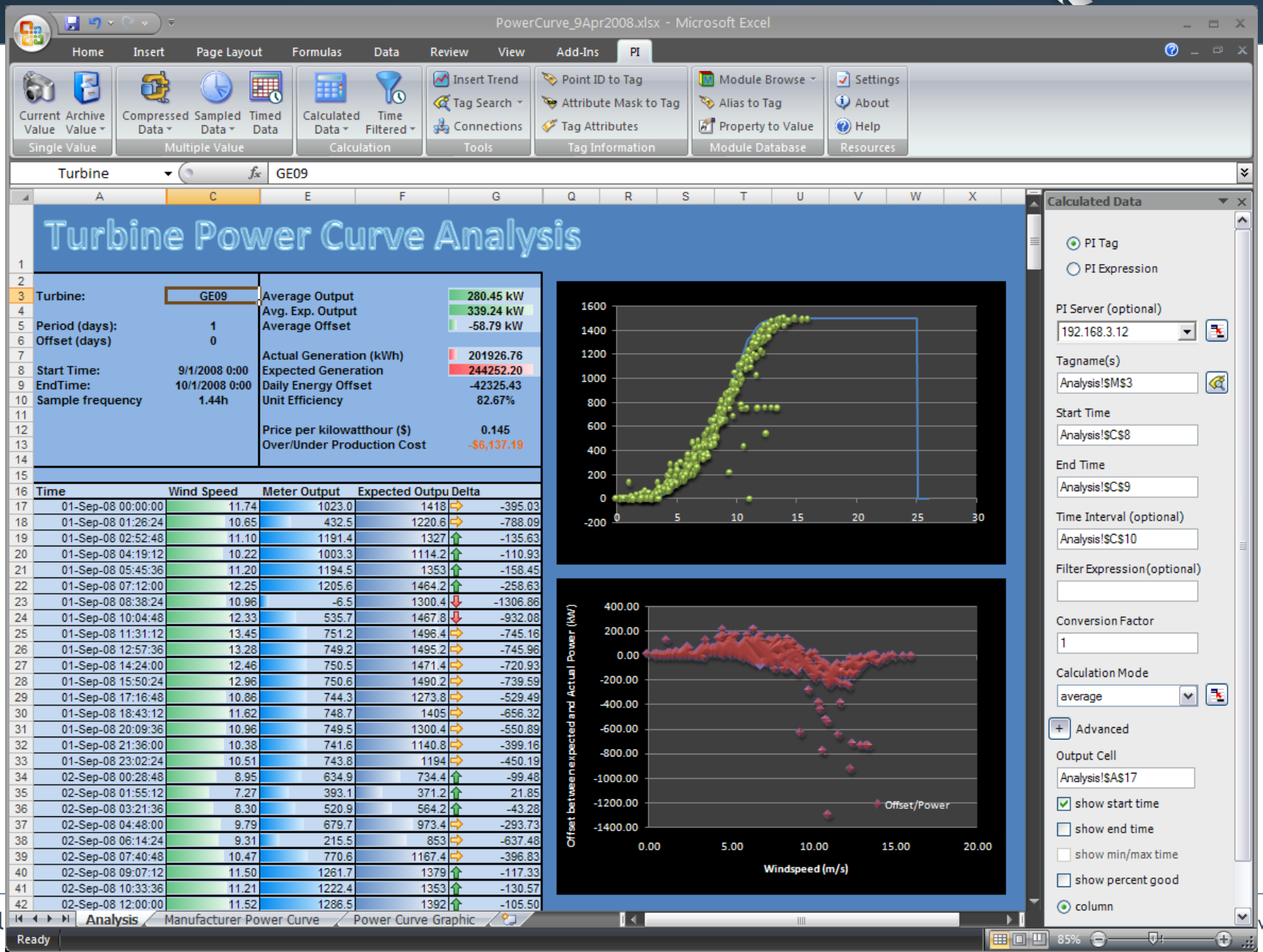
Power Curve Analysis (Efficiency)



ved.

Availability

- Customer—PPM (owned by Iberdrola)
- OSIsoft Users Conference, 2007
- Uses PI to:
  - Manage Fuel
  - Deal with many units and wide geographic distribution; often remote locations.
  - Normalizes data from several turbine Manufacturers
  - Deal with Complexity of markets

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- Reliability vs. Availability

Park Reliability & Availability Month-to-Date

As Of: 2007-04-12 11:00:00 Next Execution: 20 mins

	Klondike 1	Klondike 2	Stateline BPA	Stateline PAC	Big Horn
RELI	89.54 %	95.31 %	97.17 %	95.64 %	96.66 %
AVAIL	78.04 %	84.21 %	96.22 %	95.87 %	92.71 %

	Shiloh	Highwinds	Mt View	Phoenix	SW Wyoming
RELI	99.07 %	88.91 %	89.02 %	34.62 %	96.42 %
AVAIL	96.79 %	91.73 %	81.91 %	95.33 %	96.36 %

	Col Green	Elk River	Flying Cloud	Moraine	Trimont
RELI	98.01 %	98.71 %	83.11 %	93.24 %	95.09 %
AVAIL	91.88 %	92.88 %	83.38 %	83.23 %	93.89 %

	MapleRidge 1	MapleRidge 2
RELI	92.61 %	89.86 %
AVAIL	89.72 %	89.33 %

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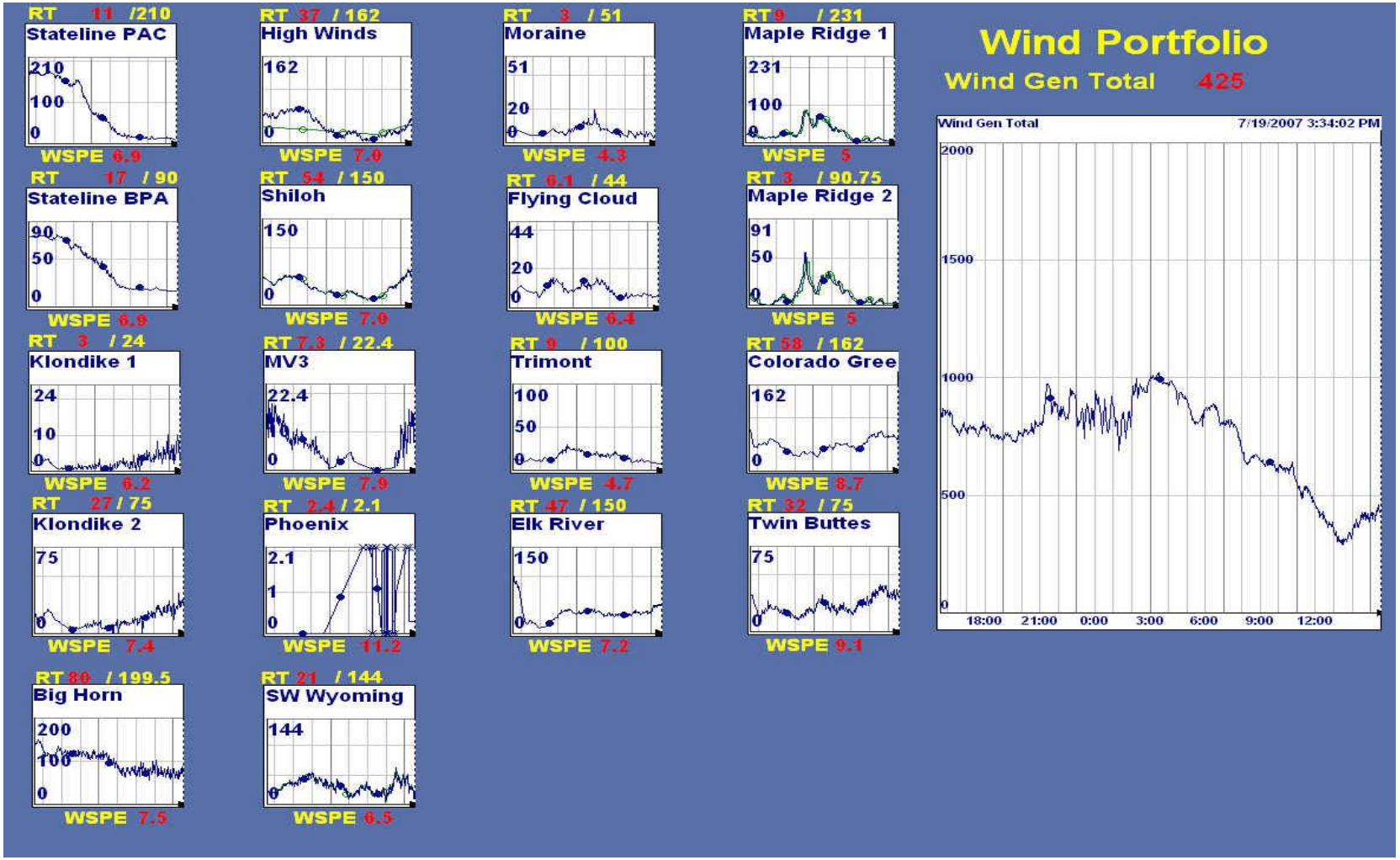
PPM (Now Iberdrola)



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Dealing with Markets

- PPM—Scotty Gilbert
  - 14 day forecasts; about best at this time
  - 24 hour forecasts—climatology and park data
    - They bank on this—trading is done 24 hours in advance.
    - Supply vs. buy decisions

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Dealing with Markets

- PPM—Scotty Gilbert
  - At end of day reconcile reality with forecast
    - Did you get the fuel predicted?
    - Did you convert to power as predicted?
  - Evaluate Market exposure
    - Were assumptions true?
  - Imperative to go back and understand and improve.

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Dealing with Markets

- Scotty Gilbert's words of wisdom
  - Collect all the information
    - True production vs. predicted
    - Evaluate reasons
    - Evaluate where to invest to improve
    - Answer questions in real time.
      - Don't take weeks to answer the CEO's questions
  - "Have the courage use the historical data to evaluate performance"

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Importance of Forecasting

- ERCOT
- Bonneville Power Authority
- UWIG--AWEA

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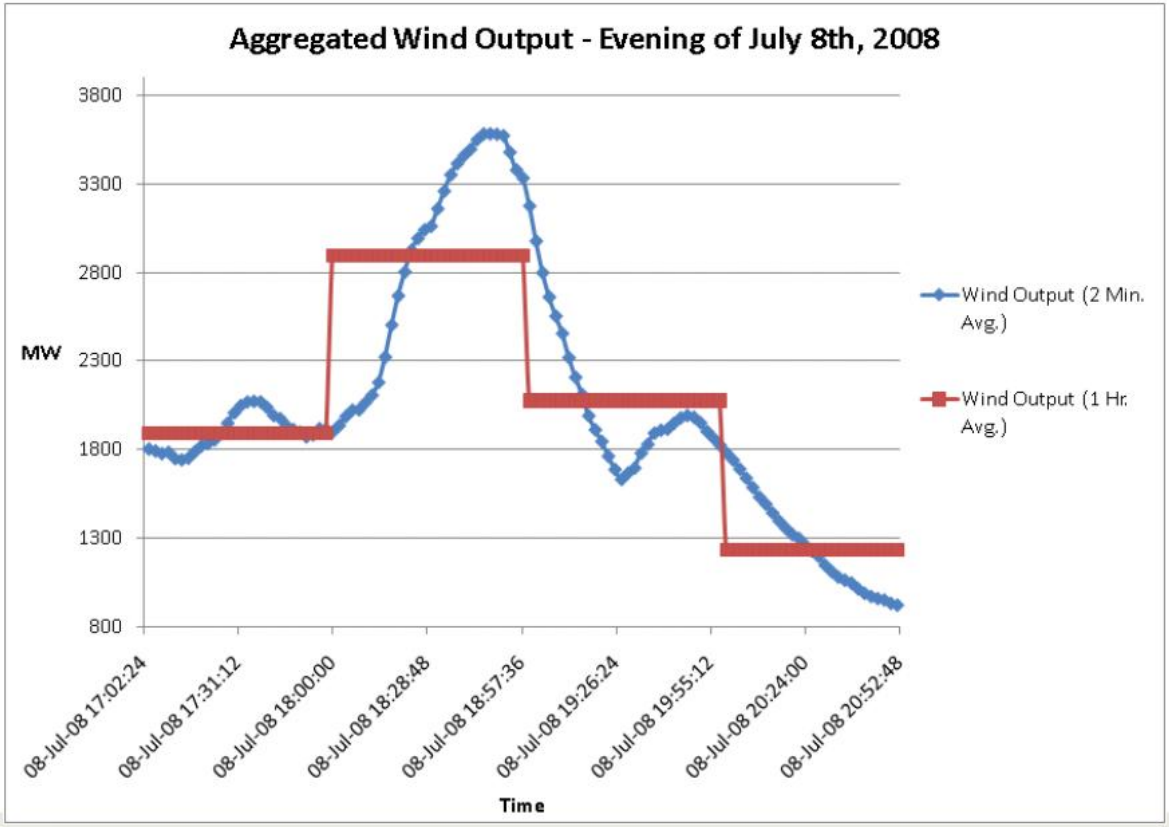
Ramp Event Caught By ERCOT

Ramping Example 1 cont.



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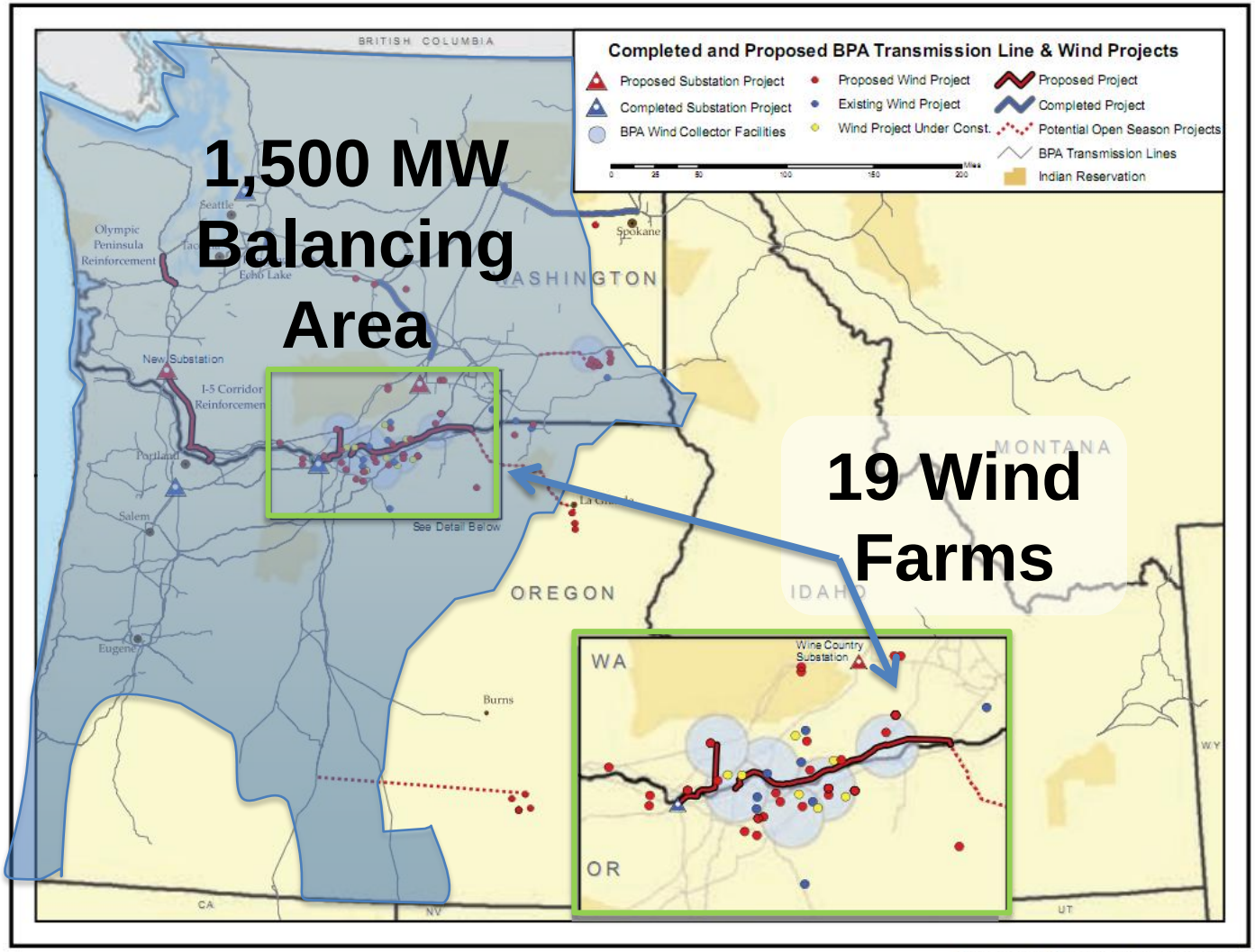
Balancing—Bonneville Power Authority



Map by Geospatial Services

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Value of Forecasting

UWIG Utility Wind Integration Group

GE-NYSERDA Study for NYISO, 10% Penetration, 2005 Operating Costs with Wind Forecasts

- Day-ahead unit commitment considers forecasted wind generation

	No Wind Forecast	SOA Wind Forecast	Perfect Wind Forecast
Total Variable Cost Reduction	$335 M	$430 M	$455 M
Net Benefit		$95 M	$ 120 M
Wind Generation		8900 GWH	8900 GWH
Value of Forecast		$10.70/MWH	$13.50/MWH

Presented by GE at UWIG Sacramento Meeting, Nov. 2005

UWIG OP Impacts Meeting – April 2008 -- 8

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Scheduling and Forecasting

- Keys—
  - Best 1 hour prediction is current conditions.
  - Schedule maintenance when wind is likely to be down.
  - Real-time data to make better maintenance decisions
    - Final maintenance planning done based on current and immediate forecast

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Scheduling and Forecasting

- Send to regulators production plan
  - Hour to two hours in advance
    - Failure to deliver requires purchasing power
  - Forecasting services
    - Feed them your wind data
    - Their models forecast the next few hours
    - Calculate output potential
  - Use PI to track forecast accuracy

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Warranty Management

- Based on availability
  - (Often part of O & M contract)
- Non-competitive during boom of last few years
  - Owner now has opportunity of doing O & M on day 1
- Close monitoring of guaranteed asset provides key knowledge to transition into post warranty mode.

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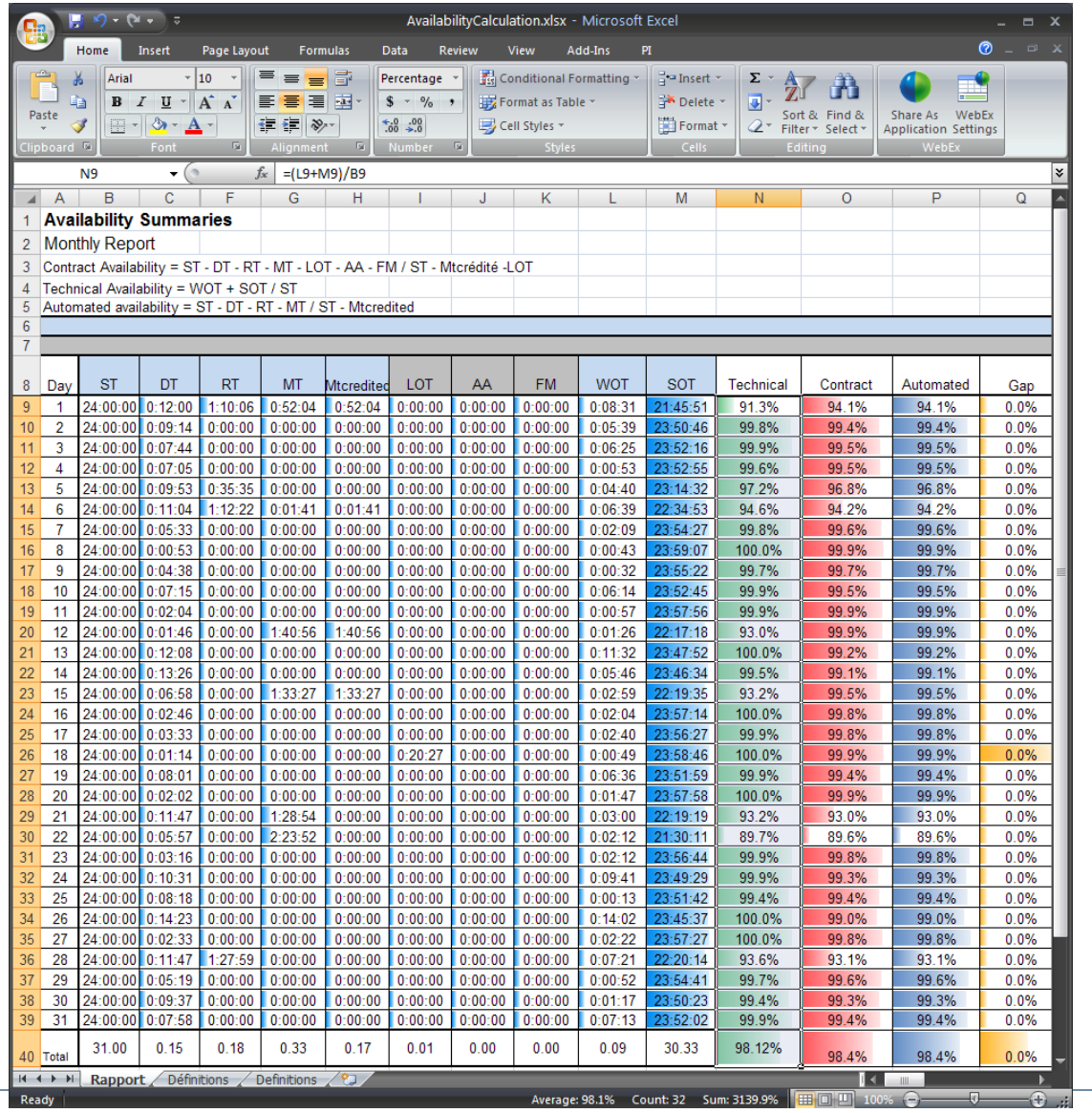
Warranty Management

- Manufacturers provide warranty based on availability
- Availability is natively only found in their SCADA
- PI Acts as the “Fox Watching the Hens”



AvailabilityCalculation.xlsx - Microsoft Excel

=(L9+M9)/B9

Availability Summaries

Monthly Report

Contract Availability = ST - DT - RT - MT - LOT - AA - FM / ST - Mtcrédité -LOT

Technical Availability = WOT + SOT / ST

Automated availability = ST - DT - RT - MT / ST - Mtcredited

Day	ST	DT	RT	MT	Mtcredited	LOT	AA	FM	WOT	SOT	Technical	Contract	Automated	Gap
1	24:00:00	0:12:00	1:10:06	0:52:04	0:52:04	0:00:00	0:00:00	0:00:00	0:08:31	21:45:51	91.3%	94.1%	94.1%	0.0%
2	24:00:00	0:09:14	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:05:39	23:50:46	99.8%	99.4%	99.4%	0.0%
3	24:00:00	0:07:44	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:06:25	23:52:16	99.9%	99.5%	99.5%	0.0%
4	24:00:00	0:07:05	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:53	23:52:55	99.6%	99.5%	99.5%	0.0%
5	24:00:00	0:09:53	0:35:35	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:04:40	23:14:32	97.2%	96.8%	96.8%	0.0%
6	24:00:00	0:11:04	1:12:22	0:01:41	0:01:41	0:00:00	0:00:00	0:00:00	0:06:39	22:34:53	94.6%	94.2%	94.2%	0.0%
7	24:00:00	0:05:33	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:02:09	23:54:27	99.8%	99.6%	99.6%	0.0%
8	24:00:00	0:00:53	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:43	23:59:07	100.0%	99.9%	99.9%	0.0%
9	24:00:00	0:04:38	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:32	23:55:22	99.7%	99.7%	99.7%	0.0%
10	24:00:00	0:07:15	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:06:14	23:52:45	99.9%	99.5%	99.5%	0.0%
11	24:00:00	0:02:04	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:57	23:57:56	99.9%	99.9%	99.9%	0.0%
12	24:00:00	0:01:46	0:00:00	1:40:56	1:40:56	0:00:00	0:00:00	0:00:00	0:01:26	22:17:18	93.0%	99.9%	99.9%	0.0%
13	24:00:00	0:12:08	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:11:32	23:47:52	100.0%	99.2%	99.2%	0.0%
14	24:00:00	0:13:26	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:05:46	23:46:34	99.5%	99.1%	99.1%	0.0%
15	24:00:00	0:06:58	0:00:00	1:33:27	1:33:27	0:00:00	0:00:00	0:00:00	0:02:59	22:19:35	93.2%	99.5%	99.5%	0.0%
16	24:00:00	0:02:46	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:02:04	23:57:14	100.0%	99.8%	99.8%	0.0%
17	24:00:00	0:03:33	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:02:40	23:56:27	99.9%	99.8%	99.8%	0.0%
18	24:00:00	0:01:14	0:00:00	0:00:00	0:00:00	0:20:27	0:00:00	0:00:00	0:00:49	23:58:46	100.0%	99.9%	99.9%	0.0%
19	24:00:00	0:08:01	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:06:36	23:51:59	99.9%	99.4%	99.4%	0.0%
20	24:00:00	0:02:02	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:01:47	23:57:58	100.0%	99.9%	99.9%	0.0%
21	24:00:00	0:11:47	0:00:00	1:28:54	0:00:00	0:00:00	0:00:00	0:00:00	0:03:00	22:19:19	93.2%	93.0%	93.0%	0.0%
22	24:00:00	0:05:57	0:00:00	2:23:52	0:00:00	0:00:00	0:00:00	0:00:00	0:02:12	21:30:11	89.7%	89.6%	89.6%	0.0%
23	24:00:00	0:03:16	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:02:12	23:56:44	99.9%	99.8%	99.8%	0.0%
24	24:00:00	0:10:31	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:09:41	23:49:29	99.9%	99.3%	99.3%	0.0%
25	24:00:00	0:08:18	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:13	23:51:42	99.4%	99.4%	99.4%	0.0%
26	24:00:00	0:14:23	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:14:02	23:45:37	100.0%	99.0%	99.0%	0.0%
27	24:00:00	0:02:33	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:02:22	23:57:27	100.0%	99.8%	99.8%	0.0%
28	24:00:00	0:11:47	1:27:59	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:07:21	22:20:14	93.6%	93.1%	93.1%	0.0%
29	24:00:00	0:05:19	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:52	23:54:41	99.7%	99.6%	99.6%	0.0%
30	24:00:00	0:09:37	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:01:17	23:50:23	99.4%	99.3%	99.3%	0.0%
31	24:00:00	0:07:58	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:00:00	0:07:13	23:52:02	99.9%	99.4%	99.4%	0.0%
Total	31.00	0.15	0.18	0.33	0.17	0.01	0.00	0.00	0.09	30.33	98.12%	98.4%	98.4%	0.0%

Rapport | Définitions | Definitions

Ready — Average: 98.1% Count: 32 Sum: 3139.9%

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Thank You!

❑ Resources

- http://www.osisoft.com/Resources/Multimedia/Multimedia.htm
- T&D Users Group—fall
- http://www.osisoft.com/Industries/Transmission%20and%20Distribution%20Utilities/

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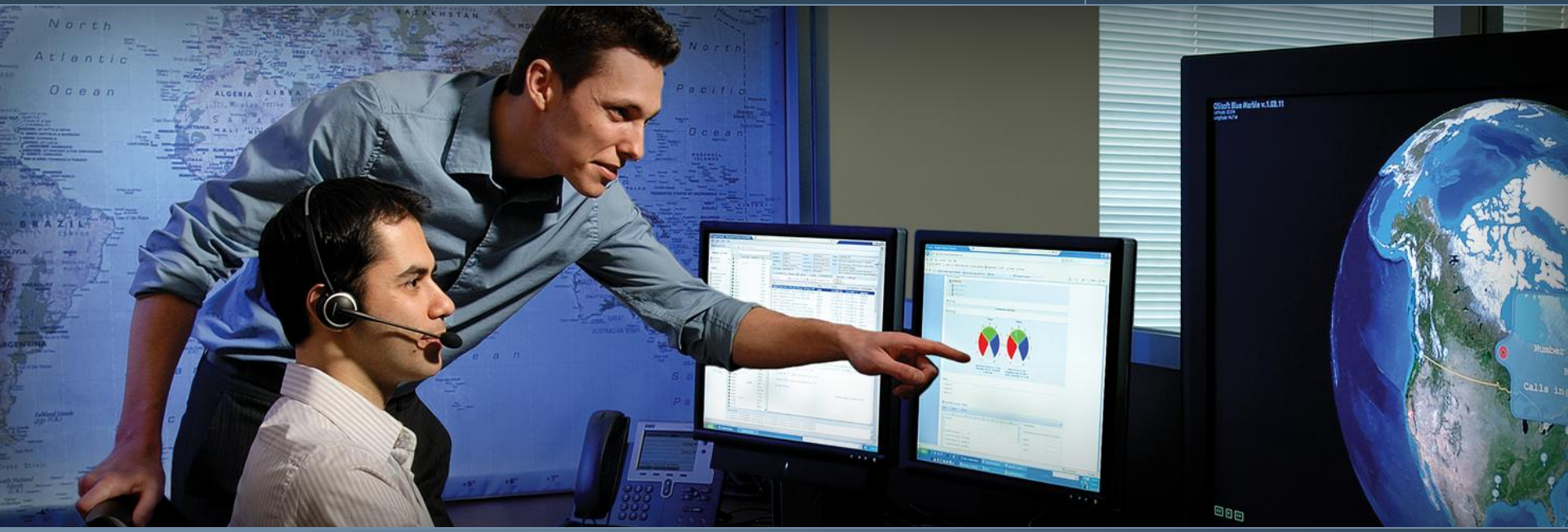

Questions? Or can dig into products.

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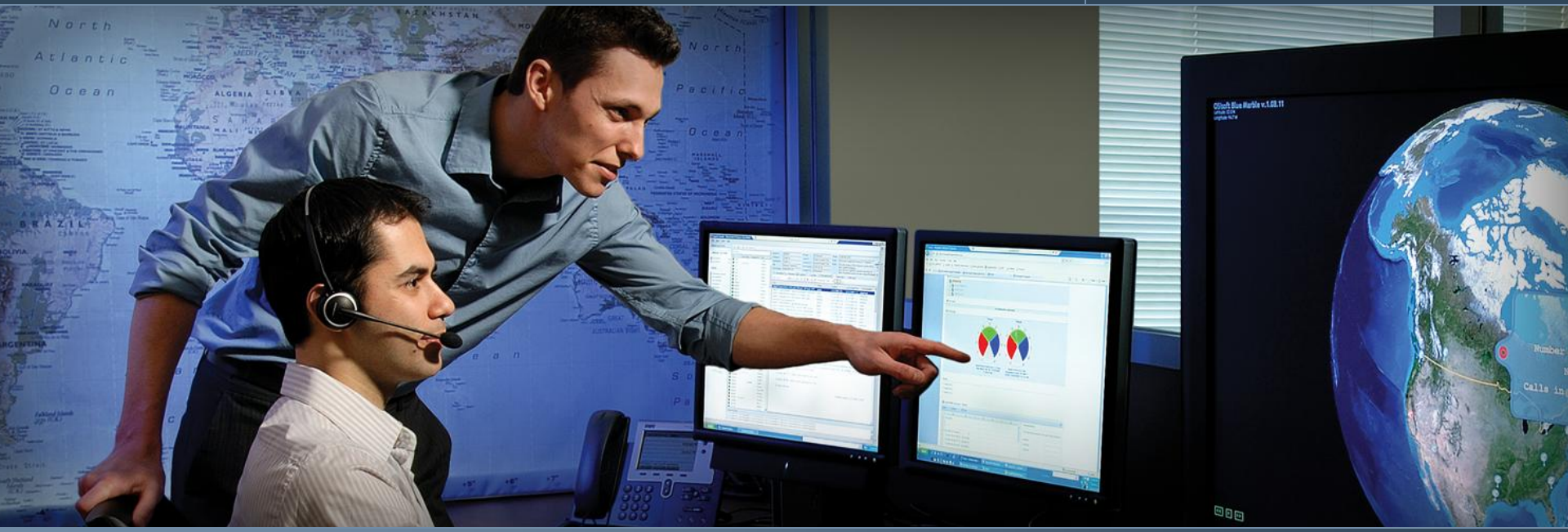

Product Overview

Value now, Value over time.

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What is PI?

- System that
  - **Connects & Collects** (streaming data, events, strings, etc.)
  - **Archives & Manages** (long time at resolution of acquisition)
  - **Processes** (calculates, aggregates, analytics)
  - **Visualizes** (thick, thin, portal, web, etc.)
  - **Contextualizes** (metadata, structure, etc.)
  - **Alerts and Notifies (**alarm, notifications, messages, etc.)
- Real Time Data & Events

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The PI System

Connect

Collect data from hundreds of sources.

Interfaces

Manage

Gather and archive large volumes of data. Scale to meet your growing business needs.

Servers

Analyze

Access real-time or historical role-based data for the entire enterprise at any time.

Analytics

Present

View data, identify problems, and take corrective action with familiar, easy-to-use graphical tools.

Visuals

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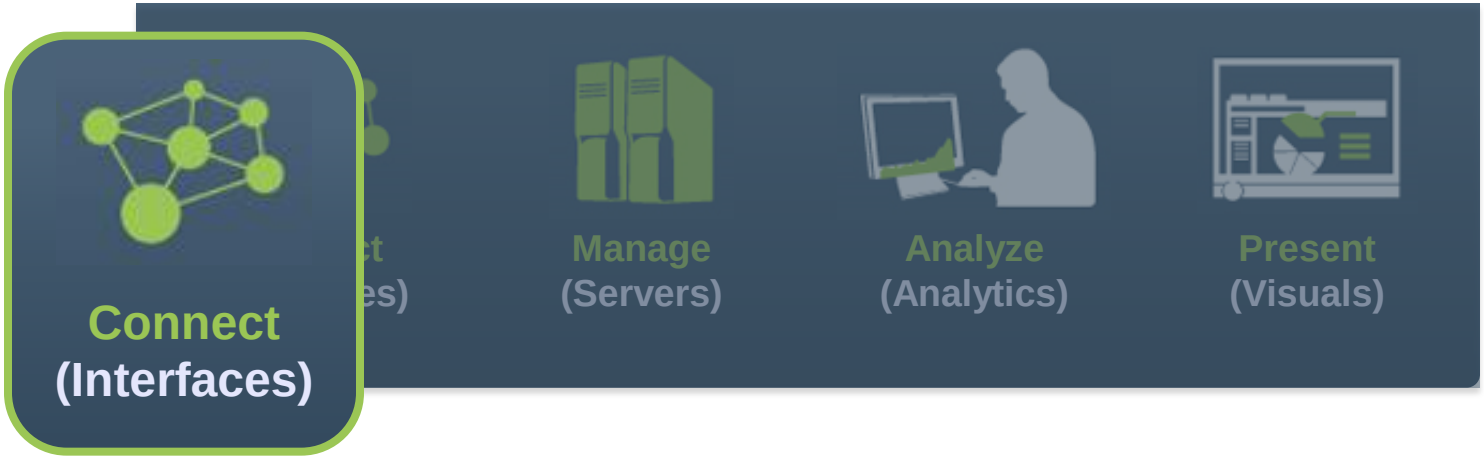
The PI System: Connect



The PI System® connects to real-time and event data every second, every minute, every day, and archives it indefinitely.

- Measure and interpret a variety of data
- Both time-series and event data
- Secure access
- From virtually anywhere and any source
- Using time intervals and sampling rates customized to your business needs

Connect to over 400 data systems and sources out of the box.

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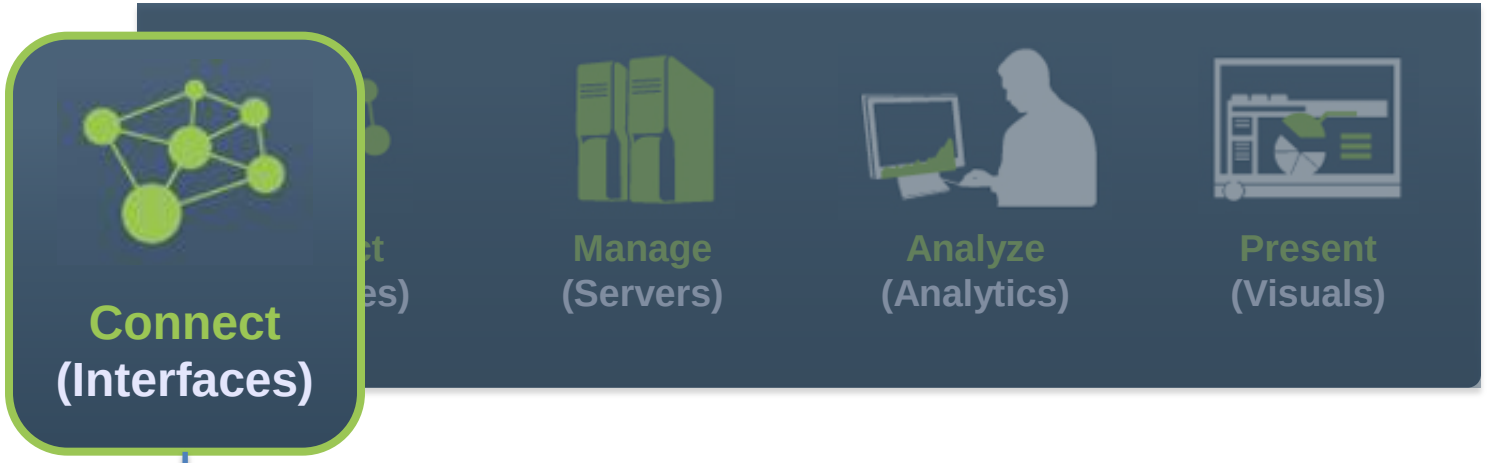
The PI System: Connect



Real-time
DCS
PLC
SCADA
OPC
3rd Party
COM
Connector

Custom
SDK
API

Relational
OLEDB
ODBC
ORACLE
SQL

AMI
Power Meter
Interfaces

Web Services
Enterprise
Gateway
SOA
LEGACY APPS

ERP
RLINK
SERVERS

IT
MCN Health Monitor

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The PI System: Manage

The center of the your real-time data infrastructure.

- Highly-available
- Secure
- Accessible
- Reliable
- Mission-critical, role-based information to make informed decisions

Ensure that everyone has the same information.

The standardized system provides— “one version of the truth.”

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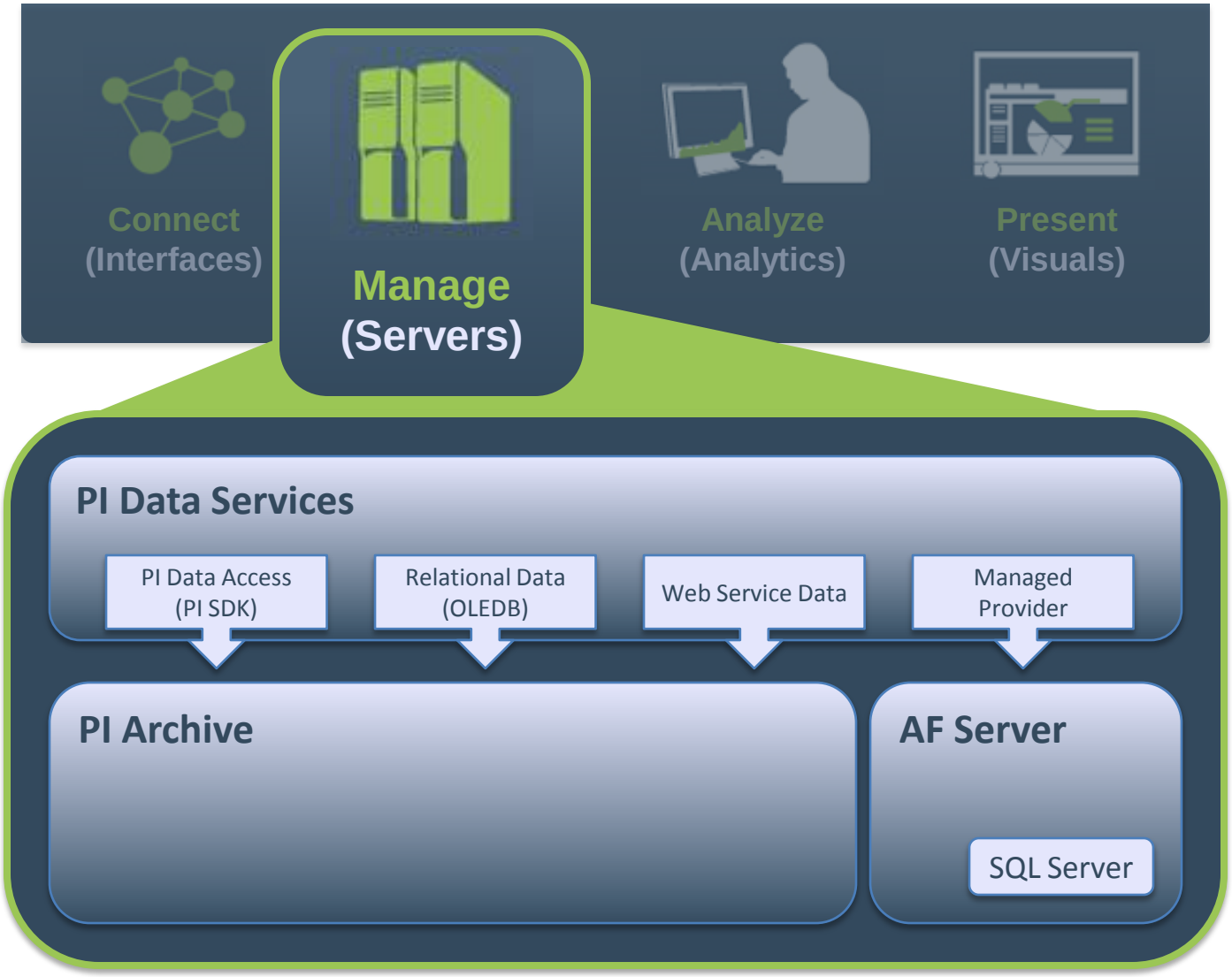
The PI System: Manage



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The PI System: Analyze

Convert real-time data into actionable information (post processing)

- Equations, calculations and business rules
- Reports
- Batch reports
- Notifications and Alerts

Measure and improve business performance.

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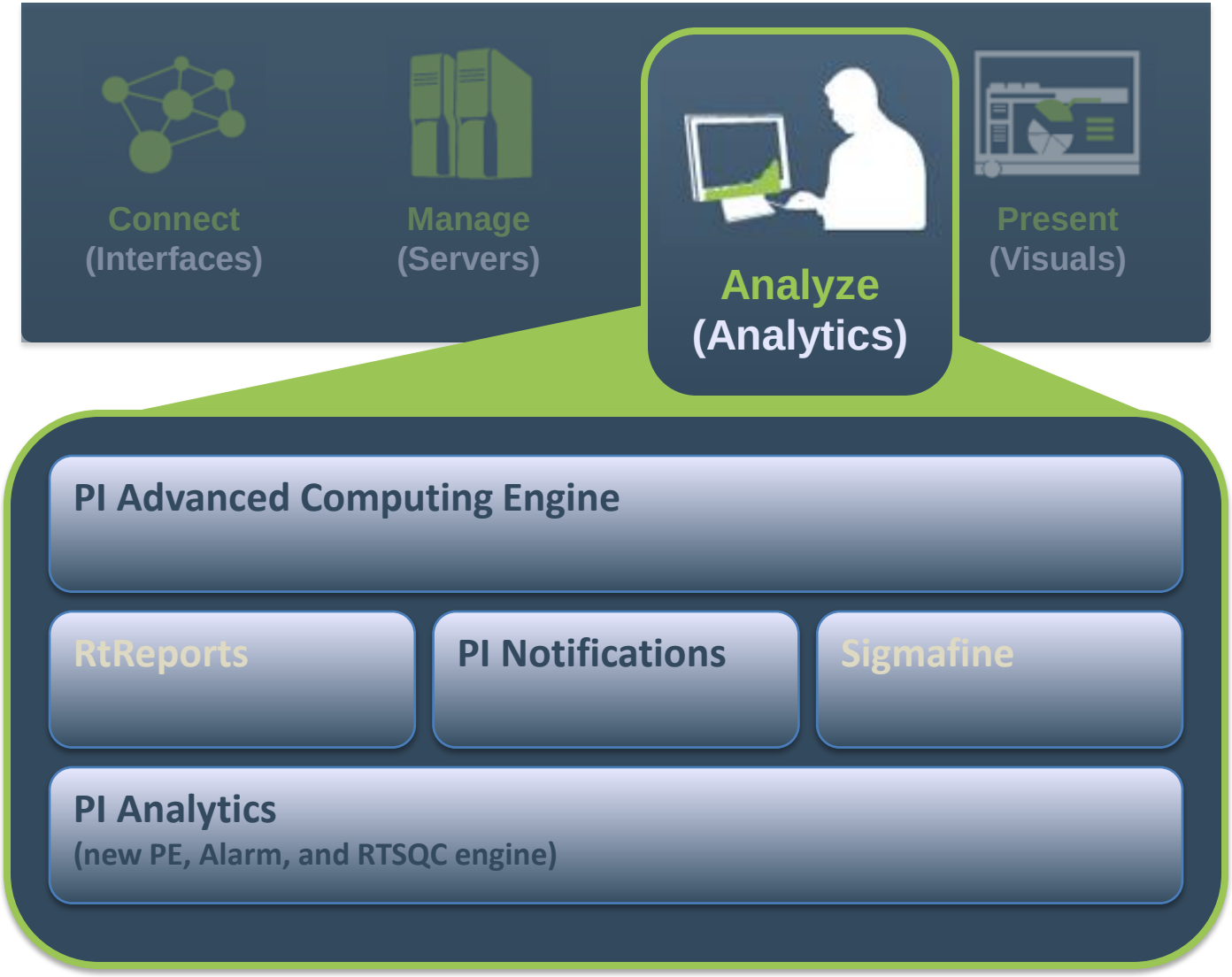
The PI System: Analyze



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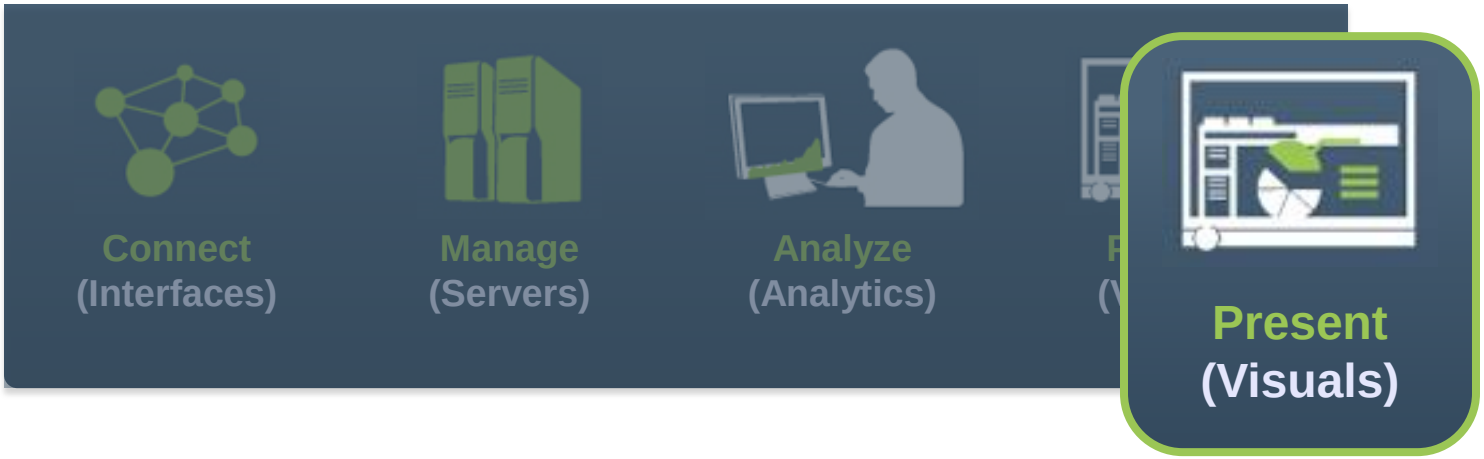
The PI System: Present



PI System® Visuals are a configurable suite of intuitive, easy-to-use graphical tools that simplify decision-making.

Decision makers can use familiar desktop tools such as:

- OSIsoft's PI ProcessBook
- Microsoft Office Excel or Microsoft Office SharePoint Server
- SAP Enterprise Portal

Empower informed decisions and drive business success.

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The PI System: Present

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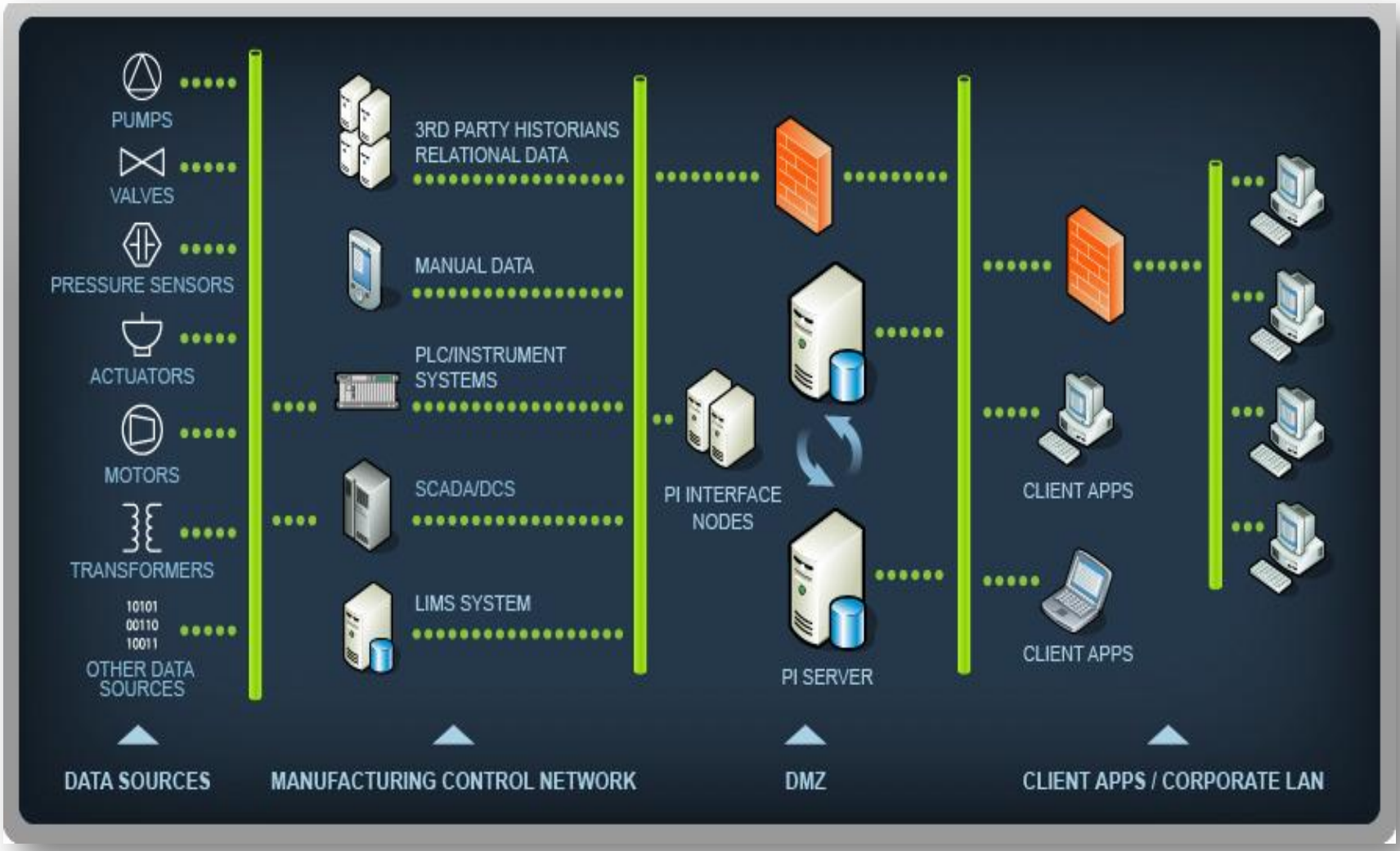
The PI System: Architecture



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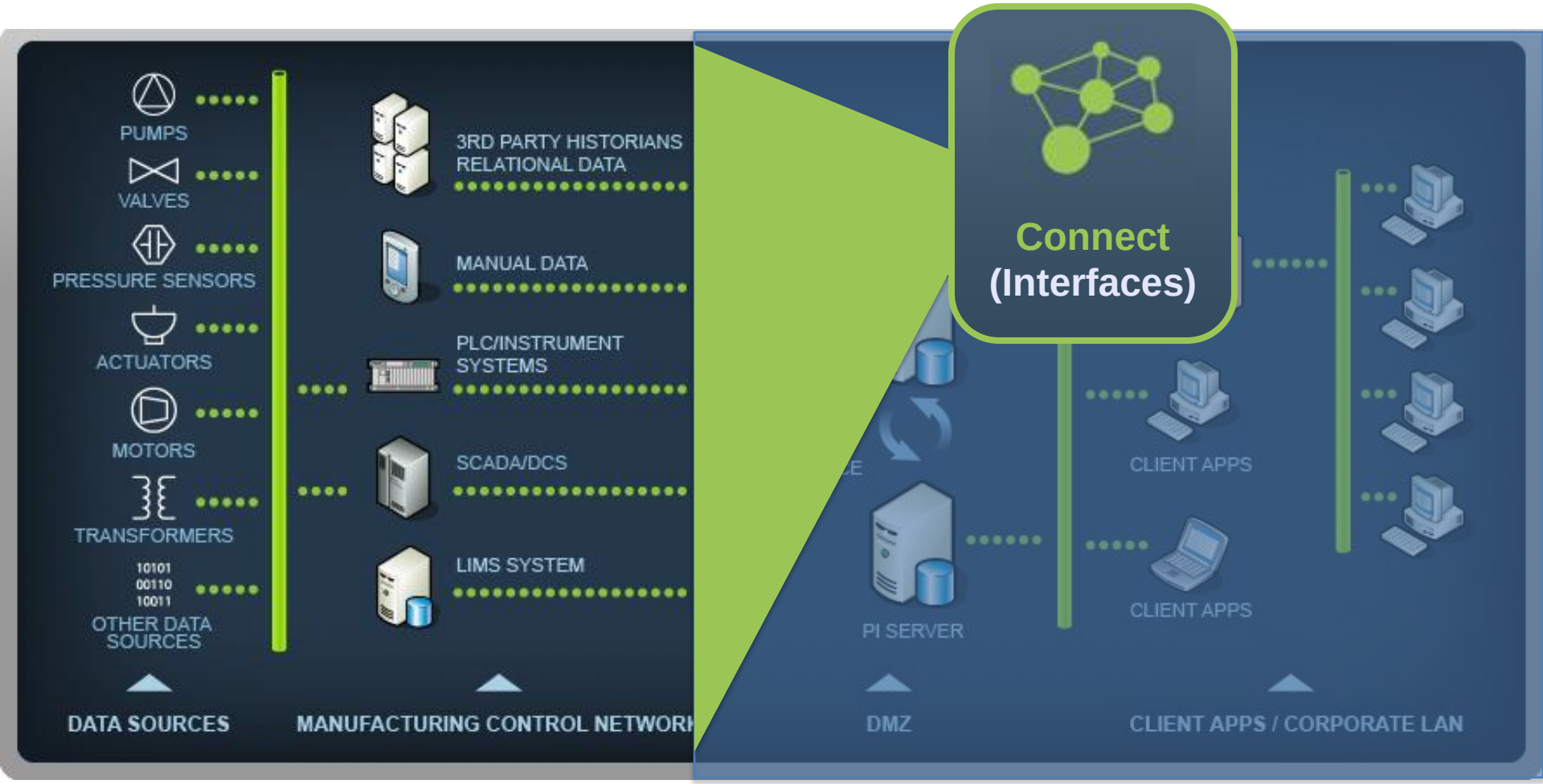
The PI System: Architecture



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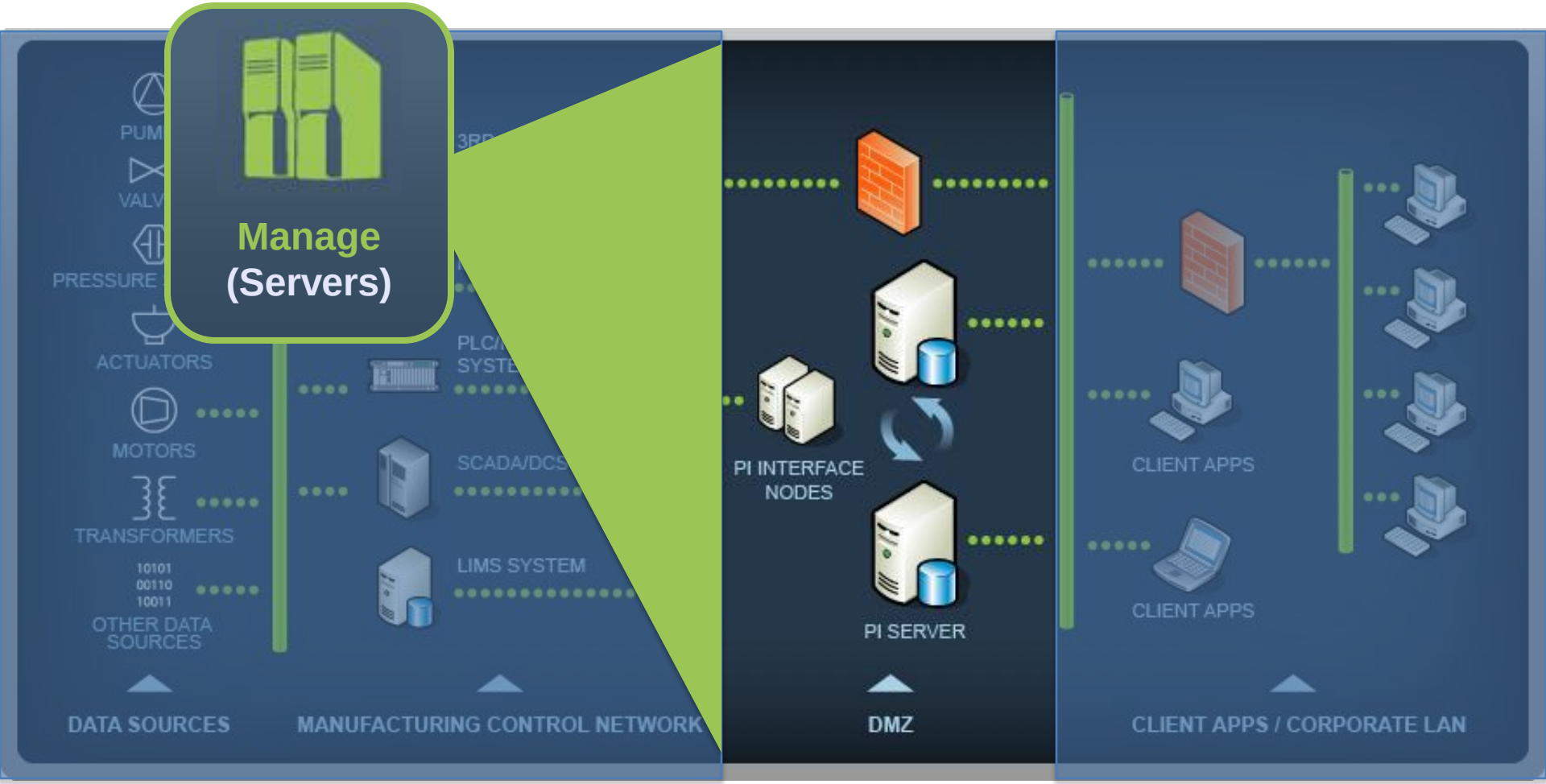
The PI System: Architecture



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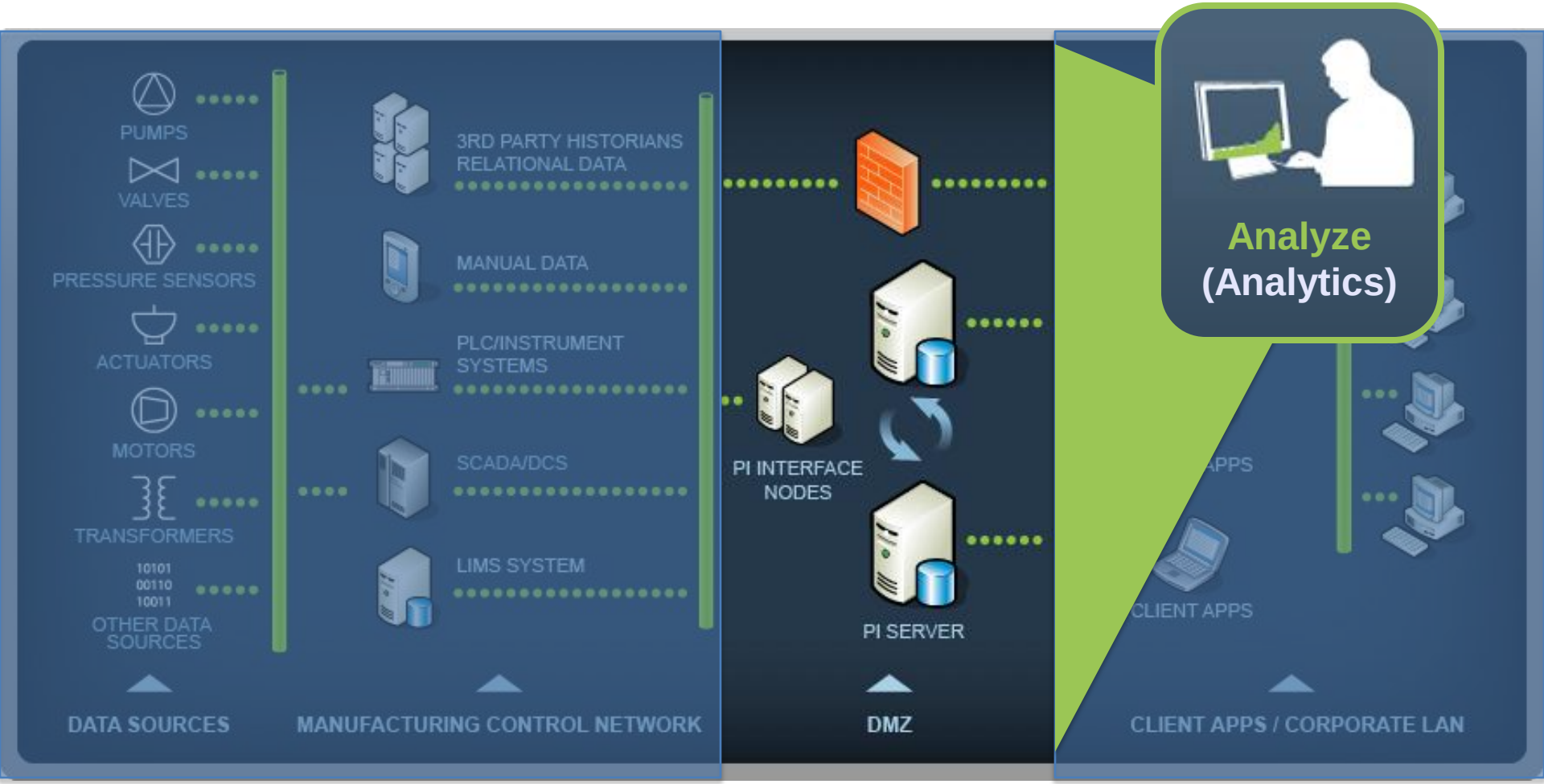
The PI System: Architecture



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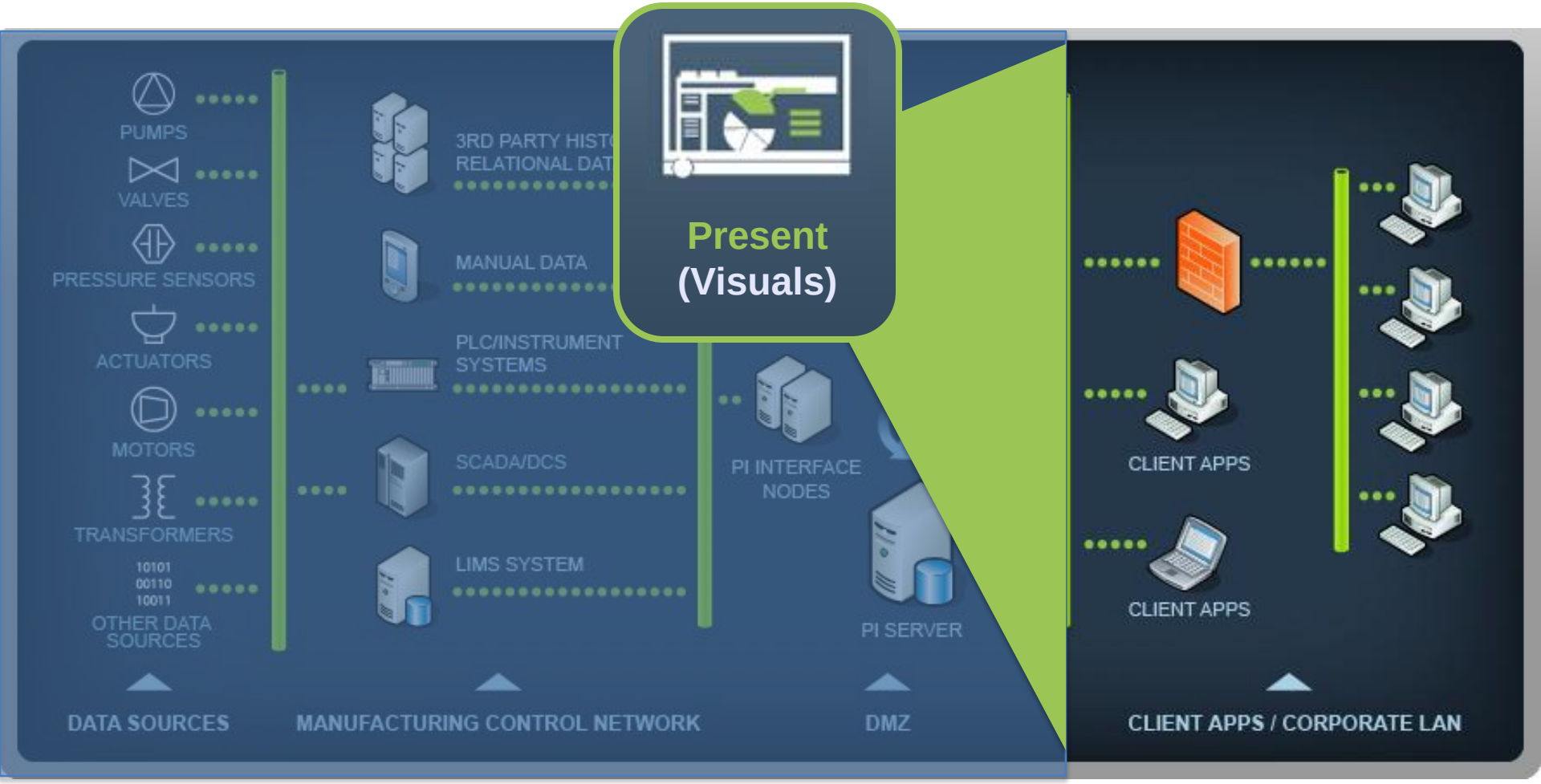
The PI System: Architecture



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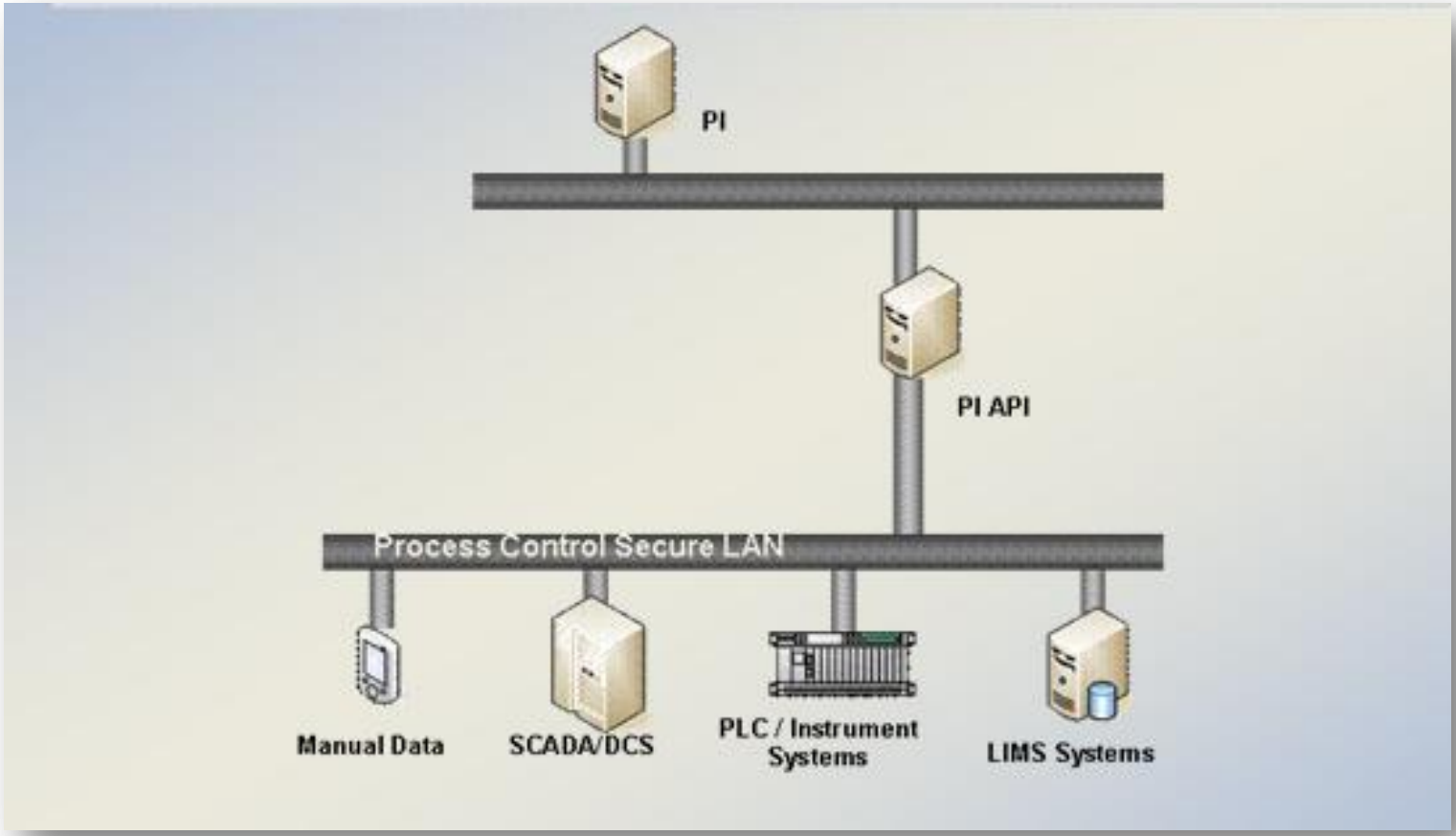
PI System – Simple System



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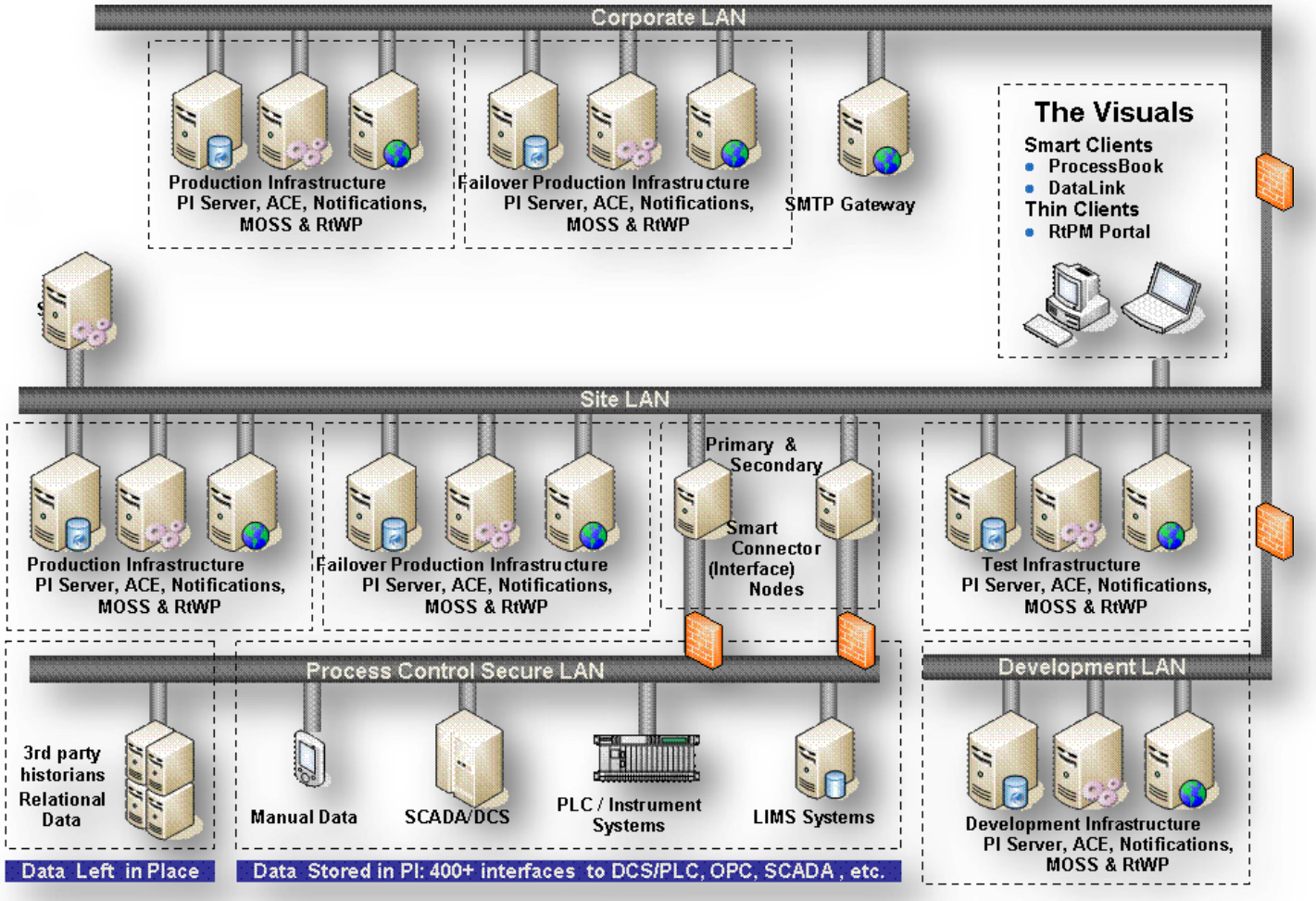
PI Infrastructure - Large Complex



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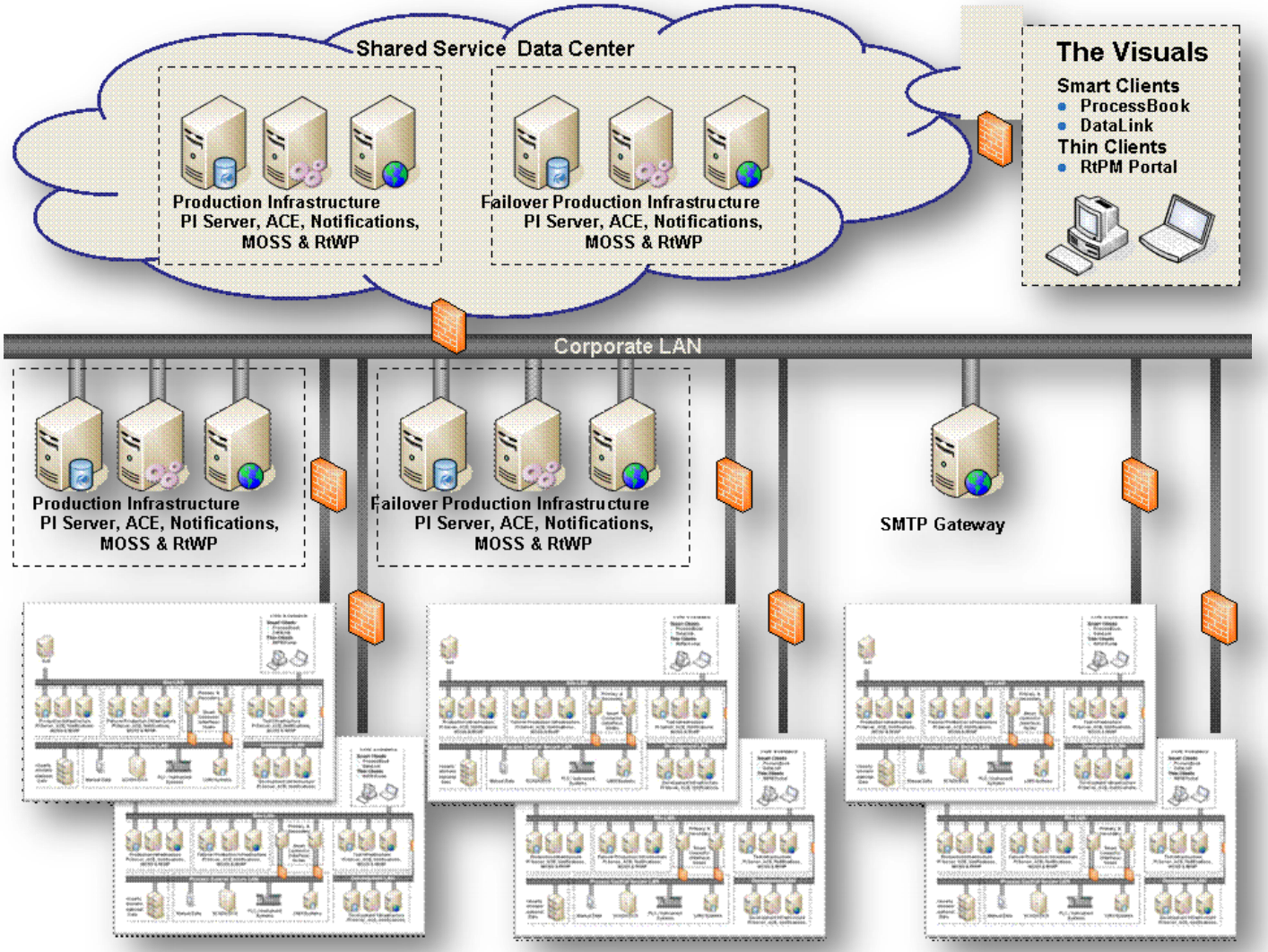
Enterprise Wide Infrastructure (EWI)



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How PI delivers value…

- Application and industry “Agnostic”
- Value out of the box
- “Fits in place”
- Scalable
  - **Small, through medium to large and very large system**
  - **Simple to complex systems**
  - **Slow to high fidelity in the data rate (events per second),**
  - **Low to high intensity of pre and post processing (analytics)**
- Preserves operational knowledge of an enterprise
- Enhances the capability of scarce workers
- Reliable and low maintenance by the user (striving to remain)
- Manages both the real time data and its data communications infrastructure - convergence

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What is tangible value for Customers?

- Avoided $150 Million in Capital Spending to meet Environmental legislation

- Reduced maintenance costs by 3% and lowered systems management costs by a 3 to 2 ratio

- Saved $20 million in Energy Costs

- Eliminated $12 million in annual recurring energy costs

- Saved $5 per ton in Maintenance costs in Paper Mill operations

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What is tangible value for Customers?

- $2.4 million savings in just one chemical plant, in production and maintenance
- Improved controlling over operations gains 41% return in 3.5 years (OEE, KPI's)
- $1M Reduction of Electricity Costs in First Year
- $5 million benefits from capture of KPI's and related performance data from operating facilities
- Increased diesel yield earned an $1 million increase in profitability
- Saved over $500,000 in one mill by using PI for real time costing and decision support for operators

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