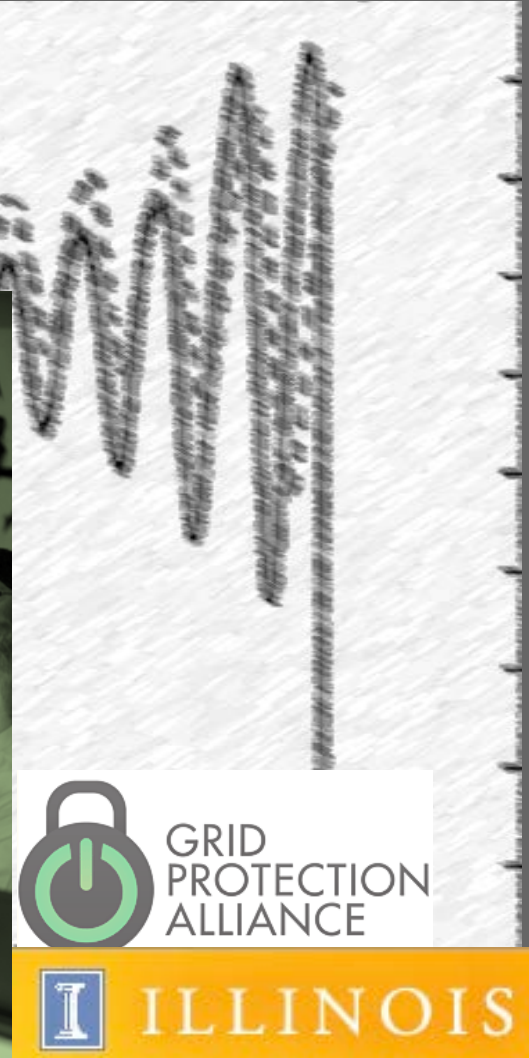
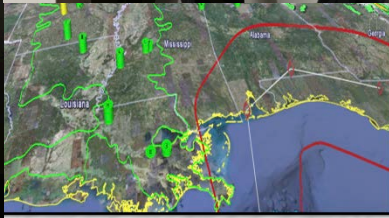


# Entergy Phasor Project Phasor Gateway Implementation



ILLINOIS

**Floyd Galvan, Entergy**  
**Tim Yardley, University of Illinois**  
**Said Sidiqi, TVA**

Denver, CO - June 5, 2012

# Entergy Project Summary

PMU installations on schedule  
and on budget

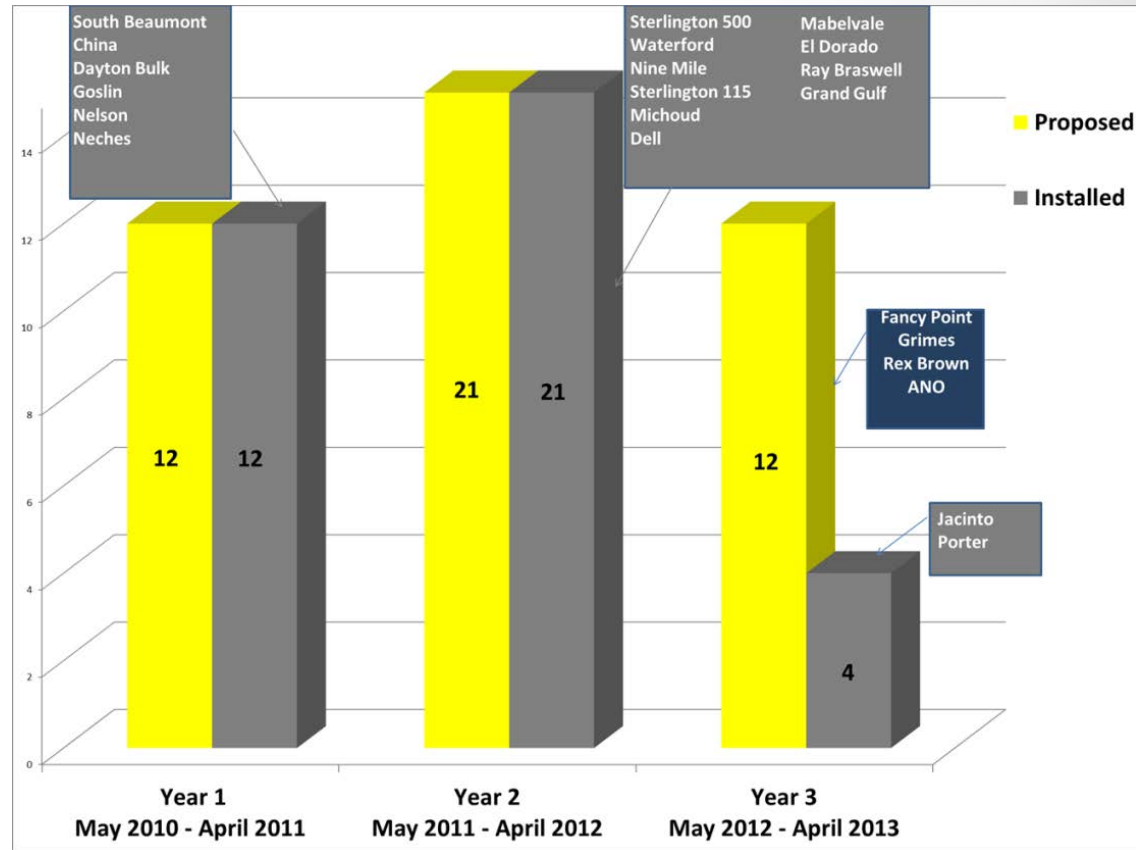
CPI .973, SPI .938

Entergy continues to follow and  
maintain full compliance with our  
approved CSP

Training & Education has  
reached over 600 Entergy  
employees

Beta version Analytics &  
Applications have been Installed.  
Testing Phase I: 5/1 to 10/1  
Test Phase II: 2013  
Test Phase III: 2014

## PMU Installations



# OpenPG Implemented and Installed Entergy & TVA

## March 20, 2012



- GPA & UIUC
- NERC co-funder OpenPG
- **“SSE Principle”**
  - Selectable
  - Secure
  - Exchange of Real-Time Data
- OpenPG provides the ability to gather and deliver wide-area data to advanced decision support tools





# OpenPG Activities

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- Duke and Dominion are planning on installing the openPG to replace their current PDC-based connection to TVA
- WECC is planning on installing the OpenPG for testing and demonstration purposes in late 2012.
- Other utilities are interest in the OpenPG

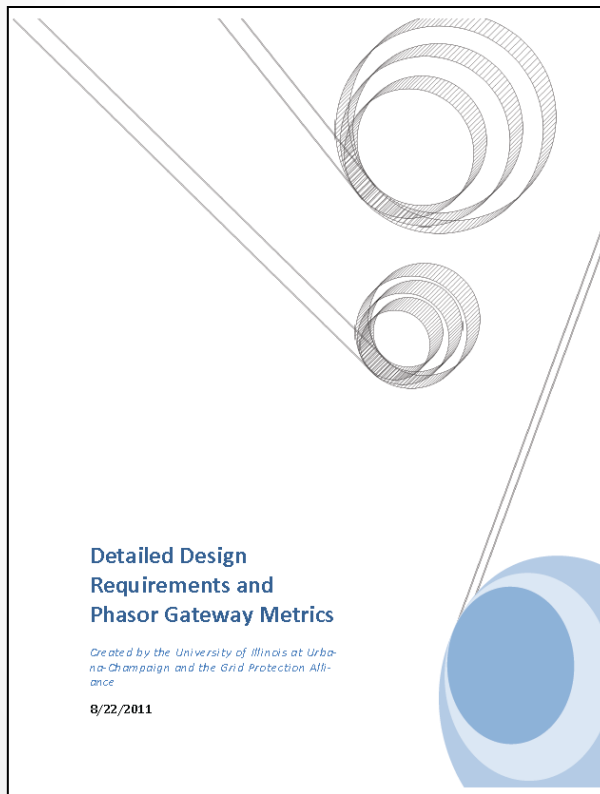
# The Phasor Gateway

• • •

The Details

# The Gateway Design

A phasor gateway requirements document was developed in 2011.



- Utility driven design
- Using COTS hardware
- CIP v5 ready
- Built with high availability and reliability
- Easy publish and subscribe point configuration
- Rapid extensibility to support new protocols
- Bridging multiple namespaces
- Ability to detect and alarm on communication or data issues

# The Gateway Implementation

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- Designed by GPA and UIUC, with extensive input from Entergy and feedback from other utilities.
- Derived from TVA/GPA OpenPDC code library.
- Open-source and security reviewed.
- Security features augmented, performance enhanced, and much more.
- Released as OpenPG 1.0.

# The Gateway Security

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- **Conducted security review of the full code base**
- **Implemented CIP-informed controls and measures to be CIP v5 ready**
  - Logging, Algorithm selection, Key storage, etc.
- **Leveraging Microsoft SDL-based approach to software development and testing to ensure security model**
  - Design, Attack/Threat models, fuzz testing, unit testing, code reviews, integration testing, functional testing, and security testing
- **Standards based communication layer (TLS)**
  - Alpha implementation
  - Leverages X.509 Identity Certificates and secure key storage



# The Gateway Testing

- **Functional Testing**

- Ensures everything works
- Unit testing covers the code
- Includes requirements driven by CIP

- **Performance Testing**

- Baseline performance
- Extensive stress testing

- **Security Testing**

- Prior code review
- SDL-based process forward
- New TLS subsystem option
- Reviewed with CIP in mind

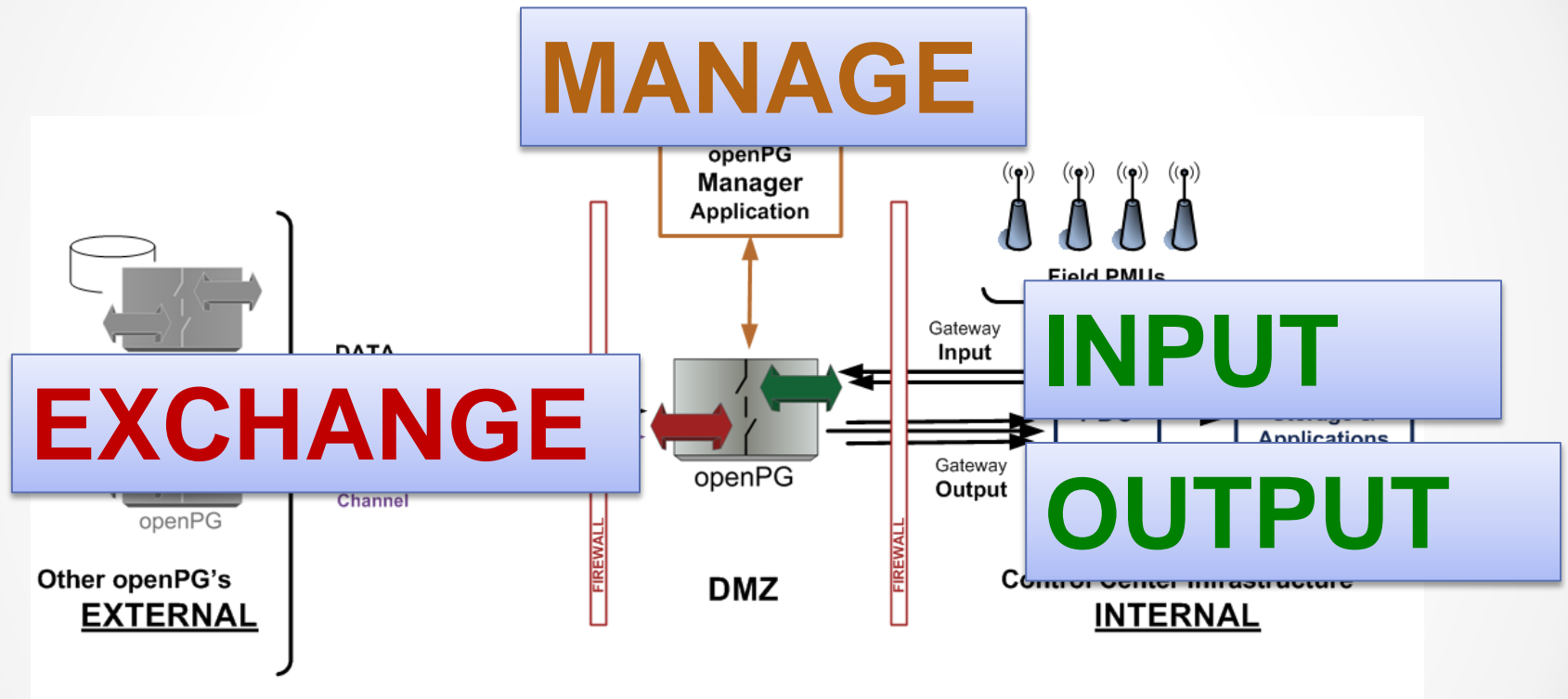


# The Gateway Metrics

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- **Performance (target)**
  - 1,000,000 points/second aggregate
  - Multiple streams, connections, and hosts
- **Statistics**
  - Connections, Points {transmitted, received, dropped, expected, out-of-order}
  - Uptime, errors, security events, alarms
- **Logs**
  - Security, Informational, Error, etc.
- **Reports**
- **Centralized management and monitoring**

# Phasor Exchange Architecture



## openPG Inputs

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- **Frame-based Protocols**

- IEEE C37.118 R1 & R2 (up to 120 samples per second)
- IEEE 1344
- BPA Stream
- Macrodyne G and M\*
- SEL Fast Message
- IEC 61850-90-5

- **Point-based Protocols**

- GPA's Time-series Data Transport Protocol (TDTP) used for PDC to PDC communication
- GPA's Gateway Exchange Protocol (GEP)

\* Future (Summer 2012)

## openPG Outputs

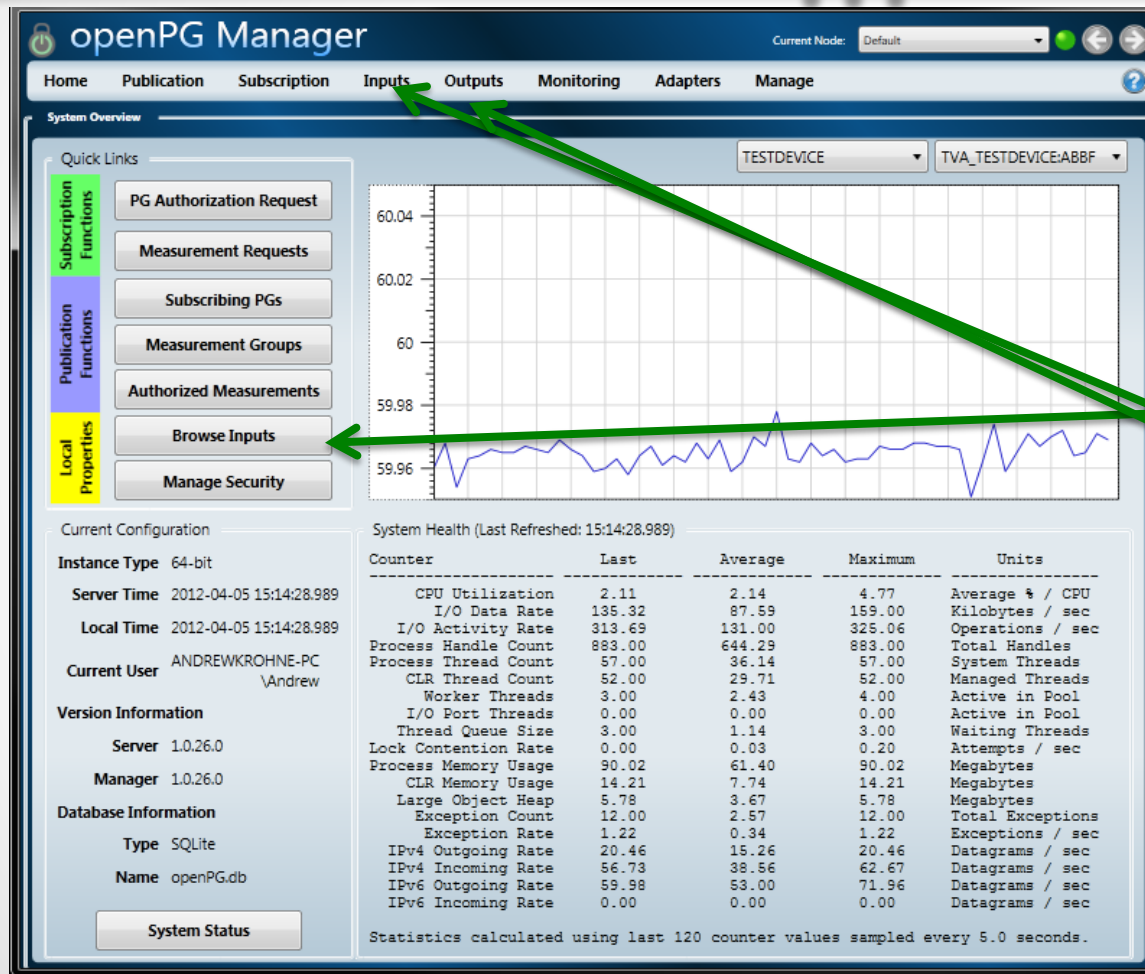
- **Point Based Data** (open, but custom protocols)
  - Time-series Data Transport Protocol (TDTP)
  - Gateway Exchange Protocol (GEP)
- **Mirrored C37.118 Streams**
- **Database (ADO) adapter for MS SQL Server**
- **API (library) for development of custom interfaces**
  - C#, C++, and Java

*Typically a gateway outputs data to a Phasor Data Concentrator that time-aligns external data from the gateway with internal phasor data.*



# INPUT/OUTPUT

## Create Inputs/Outputs



openPG Manager  
Configure Outputs

# Gateway-to-Gateway Exchange

- The openPG uses a TCP command channel and an UDP data channel (when not using alpha TLS mode)
- **Command Channel**
  - Authenticates other gateways
  - Exchanges metadata on points
  - Requests points for subscription
- **Data Channel**
  - Protocol is a 9-byte packet for phasor data
    - Point ID, Time, Value, and Quality Flags

*Data exchange efficiency is among the most important design considerations for a phasor gateway.*

The screenshot displays the 'OpenPG Manager' application window. The top navigation bar includes 'Publication', 'Subscription', 'Inputs', 'Outputs', 'Monitoring', 'Adapters', and 'Management'. The 'Subscription' tab is active, showing a 'Subscriber Measurement Access' section with a dropdown menu. Below this, there are three main panels: 'Allowed Measurements', 'Denied Measurements', and 'Available Measurements'. The 'Available Measurements' panel contains a table with columns 'Point Tag' and 'Signal Reference'. The table lists several entries, including 'DEFAULT!SYSTEM:ST1' through 'DEFAULT!SYSTEM:ST14'. Below the table, there are 'Allowed Measurement Groups', 'Available Measurement Groups', and 'Denied Measurement Groups' sections. Annotations with green arrows point to various elements: 'Allowed Measurements' points to the top-left panel; 'Denied Measurements' points to the middle-left panel; 'Available Measurements' points to the top-right dropdown menu; 'Allowed Groups' points to the 'Available Measurement Groups' section; and 'Denied Groups' points to the 'Denied Measurement Groups' section.

Allowed Measurements

Denied Measurements

Available Measurements

For a particular Subscriber

Allowed Groups





Denied Groups


| Point Tag           | Signal Reference |
|---------------------|------------------|
| DEFAULT!SYSTEM:ST1  | STAT:15          |
| DEFAULT!SYSTEM:ST10 | STAT:24          |
| DEFAULT!SYSTEM:ST11 | STAT:25          |
| DEFAULT!SYSTEM:ST12 | STAT:26          |
| DEFAULT!SYSTEM:ST13 | STAT:27          |
| DEFAULT!SYSTEM:ST14 | STAT:28          |
| DEFAULT!SYSTEM:ST2  | STAT:16          |
| DEFAULT!SYSTEM:ST3  | STAT:17          |
| DEFAULT!SYSTEM:ST4  | STAT:18          |
| DEFAULT!SYSTEM:ST5  | STAT:19          |
| DEFAULT!SYSTEM:ST6  | STAT:20          |
| DEFAULT!SYSTEM:ST7  | STAT:21          |
| DEFAULT!SYSTEM:ST8  | STAT:22          |
| DEFAULT!SYSTEM:ST9  | STAT:23          |

Page Size: 11 << < 1 of 5 > >>

# MANAGE

## Create Alarms on Data or Stats

 **openPG Manager** Current Node:    

[Home](#) [Publication](#) [Subscription](#) [Inputs](#) [Outputs](#) [Monitoring](#) [Adapters](#) [Manage](#) 

**Manage Alarms**

Tag Name\*

Signal  Node

Operation  SetPoint




Tolerance

Delay  seconds Hysteresis





Description  Severity

Load Order\*  ☐ Enabled

☒ Create Associated Measurement

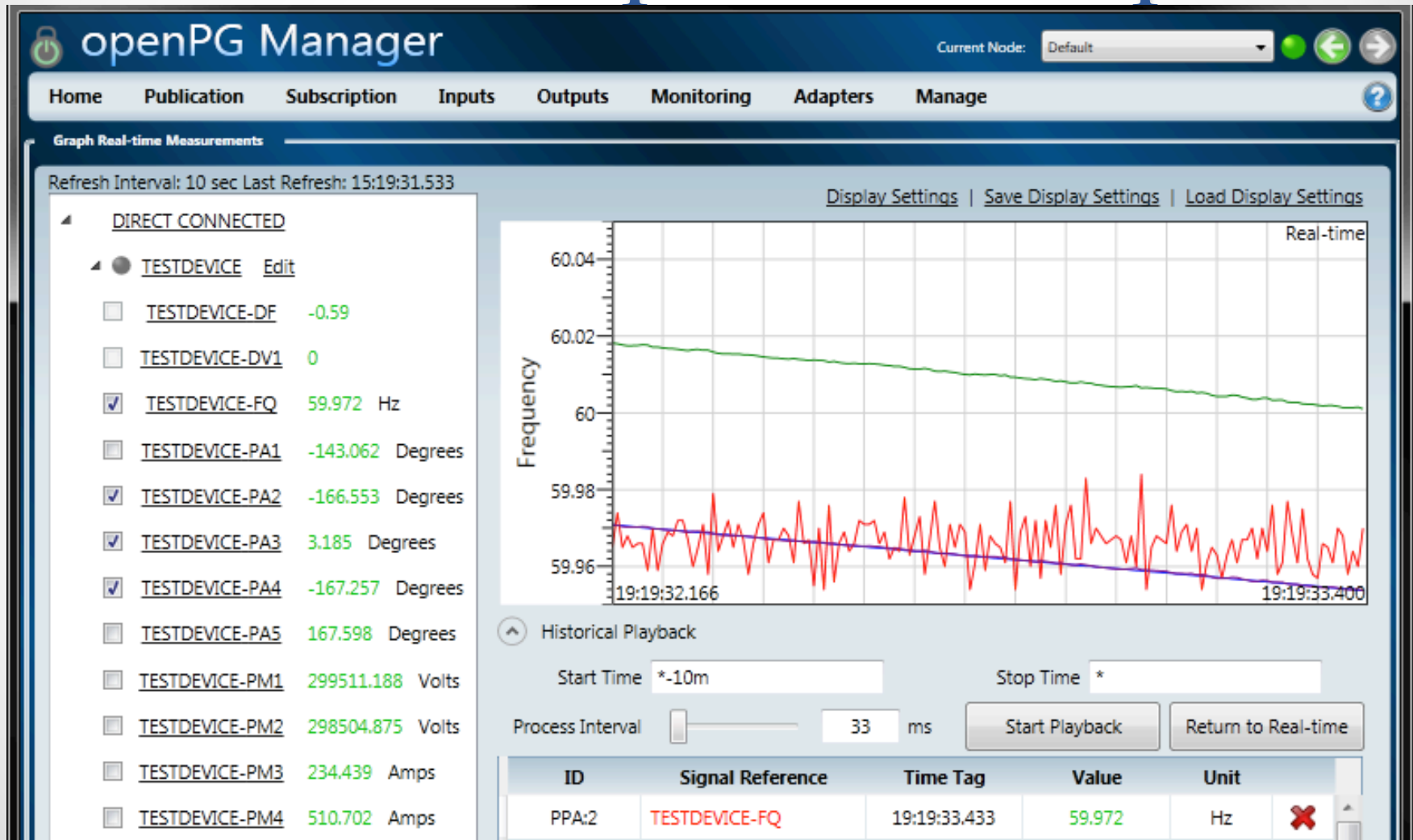
 Delete  Clear  Save

| TagName | Operation | Severity | Description | Enabled |
|---------|-----------|----------|-------------|---------|
|---------|-----------|----------|-------------|---------|

Page Size: 10  of     

# MANAGE

## Monitor Inputs & Outputs





# Gateway Installation

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Entergy and TVA Early Experiences

# Implementation Goals

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- **Validate & Document process for**
  - Installation
  - Configuration
- **Obtain statistics on long-term stability and performance**
- **Entergy will report initial findings in early 2013**

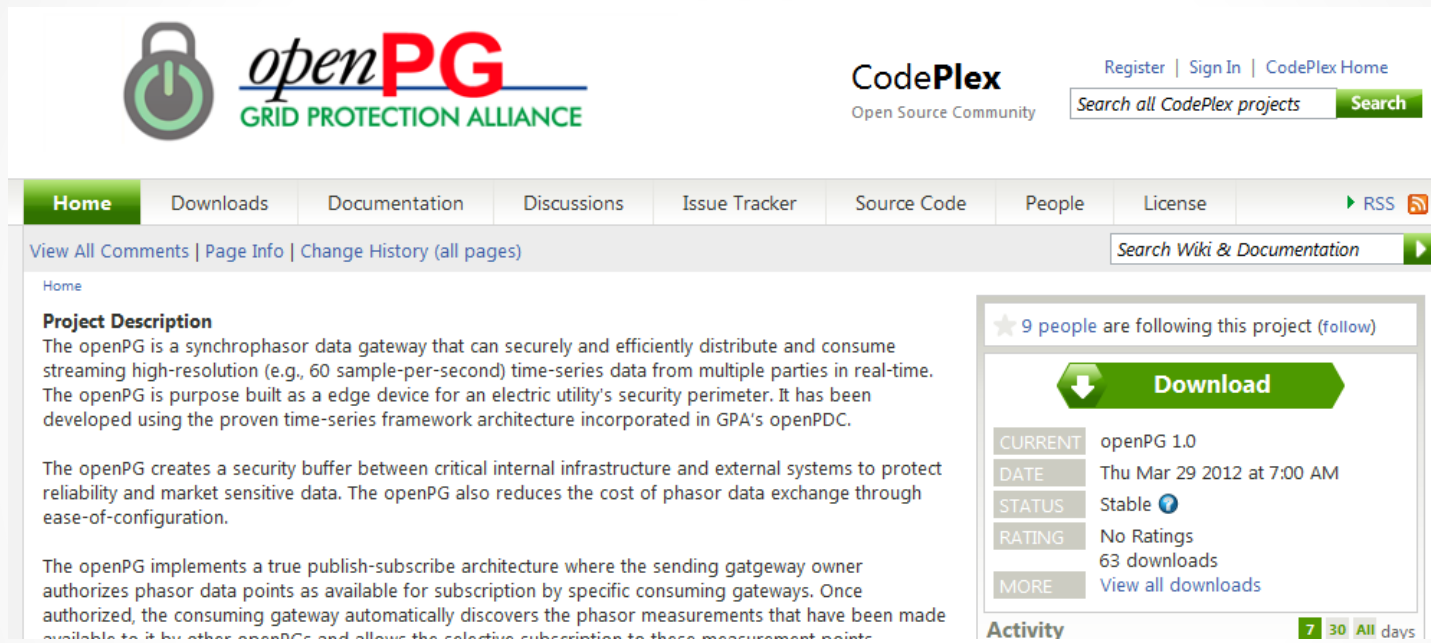
# Early Experiences

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- The installation can be done remotely via webex and conference calls
- Firewall changes/updates will be needed
- The Network Admin, Server Admin and PG admin of each gateway need to work together
- GPA's guidance throughout the process is vital
- Have your Cyber Security team working with you from the start on the Gateway

# Download the openPG

Free, Open Source Software



The screenshot shows the openPG project page on CodePlex. The page features the openPG logo (a green padlock with a power button) and the text "openPG GRID PROTECTION ALLIANCE". The CodePlex logo and "Open Source Community" text are also present. Navigation links include "Home", "Downloads", "Documentation", "Discussions", "Issue Tracker", "Source Code", "People", and "License". A search bar for "Search all CodePlex projects" is visible. The main content area includes a "Project Description" section with text about the openPG project, a "Download" button, and a table of project details. The table lists the current version as openPG 1.0, the date as Thu Mar 29 2012 at 7:00 AM, the status as Stable, and the rating as No Ratings with 63 downloads. A "View all downloads" link is provided. The activity section shows 7 new downloads in the last 30 days.

**Project Description**

The openPG is a synchrophasor data gateway that can securely and efficiently distribute and consume streaming high-resolution (e.g., 60 sample-per-second) time-series data from multiple parties in real-time. The openPG is purpose built as a edge device for an electric utility's security perimeter. It has been developed using the proven time-series framework architecture incorporated in GPA's openPDC.

The openPG creates a security buffer between critical internal infrastructure and external systems to protect reliability and market sensitive data. The openPG also reduces the cost of phasor data exchange through ease-of-configuration.

The openPG implements a true publish-subscribe architecture where the sending gateway owner authorizes phasor data points as available for subscription by specific consuming gateways. Once authorized, the consuming gateway automatically discovers the phasor measurements that have been made available to it by other openPGs and allows the selective subscription to those measurement points.

**Download**

|         |                                    |
|---------|------------------------------------|
| CURRENT | openPG 1.0                         |
| DATE    | Thu Mar 29 2012 at 7:00 AM         |
| STATUS  | Stable                             |
| RATING  | No Ratings<br>63 downloads         |
| MORE    | <a href="#">View all downloads</a> |

**Activity** 7 30 All days

<http://openpg.codeplex.com/>

# Acknowledgment and Disclaimer

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