Hydro One’s Advanced Distribution Solution
A Case Study
Mar 2013 – Schneider Electric LINK2013
Agenda

- Background
  - Who Is Hydro One (aka HONI)
  - Why ADS – What’s the driving business need

- What is ADS

- Who is involved

- How are we executing

- What have we done to-date

- What’s Coming

- What are key Challenges and Lessons Learned so far
Who is Hydro One

**Transmission:**
- 28,600 (circuit - km) interconnected
- 85,000 towers, 4000 km fibre
- Peak demand: 27,005 MW
- Energy transmitted: 157 TWh
- ~1200 Employees

**Distribution:**
- 123,000 km of distribution lines,
- 1.8M poles, 1.3M customers
- Avg 2.3 Customers / Service Transformers
- 640,000 sq km service territory (> than Texas)
- Acquired 90 LDCs since 2000 — 85 remain
- ~4000 Employees
There are a number of Forces Driving the Need to Modernize HONI’s Distribution System

**Environmental**
Green Energy and Green Economy Acts
FIT Program (DGs)

**Aging Infrastructure**
With increased expectations on Reliability

**Expected**
Productivity Gains
& Operational Efficiencies

**Increased**
Customer Involvement
Conservation & Management
In response HONI launched the ADS Program with Four Business Objectives

- Optimize connection of DGs into the distribution system
- Improve Dx Reliability and Operations
- Outage Restoration Improvement & Optimization
- Optimize Network Asset Planning

Enabling Ontario’s Green Energy Goals

Modernize Ontario’s Distribution Grids
Expedite the growth of clean, renewable sources of energy
Provides tools and solutions to use less energy
HONI identified a preferred 3 phase approach leveraging a “Living Lab” concept to deploy and validate the solutions

- **Phase 0 – Strategy & Target Model**
  - Clarify Requirements
  - Build a Target Operating Model (TOM)
  - Develop Business & Technical Conceptual Solution Architectures
  - Refine the Business Case

- **Phase 1 – Trial Area Pilots Over Multiple Releases**
  - Releases of:
    - Detailed Requirements
    - Design
    - Build
    - Deploy
    - Validate

- **Phase 2 – Provincial Rollout**
  - Validated Business Value
  - Move to Standards
  - Transition to sustainment
  - Deploy across Province

Jun 2010 – Dec 2010

Jan 2011 – Dec 2016

2014 - 2040
The ADS Program was structured to Partner for Success

- **Hydro One**
  - LOB - Org alignment and Change
  - Engineering & Deployment
  - IT Infrastructure & Operations
  - Testing

- **IBM - SI**
  - Overall Systems Integrator & PMO
  - Solution Architecture
  - Business Transformation- BPR / OC
  - IT Integration and Infrastructure setup
  - QM

- **Telvent – DMS**
  - DMS software solution
  - GIS
  - eSCADA (central office) & ICCP
  - Services and customizations – sub to IBM

- **GE – Lead Engineering solutions**
  - Substation automation
  - Field automation
  - Protection applications
  - SCADA (stations & field)
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The project was delivered using IBM’s Intelligent Utility Network (IUN) methodology as the framework and adapted for HONI’s multi-phase and multiple release approach.

The IUN method is designed to help clients from Strategy to deployment:

1. Mobilize
2. Assess
3. Formulate
4. Define
5. Design
6. Deliver

**Phase 0 - Project Launch**

- 1. Develop Enterprise Overview
- 1. Assess Current Position
- 1. Articulate the Smart Grid Strategy
- 1. Define Program & Prioritized Projects
- 5. Define Field Deployment Plan
- 1. Design To-Be Process
- 1. Develop Organization

**Phase 0 – Requirements & Conceptual Design**

- 2. Confirm Project Scope & Purpose
- 2. Assess External Environment
- 2. Create Target Operating Model
- 2. Develop Project Plans
- 6. Define Solution Test Strategy
- 2. Design Target Technology
- 2. Deploy Technology Solution

**Phase 1 Design, Build, Test, Deploy in Living Lab**

- 3. Plan & Launch Project
- 3. Assess Internal Environment
- 3. Develop Business Case
- 3. Define Requirements
- 7. Define Organization Plan
- 3. Design Target Organization
- 3. Test Solution

**Phase 2 Provincial Rollout**

- 4. Launch Strategy
- 4. Define Technology Strategy
- 8. Identify Partners
- 4. Confirm Partner Selections
- 4. Deploy Field Devices & Transition to Operations
Smart Grid ==Highly Transformational
We assisted HONI to develop a new Target Operating Model
Leveraging Component Business Modeling we mapped the Key Objectives across 30 Capabilities

OBJECTIVES
- DG Integration
- DX Reliability & Operations Improvement
- Outage Restoration Optimization
- DX Network Asset Planning Improvement

VALUE PROPOSITIONS
- Support for DG Mandate
- Mitigate risks / connecting DGs
- Manage and Empower Crews
- Forecast Load & DGs
- DG Integration
- DX Reliability & Operations Improvement
- Outage Restoration Optimization
- DX Network Asset Planning Improvement

CAPABILITIES
- Monitor the System
  - Monitor Distribution Network
  - Monitor DG
  - Monitor Asset Status
  - Monitor Physical Security of Network
- Forecast Load & DGs
  - Forecast DG Production
  - Forecast Load
  - Model Distribution Network
  - Plan Network
- Engineer and Build
  - Evaluate & Implement DG Applications
  - Ensure Power System Protection & Control
  - Enable Asset Maintenance Strategies
- Control the System
  - Control DG
  - Control Assets
  - Control Energy Storage
- Make Operations Decisions
  - Enable Voltage Regulation
  - Enable Conservation Voltage Reduction
  - Enable Fault Management
  - Perform Operational Planning
- Manage and Empower Crews
  - Manage Workforce Remotely
  - Workforce, Asset Service Mgt
  - Monitor and Control Equipment (Mobile)
  - Manage asset & work lifecycle remotely
- Inform Stakeholders
  - Inform Customers on Outages
  - Inform DG on Outages and Control Actions
  - Inform Stakeholders on Performance

Enable Technology Management
Ensure Business Resilience and Cyber Security
Manage Cyber Assets
Manage Information
Enable Service and Solution Management
A fit analysis demonstrated that the Telvent DMS supports 20 of the 30 Capabilities

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<thead>
<tr>
<th>OBJECTIVES</th>
<th>VALUE PROPOSITIONS</th>
<th>CAPABILITIES</th>
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<tbody>
<tr>
<td>DG Integration</td>
<td>Mitigate risks / connecting DGs</td>
<td>Monitor the System Monitor the System</td>
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<tr>
<td>DX Reliability &amp; Operations Improvement</td>
<td>Lower Capex</td>
<td>Forecast Load &amp; DGs Forecast Load &amp; DGs</td>
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<tr>
<td>Outage Restoration Optimization</td>
<td>Lower Costs to Customers / DGs not Related to Del.</td>
<td>Engineer and Build Engineer and Build</td>
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<td>DX Network Asset Planning Improvement</td>
<td>Enablement of non ADS benefits</td>
<td>Control the System Control the System</td>
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<td>Lower Env. Impact from Hydro One Operations</td>
<td>Make Operation Decisions Make Operation Decisions</td>
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<td>Increase Reliability / Faster Restoration</td>
<td>Manage and Empower Crews Manage and Empower Crews</td>
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<td>Decrease Risk to Worker Safety due to MVs</td>
<td>Inform Stakeholders Inform Stakeholders</td>
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<td>Increase DG &amp; Customer Service</td>
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<td>Greener Province</td>
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<th>Forecast DG Production</th>
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<td>Forecast Load</td>
<td>Ensure Power System Protection &amp; Control</td>
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<tr>
<td>Monitor Asset Status</td>
<td>Model Distribution Network</td>
<td>Enable Asset Maintenance Strategies</td>
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<td>Monitor Physical Security of Network</td>
<td>Plan Network</td>
<td>Control DG</td>
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<td>Control Assets</td>
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<td>Control Energy Storage</td>
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<td>Enable Voltage Regulation</td>
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<td>Enable Conservation Voltage Reduction</td>
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<td>Enable Fault Management</td>
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<td>Perform Operational Planning</td>
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<td>Identify customers and DG affected by an outage</td>
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<td>Manage asset &amp; work lifecycle remotely</td>
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<td>Manage Workforce Remotely</td>
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<td>Workforce, Asset Service Mgt Integration</td>
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<td>Monitor and Control Equipment (Mobile)</td>
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Enable Technology Management
Enable Business Resilience and Cyber Security
Manage Cyber Assets
Manage Information
Enable Service and Solution Management
We developed a conceptual Solution Architecture across Four Technology Pillars.

- **Enterprise Information & Integration**: GIS (PSDB, PCMIS)
- **DMS & Other Power System Applications**: DMS
- **Ubiquitous Network**: WiMIMX
- **Substation Automation, Protection, Intelligent Electronic Devices**: Transmission Station, Distribution Station, Field Devices & DGs
We are nearing completion of Release 1:
Scope for – Living Lab / Pilot area Owen Sound Area

Scope of Release 1:

- Business process reengineering.
  - Designed but not fully deployed
  - Selective deployment (to be non-disruptive)

- Data Remediation of corporate data to support DMS CIM based Network Model

- Deploy DMS at the control center (OGCC).

- Substation and field automation using IEC 61850.

- Communication infrastructure (WiMAX, WAN) to support SCADA and power system automation.
The Living Lab or Pilot Area == Owen Sound

### High Level Asset Types

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<th>Asset Type</th>
<th>Count</th>
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<tbody>
<tr>
<td>Tx Stations</td>
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<tr>
<td>Dx Stations - fully modeled</td>
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<tr>
<td>Dx Stations - modeled as load points</td>
<td>33</td>
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<tr>
<td>M class Feeders</td>
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<tr>
<td>F class feeders</td>
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<tr>
<td>Large Distribution Customers</td>
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### Detailed Asset Types

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<td>Breakers</td>
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<td>Station based Capacitors</td>
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<td>Station based Fuses</td>
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<td>Instrument Devices</td>
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<td>Station based Reclosers</td>
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<td>Switches</td>
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<td>Feeder based Fuses</td>
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<td>Feeder based Reclosers</td>
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<td>Feeder based Capacitors</td>
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<td>Transformers Grounding</td>
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<td>Transformers Loadloss</td>
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<td>Transformers OLTC</td>
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<td>Transformers Pos Seq Imedance</td>
<td>16</td>
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<tr>
<td>Transformers ULTC</td>
<td>8</td>
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<tr>
<td>Transformers Windings</td>
<td>60</td>
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DMS for Hydro One in Rel 1

Advanced Power Applications
- 18 DMS Apps Installed 2 in study only mode
- Real time Dx operations – Load Flow and State Estimation
- Support DG penetration in the network:
  - DG Monitoring – real-time
  - DG Dispatch – study mode
- Relay Protection analysis with detailed protection logic modeled to ensure protection coverage
- SOM – used for validation of switching sequences
- Fault Location, Isolation, and Supply Restoration (FLISR)

Integrations
- Model Creation and Maintenance
  - GIS – Normal Status Connectivity and Device Statuses
  - EMS – Transmission Substation Connectivity
  - Corporate Databases – Detailed Power Characteristics and Settings
  - CIS and AMI – Historical Load Data for Seasonal/Daily Load Profiles
- Dynamic Data Exchange
  - EMS & DMS Integration will exchange analogue values, state estimation results and device statuses
  - DMS & OMS Integration is one way, from ADMS to OMS
  - DMS Network Model to Field Controllers for DGCP and UFLS
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- What are key Challenges and Lessons Learned so far
Over the next 4 years we will deploy the remaining 3 releases

**Phase 0 – Strategy & Target Model**
- Jun 2010 – Dec 2010

**Phase 1 – Trial Area Pilots**
- Jan 2011 – Dec 2016

**Phase 2 – Provincial Rollout**
- 2014 - 2040

**Release 1**
- 2011/2012
  - DMS
  - New PCT (using IEC61850)
  - Distribution Automation
  - Dx LL Data Remediation
  - Process Reengineering Including - DX Data Change Control
  - Network Model Integration (CIMGen)
  - MicroFIT DG Dispatch
  - WiMAX
  - Grid Ops – OGCC

**Release 2**
- 2013/2014
  - AMI Enablement for Grid Ops
  - Consumer Demand Mgmt
  - Energy Theft
  - Conservation Voltage Reduction
  - Integration elements - OSB
  - Large DG Dispatch
  - MicroFIT DG Dispatch
  - Energy Storage
  - SCADASync
  - DMS-based FLISR
  - Grid Ops transformation
  - Mobile Workforce base

**Release 3**
- 2014
  - Mobile Workforce DMS
  - Operational Data Store
  - Dynamic Vol-Var Control
  - Online Operating Diagrams
  - Condition Based Maintenance (CBM)

**Release 4**
- 2015/2016
  - Mobile Workforce OMS
  - Demand Response for Grid Operations
  - Under-frequency Load Shedding - UFLS
  - Selective Load Shedding
A Stage Gate approach will ensure prudent Investments over time with Provincial deployment initiated with validated components.

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<tr>
<td>Executive Approvals</td>
<td>RELEASE 1</td>
<td>RELEASE 2</td>
<td>RELEASE 3</td>
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<td>VALIDATION PHASE</td>
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<td>Functional Stage-Gates</td>
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- **OEB**: 2010/2011
- **RELEASE 1**: OEB Approval
- **RELEASE 2**: OEB Approval (Aug 2012)
- **RELEASE 3**: OEB Approval
- **RELEASE 4**: OEB Approval

- **DMS Cutover**: GO
- **DMS Operational**: GO
- **CVR Program**: GO
- **VVO Program**: GO
- **UFLS**: GO
- **Selective Load Shedding**: GO
- **GO**
- **61850 PCT Redesign**: GO
- **Control Room Redesign**: GO
- **Large DG Dispatch**: GO
- **Energy Storage**: GO
- **Large DG Dispatch**: GO

**Timeline**: 2014 → 2040
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ADS is Innovational - R&D – FOAK

- **Advanced Distributed Generation (DG) Management (DGCP)**
  - Integrated with DMS power applications such as Relay Protection Analysis.
  - Centralized DG dispatch (support for surplus-based generation)
  - Proactive anti-islanding (Hydro One does not allow micro-grids).
  - Reconnection support (desensitize feeder protection during in-rush current).
  - Feeder segmentation with topology-based tripping to reduce scope of outages.

- **Centralized topology management (DMS), decentralized DG management.**
  - Integration between DMS and substation / feeder automation using custom protocols.

- **61850 Substation Design**
  - New PCT designs for HONI – new standards assessment - complex

- **Feeder protection using IEC 61850 over wireless media.**
  - GOOSE over WiMAX.

- **Enhanced UFLS with Integration of Centralized DMS with Field controllers.**

- **IEC 61970 (CIM) for data exchange from corporate databases to DMS.**
  - New CIM profile created for systems of record for Dx network model
  - CIM files combined and augmented with traditional data sources via ESB.
  - CIM profiles extended with “stitching points” to allow combination of independent network segments (e.g. feeders to station breakers).
Key Challenges to a successful Smart Grid Initiative

- **Need to Recognize Dx SG Automation** – is “Transformational” to your business
  - Re-engineer processes with technology adoption
  - CA moved from Field (Provincial Lines) to Control Centre
  - Assess and be willing to change current business models
  - Engage workforce early – Transformational = Disruptive
  - Leverage tools like Component Modelling to prioritize and focus changes
  - Don’t underestimate your workforces ability to adapt
  - Skills – dramatically change and take a LONG time to adopt
  - Bottom line Adapt --- or --- Fail

- **Energy Management Systems** – DMS and DATA
  - Requires significant amounts of DATA – New CIM Model
  - Accuracy = Very & Currency = Now
  - Creating a seamless process and workflow to naturally manage data from Source to DMS will be a necessity for ADMS to be successful long term at a Utility

- **R&D Vs Operations**
  - Plan and Execute projects for R&D differently than Operational deployments
  - Leverage “Lab” models for R&D – limited use of “real world” scenarios
  - Limit R&D in deployment models – risks are too great for delays

- **Use Technology before customizing**
  - Learn its capabilities
  - Adapt where appropriate
  - Customize where needed
Project team
Key Lessons Learned from first Release of DMS

- Accurate, Current Data is NOT easy to obtain
- Distribution is NOT Transmission
  - Dx cannot afford the Tx model for management and support
  - MUST Optimize Data Model and Data Chg Mgmt
- Would have considered a “real Pilot”
  - trial DMS functions somehow and then customize
- Apply more focus on Key deliverables with Telvent
  - Data Dictionary – key element for Data intensive application
  - Network Model Build Procedures
- Virtual teams Don’t work
  - Key personnel must be with client for “transformational and disruptive technology based changes” - Org Change fundamental
- More proactive stakeholder management - with key LOB executives
- Better understanding of Vendor Development processes and approach
- Understand and design support model and processes much earlier in the program
- Higher focus on testing