Passive Wireless Sensor Applications for the Oil and Gas Industry

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Imagination at work.
GE Overview
Our Businesses

- **Power & Water**: 27.6B
- **Healthcare**: 18.3B
- **Transportation**: 5.7B
- **Oil & Gas**: 18.7B
- **Energy Management**: 7.3B
- **Aviation**: 24.0B
- **Appliances & Lighting**: 8.4B
- **Capital**: 42.7B

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$148.6B$ revenues
$15.3B$ earnings from continuing operations
$16.7B$ operating earnings
175 countries in which we compete
305,000 employees

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2016 OPERATING EPS GOAL

75% INDUSTRIAL
25% FINANCIAL SERVICES
**GE Oil & Gas Overview**

### Subsea Systems
- Subsea trees & wellheads
- Subsea power & processing
- Controls
- Manifolds
- Flexible risers
- Drilling Risers
- Flow lines
- Specialty connectors & pipes
- BOPs
- Valves and Actuators
- Drill Stem Valves
- Pulsation Dampers
- Running Tools
- Connectors
- Tensioners
- Gas Handlers
- Diverters

### Turbomachinery Solutions
Turbomachinery equipment and services for the upstream, midstream and LNG segments including:
- Gas turbines
- Axial & centrifugal compressors
- Electric motor driven compressors
- Turn-key industrial modular solutions
- Turbo-expanders & heat exchangers
- Contractual & maintenance services
- Upgrades & industrial applications
- Monitoring & diagnostics

### Measurement & Control
- Asset condition monitoring, control sensing & inspection solutions
- Optimization & diagnostic software
- Pipeline inspection and integrity services
- Control & safety relief valves
- Fuel dispensers & payment terminals
- Fuel control & retail systems

### Downstream Technology Solutions
Equipment & services for the refinery & petrochemical, distributed gas and industrial applications including:
- Steam turbines
- Reciprocating compressors
- Distributed gas solutions – small LNG & CNG
- Pumps, valves & distribution systems
- Blowers & compressors
- Maintenance services & remote monitoring & diagnostics

### Surface
- Artificial lift equipment
  - ESPs
  - Mechanical Lift Units
- Surface pumping systems
- Large Industrial gears.
- Valves and Actuators
- Shale 360
  - Frac Manifolds
  - Goosenecks
  - Drape Hoses
- Trees
- Wellheads
- LWD and MWD equipment

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**44,000 employees**

**$18.7B revenues ’14**
GE Global Research
A research network that connects GE across the globe

• 6 global sites
• >7,000 technologists
• Two Nobel Prize winners
• First U.S. industrial lab
• $600 million annual funding
• Founding principle ... improve businesses through technology
The Industrial Internet
Forces Shaping The Industrial Internet
Setting the stage for true business transformation

1. Internet of Things
   A living network of machines data and people

2. Intelligent Machines
   Increasing system intelligence through embedded sensors and software

3. Big Data
   Transforming massive volumes of information into intelligence

4. Analytics
   Generating data-driven insights, enhancing asset performance by detecting and predicting
GE Equipment

200,000+ assets connected

- 21,000 aircraft engines
- 10,000 gas & steam turbines
- 15,000 wind turbines
- 110,000 medical equipment
- 12,500 locomotives

Plus...

- Power transformers
- Motors
- Water treatment
- Pumps, Valves
- Turbomachinery
- Compressors

“Process Industry stores more data than any other sector — close to 2 Exabyte's($10^{18}$) of new data stored in 2010.”

- McKinsey & Company
GE M&D Center
Big Data and Analytics
Oil & Gas has unique challenges for Passive Wireless Sensors.

Harsh Environments
- Hot (up to 600F)
- Corrosive (Salt, Acidic)
- High Pressure (30,000 psi)
- High Vibration (1000g p-p)
- Subsea Environment-RF Coms

Long Term Reliability-20 to 30 years
SAW Sensor And System Development
Extreme Environments

Challenges
- High temperature piezo electric material
- Metal adhesion
- Agglomeration and phase separation
- Diffusion
- Electrical property degradation

Challenges
- Hermeticity and sealing
- Attachment of chip
- Carrier material and bonding to surface

Challenges
- Antennas (size, efficiency, ability to radiate)
- Multipath fading and delay spread, range

SAW Sensor Development
ongoing

Packaging and bonding to sensing surface
Future work

Antenna design and Wireless Technology Interrogation
Brainstorming and Experiments
Passive Wireless Sensors
Oil and Gas
Potential Applications
Passive Wireless Sensor Applications-Oil & Gas

- Industrial Gas Turbine Testing/Health-Under Development
- Fugitive Methane Emissions-Beginning Development
- Equipment Load History and Monitoring-Ideation Phase
Industrial Gas Turbine Instrumentation

Compressor Discharge: Temperature profile measurements

Stage 1
Stage 2
Stage 3

Compressor

Temperature and strain for all buckets, compressor stator vanes
- Testing and validation (Preliminary focus)
- Lifting, services and controls (Longer term)
- Wheel box tests for mechanical failure and testing

Low T

High T
Fugitive Methane Emission Detection

“While the standard figure used for emissions trading and technology evaluation says that, gram for gram, methane is about 30 times as potent a greenhouse gas as CO$_2$…”

“…methane’s initial impact is much greater than that of CO$_2$ — by about 100 times.”

Source: Methane is 10-100X more damaging to environment than CO2
Global methane estimates

Data source: Global methane initiative.
(These are estimates and there are challenges with their validity and accuracy)
Key Actions to Improve Methane Emissions Measurement and Monitoring by US

Improving the bottom-up emissions data relevant for mitigation; and advancing the science and technology for monitoring and validating atmospheric concentrations.

• **Encouraging the Development of Cost-Effective Measurement Technologies**
• Enhancing the US Greenhouse Gas Inventory
• Building our National Methane Monitoring Network
• Improving Local & Regional Emissions Modeling
• Improving Global Emissions Monitoring and Estimates
Detection to Enable Mitigation

Specific GE Technologies for FME mitigation
Breakdown by source of emissions & associated GE product that reduces the FME

Pipeline Leaks & Meters
- USM Go, Righttrack RVI KL Rouver, X-ray ERESCO
  - Ultrasonic, remote visual inspection, and x-ray tools for monitoring and preventing leaks
  - Reduce leak service calls

Centrifugal Compressors
- ICL Compressor Line
  - Electric powered hot nitgas
  - No venting when stopped
  - Completely closed design means no seal leaks
- Dry Gas Seal RulePak
  - Software for non-ICL compressor seals

Gas Engine Exhaust
- Waukesha 275GL+
  - 1.2% greater fuel efficiency
  - Reduces CO2 by 1,900 tons/yr
  - 5 g/kwh-lhr w/ emissions after treatment

Reciprocating Compressors
- Low Emissions Rod Packing
  - Reduces packing emissions 70%
  - Standard offering on small HP today, extending to high HP

Well Venting & Flaring
- PEMS, GF668, GM686, XQMB686
  - Predictive Emissions Monitoring System software
  - Reliable, accurate meters for new installations or retrofits

Oil & Gas Production 22%

* POLLUTION * POLLUTION * POLLUTION *

- Well Venting & Flaring
- Pneumatic Devices
- Reciprocating Compressors
- Offshore Operations
- Gas Engine Exhaust
- Centrifugal Compressors
- Dehydrators & Pumps
- Pipeline Leaks & Meters
- Other Sources
- Station Venting
- Storage Tank Venting
- Plant Fugitives
- Blowdowns
Monitoring of CH₄ Leaks Using Wireless Sensor Network

• Low-power operation - long-term operation without battery replacement or energy harvesting
• Cost-effective leak detection - wireless installation, unattended monitoring
• Reduced false alarms - based on high selectivity of GE’s multivariable resonant sensors
Load Monitoring Applications

Shaft Torque Sensors
- Pumps
- Compressors
- Turbines

Equipment Load/Environment History Subsea
- Peak Strains
- Load Cycle Counts
- Corrosives-H$_2$S, CO$_2$

“a miniature black box”
Summary of PWST in O&G Space

- PWS are in infancy into O&G space
- Technology development is accelerating
- This is a “target rich” environment for development
- Development of sensors should have readily available field trial opportunities.
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