Spectra Energy T North N4 Station Upgrade Project
Solar Titan 250 + C85 Unit addition
by
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Spectra Energy

• **Spectra Energy Corp** *(NYSE: SE)*,
  - At a Glance - Spectra Energy
  - Spectra Energy Fact Sheet

• **Major Operations**
  - US Transmission
  - Union Gas
  - Western Canada Transmission and I
  - 50% ownership in DCP Midstream
  - Express Platte System
Spectra Energy
Business Segment Overview

NYSE: SE

U.S. Transmission
- Texas Eastern Transmission
- Algonquin Gas Transmission
- Bobcat Gas Storage
- Maritimes & Northeast, Canada (78%)
- Maritimes & Northeast, US (39%)
- Market Hub Partners (50%)
- Southeast Supply Header (50%)
- Steckman Ridge (50%)
- Gulfstream Natural Gas (1%)
- Southern Hills Pipeline (33%)
- Sand Hills Pipeline (33%)
- Spectra Energy Partners (61%)

Distribution
- Union Gas

Western Canada Transmission & Processing
- Gathering & Processing
- BC Pipeline
- Natural Gas Liquids Division

Field Services
- DCP Midstream (50%)
- DCP Midstream Partners (14%)

NYSE: DPM

NYSE: SEP
- East Tennessee Natural Gas
- Ozark Gas Transmission
- Saltville Gas Storage
- Gulfstream Natural Gas (49%)
- Market Hub Partners (50%)
- Maritimes & Northeast, US (39%)
- Big Sandy Pipeline
Spectra Energy
U.S. Transmission

- Access to multiple supply sources
- One of the largest storage positions in North America (~140 Bcf)
- Largest transporter of natural gas to New England, 2nd largest to NYC
- One of the largest pipeline systems in North America (12% of gas consumed)
- System oriented to high-growth U.S. markets
- Strong base of contracts with high credit quality customers and a high rate of contract renewal
- Majority of capacity sold under multi-year firm contracts
- Changing supply and market dynamics provide opportunities for growth

2012 Pipeline Throughput: 2.7 Tcf
Transmission Pipe: 14,520 mi
Total System Compression: 2.5MM HP
Total Storage Capacity: ~140 Bcf
Spectra Energy Distribution

- Union Gas – 2nd largest natural gas distributor in Canada; provides distribution or storage and transmission services to all gas-fired generation plants in Ontario
- Dawn Storage facility – largest underground storage facility in North America
- A portion of storage business is market based (unregulated)
- Dawn Hub location provides new supply flow balancing options
- No direct exposure to commodity price risk

Retail Customers: 1.4 million
2012 Pipeline Throughput: 818 Bcf
Distribution Pipe: 39,000 mi
Storage Capacity: 160 Bcf
Transmission Capacity: 6.3 Bcf/d
Transmission Pipe: 3,000 mi
Spectra Energy
Western Canada Transmission & Processing

- Assets located in some of the most productive fields within Canada
- Strong base of contracts with high credit quality customers
- Majority of transportation capacity is sold under multi-year firm contracts
- Gathering and Processing business is fee for service

Natural Gas Gathering & Processing
Miles of raw gas gathering: 2,200 (3,500 km)
17 gas processing plants
Processing capability: 3.6 Bcf/d
Major markets: BC, AB

BC Pipeline
Miles of pipeline: 1,800 (2,900 km)
Peak day capacity: 2.9 Bcf/d
Major markets: BC, AB, US Pacific Northwest

Natural Gas Liquids – Empress System
NGL extraction capacity: 2.4 Bcf/d
NGL fractionation capacity: 63,000 Bbls/d
NGL storage capacity: >4.0 MMBbls
Miles of NGL pipeline: 590 (950 km)
Major markets: Western Canada, Northern US
Spectra Energy
Field Services

Competitive Advantages
• Premier US gas gatherer and processor
• Largest natural gas liquids (NGL) producer in the U.S.
• Located in most major oil & gas producing basins
• Liquids rich footprint
• Predominantly ‘Percentage Of Proceeds’ (POP) contracts

DCP Midstream Stats*

2012E Volumes:
Total Throughput 7.0 TBtu/d
Gathered & Processed 6.3 TBtu/d
Natural Gas Liquids 400 MBbls/d

2013E Volumes:
Total Throughput 7.6 TBtu/d
Gathered & Processed 6.5 TBtu/d
Natural Gas Liquids 460 MBbls/d

*Includes DCP Midstream Partners
Spectra Energy Transmission West
Asset Overview

**BC Field Services**
- Number of process plants: 6
- Booster stations: 17
- Raw gas gathering infrastructure: 2,500 kilometers / 1,550 miles
- Processing capacity: 2.85 Bcf/d
- Acid gas injection: 42 MMscf/d
- Sulphur capacity: 3,000 tonnes/day
- Major markets: BC, AB

**Midstream**
- Number of process facilities: 11
- Raw gas gathering infrastructure: 990 kilometers / 620 miles
- Processing capacity: 762 MMcf/d
- Acid gas injection: 17 MMscf/d
- Major markets: BC, AB

**Natural Gas Liquids – Empress System**
- Processing capacity: 2.4 Bcf/d natural gas; 63,000 bbls/day C_2+
- NGL fractionation capacity: 63,000 bbls/d
- NGL storage capacity: 4.2 MM bbls
- PTC Pipeline: 960 km / 595 miles NGL pipeline
- 7 product sales terminals
- Major markets: Western Canada, Northern US

**BC Pipeline**
- Length of pipeline: 2,900 kilometers / 1,800 miles
- Transportation capacity: 2.9 Bcf/d
- Compression horsepower: 600,000 (19 compressor stations)

**Natural Gas Liquids**
- Empress System
  - Processing capacity: 1.2 Bcf/d natural gas
  - NGL fractionation capacity: 42,000 bbls/d
  - NGL storage capacity: 3.3 MM bbls
  - Major markets: Western Canada, Northern US

**Spectra Energy Western Canada Operations**
- BC Pipeline
- BC Field Services
- Midstream
- Natural Gas Liquids
- NGL Storage Facilities

[Map and diagram showing asset locations]
Paper Presentation

- **Section 1** – Spectra Energy Project Team

- **Section 2** – Solar Turbines Inc.
  Program Management

- **Section 3** – Spectra Energy Operations
Paper Presentation

• **Section 1** – *Spectra Energy Project Team*
Spectra Energy T North N4 Station Upgrade Project

Spectra Energy Transmission West
Proposed T-North Expansion – 2011

N4 – Compressor Upgrade

24 km of 36"
D/S of MP 158.6

PROPOSED GROUND BIRCH CS SITE OPTIONS

20 km of 36"
Lateral off MML2

SOUTHWEST GATHERING AREA

WAC BENNETT DAM

Hudson's Hope

Cecil Lake

Fort St. John

Taylor

Cecil Lake

Ft St John

Blucher River Flx

Ft St John

Boundary Lake Plant

Dawson Creek

Poise Crude Plant

Poise Crude Plant

Mackenzie

Sicamous Plant

Kamloops Plant

Thomass Lake

McLeod Lake

Sicamous Plant

Kamloops Plant

Thomass Lake

McLeod Lake

BC

ND

South Peace Gathering Area

IAGT™
Spectra Energy T North N4 Station Upgrade Project

• T-North Transmission Expansion Program
• Business Case – 170 MMscfd of additional Fort Nelson Mainline (FNML) long-haul capacity Fort Nelson Plant (FNP) receipt point to Compressor Station 2 (CS 2).
• Facility Requirement
  – 24 km of loop extension of 36” between Compressor Stations N4 and N5
  – Addition of 1 x 30000 ISO hp Unit at N4
Spectra Energy T North N4 Station Upgrade Project

T-North 2011
CS-N4 Cypress Compressor Station
Project No. U1194 (February 2012)
Spectra Energy T North N4 Station Upgrade Project
Solar Titan 250 + C85 Package
Unit Selection Considerations

• Spectra - Solar Alliance agreement, LTSA
• Set West Solar Fleet - 23 packages, 200,000 HP.
• Capital cost, successful operating history, schedule, quality, and operational requirements
• Titan 250 unit (T250), with ISO 30,000 HP, was selected to be added.
• Published HP and efficiency performance met the system design model,
• Footprint for modular skids worked at existing N4 site
Key Drivers

• Solar Design Philosophy using skidded units
• Reliability and Operability - familiar to Spectra thru the fleet experience.
• T250 maintenance program - similar to existing units and leveraged existing support network in Western Canada.
• Solar’s “Order Fulfilment Process” for Project Delivery”
• Cost and delivery commitments
Risks

• **T250 was a newly developed unit** – It was a prototype unit with less than 16,000 fired hours for the fleet

• **Un-proven Performance & Reliability** in High Elevation and Cold Weather Applications
Risk Sharing and Mitigation

Solar initiatives and commitments

- Solar Senior Management commitment to support on all issues
- Extensive testing regime in development of unit
- Exhaustive listing of issues and design improvement
- Complete transparency on sharing of all issues
- Inclusion of this unit in a “Field Evaluation Program”- committed field service monitoring and engineering support.
- Insight remote monitoring program - part of Field Evaluation Program
- Immediate and well coordinated response to unit issues post commissioning involving engineering, manufacturing and field support
Risk Sharing and Mitigation

Spectra initiatives and risk sharing

- Spectra Senior Management Support
- System design - consider spare capacity on the system in case the unit is down due to issues
- Continuous team engagement with Solar team.
- Witness testing and collaboration on issues
- Adjust construction schedules to accommodate delays
- Collaborate in commissioning
- Ensure detailed communication on all issues to Operations and other Stakeholders - no missed messages.
- Patience – allow Solar to work issues
Paper Presentation

• Section 2 – Solar Turbines Inc.  
  Program Management
THE PEOPLE, PLACES AND EVENTS THAT HELPED SHAPE SOLAR TURBINES.

The rich history of Solar dates back to 1927 when it began as an aircraft manufacturing company, evolving into a gas turbine technology company in the mid-1940s. Today, Solar Turbines leads the way in mid-range industrial gas turbine engines. That leadership position is made possible with over 60 years of technological innovations, manufacturing expertise and customer support.
Product Family Tree and Design Heritage

TITAN 250

- 30,000 HP
- 40% Efficiency
A Hybrid Design Based on Proven Platforms, Materials, Coatings and Temperatures

Titan 130
1,250 Sold
132M Hours

Taurus 6

Mars 100
750 Sold
30M Hours

Titan 250
Titan 250 Gas Turbine Engine

- **Power Turbine**: Three-Stage
- **Gas Producer Turbine**: Two-Stage
- **Combustor**: Dry Low Emissions or Conventional
- **Compressor**: 16-Stage Axial
Engine Size Comparison

Titan 250

Titan 130

76.2 cm (2.5 feet)
Product Capabilities

- **22.4 MW (30,000 hp)**
- **40% Efficiency**
- **Low Emissions (15 ppmv NOx)**
- **Expanded DLE Mode:** 100%-40% Load
- **Improved Availability**
  - Higher Reliability
  - Improved Durability
  - Longer Run Times
- **Traditional Arctic Options**
- **Matching Line of Gas Compressors**
- **Improved Serviceability**
  - Equipment Health Monitoring
Matching Gas Compressors

- C41 and C51
- C61
- C75
- C85

Production

Pipeline
Centrifugal Compressor Coverage

- HP Re-Injection
- HP Gas Lift, HP Storage
- Transport, HP Pipeline, Export
- Gas Gathering, HP Pipelines
- Future
- 30,000 hp
- C41, C51, C61
- C75, C85
- Pipelines
• ~30 Packages Released
  • 18 Shipped
  • 9 Running
  • 7 Starting
  • 2 in Installation

• Fleet >110,000 hours

• 4 Sites >18,000 hours

• Regional Parts, Tools and Spare Engines
Titan 250 Program Status

~ 30 Packages Released for Production

(6) C85 Compressor Sets
Tenn, Utah, 3x Germany, Canada BC

(6) Generator Sets - CHP
3x Turkey, Spain, 2x Australia

(3) C61 Compressor Sets
3x China (on-shore)

(1) C51 Compressor Sets
Canada Alberta

(2) C41 Compressor Sets
2x China (offshore)

(2) Mechanical Drive
North Sea (offshore 2x MAN), Korea (MHI)

(3) C75 Compressor Set
2x Penn, 1x Penn

(4) Mechanical Drive
Russia - Gas Transmission

(2) Generator Set - Conv. Dual Fuel
Middle East

Several More Pending
Worldwide

Project Locations: 11 Countries, 5 Regions

(5) EU, (5) China, (3) Turkey, (5) USA, (2) Aust, (2) Canada, (1) Korea (4) Russia

Market Mix:

(24) Oil & Gas - many different applications
(6) Power Generation - all in CHP

9 Units are Operational and 7 More are Staring IN 4Q 2013

> 110,000 combined hours
> 125,000 hours by year-end 2013
> 4 sites >18,000 hours
> > 250,000 hours by year-end 2014
Summary

In Full-Scale Production
- Similar Application Options as Other Product Lines
- Wide Range of Driven Equipment: Gas Compressors and Generator

Best Efficiency in Class
- 40% at 22.4 MW (30,000 Hp)

Wide Range of Fuel Capabilities
- Dry Low Emissions (SoLoNOx): 15, 25, or 40 ppmv

Lowest Emissions in Its Class
- Down to 40% Load in Dry Low Emissions-Mode

Higher Availability
- Increased Durability
- Additional Instrumentation
- Most Modular, Repairable, Serviceable

Cold to Full Load in 8-10 minutes
Regionally Stocked Tools, Parts and Spare Engines
Paper Presentation

• Section 3 – Spectra Energy Operations
  New Unit Integration
New Unit Integration

Integration topics being presented:

• Start-up Findings
• Spares Selection
• Preventive Maintenance
New Unit Integration

Site Layout

• One new Solar Titan 250S driving a C85 compressor
• 2 I.R. GT51 gas turbines each driving a CDP-30 compressor
• Each turbo-compressor package can operate alone or in series with one of the others
New Unit Integration

Start-up Findings

Headings

• **Control Systems**
  – Unit and station

• **Speed Control Issue**
  – Conflicts between panels

• **Fast Stop Issue**
  – Philosophy resulting in operating impediment
New Unit Integration

Control Systems, Outline

• Two control panel configuration
  – Unit Control Panel (UCP)
  – Station Control Panel (SCP)

• UCP
  – For the turbo-compressor and ancillary equipment

• SCP
  – For the station equipment and safety systems
New Unit Integration

UCP

• Solar supplied, Allen-Bradley
• Skid mounted
• For equipment:
  – Gas Turbine
  – Natural gas compressor
  – Unit Fuel Gas Skid and Main Valves
  – Unit safety systems and control valves
New Unit Integration

SCP

• Spectra Sourced, standard is GE RX3i
• Control room panel with remote terminals
• Equipment:
  – Station valves
  – Overriding unit operation to prevent overpressure
  – Gas cooler control
  – Station safety systems
  – SCADA communications
New Unit Integration

Unit Speed Control Issue

• 2 methods
  – UCP under Process Control
  – SCP overriding speed signal to UCP for load balancing between two units running in series
New Unit Integration

Unit Speed Control Issue

- Solar NGP speed range: 0 – 102.5%
- 102.5% limit was to allow for higher power
- SCP programming was for 0 – 100% NGP
- Too much work to change many ladders of code in SCP program
- Accepted performance compromise
New Unit Integration

Fast Stop Issue

• Aka: Emergency Shut Downs
• T250 has two types
  – Fast Stop, Slow Roll Enabled
  – Fast Stop, Slow Roll Disabled
• Engine has a heavy GP rotor and fitted with a turning motor
• The Fast Stop logic is posing problems
New Unit Integration

Fast Stop Issue

• Fast Stop, Slow Roll Enabled
  – Soft button within HMI screens
  – Manual operation only

• Fast Stop, Slow Roll Disabled
  – Hard button operation
  – SCP trip signal operation

• No auto Slow Roll Enabled functionality
New Unit Integration

Spares Selection

• Many ways to look at this:
  – Critical sparing (many definitions)
  – Consumable spare needs
  – Business Unit (local or remote)
  – Available Redundancy
  – Inventory Management Internally vs Externally
  – Availability of parts and/or Service
  – Available Funds
New Unit Integration

Spares Selection

• Spectra Materials Management
  – Uses the SAP materials Module
  – Creates a unique material #
  – Allows for usage, ordering and tracking
  – Organizes information to allow Purchasing
  – Material # is created for all spares, consumable or non-critical part that will one day need to be purchased
New Unit Integration

Spares Selection

• To select what would be needed as inventory spares, the following questions were asked:
  – How long can the unit be down (unscheduled)?
  – What are the available maintenance capabilities?
  – What is likelihood of widget failure?
  – How much can be spent?
New Unit Integration

Spares Selection

- Result was for parts selection:
  - Lead time for delivery greater than 4 weeks
  - Consumable parts that are required to install the critical parts / assemblies
  - Exclude parts which had a low likelihood of failure
  - Parts / assemblies that can be used in the field
  - Costs not to exceed $1.25M (to also include special tooling)
New Unit Integration

Spares Selection

• During selection process:
  – Preference is to also spare PM consumable materials, these were identified
  – Non-critical parts were also identified
  – Special tooling was selected to support PM and those needed for the selected parts
New Unit Integration

Spares Selection

- Solar can provide a Consolidated Ownership Report (COR) on spare parts and tooling
  - Very useful
  - Allows for easy checks with existing spares
  - Identifies common items between packages
  - Spreadsheet form provided early in the project delivery
New Unit Integration

Spares Selection

- COR components:
  - SPY1, Operational Consumable Parts
  - SPY2, Insurance Critical Items
  - SPY3, Insurance Non-Critical Items
  - SPY4, Repair Kits / Components
  - SPY6, Maintenance Tools
  - SPY7, Special tools
New Unit Integration

Spares Selection

• Final results, Parts:
  – Total # of items listed (SPY1 – 4): 326
  – Total # of items passing selection criteria: 205
  – Total # of common items already in the system: 56
  – Of the 56 # of them that needed no changes: 51
  – Total # of items that needed to be created or changed: 154
  – Actual item item count ordered: 139 (including multiples of same part)
  – Total cost of 139 parts: $795,791.60
New Unit Integration

Spares Selection

• Final results, Tools:
  – Total # of tools listed: 80
  – Total # of tools passing selection criteria: 43
  – Total cost of 43 Tools: $423,342.66
New Unit Integration

Spares Selection

• One major flaw in the process
  – COR file provided early
  – Goal to have parts identified and in Spectra inventory by start up
  – Illustrated Parts Lists not issued until project end
  – Difficult to identify part without parts book

• Issue overcome with plenty of clarification questions and a few meetings
New Unit Integration

Preventive Maintenance

• Consideration Criteria:
  – Spectra uses SAP Maintenance Module
  – Plans for complete O/H cycle
  – OEM plans are tempered by Operating environment
  – Spectra and Solar have a Fired Hour agreement in place
New Unit Integration

Preventive Maintenance

• Solar plans outlined:
  – Daily, weekly, Semiannually (or 4000 hr) and Annually (8000 hr), Outlined in O&M manual.
  – Solar outlined three O/H phases
    • 30,000 GP Hot Section
    • 60,000 GP
    • 90,000 PT
• Fired Hour Agreement O/H at 30,000 hrs
New Unit Integration

Preventive Maintenance

• Initial Spectra Plan:
  – Daily, weekly: Operator level, not in SAP
  – Semiannually, SAP:
    • Washes, Borescopes, oil samples
  – Annually, SAP:
    • Oil and fuel filter changes, instrument calibrations
  – 30,000 Complete O/H, SAP

• Now covered by an LTSA with Solar