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DAWN HUB AND COMPRESSOR UTILIZATION

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ABSTRACT

The Dawn hub and compressor facility is located in Lambton County about 20 miles south east of Sarnia Ont. The facility consists of approximately 175 MW (235,000 Hp) made up of 9 gas turbines from Siemens (Rolls Royce) and Solar Turbines. This horsepower is instrumental in the injection and withdrawal of approximately 7.93 x 10^9 m^3 *(280 Bcf) of underground storage, as well as moving transmission gas for TCPL (Great Lakes Gas Transmission) and Vector Pipelines. Other interconnects such as Panhandle Eastern, Michcon/Nexus, and Bluewater also move gas to and from the Dawn hub. The Dawn Station is unique in its design due to the flexibility to both inject and withdraw gas based on market demand on any given day. Its piping system within the plant consists of many 42" and 48" headers used to move gas in and out of the station at various pressures required to meet the demands of the system. During peak winter demands, the storage withdrawals can reach over 6000* sm^3 */ hr (over 5 bcf/d) for extended period of time. Much of this storage gas requires dehydration, which is also done at the Dawn plant. The Dawn Dehydration Facility can dry* 6086 sm^3/hr (5.17 bcf/d) *of wet storage gas, making it acceptable for transmission, and is one of the largest gas dehydrators in North America. Our plant and storage system operates at multiple pressure levels with process control on each unit and also within the yard on various controllers. This paper will describe peak operation during extreme cold across the country and what role it plays in meeting the demands of the market during these times.*

INTRODUCTION TO THE DAWN STORY

Oil production in Lambton County dates back to the mid 1800’s when `gum beds were recognized as a form of asphalt. Oil Springs, near the Dawn hub, was the site of Canada’s first commercial oil well in 1858. Gas reserves were identified in the surrounding area as part of the oil exploration activities in the late 1800’s early 1900’s.

Natural gas soon became an affordable energy source it was in high demand. Demand quickly began to outpace supply. Shortages were first felt during the cold winter of 1918, prompting the provincial government to restrict the use of natural gas for industries in favour of residential consumers. Despite this, shortages continued into the 1920s until in 1931 with the discovery of two large natural gas wells in Dawn Township.

Over the next decade, the growing popularity of natural gas as an affordable choice for home heating and more efficient automatic natural gas hot-water heaters and individual room heaters drove increased consumption.

Concerns about supply remained, however, because while supply had continued to increase, growth had come through existing, rather than new, natural gas fields. It was becoming increasingly clear new solutions were needed. So, in 1938, Dr. Charles S Evans, who would become one of Eastern Canada's leading geologists, proposed using depleted natural gas reservoirs in the company's Dawn gas field for underground storage.

By 1940, Ontario's natural gas industry was in full-blown crisis. Consumer demand for natural gas was at an all-time high, while production had dropped to new lows, so it was clear the province needed to find new sources of supply. Early in 1941, Union Gas contracted two different engineering firms to test Evans' underground storage proposal. Both firms agreed it would be feasible to inject natural gas into Dawn's depleted reservoirs and – most importantly – ensure that no gas would be lost when withdrawing it. So, on Oct. 28, 1942, natural gas was injected into a depleted reservoir at Dawn, marking the birth of Canada's first commercially successful underground storage. Union Gas could now store natural gas during the summer for use during cold winter months when demand was at its highest, alleviating concerns over winter shortfalls and restoring consumer faith in natural gas to heat their homes

As this storage concept grew, along with the residential, commercial and industrial markets for natural gas, the need to efficiently move natural gas in to and out of Dawn, drove the development of pipelines and compression required to best utilize the storage market.

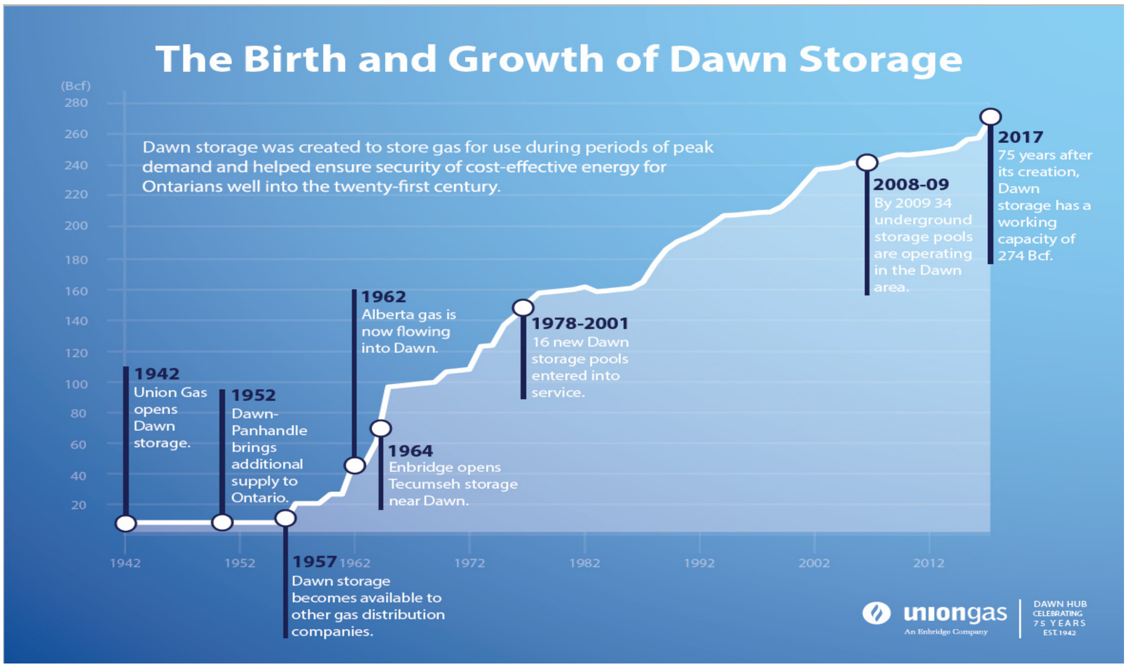

Figure 1: Dawn Storage Birth and Growth

DAWN STORAGE AND TRANSMISSION GROWTH

As the years passed, The Dawn Hub has transitioned from 70 Hp single cylinder reciprocating compressors and a 26" pipeline, servicing the Ontario Canada market to a fleet with over 175 MW (235,000 Hp) of centrifugal compressors managing over 7.93 x 109 m3 (280 Bcf) of working storage in 34 storage pools. These pools, along with the over 355 MW (480,000 Hp) of transmission compressors servicing our own 26", 34", 42" and 48" pipelines connects Dawn to five major pipelines and supplies gas to Ontario, Quebec, New Brunswick and the North Eastern United States. This growth was both slow and deliberate punctuated with periods of grand expansion.

As demand increased, the Dawn plant expanded its fleet of reciprocating compressors up to 15,000 HP in 1972, we had started to add Rolls Royce Avon driven centrifugal compressors to our transmission fleet and Dawn was to be next.

The first turbine driven compressor unit was constructed at Dawn in 1978. Unlike the single compressors used at our transmission facilities, the package included a Rolls Royce RB211-22, driving two compressor cases that could be operated in a series or parallel mode. At 26,700 HP, this package almost doubled the existing power available in the entire reciprocating plant. The series and parallel modes, made it flexible to perform storage injection and withdrawals, and the parallel mode was used primarily for transmission applications. At first the two compressors were fixed together, but the addition of a hydraulic coupling after the original build allowed the use of only the inboard compressor, which then allowed for more flexibility with smaller gas flows.

As the storage activity increased, so did complexity of operation and the need for high volume withdrawals during peak times became common. Between 1982 and 1992, Dawn added three new RB211 driven dual train compressor packages and one three train package. In addition to the growth in compressions, the increased withdrawal activity resulted in the need for gas dehydration to meet the current 4 lbs / mmcf tariff standard of pipeline quality. A four tower triethylene glycol dehydration station was built on the Dawn site which can flow up to 6086 sm^3/hr (5.17 bcf/d) and reduce moisture content from 20 to 4 lbs/ mmcf.

With the discovery of shale gas in the New York, Pennsylvania, and Ohio, and the demand for of natural gas in the Maritimes and North Eastern US, Dawn has seen additional storage infrastructure builds and the addition of 2 Rolls Royce/Siemens RB211 GT and three Solar Taurus 70 added to the station and the old reciprocating compression decommissioned. Also, with the amalgamation of the Enbridge and Spectra Energy storage assets, Dawn is now the largest compressor facility in North America, the largest integrated storage facility in Canada and the second largest trading hub, for natural gas, in North America with over 6,850,000 m^3/hr (5.8 bscf/d) total design day deliverability. Dawn is literally and figuratively in the middle of North American gas.

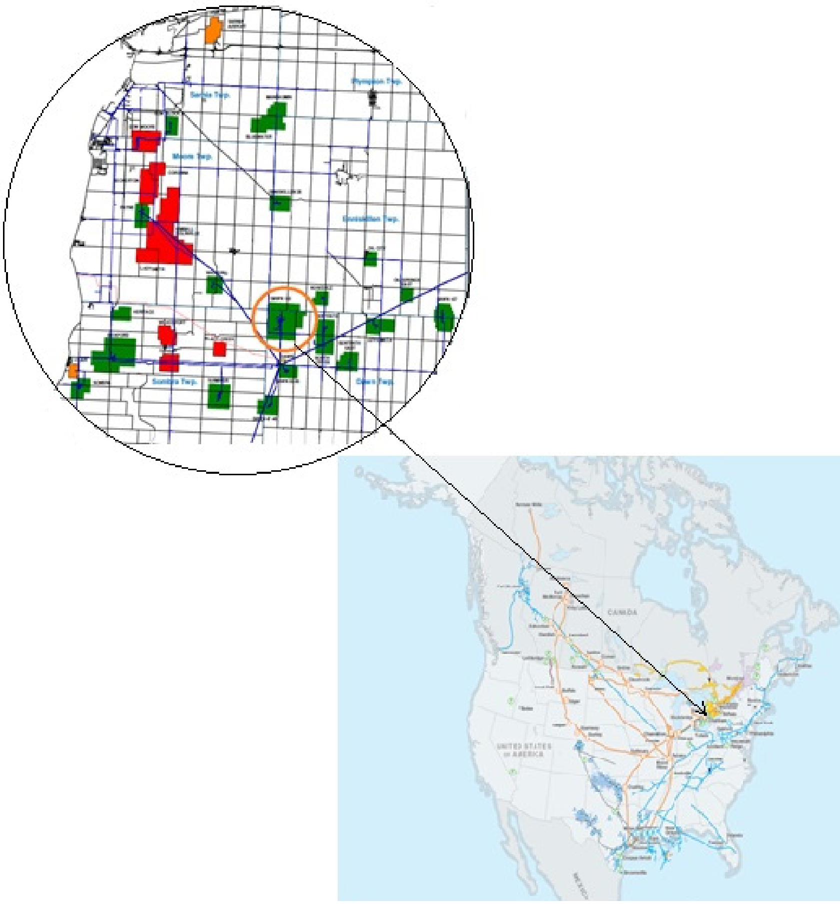

Figure 1: Dawn Storage Location Major Pipeline Connections throughout North America

With this size and breath of build, the result is a very complex system of nine centrifugal compressors, 26 remote storage compressors supplying 34 storage pools at pressures between 6950 and 11,480 kPa, volumes between 31,000 to over 800,000 km^3 and days to fill pools from 3 to 95, and that's only the summer operation, during the winter, peak operation, time, is when the real magic happens.

The Dawn system has 16 pipeline and storage interconnects running at operating pressure from 6040 to 10,550 kPa and delivers transmission gas along four pipelines running at 6,150 kPa and one distribution market line running at 1,900 kPa. Along with the nine centrifugal compressors, there are eight major headers, most of which are 42-48" diameter with ranging maximum operating pressures (MOPs) from 6895 to 10550kPa. The headers are strategically designed to meet not only the high volumes from storage during peak winter demand, but also to compress gas back into these same formations throughout the summer. Along with the two other 42" configuration headers, over 1900 valves and 105 MOP separation points, the Dawn Complex balances external pipeline deliveries and receipts, well storage and withdrawals, and gas dehydration in order to deliver gas to our transmission system, not only on peak demand days but all 365 days of the year.

For the summer months, the area of focus is underground storage where gas is pumped with specific storage compressors from the Dawn plant and either directly injected into storage pools or further boosted with either reciprocating or centrifugal compressors for injection. In addition to this compression is used to control pipeline pigging and inspections, in order to complete these tasks before the busy winter storage and transmission months and peak day deliveries.

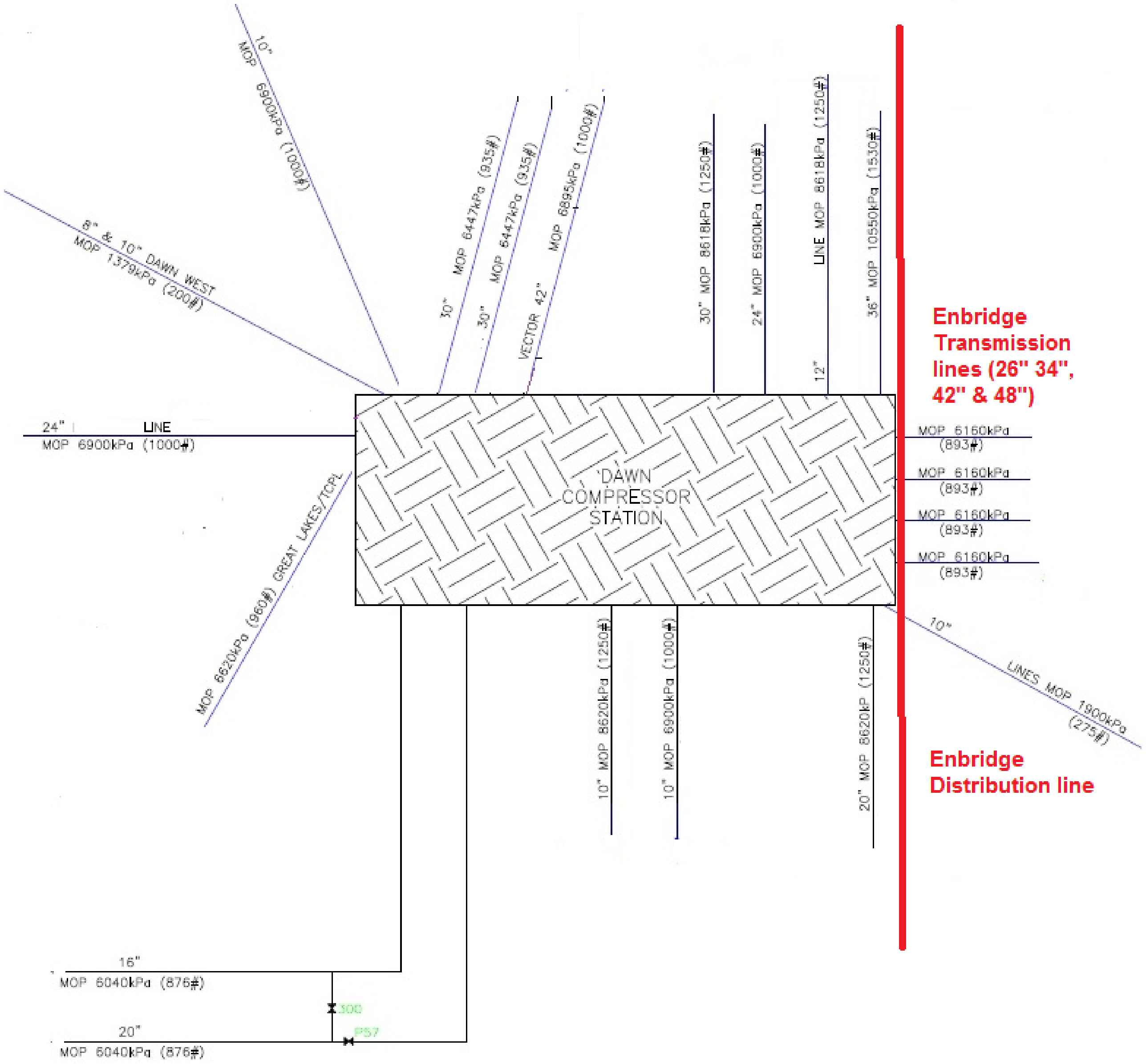

Figure 3: Dawn Pipeline Connections and Pressures

Dawn Hub Peak Day Capabilities

The peak demand days require that the Dawn system deliver in excess of 5,900,000 m^3/h (5 scf/d) to its transmission lines. During this time, the transmission system is pushed to its maximum capabilities, with the expectation that all of the transmission turbine units be on , at full power and flow capabilities at maximum spread of suction to discharge pressure. This deliver is a delicate balance between incoming pipeline quantities and storage. This balance can be exacerbated by reductions in incoming gas transmission volumes from Vector and TCE, as gas demand increases across the American Midwest, forcing more withdrawals from storage pools, increasing the reliance on dehydration of this gas to pipeline quality standards.

During the last winter cold period between Jan 30 – Feb 2, 2019` storage pool withdrawals peaked at 7,200,000 m^3 / hr (6.1 bcf/d), as transmission gas from TCE and Vector was only used to support dry 700 psi markets upstream of Dawn – used mainly for industrial and greenhouse loads. During this time, storage gas was compressed with various plants, dried through the Dawn Dehydration Facility and moved easterly on the Dawn to Parkway. One of the major challenges with storage withdrawals is moisture content. In order to maintain acceptable levels of moisture and reduce/eliminate the cost of running the Dawn dehydration plant on those low gas delivery days, the operations team will blend dry transmission gas that is received from TCE and Vector with storage gas to create an acceptable mixture for delivery to our transmission pipeline. Likewise on those high storage withdrawal days, where there is reduced delivery of dry transmission gas, at Dawn, and the output for the facility exceeds the 6086 sm^3/hr (5.17 bcf/d) drying capacity of the dehydration plant, blending is a necessity. This requires dedication of certain turbine resources to wet gas and others to dry; as well as configuration of the yard header system and controls to allow controlled comingling of “damp” gas with super dried gas, in order to achieve pipeline quality standards.

Transmission System delivery volumes were well over the expected 6,100,000 m^3/h for much of this high demand period and on the Jan 30th 2019 gas day, we surpassed the previous storage withdrawal record by 19%. The hydraulic modelled peak day requirements for our system generally expect these high load delivery requirements to be short lived. The major challenge comes when there are consecutive days of extreme cold.

The MCR – Hub of the Dawn Hub

The Dawn Master Control Room (MCR) controls the balance between storage requirements and transmission requirements, to meet the needs of the pipeline system, around the clock. SCADA systems and local DCS systems provide the MCR with the necessary information and control to maintain the supply nominations and pipeline system requirements.

In order to have the ability to meet the short term, `high demands`, gas is managed for much of the withdrawal season to have it strategically place in pools with’ high deliverability’. Many pools in our storage fleet are `baseload` pools and require long periods of injection and withdrawal with large blocks of storage horsepower. Removing the total inventory in some of these baseload pools takes months, making them less effective during high demand periods. During periods of low market demand, and when larger volumes of transmission gas are available, the Dawn System Operations will move gas to strategic ‘high deliverability’ pools to prepare for expected and unexpected draws on storage. Many system operation decisions are based on experience, instinct and a collective discussion between the System Operator, the Shift Manager, and the System Operations Advisor. Proper planning as well as experience are key to ensuring system loads and reacting to unexpected outages. Recovery time when and outage occurs, is also critical, so the MCR operators plan, as best they can, for upsets with alternate compressor units.

Many system operation decisions are based on experience, instinct and a collective discussion between the System Operator, the Shift Manager, and the System Operations Advisor. Since the operation is seasonal in nature, the System Operator may have to experience several years of seasonal change to develop adequate pipeline strategies and yard and compressor setups to meet the needs of the system. As the winter progresses and as high demand days are reached, the operation of the compressor units within the Dawn yard will vary as storage pool delivery pressures decrease. Strategic configuration changes will take place throughout the season to optimize compressor efficiency and availability. The yard becomes increasingly complex as gas balances from plant to plant are managed.

Process control within the compressor plants and points of control within the Dawn yard header system is critical to the balance each plant needs to perform its desired function. Making yard configuration changes and horsepower changes during periods of high send out is not recommended, as it may be difficult or impossible to recover from any unexpected outage during heavy system loads.

The Dawn MCR not only manages the many storage and transmission gas inputs to the Dawn hub, but also controls the balance of the entire pipeline from Dawn to Parkway by instructing the plants a Lobo, Bright and Parkway in their operation. The Operations group at Dawn, along with the Gas Control and Capacity Planning group will forecast expected Dawn delivery volumes in advance and configure the yard and available compression to anticipate future line pack (virtual compression), compressor efficiencies and compressor pressures across the system. This system not only services our contract transmission customers but also feeds our gas distribution portion of our company; ultimately serving our over 3.7 million commercial, industrial and residential customers as well as supplying gas to the American North East all from a field in the middle of Lambton County, in the middle of gas transmission in North America.