Methane to Markets

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Overview of Pipeline Pumpdown and Natural Gas STAR Partner Company, TransCanada Experience

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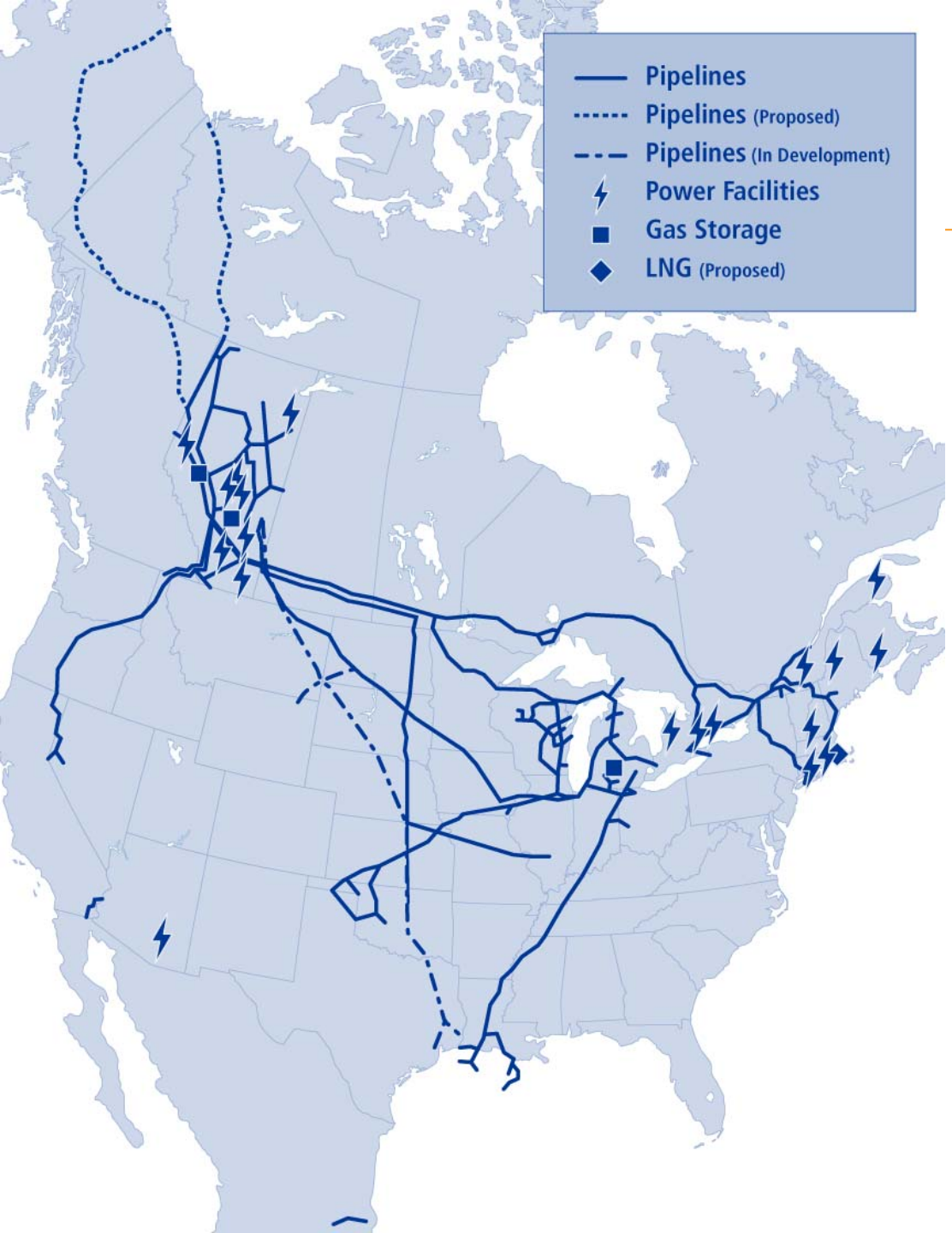
Agenda

- Background: Pipeline Pumpdown
- TransCanada Experience
  - Overview
  - Equipment Type and Process
  - Gas Savings and Fuel Consumption
  - Economics
- Summary



TransCanada Corporation (TSX/NYSE: TRP)

- **Gas Pipelines**
- 59,000 km wholly owned
- 7,800 km partially owned
- 250 Bcf of regulated natural gas storage capacity
- Average volume of 15 Bcf/d
- **Oil Pipelines**
- Keystone 1.1 million Bbl/d
- Expandable to 1.5 million Bbl/d
- **Energy**
- 19 power plants, 10,900 MW
- Diversified portfolio, primarily low-cost, base-load generation
- 120 Bcf of non-regulated natural gas storage capacity

Background: Pipeline Pumpdown

- Process in which gas is evacuated from a segment of pipeline about to undergo maintenance
  - Move gas to downstream in-service segment instead of blowing to atmosphere
- Most applicable to large pipelines operating at high pressures
- Use in-line compressors to pull down the pressure to minimum suction pressure
- Use portable compressor to pull down pressure further
- About 90 percent of gas previously vented is usually recoverable[1]
- Cost is often justified by value of gas savings

[1] EPA Lessons Learned Study

Overview: TransCanada Experience

- TransCanada found pipeline pumpdown to be economical for larger volume, higher pressure gas lines and planned maintenance activities
- Gas savings justified the purchase and operation of 8 portable compressors by TransCanada
  - Currently the company is seeking to acquire more
- Additional fuel required by portable and inline compressors during pumpdowns is less than 1 percent of the total gas savings per pumpdown
- Gas saved competes with throughput capacity to create trade-offs

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Overview: TransCanada Experience

- TransCanada typically performs approximately 30 pipeline pumpdowns per year
  - Exact number depends on amount of maintenance work and new pipeline tie-ins needed
- Most pipeline pumpdowns currently performed on TransCanada's Canadian high pressure pipelines
  - Beginning to find some opportunities at U.S. lines
- Depending on a variety of factors, the company is able to mobilize its equipment fairly quickly, typically requiring only a couple weeks notice

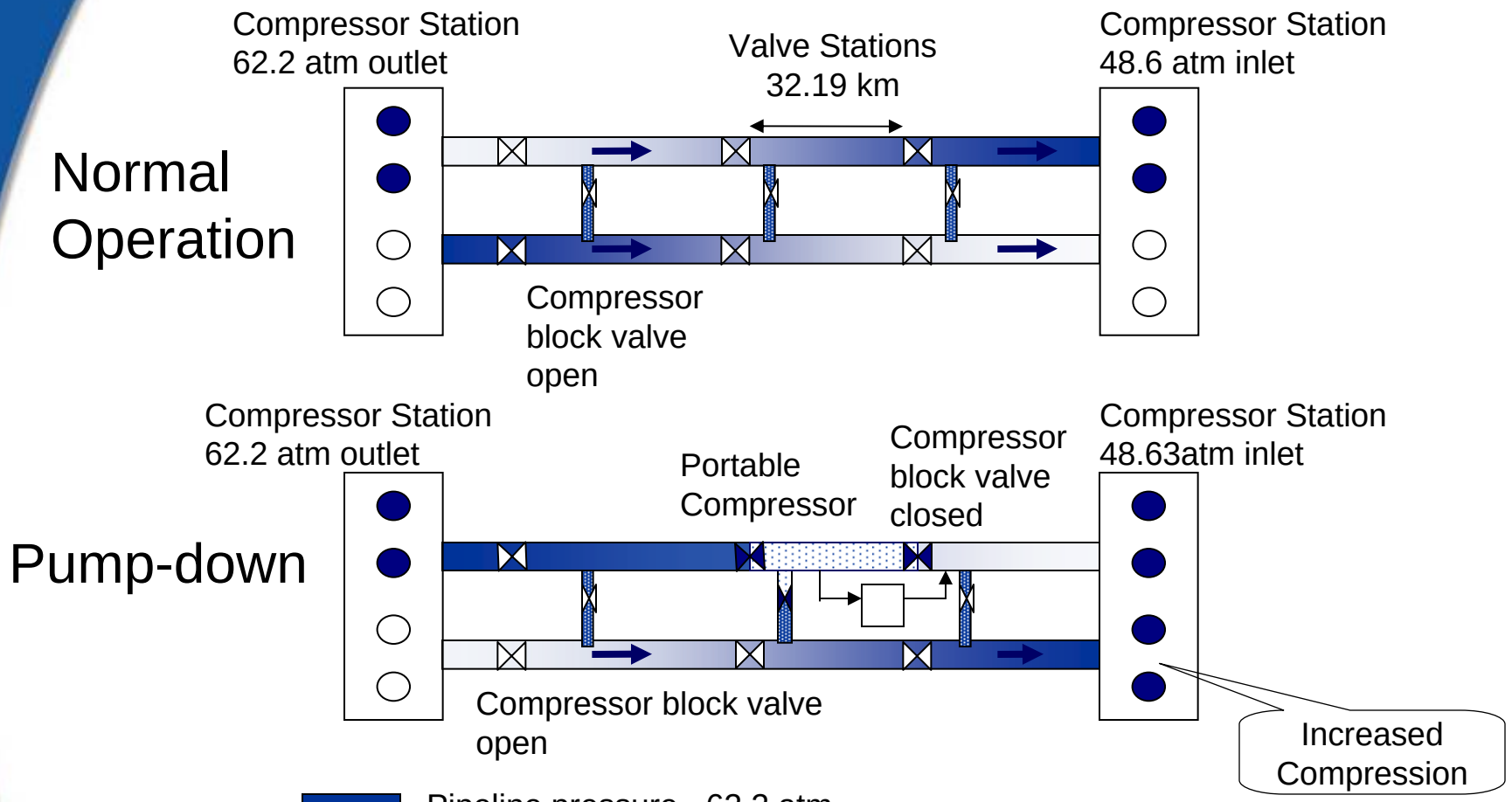
TransCanada Experience: Equipment Type and Process

- Currently the company owns 8 portable compressors
  - Mix of reciprocating and centrifugal units
  - Mix of 1 and 2 stage compression
  - Drivers range from 0.3 Megawatt (MW) to 4 MW
  - Mounted on road-ready trailers
- TransCanada rarely needs a third party to provide mobile compressor units

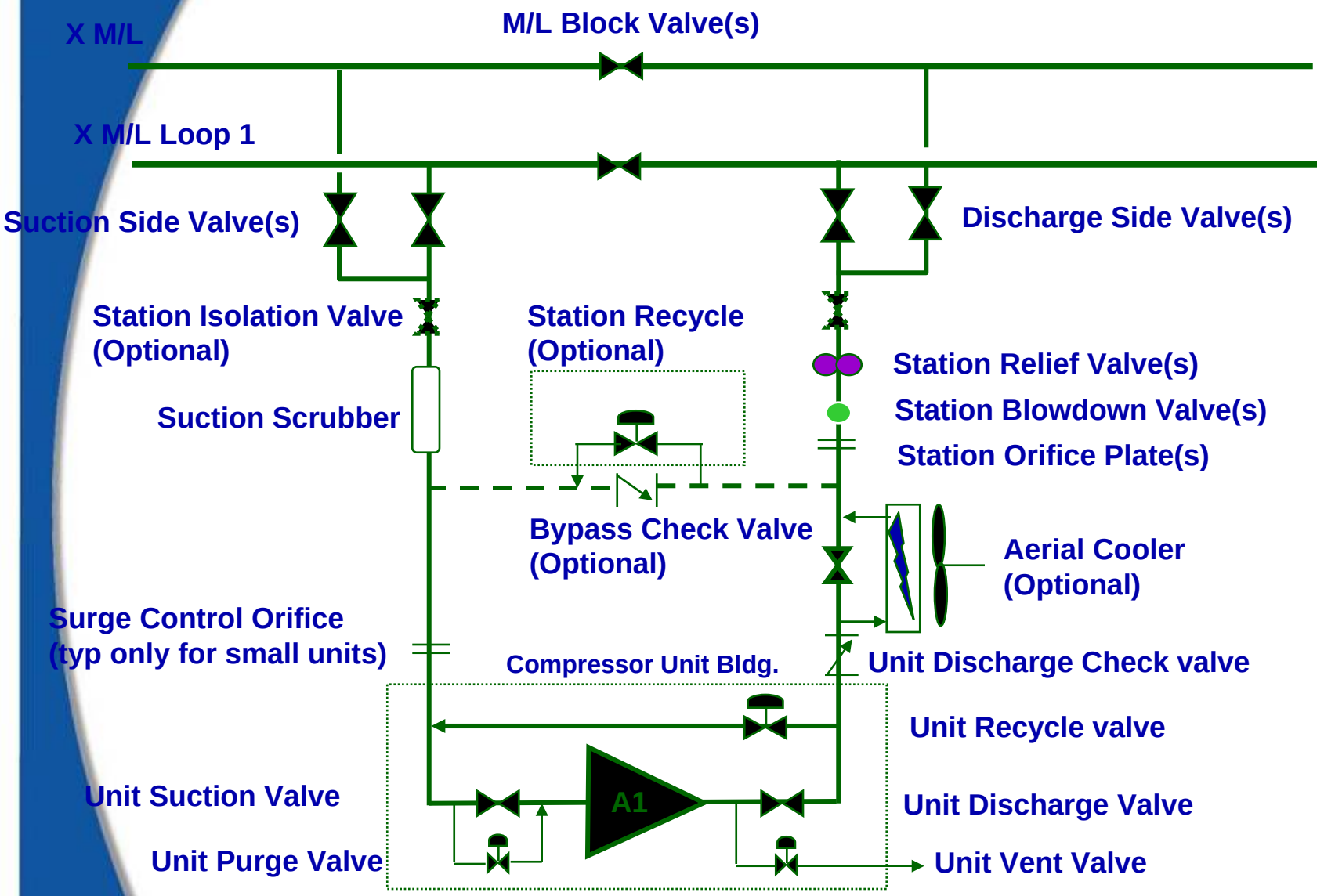
Equipment Type and Process

- A typical line for TransCanada is 106 centimeter (cm) diameter and 32 kilometers (km) to 48 km between block valves
- Most of its lines (constructed in the 1960s through 1990s) have maximum allowable operating pressure of 64.6 atmospheres (atm)
  - Line drawn down to 48.6 atm using inline compressors
  - Portable compressors used to pull the line pressure down to about 6.4 to 14.6 atm (dependent on portable compressor minimum suction pressure)

Equipment Type and Process



Compressor Station Layout



Equipment Type and Process

- Engineering calculations can estimate time required to conduct pipeline pumpdown. Variables:
  - Initial pressure of segment to be evacuated
  - Final pressure of evacuated segment
  - Discharge pressure of compressor
  - Compressor capacity curves
- Time required depends on capacity and minimum suction pressure of the specific compressor units
- For most of its large diameter pipelines, TransCanada found that pipe segment evacuations require approximately:
  - 2 hours for gas vented to atmosphere without pumpdown
  - 10 hours for pumpdowns, in-line and portable compressors plus minimal blowdown to atmosphere

Gas Savings Calculation

Gas savings	=	Total evacuated gas volume	-	Inline compr. incremental fuel gas	-	Portable compr. fuel gas

- **Total evacuated gas volume**: volume of gas drawn down from pipeline segment and pumped into operating pipeline
- **Inline compressor incremental fuel gas**: incremental fuel necessary to handle evacuated gas
- **Portable compressor fuel gas**: fuel used by portable compressor to draw line down from 48.6 atm until suction lost
  - Portable compressor connections are potential costs of pumpdowns - TransCanada already has these in place

Total Evacuated Gas Volume

Evacuated gas volume $= \frac{\pi D^2 L}{4RT}\left(P_i - P_f\right) \times MV_{ideal\,gas}$ **= 1,470,146 m³**

- D = TransCanada pipeline diameter, 106 cm
- L = Length of TransCanada pipeline segment, 32.18 km
- R = Gas constant
- T = Gas absolute temperature in pipeline segment, assumed 21.1°C
- P_i = TransCanada initial pipeline segment pressure, **62.2 atm**
- P_f = TransCanada final pipeline segment pressure, **12 atm**
- $MV_{idealgas}$ = molar volume of ideal gas (e.g. 22.4 Liters/mole)

- 1.40 million m^3 total gas evacuated

°C = degrees Celsius

Portable Compressor Portion of Gas Evacuated

Volume evacuated = $\frac{\pi D^2 L}{4RT}\left(P_i - P_f\right) \times MV_{ideal\,gas}$ = 1,067,041 m^3

- D = TransCanada pipeline diameter, 106 cm
- L = Length of TransCanada pipeline segment, 32.18 km
- R = Gas constant
- T = Gas absolute temperature in pipeline segment, assumed 21.1°C
- P_i = TransCanada initial pipeline segment pressure, **48.6 atm**
- P_f = TransCanada final pipeline segment pressure, **12.4 atm**
- $MV_{idealgas}$ = molar volume of ideal gas (e.g. 22.4 L/mole)

- 1.07 million m^3 evacuated by portable compressor in 10 hours
  - 2.56 million m^3 per day compression capacity

°C = degrees Celsius

Portable Compressor Fuel Gas

- The fuel gas required for **2.56 million m³** capacity for 10 hours can be estimated by:

$$FG = \frac{1.28 kW / thousand\ \text{m3} * 2{,}560\ thousand\ \text{m3} * 10 hours * 0.00341 MMBtu / kW - hr}{.036 MMBtu / m3 * 30\%}$$

= 10,346 m³ additional fuel gas

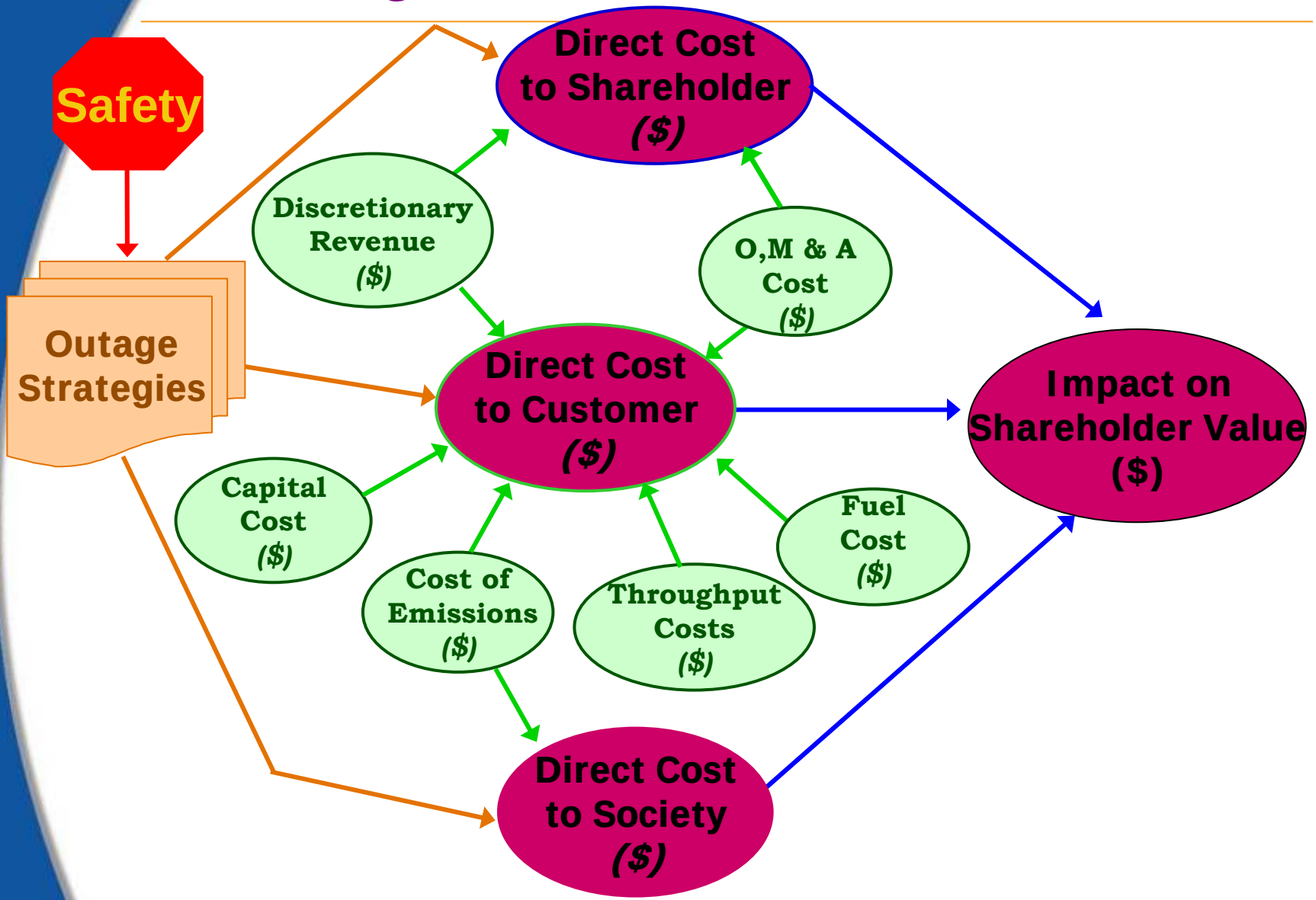
=0.70% of total gas evacuated

Compressor efficiency assumed to be 30%
Heat Content of Natural Gas assumed to be 1.02 MMBtu/Mcf

Inline Compressor Incremental Fuel Gas

- Additional inline capacity is required due to volume of gas injected by portable compressor evacuation
- At the same time, the capacity of the pipeline network is seriously constrained by having a portion of the line out of service
- Extra friction losses from the line being out of service often require considerable incremental inline compression horsepower

Outage Decision Model



TransCanada Experience: Economics

- Several variables affect the beneficial use of portable pumpdown compressors:
  - Additional fuel use from downstream compressors can be large
  - Fuel use by portable compressor
  - Extra manpower and maintenance issues
- TransCanada uses its "Outage Decision Model" to evaluate these variables and decide the economic feasibility of pumpdowns
- Other Considerations:
  - The time variable is very important, especially if service disruptions are a potential from the line being out of service
  - The extra fuel consumed by inline compression due to increased friction loss is usually the critical variable

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TransCanada Experience: Economics Summary

- The costs and gas savings from TransCanada compressor pumpdowns are summarized below:

Equipment/ Practice	$
Portable Compressor Fuel Gas used per Pumpdown	1,448
Inline Compressor Fuel Gas used per Pumpdown	442
Portable Compressor Capital Cost (69.05 atm, high flow)	3 to 6 million
Portable Compressor O&M Cost	5,000 to 30,000
Total Gas Evacuated	205,820
Labor and Transportation Cost	5,000 to 20,000
Total Natural Gas Savings	203,930

Cost of Natural Gas: $0.14/$m^3$

Source: Lessons Learned 2006

TransCanada Experience: Other Key Considerations

- TransCanada values its transit gas and fuel gas which influence pumpdown decisions
- TransCanada often has parallel lines, other operations may vary
- Running one line results in pumpdown fuel and higher fuel gas consumption at compressor stations
- Methane saved from pumpdowns will increase costs (increased fuel gas use, increased combustion emissions, portable compressor, labor) in other areas

Conclusion

- TransCanada found that pipeline pumpdown is a technically and economically feasible activity to reduce methane emissions from high pressure pipelines
  - Benefits justified purchase of 8 portable compressors
- Gas value saved per pumpdown: **U.S.$ 203,930** per pumpdown
- Total gas saved per year (assuming 30 example pumpdowns): **U.S.$ 6.1 million**