New Gas-Fired Generation
Pre-Feasibility-Level Infrastructure Requirements and Costs

1. Gas Supply and Transmission Infrastructure
Provided by Gas Transmission and Storage on 8-19-15

We have had several discussions lately about the relative costs of installing natural gas fired electric generation plants at a variety of locations within our service territory. We focused on three general locations to study – the Billings area, the Great Falls area, and the Butte/Anaconda area. You specifically asked me to give you an estimate of costs for the natural gas transmission facilities required, at each of these locations, to serve both a 50-megawatt and a 250-megawatt plant. You further supplied burn rates for various manufacturers' units, as shown below:

Turbine	Capacity (MW)	Heat Rate (Btu/kWh)	Hourly Gas Requirement at maximum capacity (MMBtu)	Yearly Gas Requirement at 85% Capacity Factor (MMBtu)
GE LMS 100	88.8	8,867	787	5,862,903
P & W FT 8	53	10,500	557	4,143,699
GE 7EA	149.7	11,286	1,690	12,580,123
GE 7FA.05	307.7	6,528	2,009	14,956,524
GE 7FA.05 DF	40.1	8,497	341	2,537,073
Wartsila 18V50SG	18.4	8,314	153	1,139,071

The results of this scoping study are detailed below. Since there are few details associated with this inquiry, I made several assumptions, as described below. I believe that the cost estimates being provided are conservative and could be considered as an "upper boundary" of actual costs. If, and when, final design criteria is selected for your project(s), a much better engineering estimate can be performed.

Assumptions Made:

1) ***There is no firm pipeline capacity available on the existing gas transmission system.*** For the purposes of this scoping study, I assumed that a new pipeline would have to be constructed from the gas source to the plant site. This is a critical assumption that results in a "worst case" requirement for gas transmission infrastructure.
2) ***That natural gas is available at the upstream supply source in the volumes desired.*** For the Billings area study, I assumed that the gas supply was available from Colorado Interstate Gas Company at our existing Grizzly connection point. For the other two studies, I assumed that the gas supply was available from TransCanada at our existing Carway connection point.
3) ***The 50-megawatt plant has a gas requirement of 557 mcfh.*** This is directly from the table above that indicates that a Pratt 7 Whitney FT 8 unit uses this volume at 53 mW. Obviously, the different units have various heat rates and fuel consumption, but for the purposes of this study, I used this unit because of its relatively high heat rate.
4) ***The 250-megawatt plant has a gas requirement of 1,632 mcfh.*** This was derived from the fuel consumption for the 308 mW GE unit as shown in the table above.
5) ***The minimum inlet pressure at the generating plant is 500 psig.***
6) ***The installed cost estimates for pipeline is $65,000 per inch-mile and for compression is $2500 per brake-horsepower.***

Cost Estimates:

Location	Billings		Great Falls		Butte/Anaconda	
Volume	**10 MMcfd**	**50 MMcfd**	**10 MMcfd**	**50 MMcfd**	**10 MMcfd**	**50 MMcfd**
Pipeline	$32.3M	$52.4M	$84.1M	$124.3M	$149.1M	$207.2M
Compressor	$3.0M	$15.0M	$3.0M	$9.0M	$9.0M	$9.0M
Total	**$35.3M**	**$67.4M**	**$87.1M**	**$133.3M**	**$158.1M**	**$216.2M**

Billings Area:

The study assumes that a 75-mile pipeline would have to be constructed to the Grizzly connection point with CIG and that a compressor station would need to be installed at that location. The current pipeline configuration from CIG to Billings is fully subscribed at this time. There may be a more cost effective option (the purchase of an existing decommissioned pipeline) that could be explored further should this project proceed.

Great Falls Area:

The study assumes that a 150-mile pipeline would have to be constructed to the Carway connection point with TransCanada and that a compressor station would need to be installed at that location. In all likelihood, it would be possible to reduce the amount of pipeline mileage required by strategically looping segments of the existing pipeline system to take advantage of the hydraulics already available in the existing system. This could be engineered in more detail in the future, if this location was ultimately chosen for the power plant.

Butte/Anaconda Areas:

Of the three areas studied, the Butte/Anaconda area would require the most gas transmission infrastructure to be built for firm gas capacity – simply because it is the furthest from the natural gas supply. The study assumes that 250-miles of pipeline would have to be constructed to the Carway connection point as well as compression there. Again, in all likelihood, it would be possible to reduce the amount of pipeline mileage required by strategically looping segments of the existing system. To give you a relative indication, we recently studied the feasibility of supplying a proposed 85 megawatt gas-fired electric generating station in the TIFID district west of Butte requiring firm gas transportation in the amount of 12 MMcfd. The gas transmission capital investments identified for this commitment was about $50M.

2. Electric Transmission Infrastructure

Provided by Transmission - Engineering Construction and Planning on 9-2-15

2A. Use Transmission Line unit cost estimates of:

$600,000/mile for 230 kV for new build

$300,000/mile for reconductor

2B. High-Level Study for New Gas-Fired Generation by Area
(sorted by planning preference)

Billings:

Steamplant 100 kV

- 250-300 MW of generation at 0.85-0.90 pf.
- Interconnection Facilities needed:
  - 100 kV terminal
    - 1 PCB
    - Breaker bay already available
- Mitigation needed to support 250-300 MW
  - Replace two current limiting 100 kV PCB (600 amps)
    - Steamplant 100-123 and Laurel Auto 100-124
  - Reconductor 3.1 miles of 100 kV line from 8th Street to Bellrock with high-temp 556 ACSS
  - Reconductor 4.7 miles of 100 kV line from Billings Meridan to Baseline with high-temp 556 ACSS
- Eliminates the following mitigation from current 15-year planning cycle with at least 200 MW of generation
  - A new 20-mile 230 kV line from Broadview to Shorey Rd (1800 amp capacity)
  - A new 40-50 MVAr synchronous condenser
  - A new 230 bus at Rimrock with 2-200 MVA 230/100 kV autos
    - Tap nearby Steamplant to Alkali Cr 230 kV line
    - Replaces 2 50+ year old 161/100 kV autos at Rimrock (removes the 161/100 kV tie)

Shorey Rd 230 kV

- 250-300 MW of generation at 0.85-0.90 pf.
- Interconnection Facilities needed:
  - 230 kV terminal
    - 1 PCB and 1 ABSW
    - 230 kV ring bus in breaker-and-half layout
    - Current design accommodates for easy addition
- No mitigation needed to support 250-300 MW
- Eliminates the following mitigation from current 15-year planning cycle
  - A new 20-mile 230 kV line from Broadview to Shorey Rd (1800 amp capacity)
  - A new 40-50 MVAr synchronous condenser

Butte:

ASiMI 161 kV

- 250-300 MW of generation at 0.85-0.90 pf.
- Interconnection Facilities needed:
  - Two 161 kV terminals (Interconnection off the cross-buses)
    - 2 PCB's and 4 ABSW's

  OR
  - Additional bus for breaker bay need
    - 2 PCB's and 5 ABSW's
- No mitigation needed to support 250-300 MW

Mill Creek 230 kV

- 250-300 MW of generation at 0.85-0.90 pf.
- Interconnection Facilities needed:
    - 230 kV terminal
        - Additional bus for breaker bay needed
        - 2 PCB's and 4-6 ABSW's
- No mitigation needed to support 250-300 MW

Great Falls:

Great Falls 230 kV Switchyard/Highwood Switchyard

- 50 MW of generation at 0.85-0.90 pf.
- Assumes withdraw of Southern MT 50 MW of Transmission Service (Great Falls to System)
- Interconnection Facilities needed:
    - 230 kV terminal
        - 230 kV Bay Available
        - 1 PCB and 1 ABSW
- Mitigation needed to support 50 MW
    - Reconductor 2.7 miles of 100 kV line from GF Switchyard to Riverview to high temp 336 ACSS
    - Reconductor 1.4 miles of 100 kV line from MT Refining to GF City to high temp 336 ACSS
    - Reconductor 4.4 miles of 100 kV line from Riverview to GF Northwest to high temp 336 ACSS
- Mitigation needed to support 250-300 MW
    - New 150 mile 230 kV line and substation facilities

One note for the Great Falls area is that it may not be feasible to add any generation. There is currently 100 MW of ATC available of the 495 MW TTC of SOGF southbound path. With system growth the TTC is likely to decline in the future by the time a plant is built and in-service and will likely lead to additional substantial mitigation needed by the end of the plants life.

3. Electric Transmission Infrastructure Update
Provided by Gas Transmission and Storage on 10-14-15

Here are the results from Electric Transmission Planning regarding interconnecting 5- 50 MW plants at various locations identified by GTS. The Shelby and Cut Bank interconnections would require interconnections with WAPA or significant line construction. Billings and Mill Creek remain the preferred locations.

A high level unit cost for reconductors is $400,000/ mile for 100 kV.
Sub Ops will need to provide high level estimates for substation interconnection costs.

Here is an update summary for the high-level study for new 50 MW gas fired generation at the following locations: Mill Creek, Silver-Bow (ASiMi), Steamplant Switchyard, Great Falls 230, Highwood, Assiniboine (Havre), Shelby, Cut Bank, Warren (Bridger Auto).

Billings:

Steamplant 100 kV:

- Easily support 50 MW.
- Interconnection Facilities needed:
  - 100 kV terminal
    - 1 PCB
    - Breaker bay already available
- No Mitigation needed to support 50 MW.

Bridger Auto 100 kV:

- Can support 50 MW
- Interconnection Facilities:
  - Rebuild of the Bridger Auto 100 kV bus. Current design does not allow easy terminal addition. May consider rebuild of the 50 kV bus as well. 50 kV bus is a straight bus, with a bus fault resulting in complete loss of the 50 kV bus.
  - 10-15 mile 100 kV generator lead line needed from the Warren site to Bridger Auto
- No additional mitigation needed to support 50 MW.
- Provides a solid 3rd source for the Cenex load at current levels.

Butte:

Mill Creek 230 kV:

- Easily support 50 MW.
  - 230 kV terminal
    - Additional bus for breaker bay needed
    - 2 PCB's and 4-6 ABSW's
- No Mitigation needed to support 50 MW.

ASiMi 161 kV:

- Easily support 50 MW.
- Interconnection Facilities same as below.
- No Mitigation needed to support 50 MW.

Great Falls:

Great Falls 230 kV Switchyard/Highwood Switchyard

Analysis remains the same as below.

- Interconnection Facilities needed:
  - 230 kV terminal
    - 230 kV Bay Available
    - 1 PCB and 1 ABSW
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- Mitigation needed to support 50 MW
  - Reconductor 2.7 miles of 100 kV line from GF Switchyard to Riverview to high temp 336 ACSS
  - Reconductor 1.4 miles of 100 kV line from MT Refining to GF City to high temp 336 ACSS
  - Reconductor 4.4 miles of 100 kV line from Riverview to GF Northwest to high temp 336 ACSS
- Mitigation needed to support more than 50 MW within Great Falls Division
  - New 150 mile 230 kV line and substation facilities

Havre/Assiniboine 69 kV or 161 kV

- Interconnection Facilities needed:
  - A rebuild of both the 161 kV and 69 kV buses will be needed.
- Mitigation needed to support 50 MW
  - Reconductor 2.7 miles of 100 kV line from GF Switchyard to Riverview to high temp 336 ACSS
  - Reconductor 1.4 miles of 100 kV line from MT Refining to GF City to high temp 336 ACSS
  - Reconductor 4.4 miles of 100 kV line from Riverview to GF Northwest to high temp 336 ACSS
- Mitigation needed to support more than 50 MW within Great Falls Division
  - New 150 mile 230 kV line and substation facilities

Shelby 115 kV or 230 kV (WAPA)

- Interconnection Facilities needed:
  - An interconnection with WAPA will be needed. WAPA to determine interconnection needs and costs.
- Mitigation needed to support 50 MW
  - Reconductor 2.7 miles of 100 kV line from GF Switchyard to Riverview to high temp 336 ACSS
  - Reconductor 1.4 miles of 100 kV line from MT Refining to GF City to high temp 336 ACSS
  - Reconductor 4.4 miles of 100 kV line from Riverview to GF Northwest to high temp 336 ACSS
- Mitigation needed to support more than 50 MW within Great Falls Division
  - New 150 mile 230 kV line and substation facilities
- Generation at this location will displace generation by Glacier Wind 1 & 2 (205MW, non-firm)

Cut Bank Area (115 kV)

- Interconnection Facilities needed:
  - A new 115 kV interconnection substation.
- Mitigation needed to support 50 MW
  - Reconductor 2.7 miles of 100 kV line from GF Switchyard to Riverview to high temp 336 ACSS
  - Reconductor 1.4 miles of 100 kV line from MT Refining to GF City to high temp 336 ACSS
  - Reconductor 4.4 miles of 100 kV line from Riverview to GF Northwest to high temp 336 ACSS
- Mitigation needed to support more than 50 MW within Great Falls Division
  - New 150 mile 230 kV line and substation facilities
- Generation at this location will displace generation by Glacier Wind 1 & 2 (205MW, non-firm)

One note for the Great Falls area/division is that it may not be feasible to add any generation. There is currently 100 MW of available transmission capacity (ATC) of the 495 MW total transmission capacity (TTC) of South of Great Falls (SOGF) southbound path. With system growth the TTC is likely to decline in the future by the time a plant is built and in-service and will likely lead to additional substantial mitigation needed by the end of the plants life.

All the locations listed above in the Great Falls area/division are located North of the SOGF transmission path. Anything above 50 MW total for Great Falls, Havre, Cut Bank, Shelby will require a new 150 mile 230 kV line and substation facilities. This was estimated previously in GIA studies (2009-2010) at over $100M.

Summary:

- A larger (200-300 MW) plant at the Billings Steamplant Switchyard is preferred by Electric Transmission Planning, as it eliminates the need for costly planned system upgrades.
- Generation in the Butte/Anaconda areas can be easily interconnected.
- Generation within Great Falls Division will require costly mitigation.

4. Electric Transmission Interconnection

Provided by Transmission – Substation Operations on 10-21-15.

The following are the Level 1 estimates for these interconnects. These are very high level estimates. Much more detail is necessary to give a credible Level 1 estimate.

Billings SteamPlant
Substation = $900,000
Relay = $300,000

Bridger Auto
Substation = $4,000,000
Relay = $1,000,000

Mill Creek
Substation = $2,000,000
Relay = $1,000,000

Aismi
Substation = $2,000,000
Relay = $1,000,000

Great Fall 230
Substation = $1,500,000
Relay = $800,000

Havre Assiniboine
Substation = $6,000,000
Relay = $2,000,000

The Billings SteamPlant estimate is applicable to both 250 and 50MW interconnects.
Cut Bank and Shelby are WAPA subs and the estimates need to come from them.

5. Gas Supply and Transmission Infrastructure Cost Update (Replacement for Colstrip)

Provided by Gas Transmission and Storage on 11-2-15

Costs for GTS to install facilities to serve various gas-fired generating scenarios. All studies are in today's dollars. The five locations for the 50 MW plants are Billings, Butte, Great Falls, Havre, and Warren. These studies are a refinement to the August 19 study as shown (above).

Size	Location	$ (Millions)
250 mW	Corette	$ 47.50
250 mW	REC Silicon	$ 146.37
250 mW	Great Falls	$ 110.88
5- 50 mW	Various	$ 99.35

6. Gas Supply and Transmission - External Supply

Provided by Transmission – Gas and Storage on 12-15-15

The study for gas supply only includes the capital costs of improving the NorthWestern energy system. Upstream of our system, it is likely that Kinder Morgan (CIG) would also have capital requirements to upgrade their system to provide the natural gas to us, if it is indeed available.