

Analysis of Benefits of Natural Gas Replacement for Boswell Unit 4

**Dr. Ranajit (Ron) Sahu
Consultant**

Introduction

From a review of the record, Minnesota Power (“MP”) considered natural gas combined cycle gas units as alternatives to the proposed retrofit of Boswell Unit 4 (“BEC4”). In my opinion, however, the environmental and health benefits of the natural gas alternatives were not fully evaluated in any of the documents or by any of the agencies or by MP to date.

Since MP has not conducted such an evaluation and since the various agencies (the MPCA, the DOC, the PUC, etc.) appear not to have done so either, I provide in this report my technical analysis of the type of natural gas combined cycle natural gas plant that MP should have fully evaluated as a replacement for BEC4, the associated emissions profile of such a plant, and the benefits of its pollutant reductions. As I demonstrate in this statement, the much greater cost benefits of avoided pollution from a combined cycle natural gas plant replacement for BEC4 are very clear.

A Proper Natural Gas Replacement Option For BEC4 Has Numerous Advantages

It is without question that the natural gas combined cycle plant of the size of BEC4 (i.e., in the range of 400 to 500 MW) is technically feasible. Nor is there any question that such a replacement would be environmentally beneficial, since natural gas emissions would be far smaller than emissions from BEC4.¹ This includes emissions of mercury, which would be

¹ In fact, MP reaffirms this itself when it states that

“Replacing BEC4 with a natural gas resource or combination of resources is an alternative to installing new emission controls, since natural gas generation results in emission of less mercury, SO₂, PM and other pollutants....” **See Letter to Mr. Haar of the MPUC dated August 31, 2012**, “In the Matter of Minnesota Power’s Boswell Energy Center Unit 4 Environmental Retrofit Project - Mercury Emission Reduction Plan Petition, Docket No. E015/M-12-920,” (hereafter “Plan Petition”), p. 67.

MP also notes that

“[T]here are other benefits that natural gas resources like a combined cycle or reciprocating engine can bring to Minnesota Power customers. Compared to a large baseload coal resource, like BEC4, a combined cycle or reciprocating engine has more flexible operation and can follow wind generation better than a large coal unit, especially the reciprocating engine alternative. The

essentially zero, thereby meeting and exceeding the MERA goal. It would also reduce emissions of particulate matter, metals, sulfur dioxide, nitrogen oxides, carbon monoxide, acid gases, other organic and semi-organic hazardous air pollutants, and greenhouse gases. Not only would emissions from the power plant stack be reduced. Fugitive particulate matter from coal-handling operations at the plant and coal-dust emissions from coal transport to the plant would also be eliminated, in addition to propulsion-driven emissions from truck and rail.

Just considering the emissions from the power plant stack and neglecting fugitive emissions for now, Table 1 below shows the emission rates than can be expected from a natural gas unit.

Table 1 - Annual Emissions from a Roughly 400 MW Combined Cycle Gas Plant [0,1,2,3]				
<i>Pollutant</i>	<i>Basis</i>	<i>Units</i>	<i>Source</i>	<i>Max. Annual Emissions (tons/yr)</i>
PM10/PM2.5	9.8	lb/hr	[0]	39.8
NOx	20.2	lb/hr	[0]	82.1
SO2	3.40E-03	lb/MMBtu	[4]	34.6
CO	12.3	lb/hr	[0]	50.0
VOC	2.10E-03	lb/MMBtu	[4]	21.3
Lead	0		[4]	0
Fluoride	0		-	0
H2SO4	4.9	lb/hr	[0]	19.9
CO2e	1000	lb/MWh	[5]	1.8E+06
Hg	0		-	0

[0] From: Pioneer Valley Energy Center PSD Permit, Westfield, MA. EPA Final PSD Permit No.: 052-042-MA15

[1] Neglecting emissions from support sources such as the auxiliary boiler, emergency generator, fire pump, and cooling tower

[2] Neglecting emissions during startup and shutdown

[3] Size of reference unit = 431 MW
2500 MMBtu/hr

[4] AP-42, Section 3.1, Stationary Gas Turbines

[5] Survey of Combined Cycle Combustion Turbine Greenhouse Gas Emission Rates, WA. State Dept. of Commerce, Nov. 2012

combined cycle is also a more efficient resource, meaning it takes less fuel than BEC4 to generate 1 MWh of energy. The greater fuel efficiency of a combined cycle equates to less fuel consumption by volume and less emissions such as mercury, SO2, NOx and carbon when compared to a large coal unit such as BEC4.” See Appendix A to the Plan Petition, p. 15.

Finally, in its 2013 IRP MP correctly states that

“[A]n existing coal unit emits just over one ton of CO2e per MWh; a natural gas unit, approximately one-half ton CO2e per MWh... Minnesota Power’s 2013 Integrated Resource Plan (IRP), Appendix E, p. 3.

Based on the emissions shown in Table 1, it is also without question that the natural gas combined cycle plant would automatically meet not only MERA but also the requirements of the Federal MATS rule.² The benefits of replacing BEC4 with a natural gas plant are also much greater than proceeding with MP's proposed improvement project. MPCA has estimated the benefits of reduced emissions in its review of the BEC4 Retrofit project.³ I will use the results from MPCA's work and provide an approximate sense of the benefits of replacing BEC4 with a natural gas unit. For reasons that I will describe below, my estimate of the benefits is underestimated compared to the benefits analysis discussed in the MPCA report.

Table 2 below shows the emission rates and maximum annual emissions⁴ for SO₂, PM, and mercury, just from BEC4, under three scenarios: using emission rates for 2011; using emission rates after installation of the BEC4 Project, and if a natural gas unit of the same size is installed, replacing BEC4.

Table 2 - Comparison of Emission Rates Per Table 2 of PCA Analysis and Including Natural Gas						
BEC4 Capacity	5615	MMBtu/hr	[1]			
	Emission Rates			Maximum Annual Emissions		
	SO ₂ (lb/MMBtu)	PM (lb/MMBtu)	Mercury (lb/TBtu)	SO ₂ (tpy)	PM (tpy)	Mercury (lb/yr)
BEC4 2011 Performance [1]	0.049	0.060	5.280	1205.1	1475.6	259.7
BEC4, After Proposed Project [1]	0.030	0.012	0.600	737.8	295.1	29.5
Natural Gas Replacement [Table 1]	3.40E-03	0.00392	0	83.6	96.4	0
Emissions Reductions Due to BEC4 Project				467.3	1180.5	230.2
Emissions Reductions Due to Gas Replacement				1121.5	1379.2	259.7
Increase in Emissions Reductions Due to Gas				140%	17%	13%

[1] Review of MP's BEC4 Improvement Plan, MPCA, March 1, 2013, Table 2

² Compare the emission rates in Table 1, for example, with those shown for SO₂, PM and Mercury in Table 2 of PCA's March 1, 2013 Report reviewing MP's BEC4 Improvement Plan.

³ Review of MP's BEC4 Improvement Plan, MPCA, March 1, 2013.

⁴ I note that the MPCA analysis, without explanation, does not use maximum annual unit performance (i.e., heat input) for BEC4 in its estimate of emissions reduction and resulting benefits – instead, using 2011 actual heat input levels. See, for example, Table 1 of the MPCA report. Since the operating permit for BEC4 does not restrict operations at levels greater than what was accomplished in 2011, I believe it is appropriate to use maximum annual heat input values, as I have done in Table 2.

In its benefits analysis, the MPCA concludes that the overall annual benefit of the BEC4 Project, due to avoided mortality alone from just SO₂ and PM reductions will be in the range of \$14 to \$31 million.⁵ In addition, MPCA estimates that the additional annual benefits due to mercury reduction would be in the range of \$370,000 to \$19 million.⁶ MPCA estimated these benefits using the emission reduction values of 414 tons/year for SO₂, 1016 tons/year for PM (for a combined total annual reduction of 1430 tons/year for SO₂ and PM), and 202 lb/year for mercury.⁷

Table 2 above shows that the maximum annual emissions benefit for a natural gas replacement option. It would result in a reduction of approximately 1121.5 tons/year for SO₂, 1379.2 tons/year for PM (for a combined total annual reduction of 2500.7 tons/year), and 260 lb/year for mercury.

Since the MPCA benefits analysis does not break out the benefits in reduced mortality separately for SO₂ and PM, I have scaled MPCA's benefits using the total SO₂ plus PM annual emissions reductions and also the increase in mercury reductions. Using the values above, since the total SO₂ and PM annual emissions reductions for the natural gas replacement option are approximately 2500.7 tons/year (as opposed to the MPCA's BEC4 improvement reduction of 1430 tons/year), the range of benefits just due to these two pollutants alone rises to \$24.5 to \$54 million per year. Similarly, the scaled benefits due to mercury reduction rises to the range of approximately \$475,000 to \$24.4 million using the reduction due to the natural gas option of 260 lb/year as opposed to the MPCA assumption of a 202 lb/year reduction due to the BEC4 Project. Combining the SO₂ plus PM and the mercury benefits, I arrive at a range of approximately \$25 to \$78 million per year for the natural gas option.

My analysis above only focuses on SO₂, PM, and mercury. Of course, as noted in discussion (and Table 1) above, a natural gas replacement will not only reduce the emissions of these three pollutants but it will also reduce emissions of all of the other pollutants in Table 1 above, including NO_x, CO, VOCs, lead, fluorides, sulfuric acid mist, and greenhouse gases. Since the MPCA benefits analysis (and my scaled analysis therefrom) only quantifies benefits due to SO₂,

⁵ Review of MP's BEC4 Improvement Plan, MPCA, March 1, 2013, Table 9.

⁶ Review of MP's BEC4 Improvement Plan, MPCA, March 1, 2013, see discussion on p. 26.

⁷ Review of MP's BEC4 Improvement Plan, MPCA, March 1, 2013, Table 7.

PM, and mercury, it is clear that benefits from a natural gas replacement option will be considerably greater than those just due to estimated reductions from these three pollutants.

Greenhouse gas emissions are an important example of emissions that MPCA would have to have considered with a natural gas plant option; the agency would need to have quantified benefit of reduced carbon dioxide emissions associated with a natural gas replacement of BEC4. Using the recently updated Federal Social Cost of Carbon estimate (3% discount, 95th percentile, as recommended), the avoided cost to society of CO2 emissions begins at \$173,607,273 (2007) million in 2016, rising to \$305,803,686 million (2007) in 2040. Cumulatively, this is nearly \$6 billion in cost impacts due to the high carbon emissions from a retrofit BEC4, all avoided with a natural gas plant replacement.

TABLE 3 Avoided Costs of CO2 Emissions -- Natural Gas Combined Cycle Replacement		
	Size of Power Plant =	400
	Annual Maximum MWh =	3504000
	Avoided CO2 Emissions Due to Natural Gas =	1000
	=	1592727
Year	Social Cost of Carbon[1]	Avoided Cost of CO2 Emissions
	(in 2007 \$/mton)	(in 2007 \$/yr)
2016	109	173,607,273
2017	109	173,607,273
2018	109	173,607,273
2019	109	173,607,273
2020	129	205,461,818
2021	129	205,461,818
2022	129	205,461,818
2023	129	205,461,818
2024	129	205,461,818
2025	144	229,352,727
2026	144	229,352,727
2027	144	229,352,727
2028	144	229,352,727
2029	144	229,352,727
2030	159	253,243,636
2031	159	253,243,636
2032	159	253,243,636
2033	159	253,243,636
2034	159	253,243,636
2035	176	280,320,000
2036	176	280,320,000
2037	176	280,320,000
2038	176	280,320,000
2039	176	280,320,000
2040	192	305,803,636
Cumulative 2016-2040 (in 2007 \$)		5,842,123,636

[1] Taken from
 Technical Support Document:
 Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866, May 2013.
http://www.whitehouse.gov/sites/default/files/omb/inforeg/social_cost_of_carbon_for_ria_2013_update.pdf

In addition, as I noted earlier, PM reductions will occur not just from the stack as assumed in all of the estimates above but also from reductions in fugitive PM emissions if BEC4 is replaced

with a natural gas plant. Clearly, the station will not handle as much coal and, as a result, all of the fugitive PM emissions due to coal transportation to BEC4, and all of the coal handling PM fugitive emissions (such as at the coal piles, the various conveyers that move the coal around, etc.) will also be proportionally reduced. My analysis does not include these additional benefits.

Finally, the operating costs of a natural gas combined cycle plant, including fuel and other operating costs are significantly lower than the corresponding operating costs of any coal unit, including BEC4. Thus, the replacement gas plant would likely be dispatched more and would be better utilized than BEC4 into the future.

Against all of the advantages of a natural gas alternative discussed above, no reason stated or implied in the record by MP or the agencies, justifies the reluctance to require analysis of the natural gas option. The MPCA's position that it could not possibly evaluate a gas option because it could not analyze the environmental impact without knowing where such a replacement gas option would be located, is inappropriate.⁸ Nothing prevented the MPCA from making the

⁸ See testimony of Mr. Kohlasch of the MPCA before the MPUC at the June 6, 2013 Hearing, relevant portions of which are reproduced below.

“MR. KOHLASCH:We included all benefits that would result from the multi-pollutant reduction strategy that was put forth in the plan by Minnesota Power. And that the cost drivers for the benefits are driven because of the particulate matter reductions that we'll be seeing by this plan.

I want to also highlight our thinking on why we did not do an environmental assessment of the natural gas alternatives provided.....And we looked back to the Department of Commerce's findings for the retirement of Boswell 4 and replacement with natural gas as not being a cost-effective option. In our light of looking at that, those natural gas retirement and replacement alternatives were not realistic. Also, when we looked at the details of those alternatives as presented, they were not tangible. They did not provide us with enough information on exactly what kind of power plant, where it would be, its emission rates, its emissions.....When we looked at the information that was provided, the finding from the Department of Commerce that retirement of Boswell 4 and replacement with natural gas had already been determined as not cost-effective, that is why we did not continue on with the environmental assessment as required....” June 6 Hearing Transcript, p. 33-34.

“COMMISSIONER O'BRIEN: You said that you looked at what the Department of Commerce did with respect to a gas plant. Did you look critically at that? Did you examine their cost assumptions as part of your charge to evaluate options?

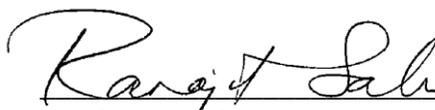
MR. KOHLASCH: We did not because the kind of cost evaluation is the traditional purview and authority of the Department of Commerce when looking at the cost-effectiveness. And when we

assumption (and then allowing Minnesota Power to suggest alternative locations, if so desired) that the replacement plant would be located at the same location as BEC4, namely at the BEC site itself. Regardless of where the replacement gas unit would be located, there would be significant emissions reductions at BEC4 itself with such a replacement, since emissions of all pollutants (including particulate matter and mercury, which drive the health benefits in MPCA's analysis to date) attributable to BEC4 would become zero at the BEC4.

Conclusion

In conclusion, it is clear that the current record is exceedingly deficient because it lacks a transparent analysis of a combined cycle natural gas replacement option for BEC4, to be located at the BEC and/or any alternative location of MP's choice so that all of the agencies and the public have a chance to properly review and assess this option.

Dated: November 25, 2013



Dr. Ranajit Sahu
Consultant to Environmental Intervenors

looked at the costs that were presented, they were -- for the natural gas they were higher than the cost to retrofit and they were bolstered by the Department of Commerce's finding." June 6, 2013 Hearing Transcript, p. 38.

"Now another question. Does the agency have the capacity to do a 216B.684 assessment on a gas plant that a utility does not want to build?"

MR. KOHLASCH: No. And that is essentially the situation that was presented with us because we do not have enough information in alternatives on a natural gas plant at this point in time to do the environmental assessment as required. We would need more information about the details about that facility, including its size, its type of operation, where it's going to be will be critically important on the environmental analysis. Because as has been discussed in general with us, the location of a replacement natural gas facility may not be in Minnesota, it may be in another state, which means we'll have to be analyzing for the environmental costs that will be borne by someone else receiving a new natural gas plant in comparison to the benefits received by retiring Boswell 4. Now, we would need much more detail from Minnesota Power on a viable, tangible alternative for a natural gas plant for us to do an analysis." June 6, 2013 Hearing Transcript, p. 39.

"MR. KOHLASCH: Madam Chair and Commissioner O'Brien, we do use that authority to ask for additional information. However, in this case, because of the status of a decided-upon IRP that had indicated that Boswell 4 should remain as a coal-fired power plant, we did not see it in our authority to tell Minnesota Power to go back and produce a specific tangible natural gas alternative plant that goes against what we understood was in the IRP." June 6, 2013 Hearing Transcript, p. 61-62.