Misuse of Integrated Planning Model as an assessment tool in the Tongue River Railroad DEIS

A Report Prepared for the

Northern Plains Resource Council

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Foreword

In this report, the authors do not address the likelihood of the construction of the proposed Tongue River Railroad nor are we attempting to address whether the mines that the proposed railroad will serve will be built. Rather, we address the validity of the basis for the Surface Transportation Board's Office of Environmental Assessment's analysis of the environmental impacts of the proposed railroad and induced mines. All assumptions of the existence of the potential railroad as well as the potential mines induced by the railroad are constructs of the Office of Environmental Assessment as is the assumption of an expansion of coal shipping ports in the Pacific Northwest.

I. Introduction

In the Draft Environmental Impact Statement (DEIS) for the Tongue River Railroad (TRR), the Surface Transportation Board's Office of Environmental Analysis (OEA) uses the Integrated Planning Model (IPM) to "*assess likely coal production, rail traffic, and distribution patterns resulting from development of the Tongue River Railroad*"[1] as well as "*to forecast CO2 emissions from the combustion of Tongue River, U.S., and global coal.*" In this report, we examine the IPM and how it was implemented by the OEA.

It is important to understand the IPM is a *tool* designed for a specific purpose. As with most tools designed for a specific purpose, there is some flexibility in how the tool can be used to achieve a desired result. This flexibility in implementation can result in a model output that does not account for key factors in the system being modeled.

II. Background on IPM

The IPM is a proprietary model developed by ICF International (originally Inner City Fund) to support government and industry analysis of the U.S. and global power sector. The IPM is a linear programming (LP) model that employs commercial grade LP solvers to minimize an objective function while adhering to a series of constraints and decision variables; this is more succinctly referred to as optimization. Specifically, the IPM calculates the mix of energy generation and transmission that meets a constant electrical demand at the lowest total cost while adhering to physical and regulatory limits. The IPM constructs a sophisticated representation of the supply side of the energy economy[2] for the United States with international fuel trading also considered. It incorporates representations of fuel extraction, transportation, and different sources of electrical generation into the model. According to the OEA, IPM is used by 18 private

[1] Tongue River DEIS Appendix C: p.C.5-1.

[2] The term energy economy encompasses all of the portions of the economy that relate to the generation or consumption of energy. The energy economy can be divided into two separate categories: the supply side of the energy economy and the demand side of the energy economy. The supply side encompasses all parts of the energy economy that are involved with the production and distribution of energy including extraction (i.e. coal mining, oil extraction, natural gas extraction, etc.), generation, and distribution of both physical commodities such as coal and oil as well as transmission of electricity. The demand side of the energy economy encompasses all parts of the energy economy that are involved with the consumption of energy including direct fuel consumption (i.e. fuel used in electric generation and transportation or gas used in heating, etc.) as well as the consumption of electricity by the residential, commercial, and industrial sectors.

sector entities,[3] which are all energy generation/transmission corporations, and at least 5 public sector entities.[4]

The IPM is used in analyses of many types of problems related to the supply side of the energy economy; however, analyzing the environmental impact of the proposed TRR is a misuse of the model because the purpose of the TRR is to serve the new coal mines which would be accessed by the TRR (called Tongue River Coal in the DEIS). The introduction of new coal mines assumes that the coal from the new mines is competitive. By modeling the addition of Tongue River coal to the market, the OEA has affected the demand side of the energy economy. However, the IPM cannot account for changes in the demand side of the economy; this constitutes a misuse of the IPM.

Publicly available documentation of the IPM is limited; the most thorough publicly available description of the model is published by the U.S. Environmental Protection Agency (EPA). The EPA uses the IPM in analysis of regulations and legislative proposals.[5] The IPM works well for these analyses because the IPM represents the supply side of the energy economy with a relatively high degree of geographic detail. This high degree of geographic detail results in a precise analysis of the effects that federal as well as local regulations may have on factors within the energy economy such as the price of energy or the mix of energy sources needed to meet a specified amount of demand. In its most recent description of how it uses the IPM, the EPA states that

> "*Electricity demand projections are input at the model region level in IPM. The 22 NEMS [National Energy Modeling System] regions level electricity demand from AEO [Annual Energy Outlook] 2015 is downscaled to 64 EPA Base Case v5.15 IPM regions.*"[6]

In other words, total electric demand is derived from the NEMS analysis of the energy economy, and is a constant. This methodology assumes zero price elasticity of demand.

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[3] Private sector users include PEPCO, Entergy, Exelon, Tucson Electric Power, Florida Power and Light (FPL), Dominion, NRG, Delmarva Power, Southwestern Electric Power Company, Calpine, APS, Duke Energy, American Electric Power, Otter Tail Power Company, Xcel Energy, Dogwood Energy, Peabody Energy, and Dynegy.

[4] Public sector users include U.S. Environmental Protection Agency, State public service commissions, Environment Canada, the European Union, and the Natural Resources Defense Council.

[5] EPA Power Sector Modeling web page accessed on 9/9/15 at: http://www.epa.gov/powersectormodeling/ . Starting 10/1/15 the page will be hosted at: http://www.epa.gov/airmarkets/powersectormodeling.html.

[6] EPA Base Case v.5.15 Using IPM Incremental Documentation, August 2015.

III. Electricity prices and the response of consumers: elasticity of demand

When determining the impacts of regulatory decisions that influence the access to coal for mining such as the proposed TRR DEIS, one of the main economic considerations that should be modeled is the price elasticity of demand.[7] Here, price elasticity of demand specifically refers to the relationship between electricity prices and consumer's electric consumption decisions. This relationship is a negative feedback loop.[8] For example, if the TRR is approved, then delivered coal prices could go down, which decreases the price of electricity. When the price of electricity decreases, end use consumers increase the amount of electricity that they use which increases demand for electricity which, in turn, causes more generators to come on-line or increase their output. The increased demand for electricity means that more fuel (coal, natural gas, etc.) is consumed and more fuel is extracted; both increased consumption *and* increased extraction[9] are likely to affect the environmental impact (specifically the GHG emissions impact) of the TRR. Reduced coal transit distances that would be a result of the TRR would lead to reduced delivered coal costs; this leads to a downward adjustment of the cost of fuels which leads to a lower electricity price. This is true for foreign markets as well as US markets. The amplitude of the price signal is proportional to the amplitude of the feedback (in this case an increase in consumption) multiplied by the elasticity factor,[10] and the feedback is not instantaneous. This price elasticity should be modeled and the sensitivity of the feedback (the elasticity) should be realistic.

Elasticity of demand needs to be considered on at least two different time scales. Soon after a price change, the short run elasticity deals with the consumers' response to a higher or lower price. This decision can be viewed, for example, as a consumer's near term response to higher electricity prices. When prices increase, in the short term, the consumer can reduce electrical use by diligently keeping lights off in unoccupied rooms. In the long term, assuming that the price of electricity stays high, that same consumer may choose to replace all of the bulbs in their house with high efficiency light bulbs. In the short term, the consumer may not be able to alter their decision making because of constraints placed on them (the need to light their house in the evening, for example), so the short run elasticity response would be small. In the long run, assuming the consumer buys the more efficient bulbs, the elasticity response could be substantial as they consume far less electricity to light their home or business.

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[7] The price elasticity of supply is also important. It is embodied in each mine's supply curve that slopes or steps upward to the right.

[8] When prices go up, consumption falls; when prices go down, consumption increases.

[9] The extraction of coal both consumes energy in the form of oil (Diesel fuel) as well as releases methane that is trapped in the coal.

[10] There can be an elastic response where the consumption increases or decreases by more than the price change or there can be an inelastic response where consumption increases or decreases by less than the price reduction. The point is that there is a market response to a change in the price.

Any model that is used to evaluate the proposed TRR needs to be able to capture the long run and short run elasticity responses of a change in the delivered price of coal.

The basic economic principle of elasticity of demand has been applied to energy modeling in many different ways. Recently in a *Nature Climate Change* article,[11] the impact of an increased supply of Canadian Oil Sands oil onto the global market by the proposed Keystone XL Pipeline was shown to increase oil consumption by 0.6 barrels of oil for every barrel of oil produced because of the incremental decrease in the price of global oil. They found a corresponding increase in the GHGs associated with the increased extraction and consumption of the oil. A 2013 White paper by Power Consulting[12] came to the same conclusion about an increase in the GHG associated with Powder River Basin coal going to China via coal export ports in the Pacific Northwest. These examples highlight the potential for increased energy consumption associated with different energy policy decisions and the important role that elasticity of demand can play. Any model that is used to look at the GHG emissions impacts associated with energy policy decisions should have price elasticities of demand that allow for a different energy future than the "base case" or whichever scenario the modeled run is compared against.

IV. The IPM and elasticity of demand

Within the EPA documentation of the IPM it is unclear if the model has the *ability* to account for elasticity of demand. In the most extensive version of their documentation of IPM, the EPA states

"*EPA Base Case v.5.13 has the capability to consider endogenously the relationship of the price of power to electricity demand. However, this capability is typically only exercised for sensitivity analyses where different price elasticities of demand are specified for purposes of comparative analysis. The default base case assumption is that the electricity demand shown in Table 3-2, which was originally derived from EIA modeling that did consider price elasticity of demand, must be met as IPM solves for least-cost electricity supply. This approach maintains a consistent expectation of future load between the EPA Base Case and the corresponding EIA Annual Energy Outlook*

[11] Erickson, P., and M. Lazarus (2014), Impact of the Keystone XL pipeline on global oil markets and greenhouse gas emissions, Nat. Clim. Chang., 4(9), 778–781.
[12] Power, T., Power, D. (2013) The Impact of Powder River Basin Coal Exports on Global Greenhouse Gas Emissions. Prepared for the Energy Foundation. http://www.powereconconsulting.com/WP/assets/GHG-Impact-PRB-Coal-Export-Power-Consulting-May-2013_Final.pdf

reference case (e.g., between EPA Base Case v5.13 and the AEO2013 reference case)."[13]

This statement indicates that in the IPM base case the price elasticity of demand is assumed to be zero. The predetermined total demand for electricity that NEMS has calculated, taking price elasticity into account, now has to be met exactly within IPM.[14] Changes in the cost of supplying electric generators with fuel cannot impact the demand for electricity within the IPM. It can only change the mix of supply sources and the transportation routes used to supply that fleet of electric generators. That is, the way EPA uses IPM does not confirm their assertion that IPM is capable of allowing endogenous adjustments of electric demand to the changes in the price of electricity. Multiple studies corroborate the conclusion that IPM does not allow for electricity demand adjusting to changes in the price of electricity. For example, when describing the IPM, Jaglom et al. (2014) state that "*An implication of using exogenously specified demand is that demand does not respond to power prices (i.e., the price elasticity of demand is zero)*"[15] and McFarland et al. categorize "*the electricity demand response to price"* of the IPM as "*inelastic."*[16]

The ultimate purpose of the IPM, then, is to find the least cost way of generating electricity under a constant demand scenario. The IPM finds this least cost solution through fuel substitution (i.e. a balance of coal, natural gas, renewables, and other energy sources as well as the least cost source of each of these fuels for each of the generating facilities).[17] When used properly, the IPM is a very powerful model that outputs precise projections of the supply side of the energy economy under a constant demand scenario. Many private corporations in the power sector find these precise projections helpful in analyzing the least cost mixture of energy generation. For example, they may use the IMP to determine where and when they should expect more production from a natural gas fired generator and less from a nearby coal fired

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[13] Documentation for EPA Base Case v.5.13 Using the Integrated Planning Model, Section 3.2.1 Demand Elasticities. EPA # 450R13002. November 2013.

[14] The NEMS models the entire energy economy on a larger grid size than the IPM. The NEMS accounts for short term price elasticity of demand by iteratively optimizing supply and demand side modules until the price does not affect the demand (to a predefined tolerance). The elasticity coefficient is low and the NEMS does not consider international elasticity of demand, however, the model is open source, meaning the code is freely available, making augmentation of the code possible. From: U.S. Energy Information Administration. Integrating Module of the National Energy Modeling System: Model Documentation 2014, July 2014. http://www.eia.gov/forecasts/aeo/nems/documentation/

[15] Jaglom, W. S. et al (2014). Assessment of projected temperature impacts from climate change on the US electric power sector using the Integrated Planning Model®. *Energy Policy*, *73*, 524-539.

[16] McFarland, J. et al (2015). Impacts of rising air temperatures and emissions mitigation on electricity demand and supply in the United States: a multi-model comparison. *Climatic Change*, *131*(1), 111-125.

[17] This is also referred to as cross-price elasticity of demand, which is not the same principle as price elasticity of demand. Cross-price elasticity of demand is the response of demand for one good to a change in price of another good. For example, if natural gas prices rise dramatically the demand for coal increases.

generator. Federal agencies, such as the EPA, use the IPM in conjunction with other energy economy models to estimate the total emissions produced under a least cost, constant demand scenario. However, when the IPM is used improperly, it outputs precise projections of the supply side of the energy economy that are inaccurate[18] and possibly misleading.[19] Since the model does exactly what the modeler tells it to do, the model output is in part determined by the input data and the constraints applied to the model. With unnecessary constraints and inaccurate inputs, the IPM output can be limited in its range of possible output solutions. [20]

V. OEA's implementation of the IPM

In the DEIS for the TRR, the OEA present a brief overview of the IPM which includes this description of the public documentation in Section 5.2.2.2:

> "*USEPA uses IPM to analyze the impact of air emissions policies on the U.S. electric power sector. As part of this analysis, USEPA publishes its assumptions and other information regarding its use of IPM on its website (U.S. Environmental Protection Agency 2012). Although this documentation provides insight into USEPA's assumptions, the data and assumptions used by OEA in this analysis are not necessarily the same as used by USEPA*."[21]

This section is followed by sections that describe the key assumptions[22] and methods[23] used in the modeling for the DEIS. The section of the DEIS quoted above leads to two

[18] The IPM is a deterministic model. This means that if the objective function is minimized to within a certain limit, the IPM will provide an output.
[19] This is true of almost any complex model. Typically there are also coefficients in the model that can be changed to 'tune' the model to the unique situation for which it is employed.
[20] In section VI of this document we show that the OEA use questionable constraints on the distribution of TRR coal and an inaccurate representation of the total energy demand (they represent the demand as static; it should be elastic) in their implementation of the IPM.
[21] Tongue River DEIS Appendix C: Model Framework – Public Documentation, C.5-8.
[22] The key assumptions section (Section 5.3 of the DEIS) includes descriptions of assumptions about surface and underground coal mine productivity; natural gas production and demand; air, waste, and water regulations; renewable energy regulations; reserve margin targets; power plant mothballing and retirement; and transmission. There is no mention of power demand or demand elasticity.
[23] The methods section (Section 5.4 of the DEIS) includes a description of how the model years 2013-2037 are aggregated into 7 model run years to reduce model complexity; a brief overview of how CoalDOM is used to model US and international coal production; a description of the aggregate Powder River Basin supply curve; a description of how coal demand is calculated and allocated in CoalDOM; a brief description of how CoalDOM and IPM estimate coal transportation costs; a brief description of how IPM implements and incorporates environmental compliance factors including constraints on pollutants, CO_2 emissions, renewable portfolio standards, and "other state and regional requirements"; a brief description of the Gas Market Module (GMM) and how it is used to construct supply curves for natural gas; a list of assumptions on natural gas demand; a description of how the GMM characterizes natural gas demand; and how the IPM and the GMM are used to develop "*a set of robust natural gas supply*

possible implications: 1) all of the data, methods, and assumptions that are NOT mentioned in the DEIS are consistent with the USEPA documentation on the IPM and 2) the OEA does not believe that it is necessary to inform the public of their modeling work using the IPM that underlies the energy modeling in the DEIS. The second implication would be a clear violation of transparency and would constitute an unacceptable practice for any assessment of the impacts of a project conducted by a federal entity such as the OEA. We assume, then, that the OEA's implementation of the IPM is consistent with the USEPA documentation in all aspects except those specifically stated in the DEIS.

From the DEIS and the USEPA documentation on the IPM, it is clear that the OEA does not consider elasticity of demand when assessing the potential impacts of the proposed TRR. Demand elasticity response is extremely important to be able to capture when predicting the impacts of energy production decisions. If the response to approving the TRR is a change in the price of energy, then there will be some short and long run demand elasticity response. The IPM *does* model fuel substitution. However, it is quite probable that the demand response[24] will be as large, or larger, than the potential demand response associated with a fuel substitution response (or cross price elasticity). While the implementation of the IPM described by the OEA will be able to capture the fuel substitution response, it does not capture any change in the overall consumption of electricity associated with an electricity price change. Thus, one of the main problems with the OEA's implementation of the IPM is that it is assuming that there is zero elasticity of demand to model a solution which should recognize the price elasticity of demand.

The IPM *does* have a place in modeling the energy economy; it solves for the supply side of the energy economy at a higher geographic resolution than other energy economy models (such as the NEMS). This higher geographic resolution is achieved by making the entire demand side of the energy economy an input instead of a part of the model calculations.[25] Where a constant energy demand assumption is valid, the IPM

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curves that incorporates these dynamics between electricity demand, new power plants, retirements of power plants, coal prices, and environmental policies."

[24] Demand response is an increase or decrease in the consumption of electricity that results from fluctuations in the price of electricity.

[25] There must be a trade-off between resolution and breadth of a model, to elucidate this we compare the IPM to the NEMS. The documentation of both the IPM and NEMS state that the model runs are typically conducted on basic workstation-grade computers, meaning they are not run on 'super computers' or via 'cloud computing'. The computational limits of the computing system results either in a limited node resolution or in a limited number of variables being modeled. Further, even if the models were run on the most advanced platforms in the world, there is a limit to the size of a matrix that LP solvers can currently solve in a reasonable amount of time (less than months). Both the IPM and the NEMS incorporate a number of variables on the order of 10^6 which quickly escalates as node resolution escalates. For example in the NEMS, there are 49 representative subsectors within the 6 major economic subsectors, 16 representative coal demand regions each with 41 representative coal supply curves; therefore there

may be an appropriate model to conduct detailed analysis of the impacts associated with regulatory decisions. However, even if the constant energy demand assumption were valid for modeling the environmental impacts of the TRR,[26] we could not validate the OEA's model results because the only publicly available documentation for the IPM is limited to a description of the source of the input variables and vague descriptions of the methods employed in the model.

This leads us to another important problem with the OEA's use of the IPM: the IPM is not independently verifiable.[27] As the EPA states:

> "*ICF Resources, Inc. maintains an IPM user manual for the purpose of training internal staff and licensees of the model. Since it contains proprietary business information pertaining to the source code, it is not available for public dissemination.*"[28]

Since the actual source code that runs the model cannot be independently accessed and verified, the IPM is essentially a "black box" to anyone outside of ICF. This leaves the reliability of the results of the IPM model open to speculation without any means to eliminate the doubt or uncertainty about the model's output in any particular application. This is unacceptable for any model that is used in any scientific endeavor. For the IPM to be a trusted source of projections that influence public regulatory decisions, such as the greenhouse gas impact of the proposed TRR, full documentation of the code and inputs must be available to the public.[29] Without this documentation, the results of the modeling are not defensible since there is no way to verify that the methodology or implementation of the model is correct or in line with accepted economic principles.

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are 16*41*49=32,144 potential representative coal transportation routes in the NEMS. In the IPM there are roughly 560 coal demand regions (since each coal power plant is considered a separate demand region), 67 representative coal supply curves, and if the transportation routes were calculated for the 49 representative subsectors of the economy defined in the NEMS there would be a potential 1,838,480 routes; more than 57 times the potential routes for the NEMS. With the current state of computing, modeling the breadth of the NEMS on the resolution of the IPM would require an unacceptable amount of time and computational expense (on the order of months per run).

[26] We show in the next section that the addition of the TRR violates the constant demand requirement of proper usage of the IPM.

[27] ICF routinely performs "*Quality assurance and verification*" of the code. However, the license cost of the IPM is hundreds of thousands of dollars (personal communication with an ICF Senior Technical Specialist) making external verification of the IPM out of reach for most private organizations. EPA Science Inventory Integrated Planning Model – EPA Applications. Accessed on 9/9/15 from: http://cfpub.epa.gov/si/si_public_record_Report.cfm?dirEntryId=74919&CFID=37279577&CFTOKEN=14581785

[28] EPA Science Inventory Integrated Planning Model – EPA Applications. Accessed on 9/9/15 from: http://cfpub.epa.gov/si/si_public_record_Report.cfm?dirEntryId=74919&CFID=37279577&CFTOKEN=14581785

[29] The source code does not need to be divulged but the equations used in the code must be available to validate model results.

Thus, the OEA's use of the IPM as part of the proposed TRR DEIS is completely inappropriate for a number of reasons including:

1. The IPM is a black box model without open external verification. Since there is no way to validate the projections of the IPM model, the public has no way to verify if the proposed TRR will have an unacceptable impact on the environment.
2. The results of the OEA modeling are also indefensible because they do not explicitly describe their methods, including any deviation from the USEPA documented methodology. As Jaglom et al. (2014) state, "[the] *IPM is flexible with respect to data and input assumptions. In general, all inputs to the model are user-defined and case-specific and reflect the specific policy, physical conditions, or market conditions being analyzed*."[30] The data and input assumptions that the OEA use in their modeling effort are not well defined in the DEIS. Instead OEA states that the data and assumptions are "*not necessarily*" [31] the same as the data and assumptions in the EPA documentation that they allude to.
3. The IPM does not incorporate the basic economic principle of the price elasticity of demand.[32] As a result the impacts of changes in transportation infrastructure and new coal supply routes that will affect the delivered price of coal are not allowed to influence the demand for coal or the environmental consequences of changes in the quantity of coal produced and consumed. The OEA cannot account for the effects of reduced coal prices on total demand with the IPM. Without accounting for price elasticity of demand the OEA has not modeled the true outcomes associated with the proposed TRR and its associated coal mines.

VI. Evidence of the specific misuse of the IPM model in the TRR DEIS

The Powder River Basin (PRB) is the largest single source of coal in the U.S. and is one of the largest coal deposits in the world. The Montana (or northern) portion of the PRB has historically lagged in coal production behind the Wyoming (or southern) portion of the PRB for more than 30 years. In 1975 Montana produced about 22 million tons of coal and Wyoming produced about 24 million tons of coal. By 1990 Montana was producing almost 38 million tons of coal and Wyoming produced 184 million tons of coal. With the passage of the Clean Air Act there was a large demand placed on the PRB to supply cheap, low sulfur coal to meet the emissions limits of coal fired generators all across the United States. Montana's coal production has been essentially stagnant since the mid-1970s while Wyoming's coal production has skyrocketed to

[30] Jaglom, W. et al. (2014). Assessment of projected temperature impacts from climate change on the US electric power sector using the Integrated Planning Model®. *Energy Policy*, *73*, 524-539.
[31] Tongue River DEIS Appendix C: Model Framework – Public Documentation, C.5-8.
[32] McFarland, J. et al. (2015). Impacts of rising air temperatures and emissions mitigation on electricity demand and supply in the United States: a multi-model comparison. *Climatic Change*, *131*(1), 111-125.

around 400 million tons of coal.[33] Although the Montana PRB coal is traditionally slightly lower in Btu content (98 percent the same) and higher in sodium, it is the transportation advantage that the southern PRB has to the coal consumption areas of the U.S. domestic market over the northern PRB that accounts for the large disparity in tons of coal that are mined in each region each year.[34]

The OEA states that "*[e]xport through the Pacific Northwest terminals would provide Tongue River coal with a rail cost advantage over Wyoming Powder River Basin coal. Montana Powder River Basin rail costs to the Pacific Northwest are about $2 per ton lower than Wyoming Powder River costs*." [35] This rail cost advantage is translated into a delivered cost advantage to the Pacific Rim (the OEA use Japan as an example) of 4 cents per million Btu (MMBtu) over the southern PRB coal. [36] Rather than building it's discussion of the market for TRR coal, the OEA asserts that the TRR coal will not be cost competitive with the southern PRB coal in the Pacific Rim market because the TRR coal has a low Btu content compared to the southern PRB coal. However, despite the lower Btu content of the TRR coal it still has a lower delivered price (per MMBtu) to the Pacific Rim than the southern PRB coal. Since the coal has a lower price delivered to the Pacific Rim, the principle of price elasticity of demand requires that it will encourage more energy consumption in the Pacific Rim. Despite this, the OEA concludes that:

> "*If some or all of the proposed terminals were constructed, there would be sufficient terminal capacity to export all of the Otter Creek coal, as well as other Tongue River coal. Regardless of the extent of new Pacific Northwest terminal capacity, the proposed rail line would not lead to a net increase in tons of coal exported*." [37]

The reason the OEA concludes that there is not an increase in the tons of coal exported is that they assume the southern PRB coal can be perfectly substituted for the TRR coal even though TRR coal has a delivered price advantage over other PRB coal to the Pacific Northwest and the Pacific Rim (per MMBtu). In fact, the OEA assumes that most of the TRR coal (the 8600 Btu/lb coal) will not be exported in favor of the southern PRB higher delivered cost coal.[38] The cost analysis mentioned above shows that both the southern PRB coal and the TRR coal competitively price into the Pacific Rim markets

[33] http://www.eia.gov/state/seds/sep_prod/pdf/PT1_MT.pdf and http://www.eia.gov/state/seds/sep_prod/pdf/PT1_WY.pdf

[34] Duffield, J., Silverman, A., and Tubbs, J. (1985), Montana Coal Market to the Year 2000: Impact of Severance Tax, Air Pollution Control and Reclamation Costs. Prepared for the Montana Department of Commerce, Helena, Montana.

[35] Tongue River DEIS Appendix C: Coal production and Markets. p.4-7.

[36] Ibid. p.4-9.

[37] Ibid. p.4-10.

[38] It appears that there is a non-economic constraint placed on the export of coal to the Pacific Rim where only 8800 Btu/lb or higher coal is exported. This is shown in their analysis by scenario #20 where only the introduction of a higher Btu coal from the induced Canyon Creek mine allows the export of TRR coal.

with the TRR coal having a 4 cent per million Btu advantage over the southern PRB coal. In the OEA scenarios, the ports are the limiting factor on volume of coal shipped to the Pacific Rim, not the delivered price of the coal.[39] This technically allows the OEA's statement that "*the proposed rail line would not lead to a net increase in tons of coal exported*" to be true. What is missing from this statement is the competitive advantage that the TRR coal has in the Pacific Rim and the effects of that competitive advantage.

If 72 million tons of TRR coal (the assumed total coal production under the Southern Alternative High Production Scenario[40]) is allowed to price into the Pacific Rim, then the Pacific Rim will receive a cost savings of at least $155 million dollars per year.[41] This, in turn, will encourage the Pacific Rim to burn more coal than they otherwise would have and thus produce more GHG than they otherwise would have without the TRR. The economic principle of the price elasticity of demand requires that this is the outcome.

The existing Montana PRB mines (not the TRR mines) have a transportation advantage to the Upper Midwest and the southern PRB mines have a transportation advantage to the southeast and southwest. Replacing these coal sources with TRR coal that has a similar production cost but a rail shipping disadvantage does not make economic sense. The TRR coal would have to travel past the existing coal fields to get to a domestic market that is already served. Thus the advantages of the TRR coal heavily points towards the PNW ports. This is confirmed by the $2.00 per ton rail shipping advantage over the southern PRB as well as the delivered 4 cent per million Btu cost advantage to the Pacific Rim.

By allowing the perfect substitution of southern PRB coal for TRR coal in the IPM modeling, the OEA is ignoring the increase in the amount of coal that would be burned by the Pacific Rim because of the competitive price advantage that the TRR coal has. Price elasticity of demand requires that access to a cheaper source of coal will encourage more consumption of coal. Since the port capacity is assumed to be limited, (it should adjust to the market-supported level of Pacific Rim demand) the additional coal consumption that will be induced by the lower delivered price of TRR coal will have to come from a different international source. Simply because it does not come from the

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[39] Again there appears to be a non-economic constraint placed on the development of the TRR coal. If it is more competitive into the Pacific Rim then why couldn't it all be developed at the same time to serve the port demand of 107 million tons? Instead the maximum capacity of the TRR is leveled off at 72 million tons. See table 3-11 in Appendix C of the TRR DEIS.

[40] Tongue River DEIS Appendix C: Coal production and Markets. p.3-31 table 3-11.

[41] Accounting for the total Btu content per ton of the TRR coal, multiplying by the 4 cent per million Btu difference, and applying the savings per ton to 72 million tons of production from the TRR under scenario #20 yields, this result. Note that this is a conservative estimate since 22 million tons of that coal would be coming from the Canyon Creek mine which has a higher heat content (9200 Btu/lb) but is assumed to be mined at the same cost as the Otter Creek 8600 Btu/lb coal. If the Canyon Creek coal can be mined at the same cost then it would be more competitive than the Otter Creek coal when compared to the southern PRB coal.

U.S. does not mean that it does not exist. This induced additional energy consumption should have been modeled and the perfect substitution of a more expensive coal source (the southern PRB) should not have been allowed in the model. Allowing a higher delivered cost source of coal (in $/MMBtu), simply because it has a higher energy content does not make economic sense. It imposes a non-economic constraint on the model and is based on faulty rationale.

As we discuss above, there is perfect substitution of one coal for another. The OEA states that there is a different delivered price per million Btu for coal delivered to the Pacific Rim; and yet one is perfectly substituted for the other without any market response. This is an economic impossibility and an argument that the courts have consistently thrown out. Judge R. Brook Jackson rejected the perfect substitution argument in a recent District Court of Colorado ruling by stating:[42]

> "*In other words, coal is a global commodity, and if the coal does not come out of the ground in the North Fork consumers will simply pay to have the same amount of coal pulled out of the ground somewhere else—overall GHG emissions from combustion will be identical under either scenario. The agencies reached this conclusion in part by relying on a U.S. Department of Energy report forecasting a small annual increase in the demand for coal. Based on that assumption, the agency concluded that perfect substitution would occur.*
>
> *I cannot make sense of this argument, and I am persuaded by an opinion from the Court of Appeals for the Eighth Circuit that rejected a nearly identical agency justification for not analyzing the future effects of coal combustion. In Mid States Coalition for Progress v. Surface Transportation Board, the court held that an agency violated NEPA when it failed to disclose and analyze the future coal combustion impacts associated with the agency's approval of a railroad line. In that case—like this one—the agency argued that emissions would occur regardless of whether the railroad line were approved because "the demand for coal will be unaffected by an increase in availability and a decrease in price." Id. The court rejected this argument as "illogical at best" and noted that "increased availability of inexpensive coal will at the very least make coal a more attractive option to future entrants into the utilities market when compared with other potential fuel sources, such as nuclear power, solar power, or natural gas.*"

[42] High Country Conservation Advocates v. United States Forest Service, 52 F. Supp. 3d 1174 (D. Colo. 2014).

Allowing the perfect substitution of one coal for another, even when there are delivered cost differences, wipes out any difference in consumption (and thus environmental impacts such as greenhouse gas emissions) associated with differences in delivered costs and demand elasticity, just as Judge Jackson recognized. There are also non-economic constraints that were placed on the model that did not allow the ports to expand in response to the markets as well as constraints that were placed on the timing of coal coming from the TRR, both of which limit the amount of TRR coal that goes to the Pacific Rim. These are major flaws in the OEA's use of the IPM.

We have identified four flaws in the OEA's implementation of the IPM which artificially predetermined the model result of a low GHG and market impacts from the proposed TRR and its induced coal mines. The first flaw is that the OEA determined that the majority of the TRR coal would be undesirable to export to the Pacific Rim, even though the delivered cost of the TRR coal per MMBtu would be cheaper than the southern PRB coal that is largely exported in its place. The second flaw is that the OEA assumed that the PNW port volume would be restricted; the port capacity should be dependent on the demand placed on it by the Pacific Rim. The third flaw is the limits that are placed on the development of the TRR induced mines. The mines should be allowed to come on line in response to the demand that they are serving. Since TRR coal is cheaper to ship to the Pacific Rim compared to southern PRB coal, all of the TRR induced mines should be allowed to come on line at the same time and send their coal to the Pacific Rim displacing more of the southern PRB coal. This would in turn show a larger total impact of TRR coal that is not perfectly substitutable for other PRB coal sources. The fourth flaw is that energy demand is held constant which neglects the basic economic principle of elasticity of demand. Because the total energy demand does not change within any given scenario, the model is not be able to pick up the induced energy consumption that would occur if the TRR coal was allowed to be shipped to the Pacific Rim in place of the southern PRB coal. If the model allowed for elasticity of demand and was not constrained by the flaws mentioned above, then there should be an increase in energy consumption that is proportional to the short and long run elasticities of demand. This increase in energy consumption, above and beyond what would have happened if the TRR was not constructed (the no action alternative), has GHG consequences that were not modeled by the OEA. Because the model was constrained by the four flaws mentioned above, the results of the model are flawed and should not be used in this DEIS process.

VII. Conclusion

It is clear that the IPM is not designed for the modeling problem for which the OEA has employed it. The IPM does not account for demand elasticity, which can have a large impact on total energy use. The IPM is not documented in a manner which would allow external validation of the results; in that sense it is a black box. The OEA's misuse of the IPM model to assess the GHG emissions impacts of the proposed TRR either reveals a complete lack of understanding of the appropriate model usage or it is an attempt to ignore a vital portion of the impact that the proposed railroad may have. It is certain that the proposed railroad would have an effect on the delivered price of coal (the OEA state this in their DEIS), thus it would have an effect on the price of energy. Any appropriate energy economy model must account for demand response that is associated with energy price changes and must be documented with a detailed description of the model methodology and the implementation of the model must be freely available for external verification. Further, the modeling must be conducted with realistic constraints and assumptions that do not predetermine the model result. We have shown in this report that the OEA's implementation of the IPM fails in all these aspects.

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