January 7, 2020

MEMORANDUM

TO: **Power Committee**

FROM: **Steven Simmons**

SUBJECT: **Upstream Methane Emissions and Power Planning**

BACKGROUND:

Presenter: Steven Simmons

Summary: This presentation will cover the methodology used to incorporate estimates of upstream methane emissions into our power planning. The presentation will also show key results when this methodology was applied to regional natural gas and coal power plants using historic generation data.

Relevance: With the technological advances in natural gas extraction – fracking and horizontal drilling – gas has been undercutting coal as a fuel for electricity generation for some time now. Natural gas, along with energy efficiency, wind and solar, have been displacing coal – leading to a cleaner electrical grid in terms of CO_2 emissions.

However, the primary component of natural gas, methane (CH_4), is a highly potent greenhouse gas. Methane that is released directly to the atmosphere is a big issue. Recent studies indicate that the natural gas supply system is leaking much more upstream methane than previously thought. Reducing these upstream methane leaks could be an important component for a decarbonization strategy. In order to gauge the impact of methane leak reductions, there needs to be a methodology to incorporate these emissions into the power planning models.

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Workplan: A.4. Forecasting and Economic Analyses

Background: The methodology to incorporate upstream methane emissions into power planning was presented to the Natural Gas Advisory Committee (NGAC) on December 18, 2019 and was followed by a good discussion.

More Info: A paper with more detail on the methodology and results is available here on the NGAC location

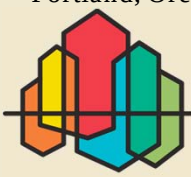
https://www.nwcouncil.org/energy/energy-advisory-committees/natural-gas-advisory-committee

Upstream Methane Emissions and Power Planning

Steven Simmons

January 14, 2020

Portland, Oregon



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Introduction

1. Background
2. Methodology for incorporation of methane emissions into power planning
3. Key results
   1. Impact of upstream methane emissions on regional greenhouse gas emission accounting
   2. Regional coal vs gas

4. A more detailed writeup is available on the NGAC site:

https://www.nwcouncil.org/energy/energy-advisory-committees/natural-gas-advisory-committee

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Background on methane

1. With the technological advances in shale gas extraction over the past 10 years – natural gas has been undercutting coal as a fuel for electricity generation
2. When combusted for electricity generation, natural gas emits CO_2 at a lower rate than coal
3. The natural gas supply system that the region relies on to source and move gas from long distances – emits methane (CH_4), the primary component of natural gas - along the way. Methane is also released during coal mining activities.
4. Methane released into the atmosphere is a big deal – pound for pound CH_4 has 34 times the global warming impact as CO_2 over 100 years and 86x over 20 years

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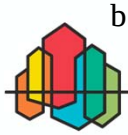
Why include methane emissions?

1. Recent studies have shown that in the US, methane emissions from the natural gas and oil supply chain are larger than expected – enough to bring into question as to whether gas is actually cleaner than coal for power generation
2. Combining estimates of upstream methane releases with emissions at the point of combustion will provide a more accurate picture of the impact of fossil fuels used for power generation
3. A focused approach to methane leak reductions may be an important piece of any decarbonization strategy



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How much upstream methane is leaking?

1. The Environmental Protection Agency (EPA)
   a. Estimates a **1.4%** leakage rate from the natural gas system
   b. Bottoms-up estimate based on equipment rates
   c. Assumes equipment is operating as designed and aggregates up to an overall leakage rate
2. The Environmental Defense Fund (EDF) Studies
   a. EDF coordinated natural gas emission studies from 2012- thru 2017. Included 140 experts from research universities and companies. Studies culminated in an estimate of a **2.3%** leakage rate.
   b. Ground based, facility-scale methane emission measurements across the US – verified with top down aircraft measurements
   c. Captured equipment not operating optimally, or even failing
3. National Energy Technology Lab (NETL) & EPA – coal mining related methane emissions
   a. Surface-mined coal from the Powder River Basin releases an estimated **38.7 scf.** of CH_4 per ton of coal mined
   b. Emissions from surface-mined coal are difficult to determine

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Methodology

Upstream Methane Emissions and Power Planning

Fuel-based emission rates

1. Determine emissions resulting from combustion for each greenhouse gas at the point of generation (CO_2, CH_4, N_2O).

   Lbs. of GHG per MMBtu of fuel consumed

2. Calculate upstream methane emissions per unit of fuel combusted for generation - using upstream gas leakage rates and coal mining releases

   Lbs. of CH_4 per MMBtu of fuel consumed

3. Use the Global Warming Potential (GWP) factors for each greenhouse gas to calculate a single value in CO_2 equivalents (CO_2e)

   Lbs. of CO_2e per MMBtu consumed

4. Using the power plant heat rates (Btu per kWh) – can calculate a generation emission rate in

   Lbs. of CO_2e per MWh produced

* Note – this is not a full life cycle model – it's only capturing the largest emission sources

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Fuel-based greenhouse gas emissions in CO_2 equivalents – applied at the point of generation - including emissions resulting from combustion at the point of generation & upstream methane

			2.3% upstream CH_4 leakage rate	1.4% upstream CH_4 leakage rate	38.7 scf.CH_4 per ton
Greenhouse Gas	Emission Source	Unit	Natural Gas	Natural Gas	Coal
Total CO_2e	**Total**	**Lbs. of CO_2e per MMBtu**	**147**	**135**	**219**
CO_2	Combustion at point of generation	Lbs. of CO_2e per MMBtu	117	117	214
CH_4	Combustion at point of generation	Lbs. of CO_2e per MMBtu	0.07	0.07	0.82
N_2O	Combustion at point of generation	Lbs. of CO_2e per MMBtu	0.66	0.66	1.05
CH_4	Upstream	Lbs. of CO_2e per MMBtu	29.4	17.7	3.16

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Key Results

Upstream Methane Emissions and Power Planning

Emissions from Regional Natural Gas Plants

1. The newly calculated fuel-based emission rates were applied to each of the natural gas plants in the region for 2016 using the eGRID2016 data set and an annual emission value was calculated in units of CO_2e
2. With an upstream leakage rate of 2.3%, the accounting for actual emissions from all the regional natural gas plants in 2016 increases by 25%.
3. The results point out the effectiveness of reducing upstream methane leakage as a decarbonization strategy. By reducing leakage rates from 2.3% to 1.0%, nearly 2 million tons of CO_2e emissions could be avoided – a reduction of over 11%.
4. The ability to quickly detect and repair leaks is key to reducing climate impacts of natural gas. Industry improvements in reducing leaks is possible – and really points to the importance of implementing an overall regulatory approach that is transparent and covers the entire system.

aMW generation from Natural Gas Plants in 2016	CO_2e at Point of Generation Only Million Tons	CO_2e with 2.3% upstream natural gas system leakage Million Tons	CO_2e with 1.4% upstream natural gas system leakage Million Tons	CO_2e with 1.0% upstream natural gas system leakage Million Tons
3,415	13.58	16.97	15.62	15.03

Comparing Regional Gas & Coal Power

The results from this limited study suggest that regional natural gas power is still cleaner than coal on a greenhouse gas basis – however the gap between the fuels is narrowed when considering upstream methane.

There are 3 key determining factors for this type of analysis:

1. The assumed methane leakage rate from the natural gas system
2. The comparative power plant heat rates (plant efficiencies) between the gas and coal plants
3. The Global Warming Potential time frame used – 20 years or 100 years

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Regional natural gas and coal compared

GWP-100 Year			
	Natural Gas	**Coal**	**Ratio Coal to Gas**
Upstream Methane Leakage	2.3 % gross production	38.7 scf per ton of coal	
Upstream Fuel emissions – Lbs. CO_2e per MMBtu	29	3	0.1
Fuel emissions at point of generation only – Lbs. CO_2e per MMBtu	118	216	1.8
Overall fuel emissions – Lbs. CO_2e per MMBtu	147	219	1.5
Regional System Average Plant Heat Rate BTU/kWh	7,716	11,047	1.4
Overall generation emission rate - Lbs. CO_2e per MWh	1,134	2,419	2.1

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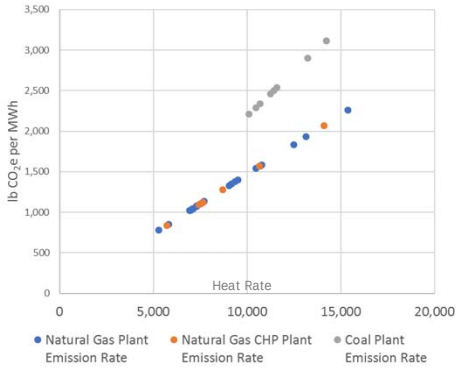
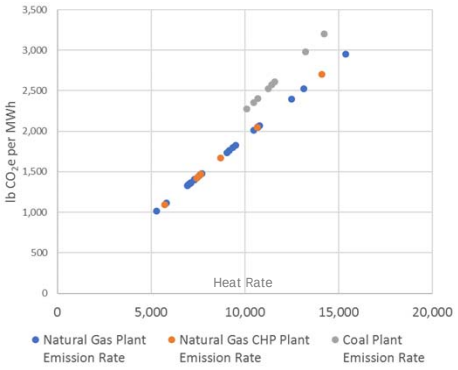
Generation-based emission rates for regional power plants assuming a 2.3% leakage rate

100-Year GWP



20-Year GWP



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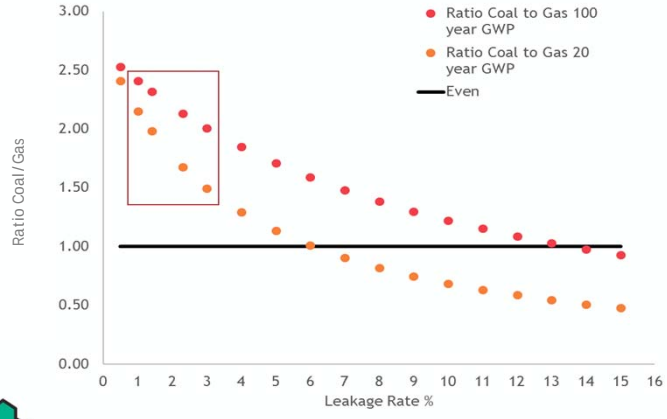
Ratio of regional coal to gas emission rates on a per MWh basis – as a function of gas leakage rate

Leakage rate cross over points: 14% (GWP-100) and 6%(GWP-20). The box indicates most likely leakage rates



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End of Presentation

Questions & Comments

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Background & Supporting Information

Upstream Methane Emissions and Power Planning

Methane Studies

EDF Studies

1. The EDF-coordinated natural gas studies (from 2012 through 2017), performed ground based, facility-scale methane emission measurements across 30% of the gas production areas in the US.
2. Though ground-based, their results were verified with aircraft measurements. The studies concluded that the natural gas supply chain is leaking at a rate of 2.3% of gross production, most of which is occurring upstream in the production, gathering, and processing stages
3. https://www.edf.org/sites/default/files/EDF-Methane-Science-Brochure.pdf

Industry efforts – ONE Future

1. There is evidence that the natural gas system can operate in a much tighter fashion.
2. ONE Future is a coalition of 20 natural gas companies that operate across the supply chain to voluntarily reduce methane emissions. The members account for roughly 10% of US natural gas production and gathering.
3. The coalition's goal is to reach a 1% leakage rate overall, and early indications are that they have achieved rates below that www.onefuture.us

1) Fuel-based greenhouse gas (GHG) emission rates from combustion at the point of generation
Lbs of GHG per MMBtu consumed

Greenhouse Gas	Units	Natural Gas	Coal (sub-bit)
CO_2	Lbs./MMBtu	117	214
CH_4	Lbs./MMBtu	0.0022	0.02425
N_2O	Lbs./MMBtu	0.0022	0.00353

https://www.epa.gov/sites/production/files/2018-02/documents/egrid2016_technicalsupportdocument_0.pdf

2a) Upstream methane leakage rates for natural gas and coal

Upstream Methane Leakage	Units	Natural Gas System	Coal Mining
Environmental Defense Fund Studies	% of gross production	2.3	
EPA	% of gross production	1.4	
EPA/NETL	Scf. CH_4 per ton of coal		38.7

EDF Natural Gas https://science.sciencemag.org/content/361/6398/186

National Energy Technology Laboratory, Life Cycle of Coal Exports from the Power River Basin, DOE/NETL-2016/1806

2b) Fuel-based greenhouse gas emissions – applied at the point of generation and including combustion and upstream methane emissions
Lbs. of GHG per MMBtu consumed

With 2.3% Upstream Leakage Rate				
Greenhouse Gas	**Category**	**Unit**	**Natural Gas**	**Coal**
CO_2	Combustion at Point of Generation	Lbs./MMBtu	116.88	213.90
CH_4	Combustion at Point of Generation	Lbs./MMBtu	0.0022	0.02425
N_2O	Combustion at Point of Generation	Lbs./MMBtu	0.0022	0.00353
CH_4	Upstream	Lbs./MMBtu	0.865	0.0930

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3) Global warming potential (GWP) factors for conversion to CO_2 equivalents (CO_2e)

5th Assessment of the Intergovernmental Panel on Climate Change		
Greenhouse Gas	**GWP – 100 Year**	**GWP – 20 Year**
CO_2	1	1
CH_4	34	86
N_2O	298	268

https://www.c2es.org/content/ipcc-fifth-assessment-report/

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4a) Regional Power Plant Heat Rates

Calculated from the EPA eGRID2016 database			
Category	**Units**	**Natural Gas**	**Coal**
Generation Weighted System Average	Btu/kWh	7,716	11,047
Most Efficient	Btu/kWh	5,292	10,102
Least Efficient	Btu/kWh	15,385	14,215

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4b) Generation-based greenhouse gas emissions at the point of generation and including upstream methane emissions
Lbs. of CO_2e per MWh

With 2.3% Upstream Leakage Rate & GWP-100 Year System Average Plant Heat Rates				
Greenhouse Gas	**Category**	**Unit**	**Natural Gas**	**Coal**
CO_2e	Total	Lbs. CO_2e/MWh	1,134	2,419
CO_2	Combustion at Point of Generation	Lbs. CO_2e/MWh	901.90	2363.01
CH_4	Combustion at Point of Generation	Lbs. CO_2e/MWh	0.58	9.11
N_2O	Combustion at Point of Generation	Lbs. CO_2e/MWh	5.06	11.62
CH_4	Upstream	Lbs. CO_2e/MWh	226.83	34.92

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