Harvard Energy Journal Club

The Global Warming Potential Misrepresents the Physics of Global Warming Thereby Misleading Policy Makers

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COLUMBIA | SIPA
Center on Global Energy Policy

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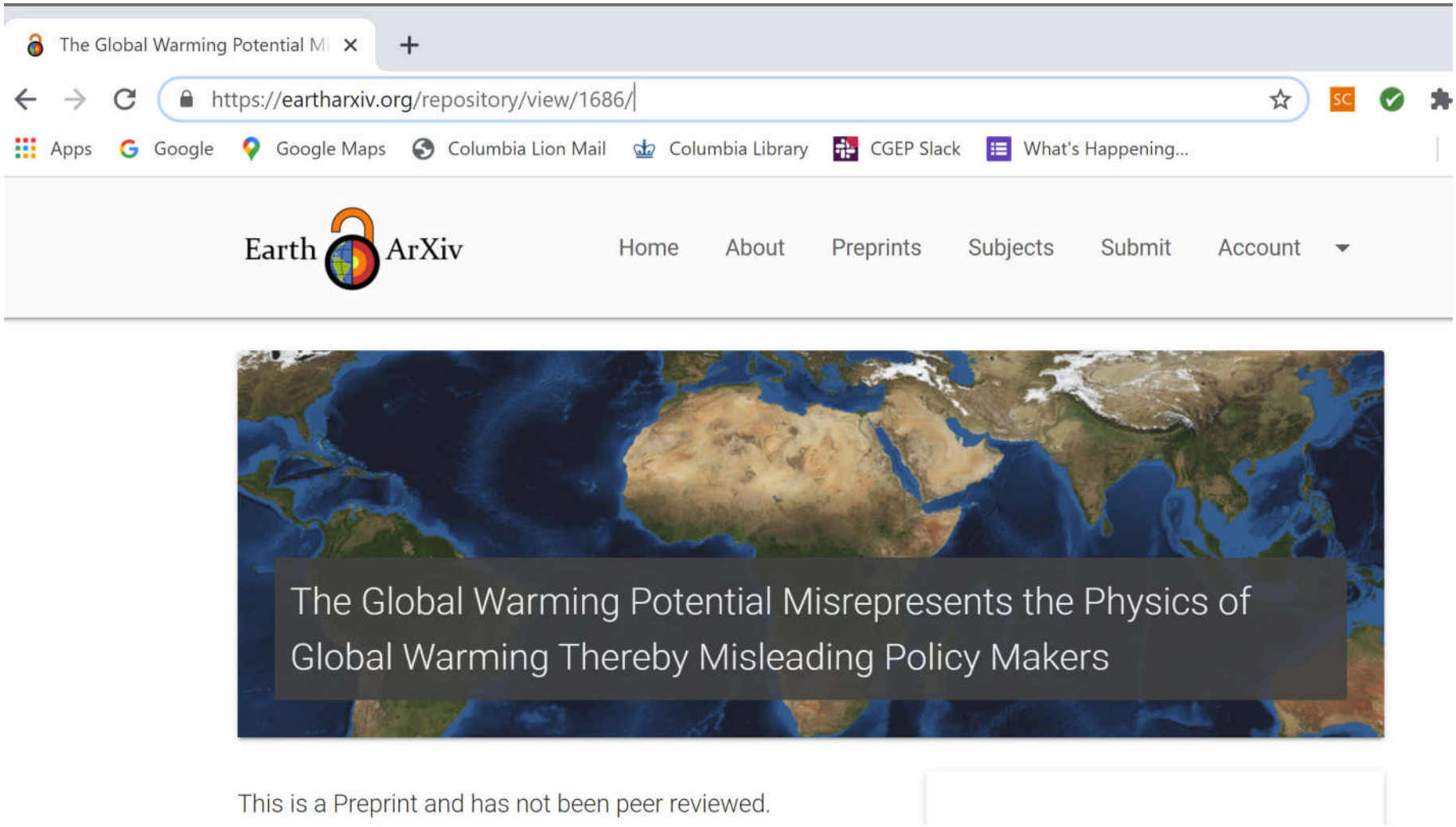


https://eartharxiv.org/repository/view/1686/

25 October 2020

Hypothetical

You are the Energy Minister of Poland. You have been charged with reducing your nation's contribution to global climate change in the most cost-effective manner possible. Do you:

- Keep burning coal, by far the most economical solution.
- Continue using cheap domestic coal, but upgrade the power plants.
- Shut down your coal burning electric power plants and buy Russian gas for your new gas turbines.
- Shut down your coal burning electric power plants and buy American LNG for your new gas turbines.

Outline

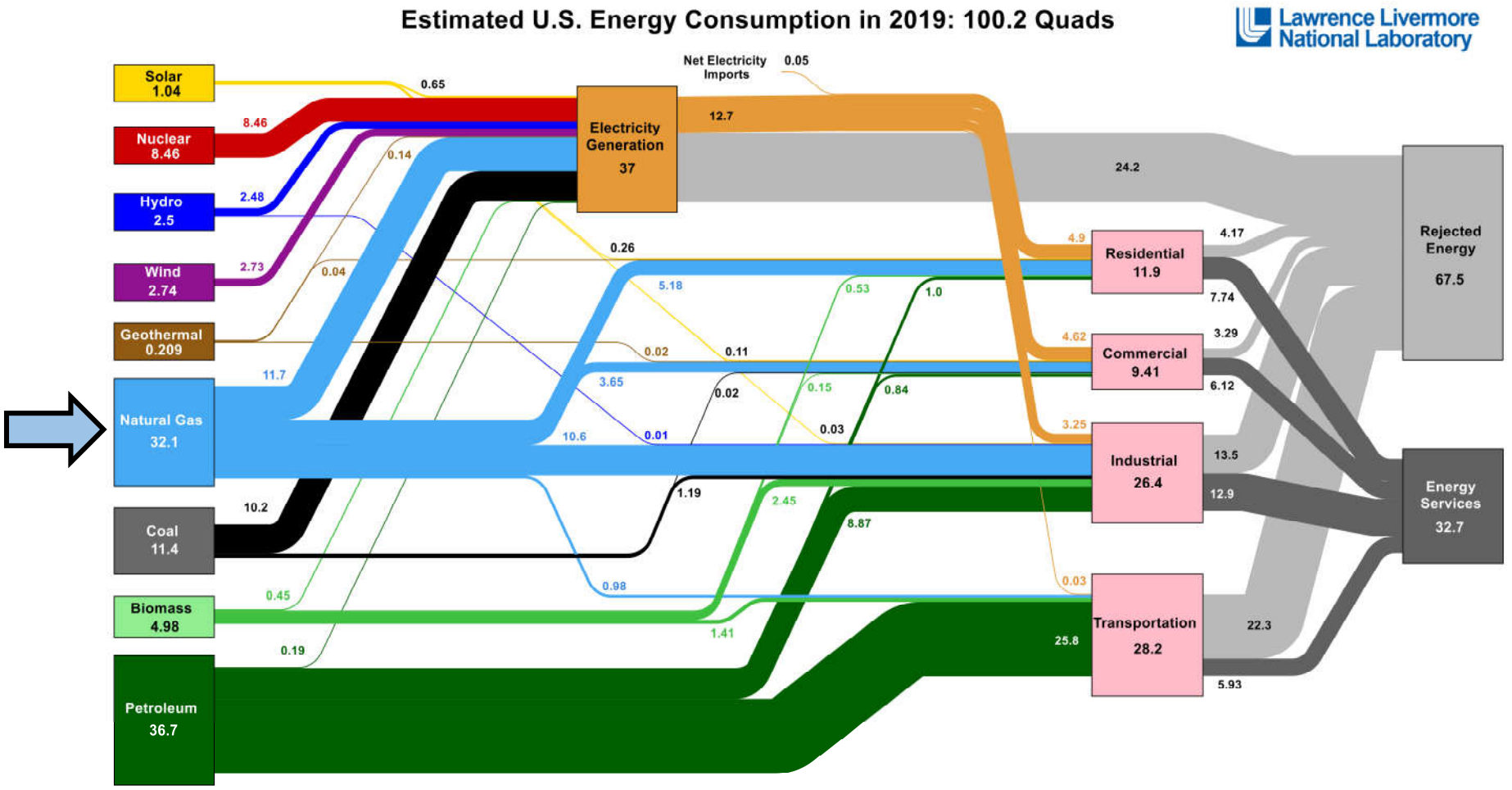
The Role of Gas in Energy Systems

What is Global Warming Potential?

GWP vs Temperature Modeling

Example: Lifecycle GHG Emissions
    Russian Pipeline Gas, US LNG, and European Coal

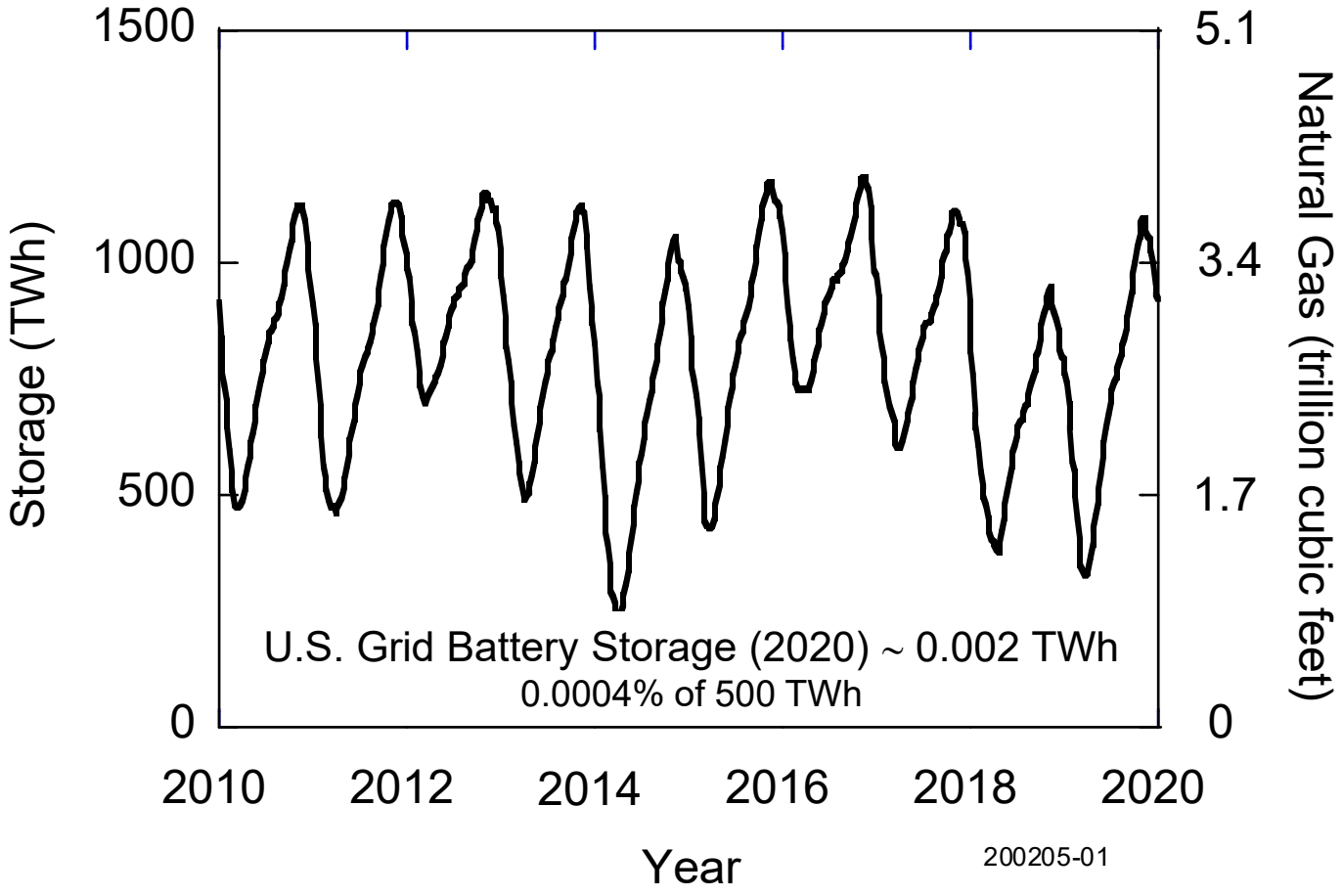
Natural Gas is the Most Versatile Source of Primary Energy



Source: LLNL March, 2020. Data is based on DOE/EIA MER (2019). If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant heat rate. The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential sector, 65% for the commercial sector, 21% for the transportation sector and 49% for the industrial sector, which was updated in 2017 to reflect DOE's analysis of manufacturing. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

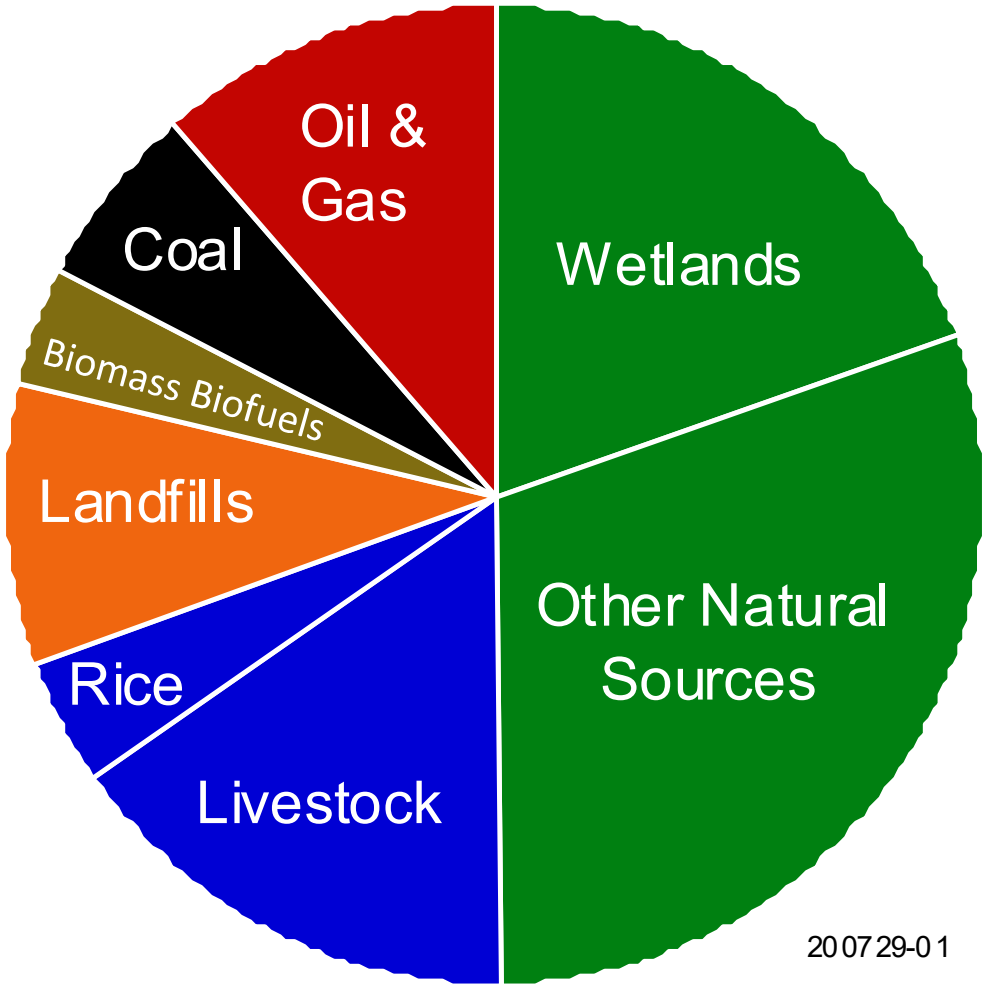
https://flowcharts.llnl.gov/

U.S. Natural Gas Storage
Essential Back Up for Intermittant Renewable Energy



Data: US Energy Information Administration
Weekly Lower 48 States Natural Gas Working Underground Storage

Natural & Anthropogenic Methane

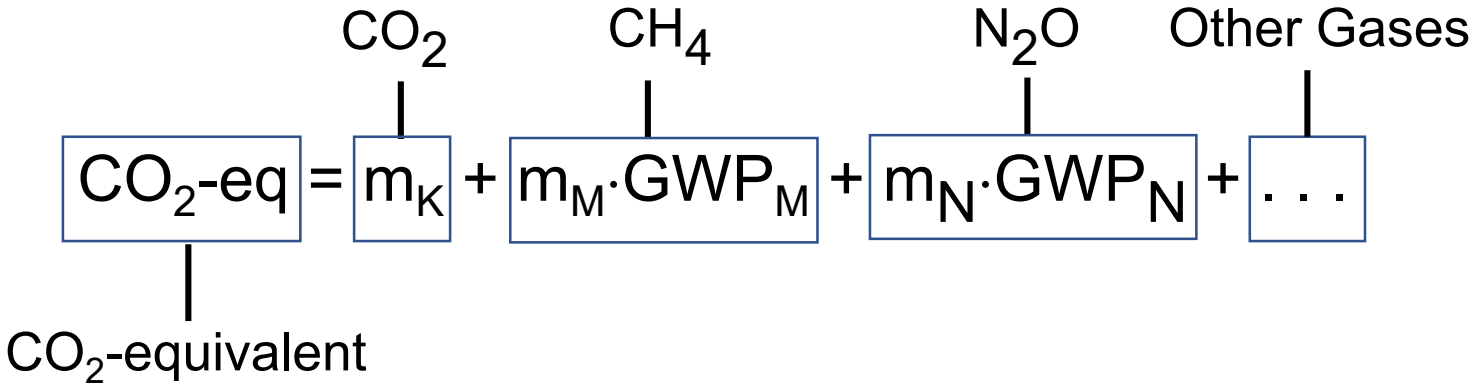


Source	Methane Mt/y	%
Wetlands	145	19
Other Natural	222	30
Livestock	115	15
Rice	30	4
Landfills	68	9
Biomass & Biofuels	29	4
Coal	44	6
Oil & Gas	84	11
Other	7	1
Total	747	100

Data: Jackson, Environmental Research Letters (2020)
Methane, 2017, Bottom-Up Estimates

The Global Warming Potential Plays an Integral Role in the Nationally Determined Contributions of the Paris Agreement

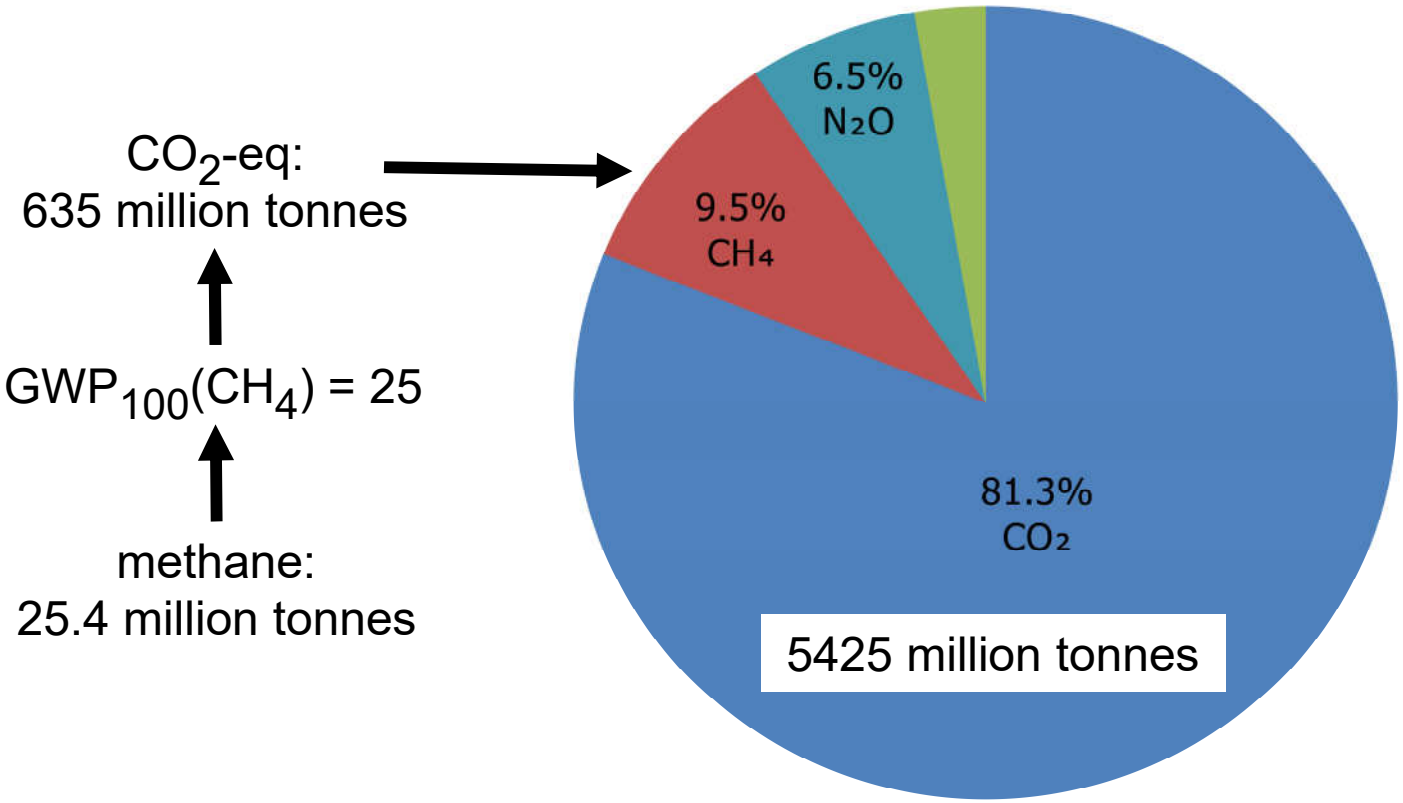
Harmonization of Effects of Various Greenhouse Gases on Climate Change



- GWP uses simple numerical multipliers to account for the differing effects of emitting various gases into the atmosphere.
- GWP varies with the time frame considered.
- The version computed over a one hundred year time frame (GWP100) was used in the implementation of both the Kyoto Protocol and the Paris Agreement.

Greenhouse Gas Emissions (USA, 2018)

CO_2-equivalent = 6677 million tonnes

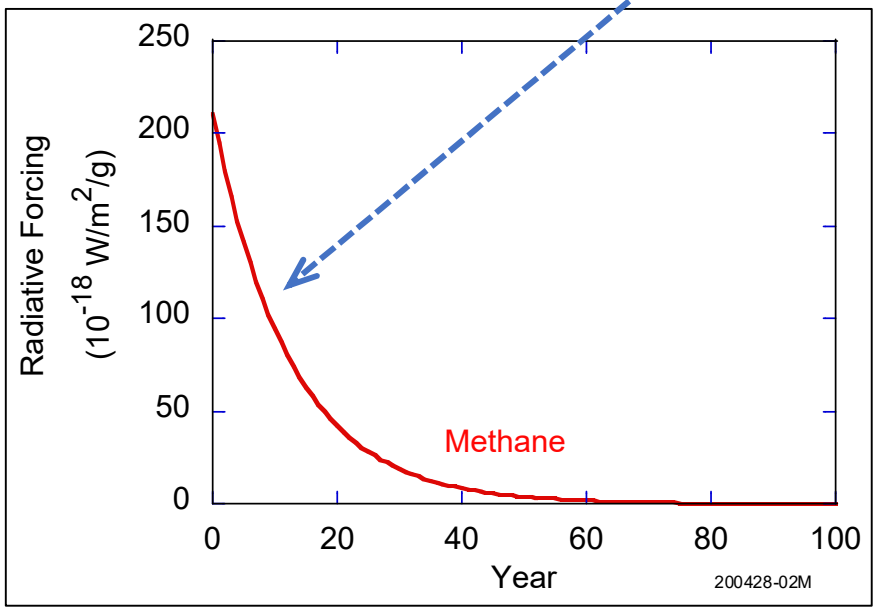


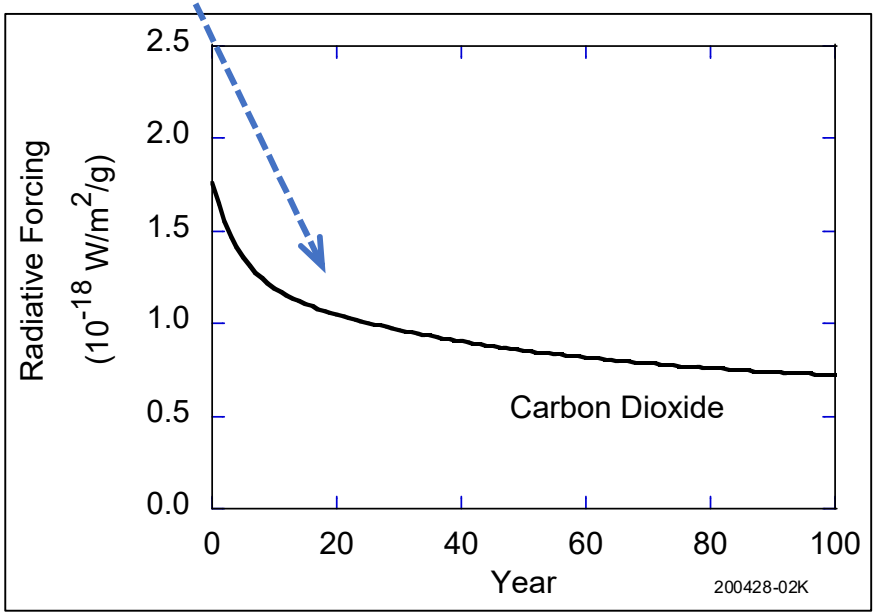
Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2018
U.S. Environmental Protection Agency, 2020, EPA 430-R-20-002
https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks

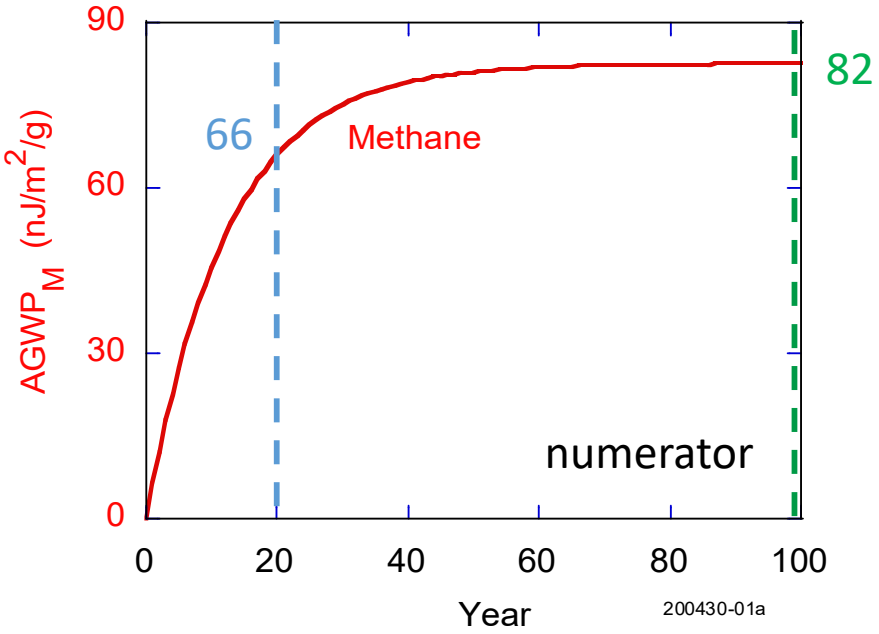
Global Warming Potential

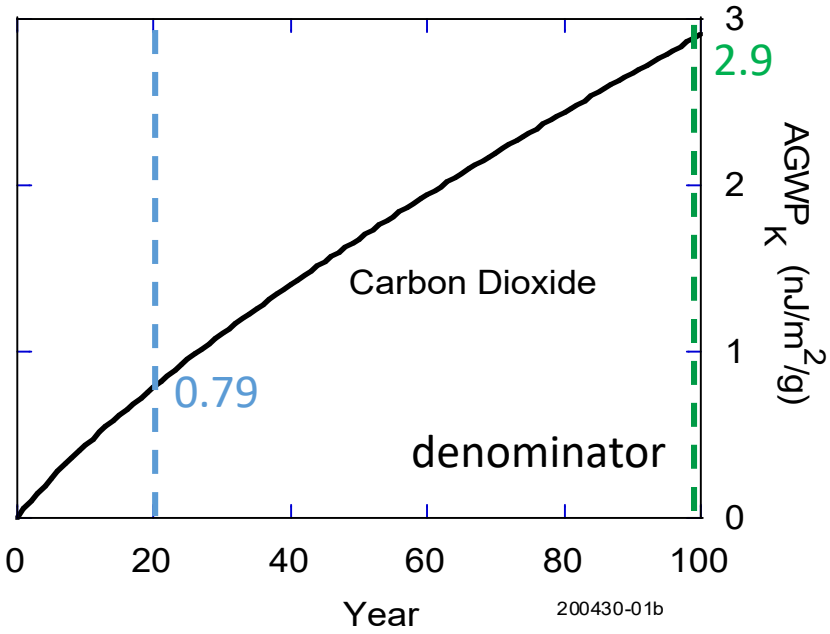
RF = radiative forcing ($W/m^2/g$)

$$GWP_{CH_4}(T) = \frac{\int_0^T RF_{CH_4}(t)\,dt}{\int_0^T RF_{CO_2}(t)\,dt}$$

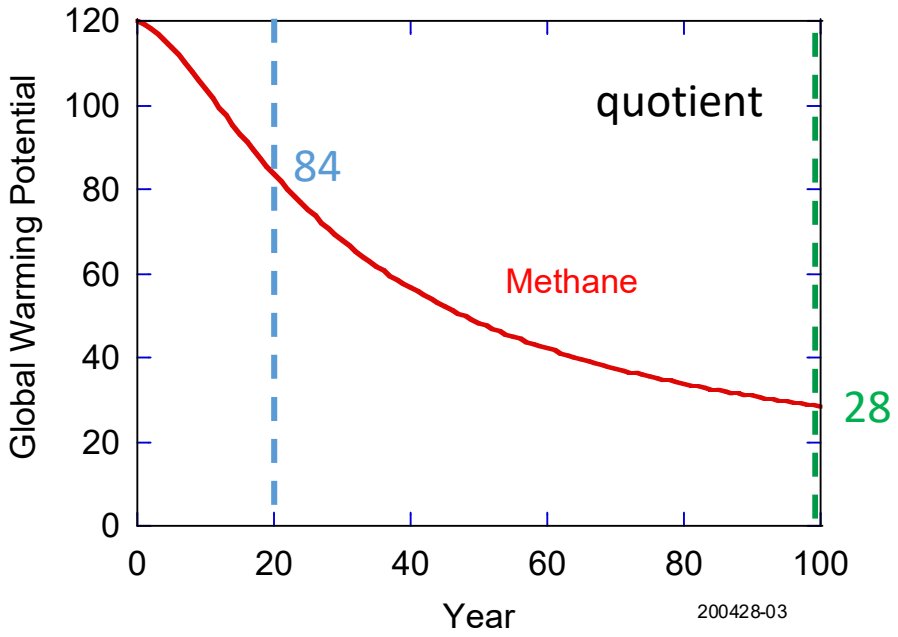








Construction of Global Warming Potential



Problems of the Global Warming Potential

Unphysical

The earth is not a simple integrator of radiative forcing. It is in dynamic equilibrium with a low temperature reservoir and has multiple thermal lags.

Arbitrary

The choice of an upper limit of integration has no clear connection to temperature trajectories.

Unintuitive

The climate scientists who invented it can't explain it.

> "It must be stressed that there is no universally accepted methodology for combining all the relevant factors into a single [metric] . . . A simple approach [i.e. the GWP] has been adopted here to illustrate the difficulties inherent in the concept." [Shine, 2009, quoting from the First Assessment Report]

Better Ways to Understand the Climate Impacts of Greenhouse Gases

- General circulation models
- Reduced complexity models (e.g. Model for the Assessment of Greenhouse Gas Induced Climate Change: MAGICC)
- Simple models of global mean temperature change based on closed form equations [Fifth Assessment Report of the Intergovernmental Panel on Climate Change, 2013]

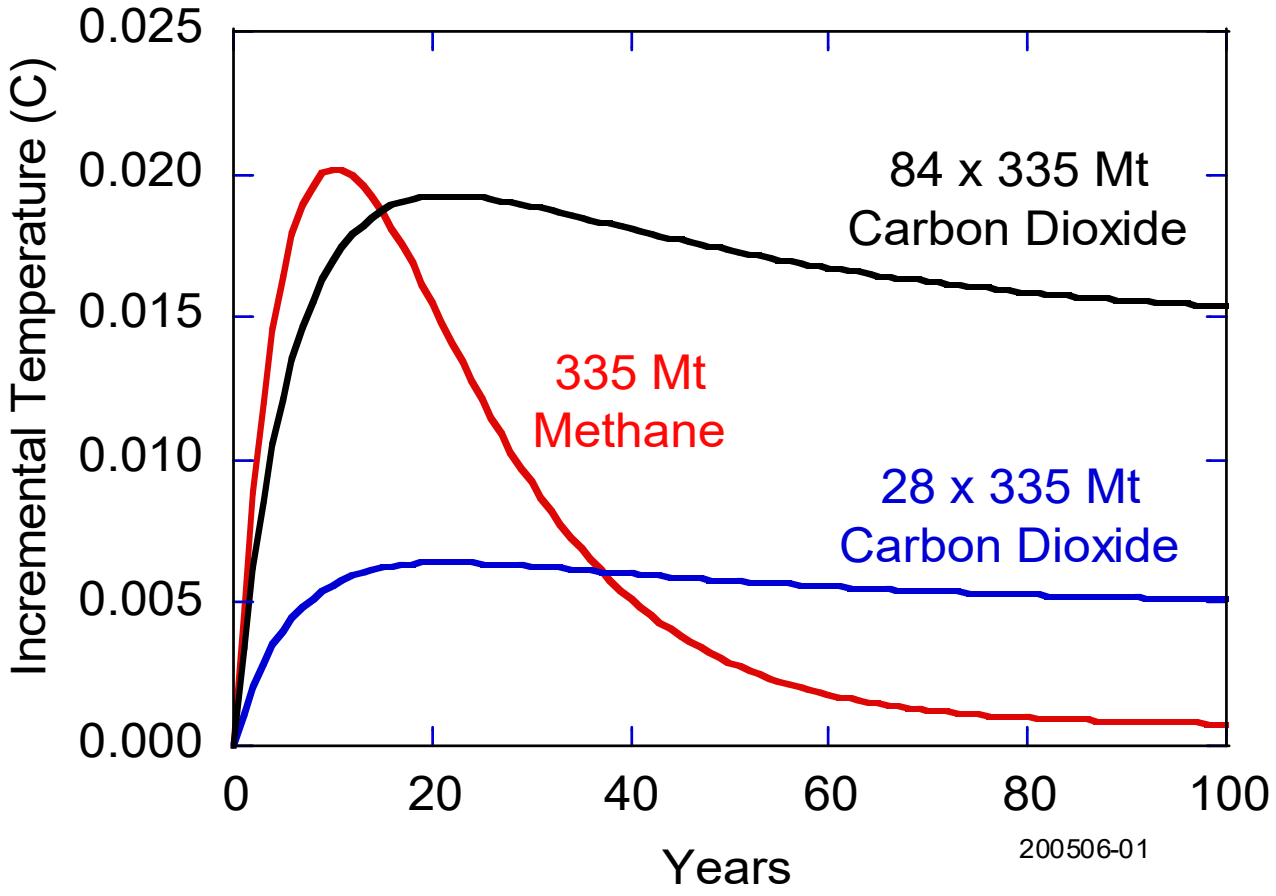
Multi-year emission model for methane

$$MAGTP_M(T) = A_M \sum_{t=0}^{T} m_M(t) \left\{ \sum_{j=1}^{2} \frac{\tau_M c_j}{\tau_M - d_j} \left[\exp(-(T-t)/\tau_M) - \exp(-(T-t)/d_j) \right] \right\}$$

R.L. Kleinberg, 2020. The Global Warming Potential Misrepresents the Physics of Global Warming Thereby Misleading Policy Makers
EarthArXiv: https://doi.org/10.31223/X5P88D

CO_2 –equivalent Method vs. Temperature Forecast

Single-Year Global Methane Emission



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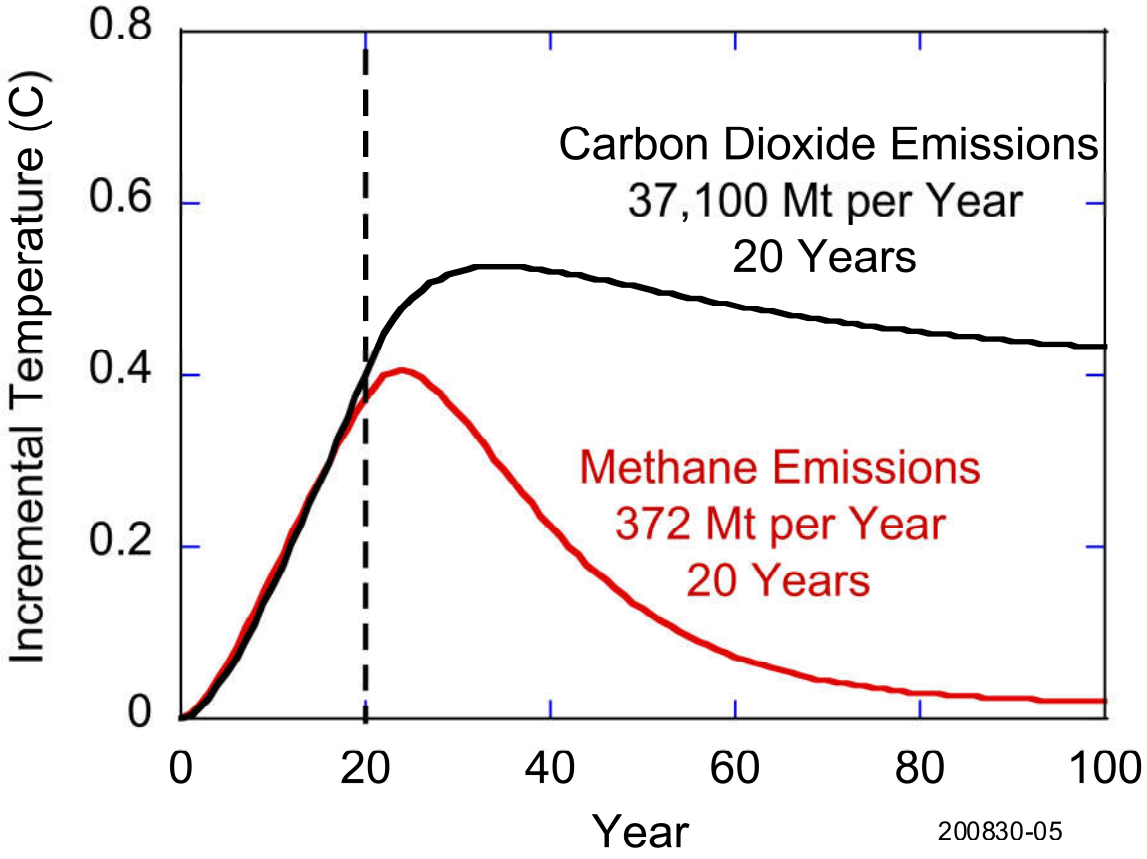
Incremental Increase of Global Mean Surface Temperature Resulting from Emission of 20-Year Quantities of CO_2 and CH_4



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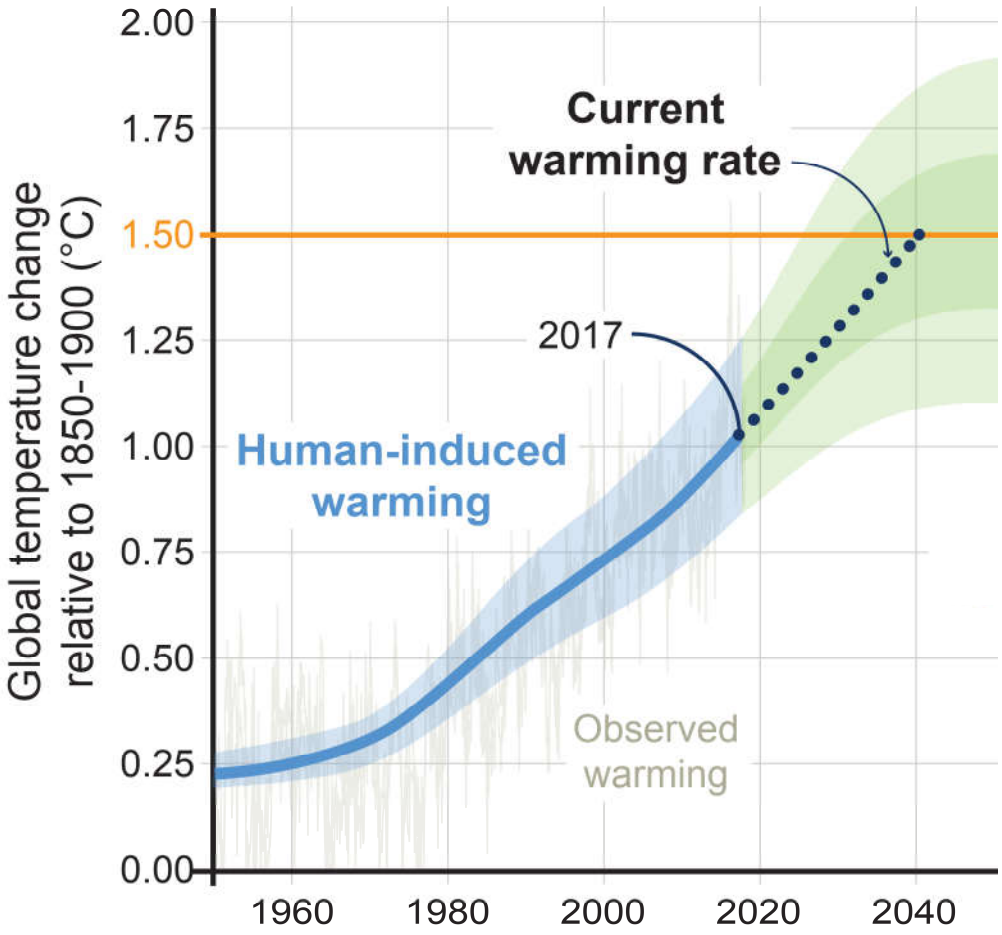
20-Year Emissions of Either CO_2 or CH_4 Alone Are Almost Enough to Push Temperature 1.5°C



IPCC Global Warming of 1.5°C, FAQ 1.2
https://www.ipcc.ch/sr15/faq/faq-chapter-1/

LIFE CYCLE GREENHOUSE GAS PERSPECTIVE ON EXPORTING LIQUEFIED NATURAL GAS FROM THE UNITED STATES: 2019 UPDATE

SELINA ROMAN-WHITE, SRIJANA RAI, JAMES LITTLEFIELD, GREGORY COONEY, TIMOTHY J. SKONE, P.E.

September 12, 2019

DOE/NETL-2019/2041

Greenhouse Gas Emissions from U.S. & Russia Natural Gas Supply Chains to Europe

methane

carbon dioxide

Exhibit 6-3. Speciated Life Cycle GHG Emissions of Natural Gas Power – U.S. LNG to Rotterdam Scenario

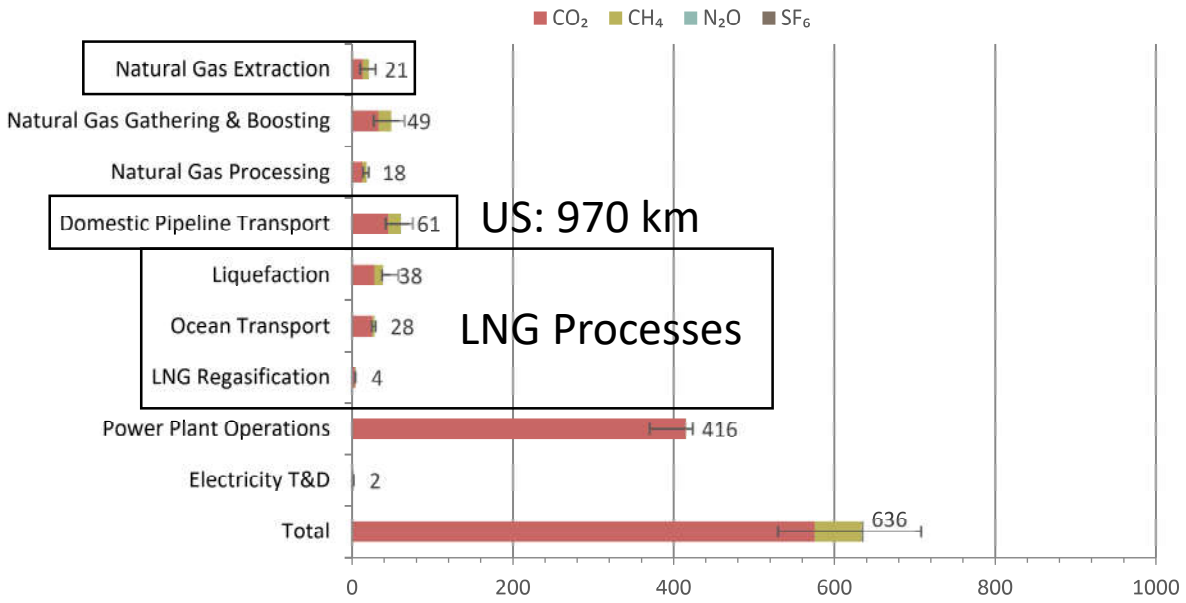
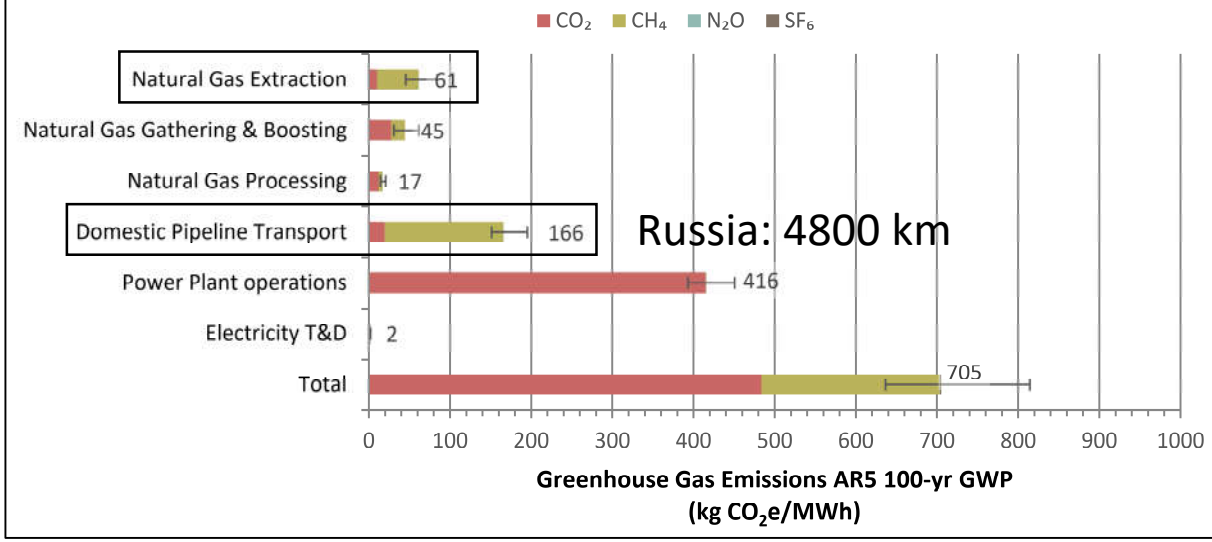
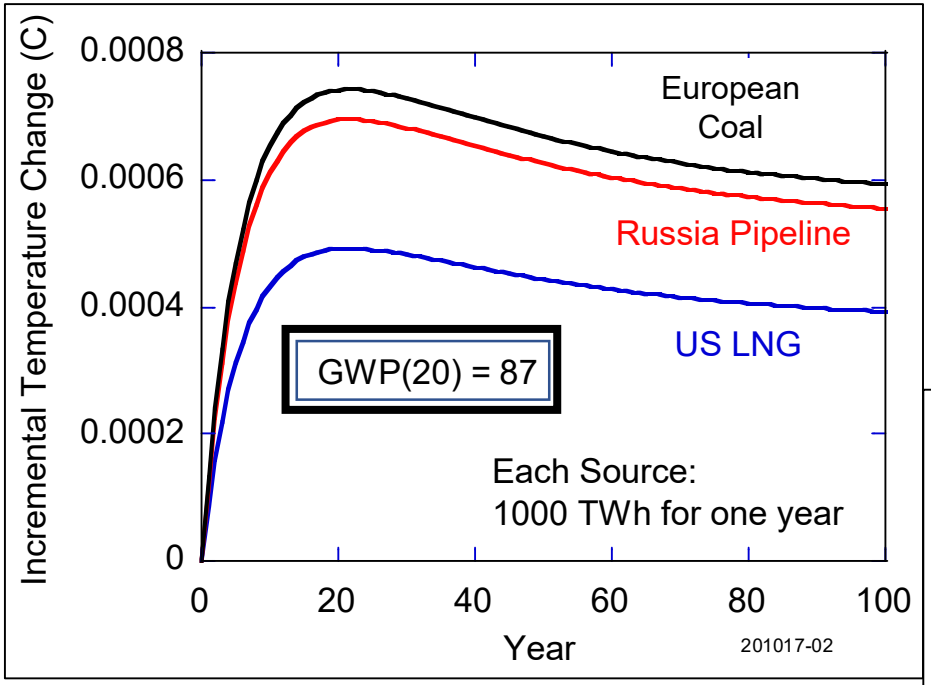


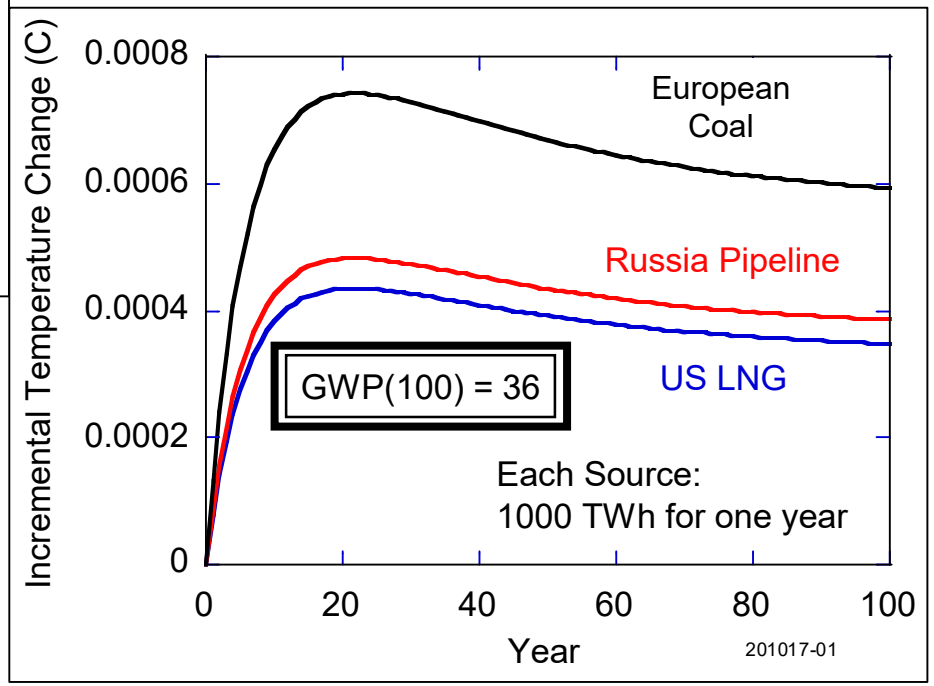
Exhibit 6-4. Speciated Life Cycle GHG Emissions of Natural Gas Power – Russian NG to Rotterdam Scenario



Global Warming Potential Modeling: CO_2-equivalent Methodology

100 Year Effects of Single-Year Emissions





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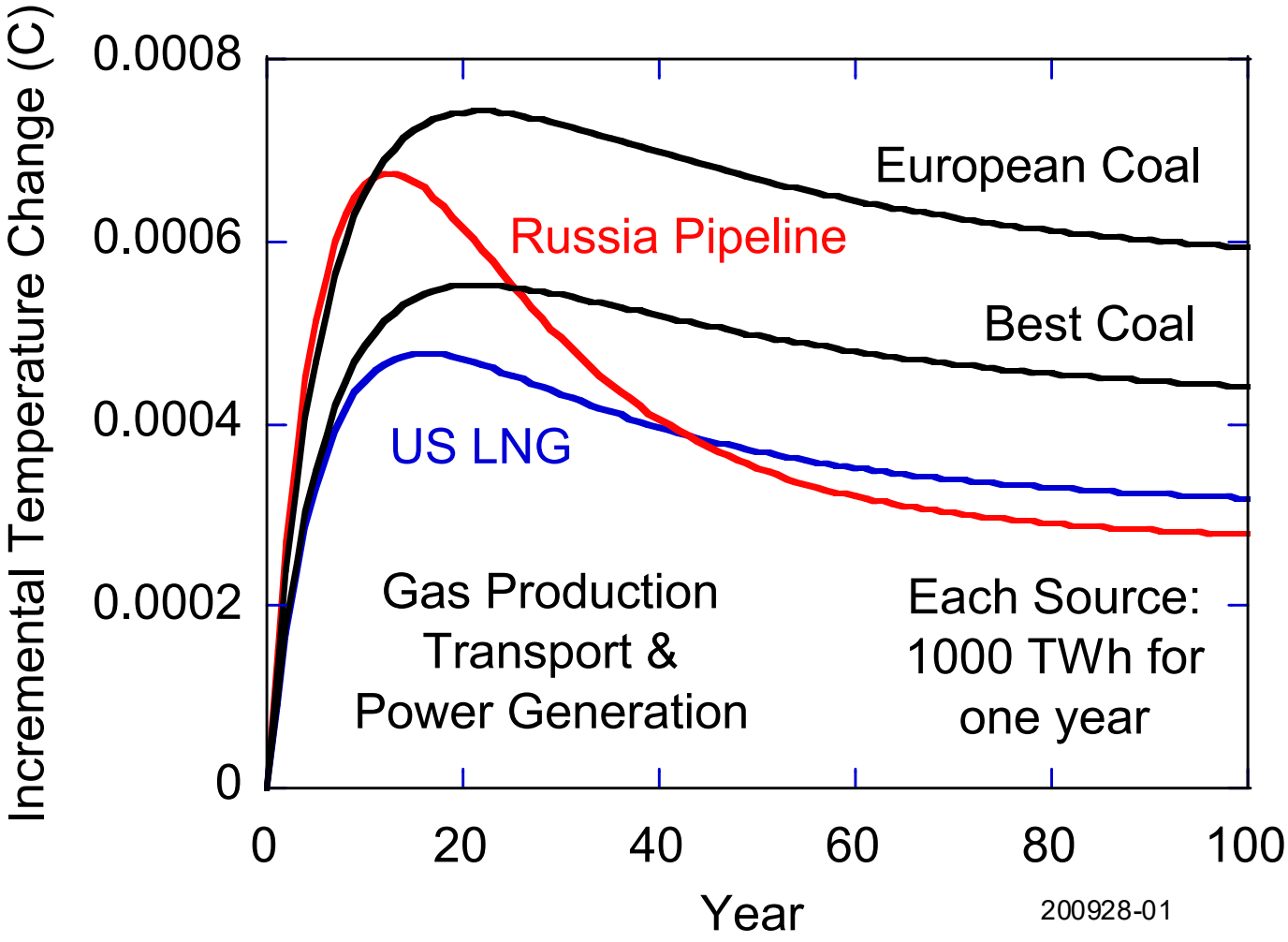
Correct Modeling of Temperature Change



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Implementing Method 21

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