Cornell University
College of Agriculture and Life Sciences

Methane Emission Mitigation by Municipalities

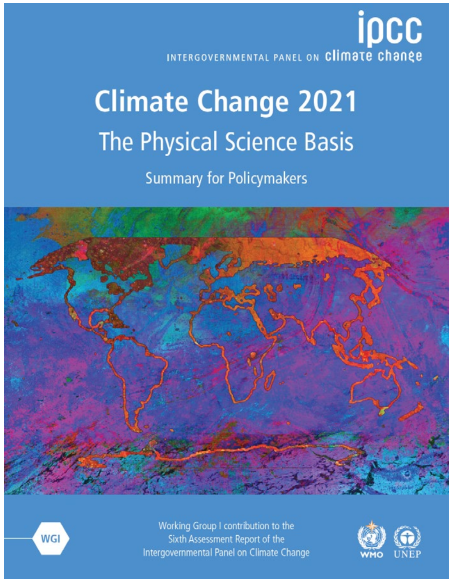
Robert Howarth

The David R. Atkinson Professor of Ecology & Environmental Biology

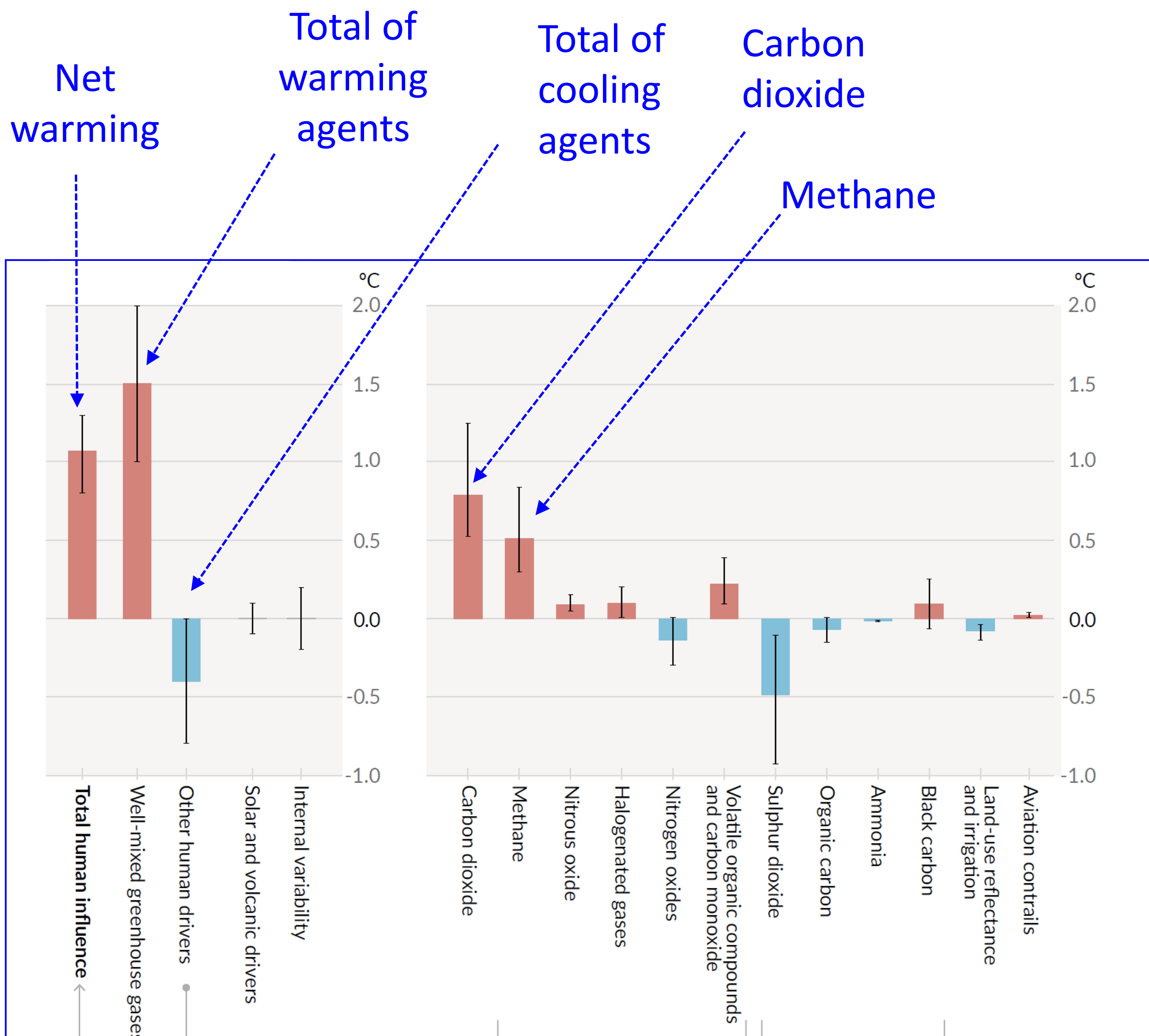
Cornell University, Ithaca, NY 14853 USA

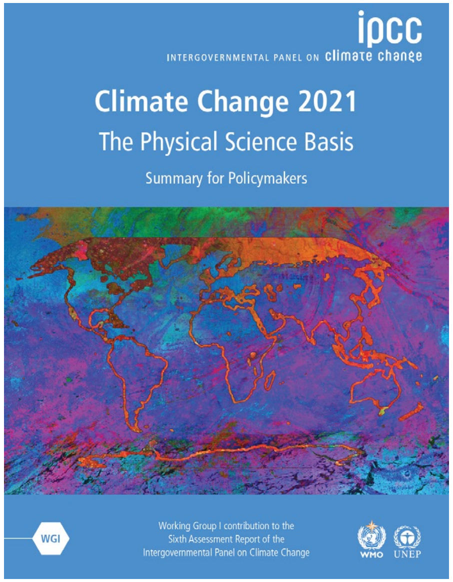
November 8, 2022

Clean Air Partnership



Average global temperature for 2010-2019 compared to 1850-1900





Average global temperature for 2010-2019 compared to 1850-1900

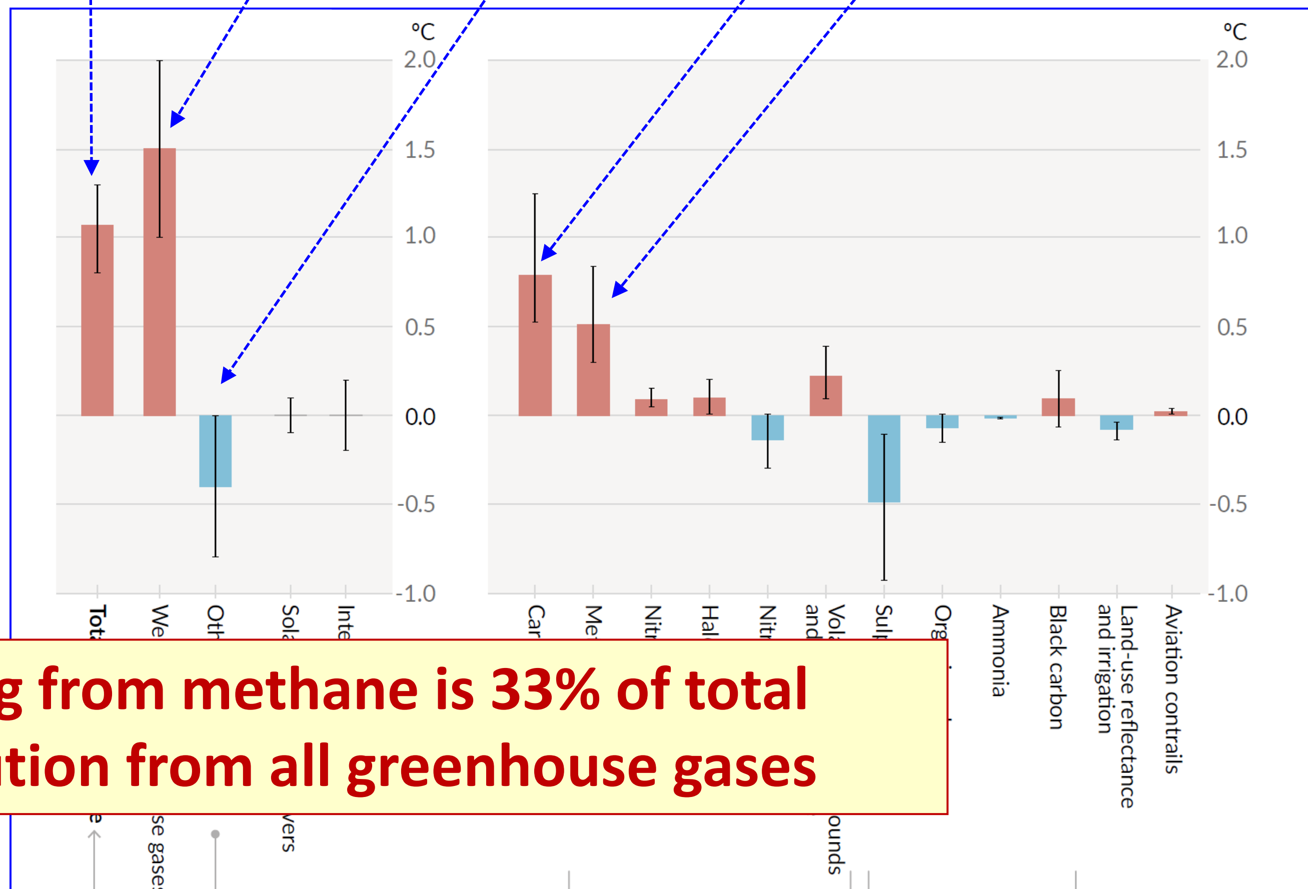
Net warming

Total of warming agents

Total of cooling agents

Carbon dioxide

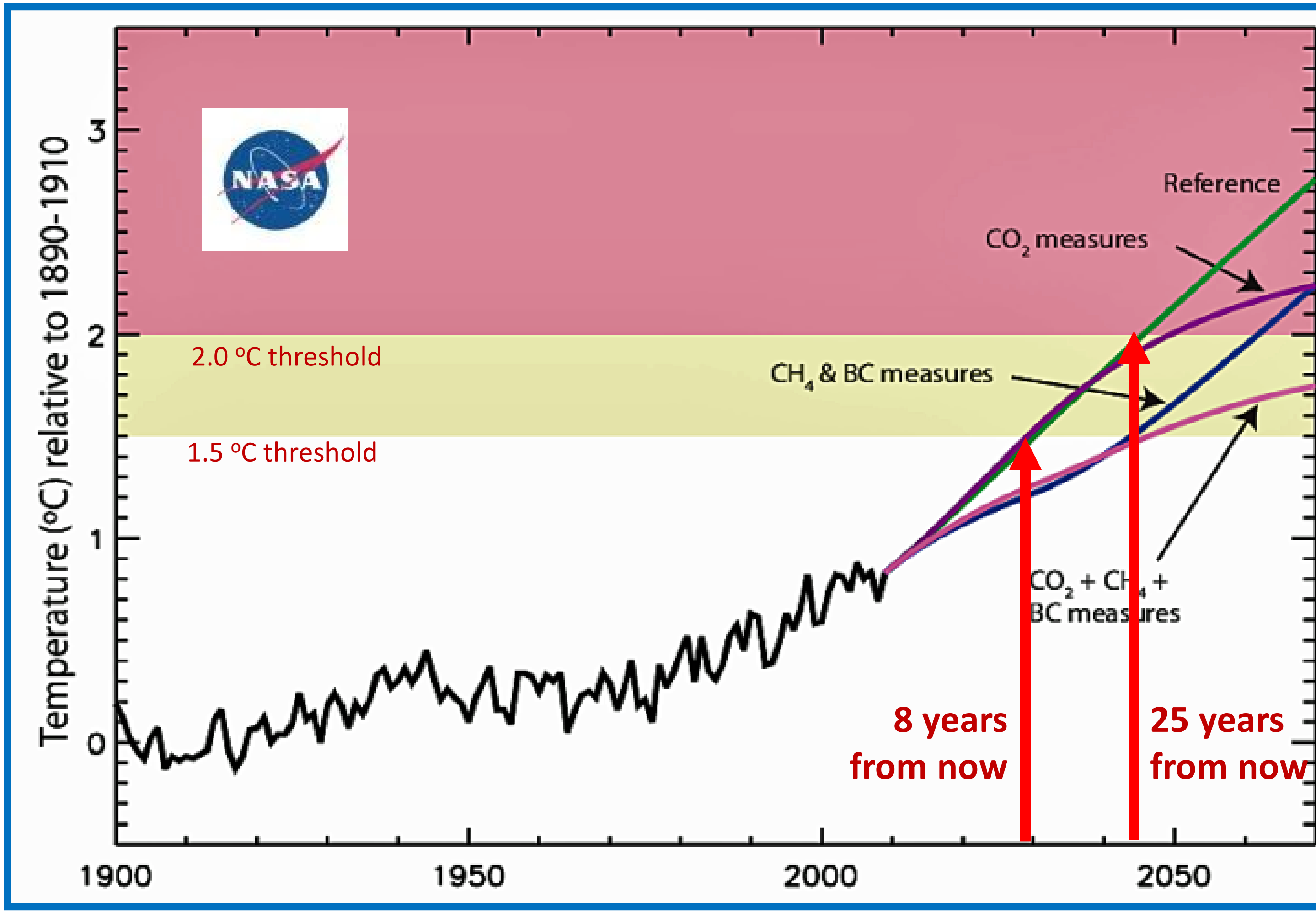
Methane



Warming from methane is 33% of total contribution from all greenhouse gases

COP21: United Nations Conference of the Parties
Le Bourget, Paris -- December 2015

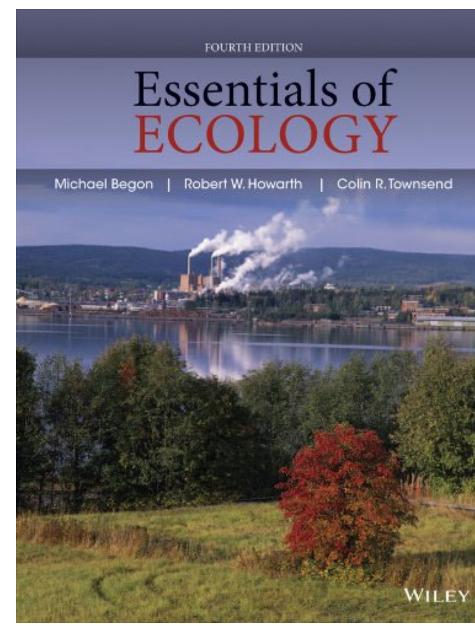
- COP21 Paris Accord target: “well below 2 deg C”
- Clear recognition that warming beyond 1.5 deg C is dangerous
- Methane reductions are critical; cannot reach COP21 target with CO_2 reductions alone



Shindell et al. 2012, *Science*

Global methane sources (Tg/yr), as of 1990 - 2000

Total	**570**
Total natural	**220**
Geological seeps	53
Biological sources	167
Total anthropogenic	**350**
Fossil fuels	115
Animal agriculture	90
Rice	60
Landfills & sewage	55
Biomass burning	30



Begon et al. (2014)

nature
International journal of science

August 2017

LETTER

doi:10.1038/nature23316

Minimal geological methane emissions during the Younger Dryas–Preboreal abrupt warming event

Vasilii V. Petrenko[1], Andrew M. Smith[2], Hinrich Schaefer[3], Katja Riedel[3], Edward Brook[4], Daniel Baggenstos[5,6], Christina Harth[5], Quan Hua[2], Christo Buizert[4], Adrian Schilt[4], Xavier Fain[7], Logan Mitchell[4,8], Thomas Bauska[4,9], Anais Orsi[5,10], Ray F. Weiss[5] & Jeffrey P. Severinghaus[5]

Methane (CH_4) is a powerful greenhouse gas and plays a key part in global atmospheric chemistry. Natural geological emissions (fossil methane vented naturally from marine and terrestrial seeps and mud volcanoes) are thought to contribute around 52 teragrams of methane per year to the global methane source, about 10 per cent of the total, but both bottom-up methods (measuring emissions)[1] and top-down approaches (measuring atmospheric mole fractions and isotopes)[2] for constraining these geological emissions have been associated with large uncertainties. Here we use ice core measurements to quantify the absolute amount of radiocarbon-containing methane ($^{14}CH_4$) in the past atmosphere and show that geological methane emissions were no higher than 15.4 teragrams per year (95 per cent confidence), averaged over the abrupt warming event that occurred between the Younger Dryas and Preboreal intervals, approximately 11,600 years ago. Assuming that past geological methane emissions were no lower than today[3,4], our

atmosphere can only produce combined estimates of natural geological and anthropogenic fossil CH_4 emissions (refs 2, 12).

Polar ice contains samples of the preindustrial atmosphere and offers the opportunity to quantify geological CH_4 in the absence of anthropogenic fossil CH_4. A recent study used a combination of revised source $\delta^{13}C$ isotopic signatures and published ice core $\delta^{13}CH_4$ data to estimate natural geological CH_4 at 51 ± 20 Tg CH_4 yr^{-1} (1σ range)[2], in agreement with the bottom-up assessment of ref. 1. This estimate, however, used $\delta^{13}C$ data that were affected by interference from krypton during mass spectrometry (see Supplementary Information section 9). Further, $\delta^{13}C$ offers only a weak constraint, because of uncertainties in past CH_4 emissions from biomass burning and in the source $\delta^{13}C$ signatures (Supplementary Information section 9). In contrast, $^{14}CH_4$ in the preindustrial atmosphere is the ideal tracer for constraining natural geological CH_4 because the ^{14}C signatures of most CH_4 sources are very well defined. The ^{14}C signature of CH_4 emitted from wetlands

nature
International journal of science

August 2017

LETTER

Minimal geological methane e… Younger Dryas–Preboreal abr…

Vasilii V. Petrenko[1], Andrew M. Smith[2], Hinrich Schaefer[3], Katja Riedel[3], …
Quan Hua[2], Christo Buizert[4], Adrian Schilt[4], Xavier Fain[7], Logan Mitchell…

Measured C^{14} in ice laid down in Antarctica 11,500 years ago (1 ton of ice per sample).

Indicates the methane from 11,500 years ago came from biological sources, not geological seeps.

Global methane sources (Tg/yr), as of 1990 - 2000

Total	**570**
Total natural	**220**
Geological seeps	0
Biological sources	220
Total anthropogenic	**350**
Fossil fuels	168
Animal agriculture	67
Rice	44
Landfills & sewage	41
Biomass burning	30

Based on Begon et al. (2014), modified March 28, 2018

Methane emissions from natural gas in the US: Preponderance of peer-reviewed literature compared to official US EPA estimates (based on industry self reporting)

	Average from peer-Reviewed literature	EPA for 2015	EPA for 2019
Upstream & midstream	2.6 %	1.4 %	0.79 %
Dowsntream (distribution)	2.2 %	0.08 %	0.14 %
TOTAL	4.8 %	1.48 %	0.93 %

Howarth, Dec 2022, EM Magazine

Methane emiss
literature comp **)**

Based in part on this comparison, International Energy Agency stated in Feb 2022 that EPA estimates and those of almost all other governments globally are at least 1.7x too low. (This also applies to IPCC estimates).

	Average from peer-Reviewed literature	EPA for 2015	EPA for 2019
Upstream & midstream	2.6 %	1.4 %	0.79 %
Dowsntream (distribution)	2.2 %	0.08 %	0.14 %
TOTAL	4.8 %	1.48 %	0.93 %

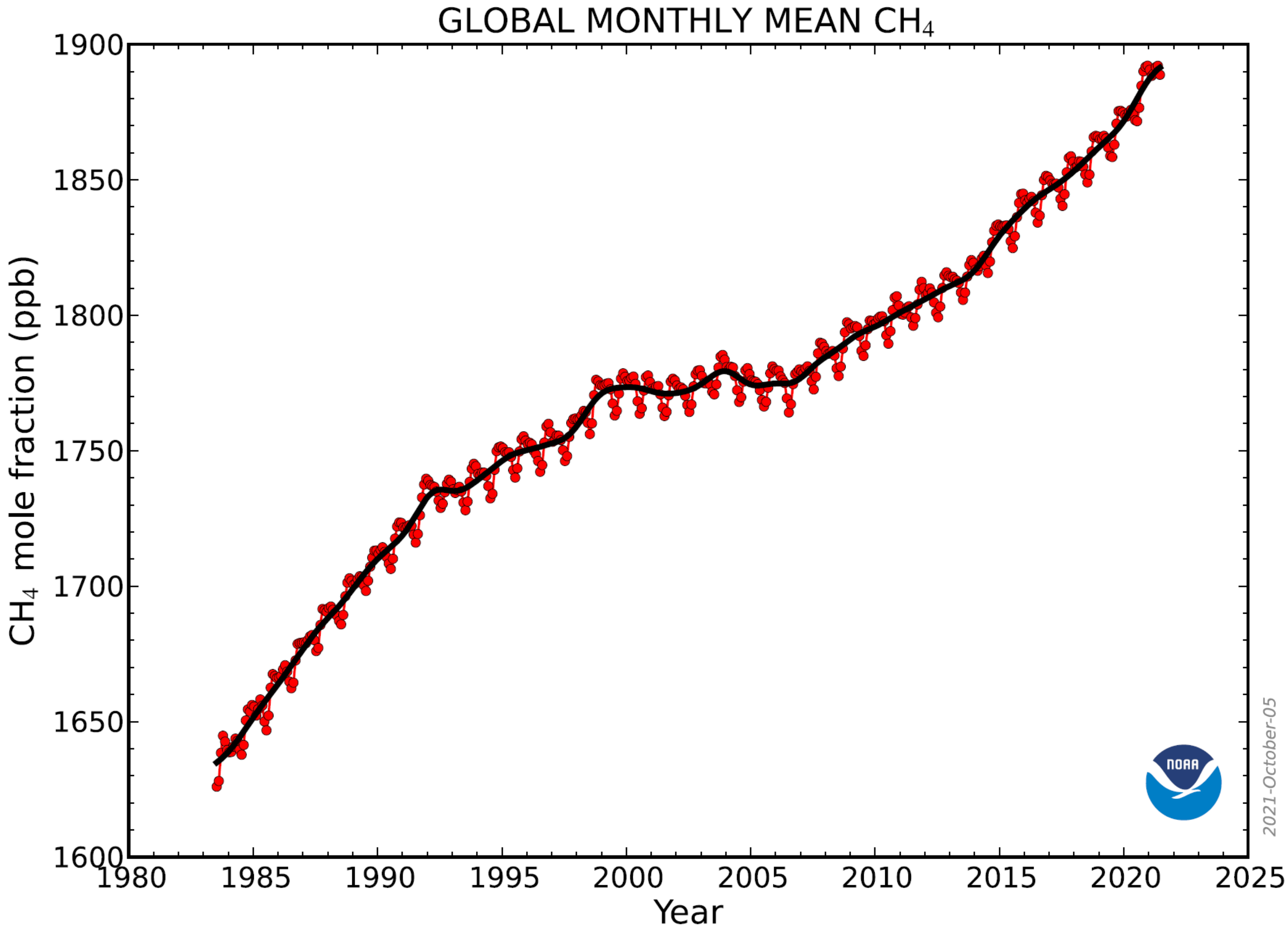
Howarth, Dec 2022, EM Magazine

Methane emiss literature comp)

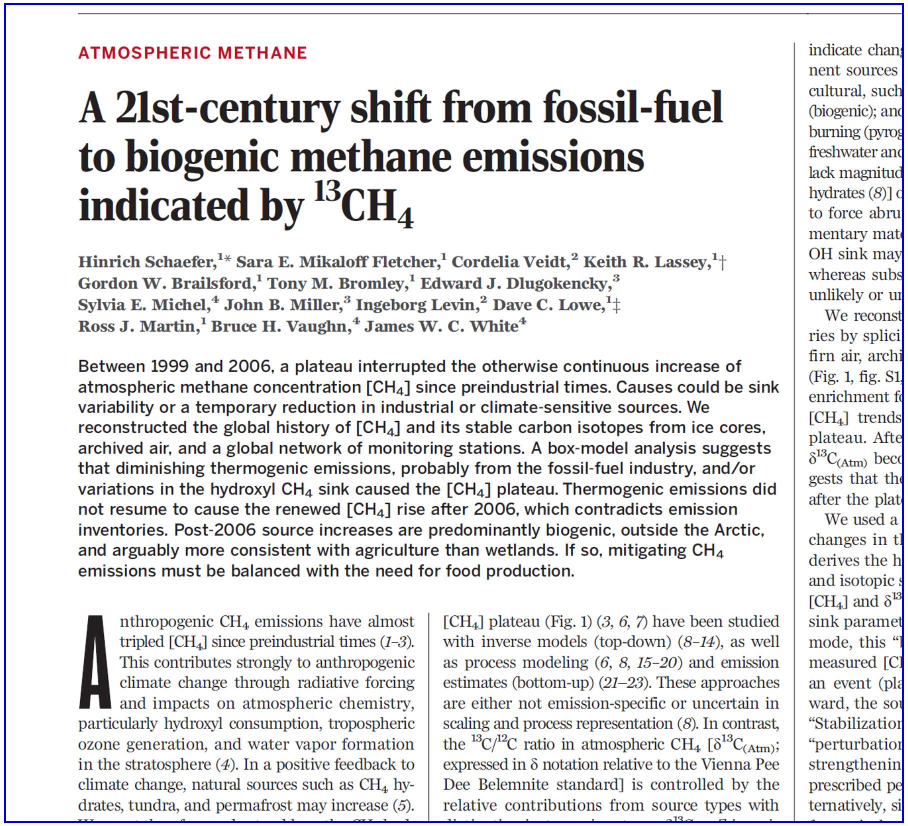
Based in part on this comparison, International Energy Agency stated in Feb 2022 that EPA estimates and those of almost all other governments globally are at least 1.7x too low. (This also applies to IPCC estimates).

	Average from peer-Reviewed literature	EPA for 2015	EPA for 2019
Upstream & midstream	2.6 %	1.4 %	0.79 %
Dowsntream (distribution)	2.2 %	0.08 %	0.14 %
TOTAL	4.8 %	1.48 %	0.93 %

EPA estimates for 2019 for total emissions are actually more than 5x too low!



Rapid rise in atmospheric methane globally since 2008



ATMOSPHERIC METHANE

A 21st-century shift from fossil-fuel to biogenic methane emissions indicated by $^{13}CH_4$

Hinrich Schaefer,[1]* Sara E. Mikaloff Fletcher,[1] Cordelia Veidt,[2] Keith R. Lassey,[1]† Gordon W. Brailsford,[1] Tony M. Bromley,[1] Edward J. Dlugokencky,[3] Sylvia E. Michel,[4] John B. Miller,[3] Ingeborg Levin,[2] Dave C. Lowe,[1]‡ Ross J. Martin,[1] Bruce H. Vaughn,[4] James W. C. White[4]

Between 1999 and 2006, a plateau interrupted the otherwise continuous increase of atmospheric methane concentration [CH_4] since preindustrial times. Causes could be sink variability or a temporary reduction in industrial or climate-sensitive sources. We reconstructed the global history of [CH_4] and its stable carbon isotopes from ice cores, archived air, and a global network of monitoring stations. A box-model analysis suggests that diminishing thermogenic emissions, probably from the fossil-fuel industry, and/or variations in the hydroxyl CH_4 sink caused the [CH_4] plateau. Thermogenic emissions did not resume to cause the renewed [CH_4] rise after 2006, which contradicts emission inventories. Post-2006 source increases are predominantly biogenic, outside the Arctic, and arguably more consistent with agriculture than wetlands. If so, mitigating CH_4 emissions must be balanced with the need for food production.

Anthropogenic CH_4 emissions have almost tripled [CH_4] since preindustrial times (*1–3*). This contributes strongly to anthropogenic climate change through radiative forcing and impacts on atmospheric chemistry, particularly hydroxyl consumption, tropospheric ozone generation, and water vapor formation in the stratosphere (*4*). In a positive feedback to climate change, natural sources such as CH_4 hydrates, tundra, and permafrost may increase (*5*).

[CH_4] plateau (Fig. 1) (*3, 6, 7*) have been studied with inverse models (top-down) (*8–14*), as well as process modeling (*6, 8, 15–20*) and emission estimates (bottom-up) (*21–23*). These approaches are either not emission-specific or uncertain in scaling and process representation (*8*). In contrast, the $^{13}C/^{12}C$ ratio in atmospheric CH_4 [$\delta^{13}C_{(Atm)}$; expressed in δ notation relative to the Vienna Pee Dee Belemnite standard] is controlled by the relative contributions from source types with

indicate chan
nent sources
cultural, such
(biogenic); an
burning (pyro
freshwater an
lack magnitu
hydrates (*8*)]
to force abru
mentary mat
OH sink may
whereas subs
unlikely or u
We recons
ries by splic
firn air, arch
(Fig. 1, fig. S
enrichment f
[CH_4] trends
plateau. Aft
$\delta^{13}C_{(Atm)}$ bec
gests that th
after the pla
We used a
changes in t
derives the h
and isotopic
[CH_4] and δ^{13}
sink parame
mode, this "
measured [C
an event (pl
ward, the so
"Stabilizatio
"perturbatio
strengthenin
prescribed p
ternatively, s

High visibility paper published in March 2016 in *Science*: Increase in atmospheric methane since 2006 is most likely biogenic in large part, probably from cows.

Based largely on stable carbon isotopic composition (^{13}C vs. ^{12}C) in atmospheric methane.

Biogeosciences
An interactive open-access journal of the European Geosciences Union

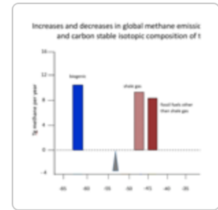
Biogeosciences, 16, 3033–3046, 2019
https://doi.org/10.5194/bg-16-3033-2019

BG | Volume 16, issue 15

Ideas and perspectives

14 Aug 2019

Ideas and perspectives: is shale gas a major driver of recent increase in global atmospheric methane?



Robert W. Howarth
Department of Ecology and Evolutionary Biology, Cornell University, Ithaca, NY 14853, USA

Correspondence: Robert W. Howarth (howarth@cornell.edu)

Received: 10 Apr 2019 – Discussion started: 23 Apr 2019 – Revised: 11 Jul 2019 – Accepted: 12 Jul 2019 – Published: 14 Aug 2019

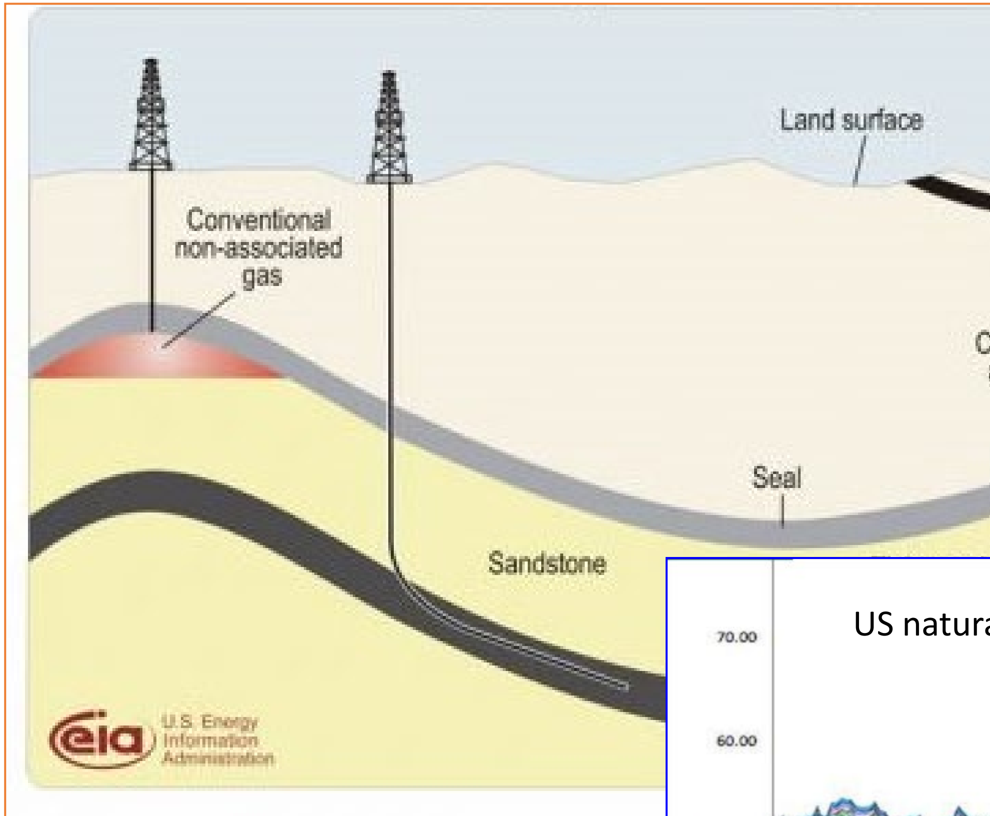
Abstract

Back to top

Methane has been rising rapidly in the atmosphere over the past decade, contributing to global climate change. Unlike the late 20th century when the rise in atmospheric methane was accompanied by an enrichment in the heavier carbon stable isotope (^{13}C) of methane, methane in recent years has become more depleted in ^{13}C. This depletion has been widely interpreted as indicating a primarily biogenic source for the increased methane. Here we show that part of the change may instead be associated with emissions from shale-gas and shale-oil development. Previous studies have not explicitly considered shale gas, even though most of the increase in natural gas production globally over the past decade is from shale gas. The methane in shale gas is somewhat depleted in ^{13}C relative to conventional natural gas. Correcting earlier analyses for this difference, we conclude that shale-gas production in North America over the past decade may have contributed more than half of all of the increased emissions from fossil fuels globally and approximately one-third of the total increased emissions from all sources globally over the past decade.

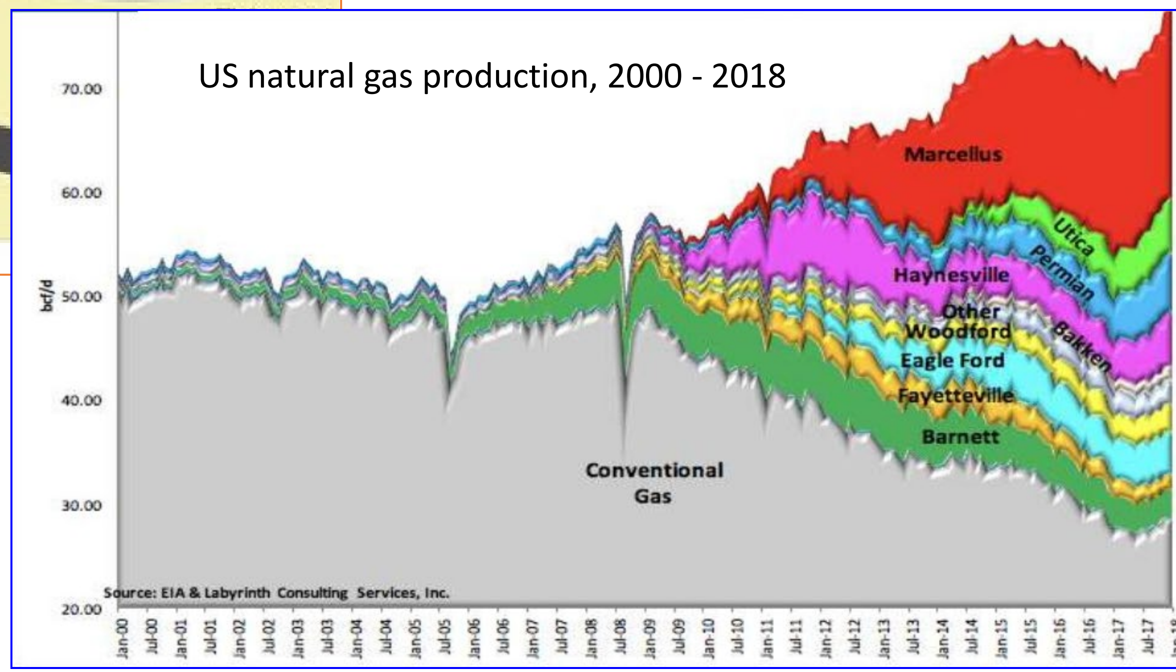
How to cite. Howarth, R. W.: Ideas and perspectives: is shale gas a major driver of recent increase in global atmospheric methane?, Biogeosciences, 16, 3033–3046, https://doi.org/10.5194/bg-16-3033-2019, 2019.

July 2019

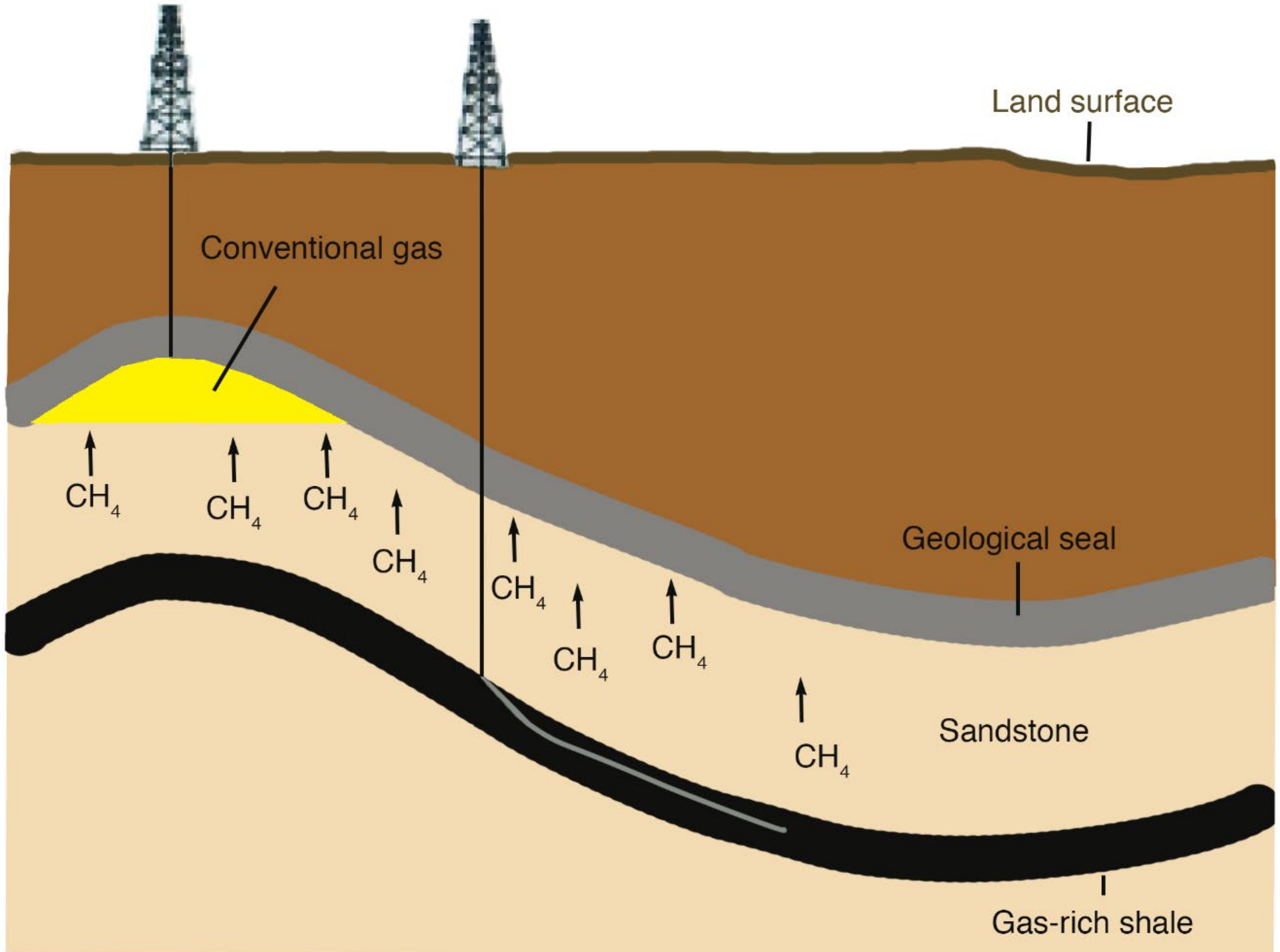


Shale gas revolution since 2006

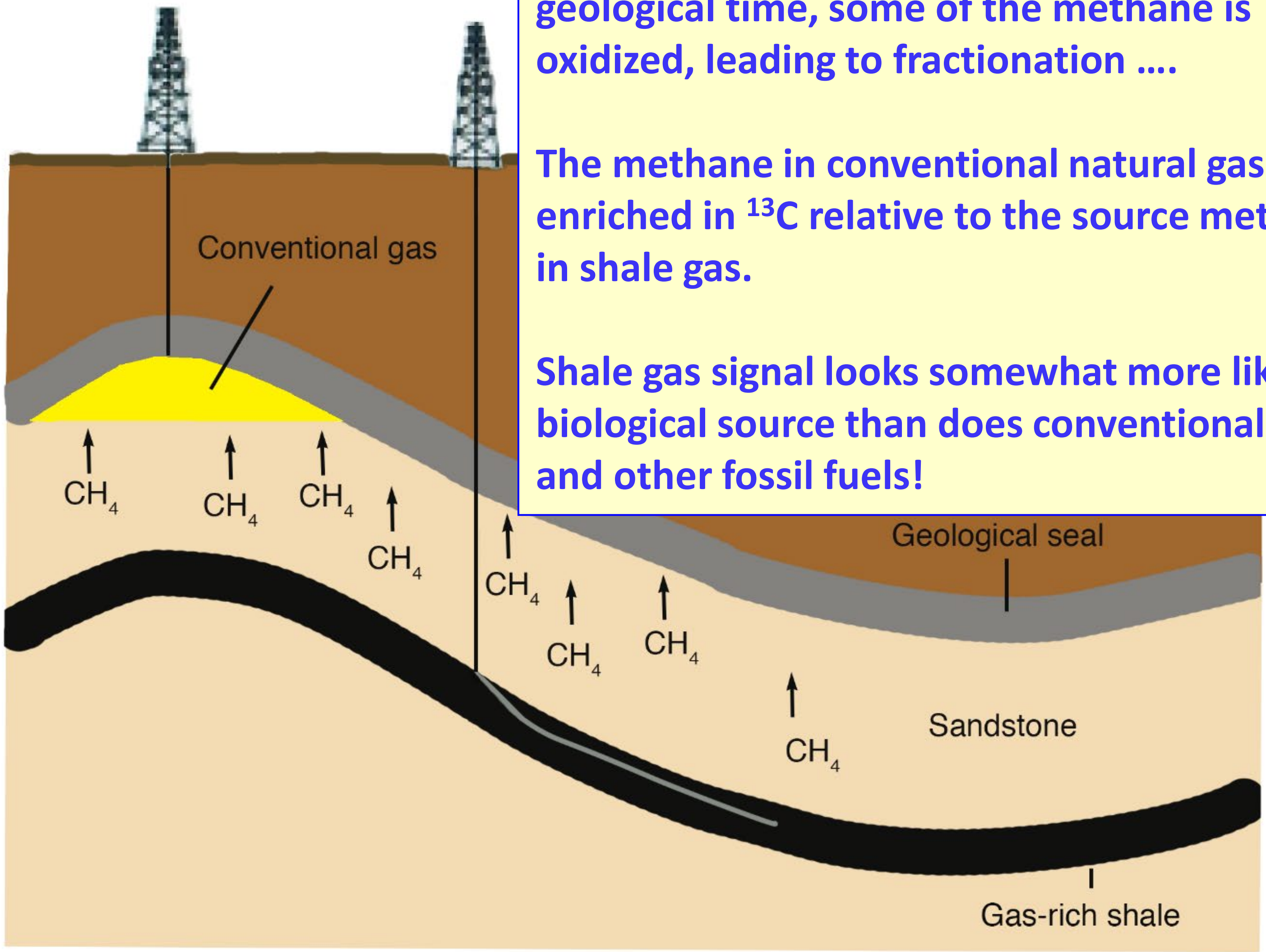
(totally a North American phenomenon, largely US, through 2015)



Jeremy Legget, Oct 2018: https://jeremyleggett.net/2018/10/16/history-of-oil-and-gas-production-from-shale-in-pictures-and-charts-why-american-shale-is-heading-for-a-crash-and-fracking-in-the-uk-is-doomed-to-costly-failure-2/



Howarth (2019)

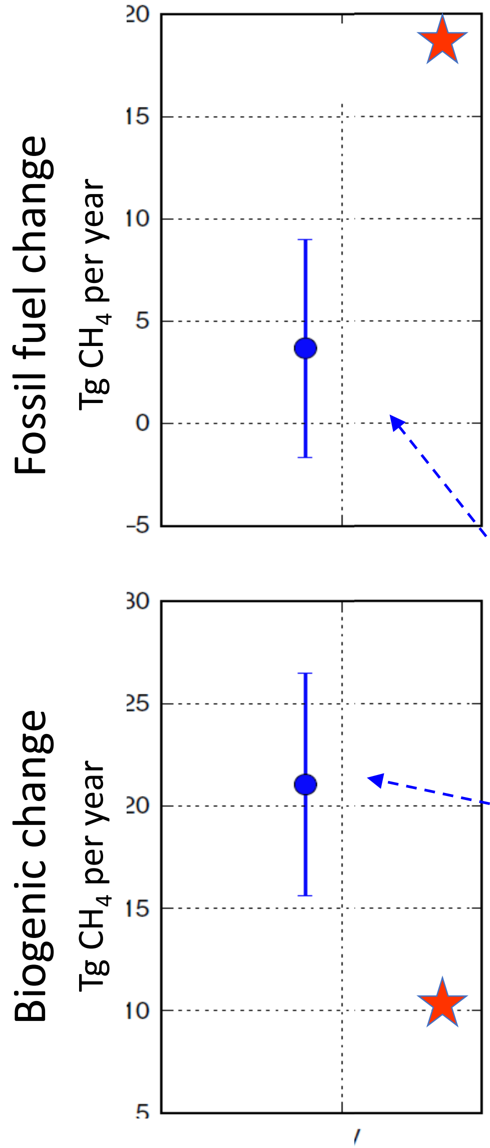


As it migrates through sandstone over geological time, some of the methane is oxidized, leading to fractionation ….

The methane in conventional natural gas is enriched in ^{13}C relative to the source methane in shale gas.

Shale gas signal looks somewhat more like a biological source than does conventional gas and other fossil fuels!

Howarth (2019)



Howarth 2019 in *Biogeosciences*

Increase in emissions of 18 Tg/yr from fossil fuels (with half of this from US shale gas) and 10 Tg/yr from biological sources such as cows

(after correcting for biomass burning from Worden et al. 2017) and for ^{13}C signal of shale gas)

Schaefer et al. 2016 paper in *Science*

Increase in emissions of 22 Tg/yr from biological sources such as cows and 4 Tg/yr from fossil fuels.

Adapted from Worden et al. (2017), with addition of Howarth (2019).

Global methane sources (Tg per year)

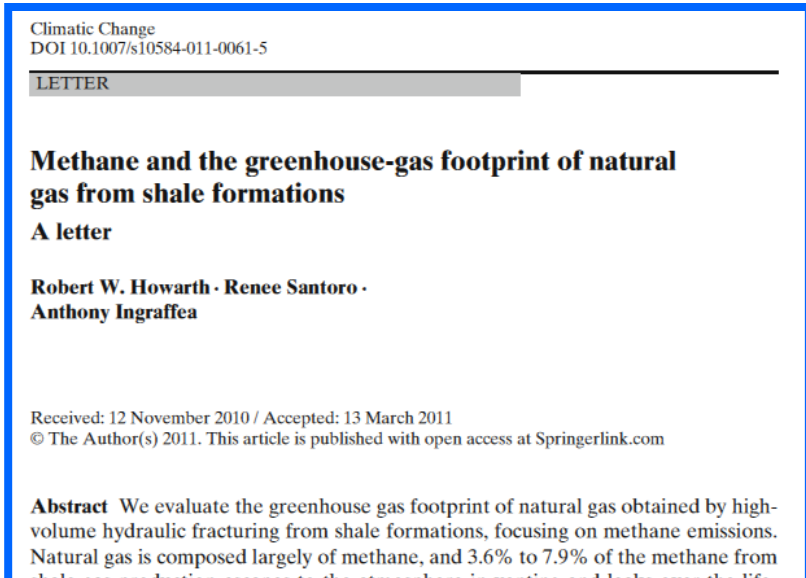
	1995	2015
Total	**570**	**595**
Total natural	**220**	
Geological seeps	~ 0	
Wetlands & lakes	220	
Total anthropogenic	**350**	**375**
Natural gas and oil	136	154
Coal	32	33
Animal agriculture	67	77
Rice	44	
Landfills & sewage	41	
Biomass burning	30	27

R. W. Howarth, based on Begon et al. (2014), modified June 2, 2019

One "climate solution" proposed around 2000 was to use natural gas as a "bridge fuel." Replace coal with gas for generating electric power. CO_2 emissions decrease by ~ 40%, since gas generates more heat energy than coal per unit of CO_2 produced.

Eventually, move beyond the bridge to a fossil-fuel-free future....

Publication of first peer-reviewed paper on methane and the greenhouse gas footprint of shale gas (Howarth, Santoro, & Ingraffea 2011)



Climatic Change
DOI 10.1007/s10584-011-0061-5

LETTER

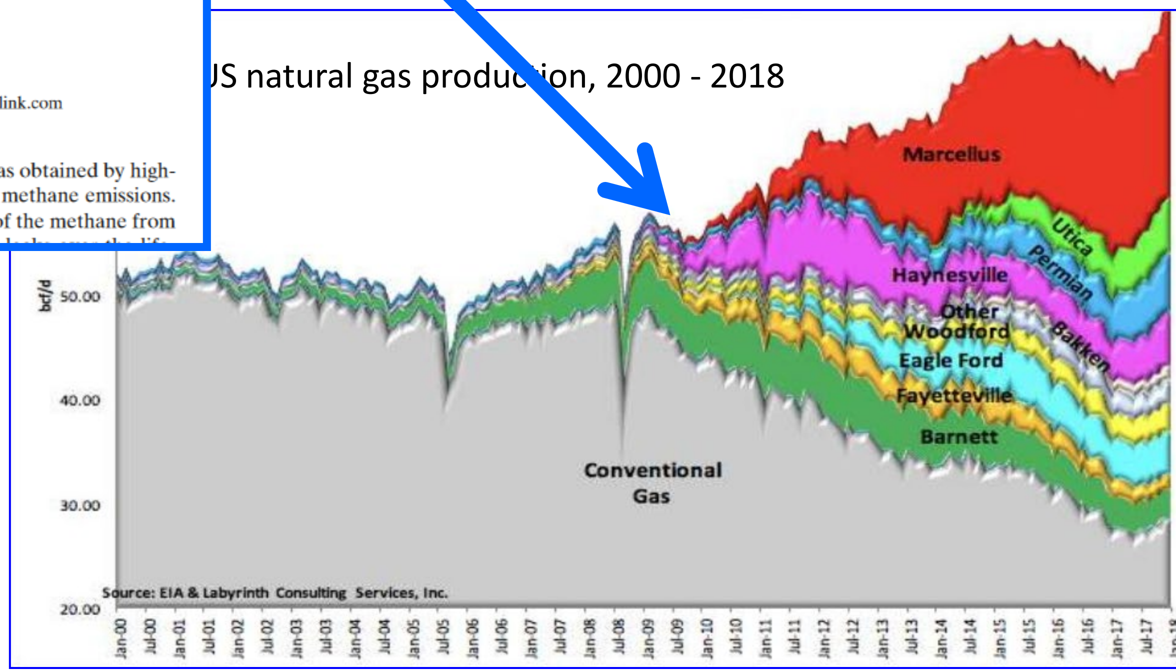
Methane and the greenhouse-gas footprint of natural gas from shale formations

A letter

Robert W. Howarth · Renee Santoro · Anthony Ingraffea

Received: 12 November 2010 / Accepted: 13 March 2011

Abstract We evaluate the greenhouse gas footprint of natural gas obtained by high-volume hydraulic fracturing from shale formations, focusing on methane emissions. Natural gas is composed largely of methane, and 3.6% to 7.9% of the methane from



Jeremy Legget, Oct 2018: https://jeremyleggett.net/2018/10/16/history-of-oil-and-gas-production-from-shale-in-pictures-and-charts-why-american-shale-is-heading-for-a-crash-and-fracking-in-the-uk-is-doomed-to-costly-failure-2/

Climatic Change
DOI 10.1007/s10584-011-0061-5

LETTER

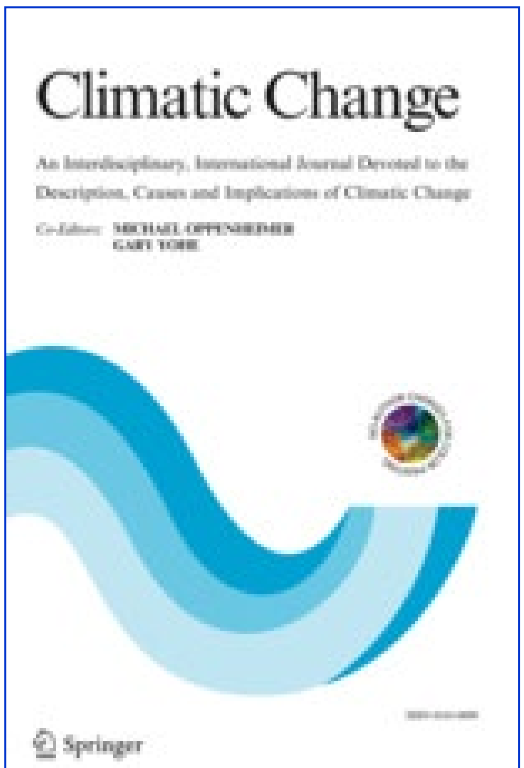
Methane and the greenhouse-gas footprint of natural gas from shale formations

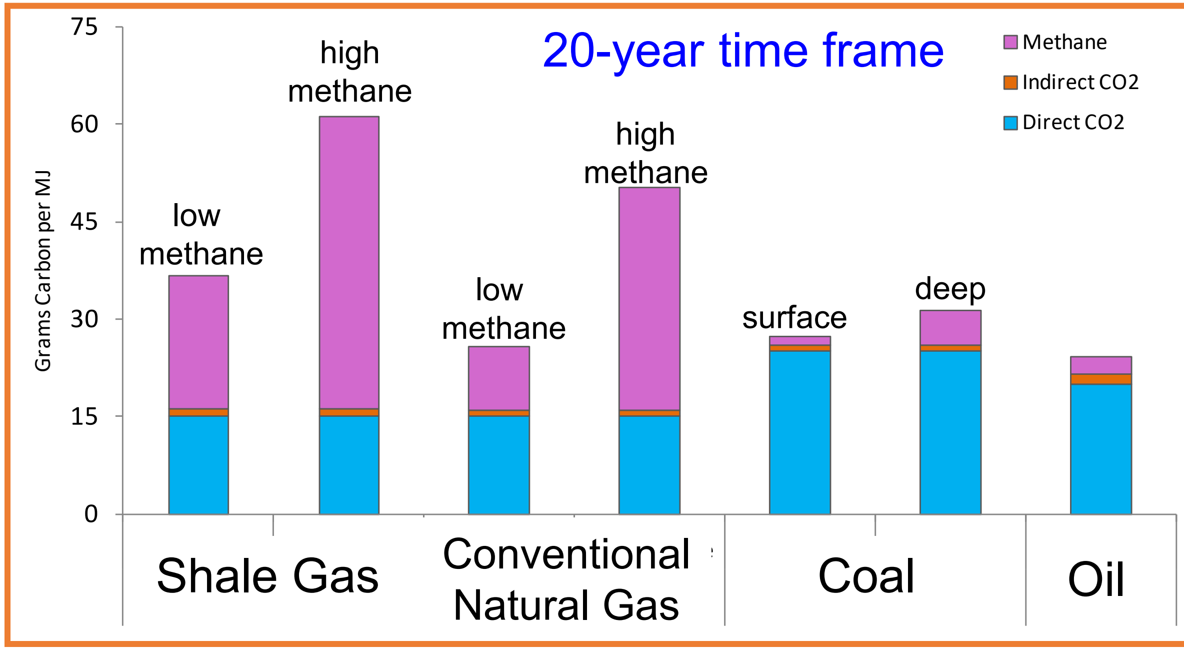
A letter

Robert W. Howarth · Renee Santoro ·
Anthony Ingraffea

Received: 12 November 2010 / Accepted: 13 March 2011

Abstract We evaluate the greenhouse gas footprint of natural gas obtained by high-volume hydraulic fracturing from shale formations, focusing on methane emissions. Natural gas is composed largely of methane, and 3.6% to 7.9% of the methane from shale-gas production escapes to the atmosphere in venting and leaks over the life-time of a well. These methane emissions are at least 30% more than and perhaps more than twice as great as those from conventional gas. The higher emissions from shale gas occur at the time wells are hydraulically fractured—as methane escapes from flow-back return fluids—and during drill out following the fracturing. Methane





- **Small leaks and emissions of methane matter**

The New York Times

Poking Holes in a Green Image

Tom Zeller

April 11, 2011

"The old dogma of natural gas being better than coal in terms of greenhouse gas emissions gets stated over and over without qualification," said Robert Howarth, a professor of ecology and environmental biology at Cornell University and the lead author ………

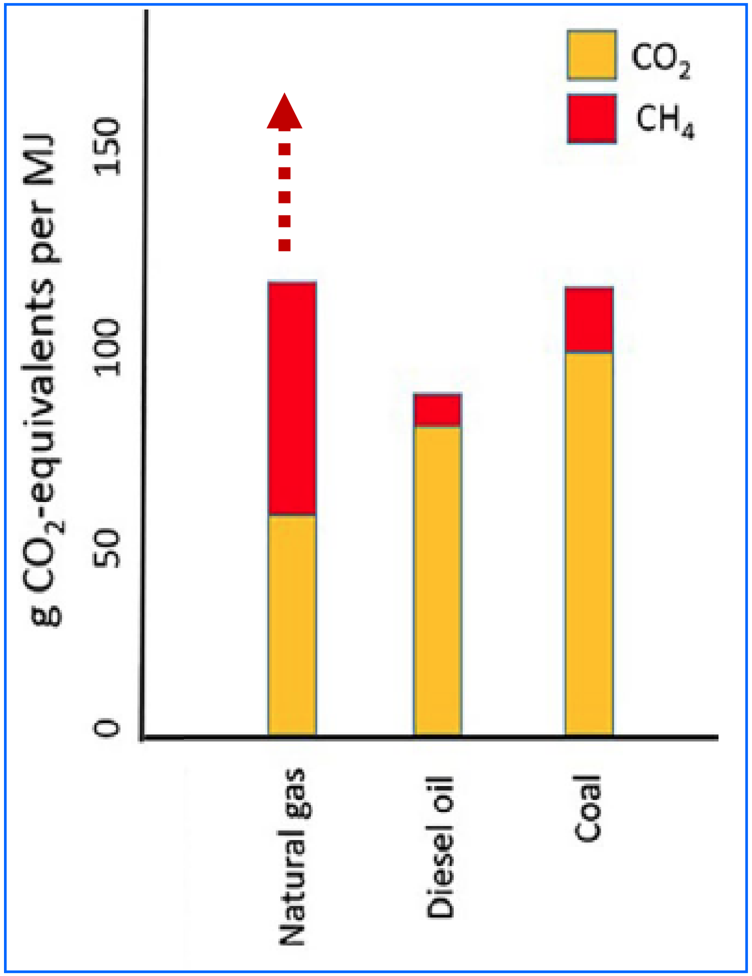
"I don't think this is the end of the story," said Mr. Howarth, who is an opponent of growing gas development in western New York. "I think this is just the beginning of the story, and before governments and the industry push ahead on gas development, at the very least we ought to do a better job of making measurements."

The findings are certain to stir debate. For much of the last decade, the natural gas industry has carefully cultivated a green reputation, often with the help of environmental groups that embrace the resource as a clean-burning "bridge fuel" to a renewable energy future.

More than a decade after our first 2011 analysis, now over 1,800 peer- reviewed scientific papers on methane from natural gas as a driver of climate change.

Considering both CO_2 and methane natural gas is no bridge fuel at all.

Greenhouse gas footprint of gas is At best similar to that of coal



Modified from Howarth & Jacobson 2021

The natural gas as “bridge fuel” idea eventually died out.

Along the way, New York State banned fracking for shale gas (in 2014 by executive order, permanently by legislative action in 2020).

Yet natural gas use in New York has increased faster than any other state since the fracking ban….

……. Almost all of this is fracked shale gas from Pennsylvania.

The New York Times

Citing Health Risks, Cuomo Bans Fracking in New York State

Give this article | 782

Members of New Yorkers Against Fracking celebrated the governor’s decision outside his Manhattan office on Wednesday. Chang W. Lee/The New York Times

By Thomas Kaplan

A Fossil-Fuel-Free Future for New York State,

Powering with Wind, Water, & Sun to Address Global Warming, Air Pollution, & Energy Security

Energy Policy ∎ (∎∎∎∎) ∎∎∎–∎∎∎

Contents lists available at SciVerse ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

ELSEVIER

ENERGY POLICY

Examining the feasibility of converting New York State's all-purpose energy infrastructure to one using wind, water, and sunlight

Mark Z. Jacobson [a,*], Robert W. Howarth [b], Mark A. Delucchi [c], Stan R. Scobie [d], Jannette M. Barth [e], Michael J. Dvorak [a], Megan Klevze [a], Hind Katkhuda [a], Brian Miranda [a], Navid A. Chowdhury [a], Rick Jones [a], Larson Plano [a], Anthony R. Ingraffea [f]

[a] Atmosphere/Energy Program, Department of Civil and Environmental Engineering, Stanford University, Stanford, CA 94305, USA
[b] Department of Ecology and Evolutionary Biology, Cornell University Ithaca, NY 14853, USA
[c] Institute of Transportation Studies, U.C. Davis, Davis, CA 95616, USA
[d] PSE Healthy Energy, NY, USA
[e] Pepacton Institute LLC, USA
[f] School of Civil and Environmental Engineering, Cornell University, Ithaca, NY 14853, USA

H I G H L I G H T S

- New York State's all purpose energy can be derived from wind, water, and sunlight.
- The conversion reduces NYS end use power demand by ~37%.
- The plan creates more jobs than lost since most energy will be from in state.
- The plan creates long term energy price stability since fuel costs will be zero.
- The plan decreases air pollution deaths 4000/yr ($33 billion/yr or 3% of NYS GDP).

A R T I C L E I N F O

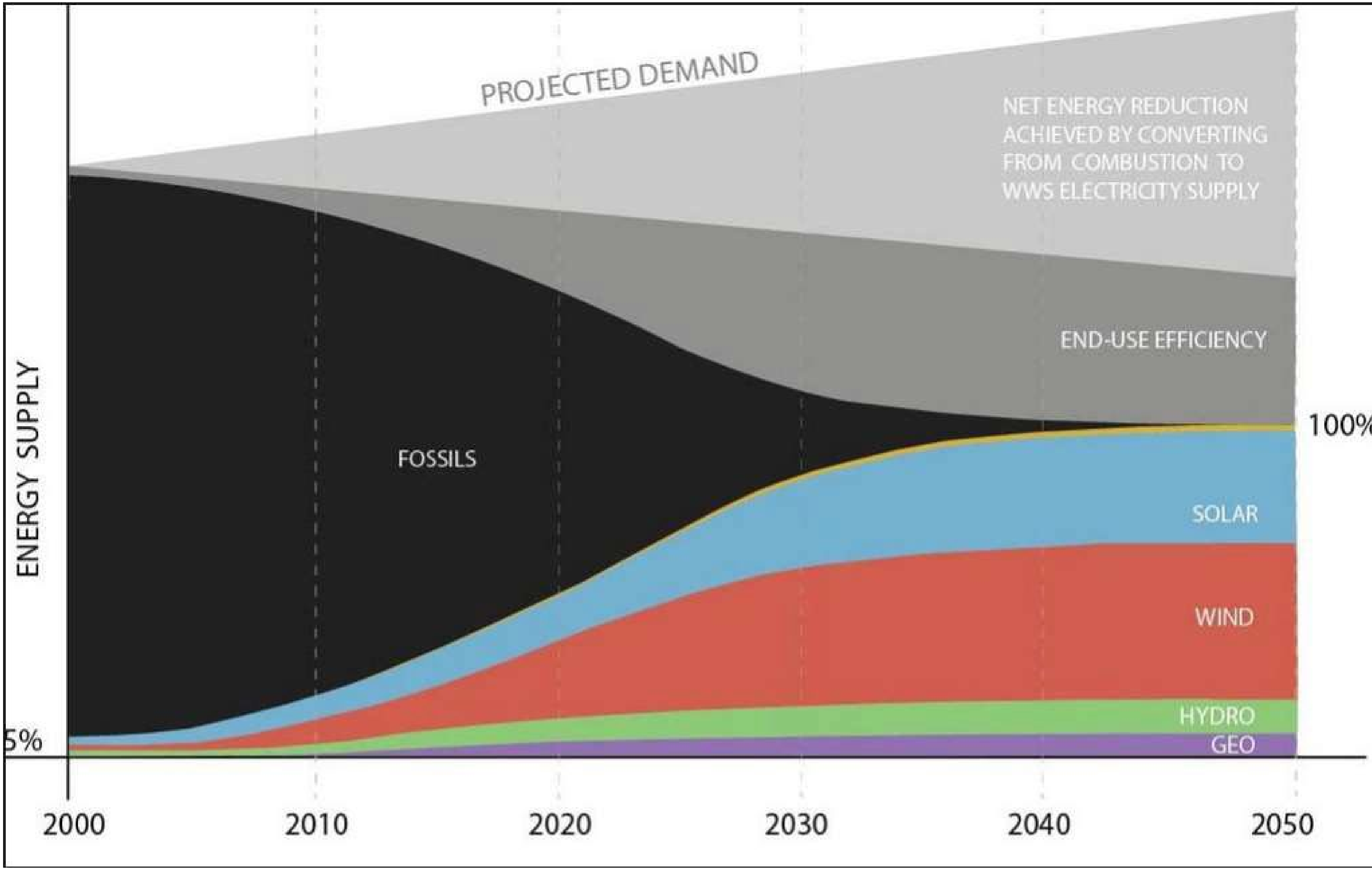
Article history:
Received 14 September 2012
Accepted 18 February 2013

Keywords:

A B S T R A C T

This study analyzes a plan to convert New York State's (NYS's) all purpose (for electricity, transporta tion, heating/cooling, and industry) energy infrastructure to one derived entirely from wind, water, and sunlight (WWS) generating electricity and electrolytic hydrogen. Under the plan, NYS's 2030 all purpose end use power would be provided by 10% onshore wind (4020 5 MW turbines), 40% offshore wind (12,700 5 MW turbines), 10% concentrated solar (387 100 MW plants), 10% solar PV

Our Energy Plan for New York State



Jacobson et al., *Energy Policy*, Feb. 2013

Our 2013 paper on a fossil-fuel-free future for New York helped lead to the Climate Leadership and Community Protection Act of New York (2019)

Kevin P. Coughlin/Office of Governor Andrew Cuomo

Climate Leadership & Community Protection Act (CLCPA) of 2019 mandates:

- **New greenhouse gas accounting for methane**
- **40% reduction in greenhouse gases by 2030**
- **85% reduction in greenhouse gases by 2050**
- **70% renewable electricity by 2030**
- **100% C-free electricity by 2040**
- **At least 40% benefits to go to historically disadvantaged**

Climate Leadership & Community Protection Act (CLCPA) of 2019 mandates:

- New greenhouse gas accounting for methane
- 40% reduction in greenhouse gases by 2030
- 85% reduction in greenhouse gases by 2050
- 70% renewable electricity by 2030
- 100% C-free electricity by 2040
- At least 40% benefits to go to historically disadvantaged

Establishes the Climate Action Council to develop policies for implementing.

Climate Act | Advisory Panels | New York Climate Action Council | Climate Justice Working Group | Resources | Events

NEW YORK CLIMATE ACTION COUNCIL

Meetings and Materials

NEW YORK STATE

Climate Action Council

The New York State Climate Action Council (Council) is a 22-member committee that will prepare a Scoping Plan to achieve the State's bold clean energy and climate agenda.

Climate Action Council Members

Co-Chairs

- Doreen Harris, Acting President and CEO, New York State Energy Research and Development Authority
- Basil Seggos, Commissioner, New York State Department of Environmental Conservation

State Agencies & Authorities

- Richard Ball, Commissioner, New York State Department of Agriculture and Markets
- Marie Therese Dominguez, Commissioner, New York State Department of Transportation
- Thomas Falcone, CEO, Long Island Power Authority
- Eric Gertler, Acting Commissioner and President & CEO-designate of Empire State Development
- Gil C. Quiniones, President and Chief Executive Officer, New York Power Authority
- Roberta Reardon, Commissioner, New York State Department of Labor
- John B. Rhodes, Chair, New York State Public Service Commission
- Rossana Rosado, Secretary of State, New York State Department of State
- RuthAnne Visnauskas, Commissioner and CEO, New York State Homes and Community Renewal
- Howard A. Zucker, Commissioner, New York State Department of Health

Council Appointees

- Donna L. DeCarolis, President, National Fuel Gas Distribution Corporation
- Gavin Donohue, President and CEO, Independent Power Producers of New York
- Dennis Elsenbeck, Head of Energy and Sustainability, Phillips Lytle LLP
- Rose Harvey, Senior Fellow for Parks and Open Space, Regional Plan Association
- Bob Howarth, Professor, Ecology and Environmental Biology at Cornell
- Peter Iwanowicz, Executive Director, Environmental Advocates NY
- Jim Malatras, Chancellor of the State University of New York
- Anne Reynolds, Executive Director, Alliance for Clean Energy New York
- Raya Salter, Lead Policy Organizer, NY Renews
- Paul Shepson, Dean, School of Marine and Atmospheric Sciences at Stony Brook University

New York's Climate Leadership & Community Protection Act of 2019 pioneers a new approach for including methane in greenhouse gas inventory for the State:

1) **We take responsibility for all methane emissions associated with use of natural gas, no matter where the emissions occur;**

2) **We compare methane to carbon dioxide over a 20 yr time period following a pulse emission** (before, a 100-yr time period was used, and is still used by all other states, the US government, and virtually all other nations….. Which severely understates the warming and climate disruption caused by methane).

Marie French @m_jfrench 10h

Changing the way planet-warming gasses are accounted for may sound like a yawn but we're seeing as New York makes policy that it has a HUGE impact on what levers in what sectors have to be pulled to meet reduction targets - and thus, implications for how fast the planet warms

Politico reporter, Twitter – April 20, 2022

- Compare methane to CO_2 over 20-yr time period (not 100-yr)
- Emissions outside of NY included if related to consumption of fuels in NY

Percentages of Total Greenhouse Gas Emissions for New York State in 2019 by Sector

Buildings	36%
Transportation	27%
Electricity	16%
Waste	12%
Agriculture	5%
Industry	4%

Inclusion of methane accounting under CLCPA gives much heavier emphasis on buildings, electricity, waste, and agriculture

Modified from DEC inventory:

3.6% emission from natural gas (rather than 2.89%)

Oil & gas industry estimate apportioned to natural gas use in buildings & electricity

New York State Methane Emissions, 2019

(million metric tons CO_2-eq per year)

FOSSIL FUELS	**84**	
Residential and commercial buildings		47
Electricity		26
Transportation		11
Wastes	**42**	
Solid waste		36
Wastewater treatment plants		6
Agriculture	**19**	
Enteric fermentation from cows		15
Manure		4
TOTAL	**145**	

(37% of all greenhouse gas emissions)

Modified from DEC inventory:

3.6% emission from natural gas (rather than 2.89%)

Oil & gas industry estimate apportioned to natural gas use in buildings & electricity

New York State Methane Emissions, 2019

(million metric tons CO_2-eq per year)

FOSSIL FUELS	**84**	
Residential and commercial buildings		47
Electricity		26
Transportation		11
Wastes	**42**	
Solid waste		36
Wastewater treatment plants		6
Agriculture	**19**	
Enteric fermentation from cows		15
Manure		4
TOTAL	**145**	

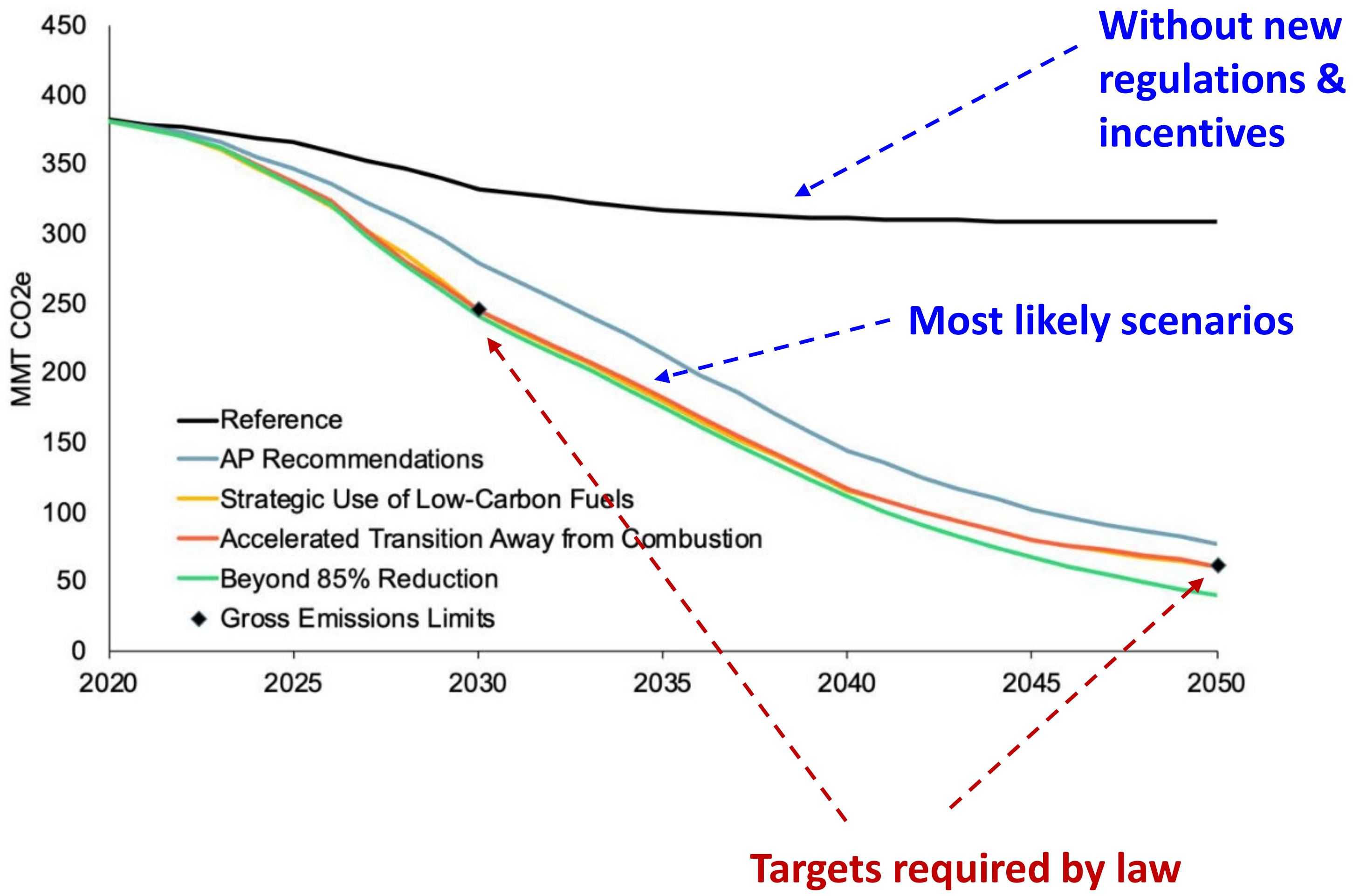
(37% of all greenhouse gas emissions)

Modified from DEC inventory:

3.6% emission from natural gas (rather than 2.89%)

Oil & gas industry estimate apportioned to natural gas use in buildings & electricity

NY Climate Action Council draft implementation plan – Future Greenhouse Gas Emissions



For buildings:

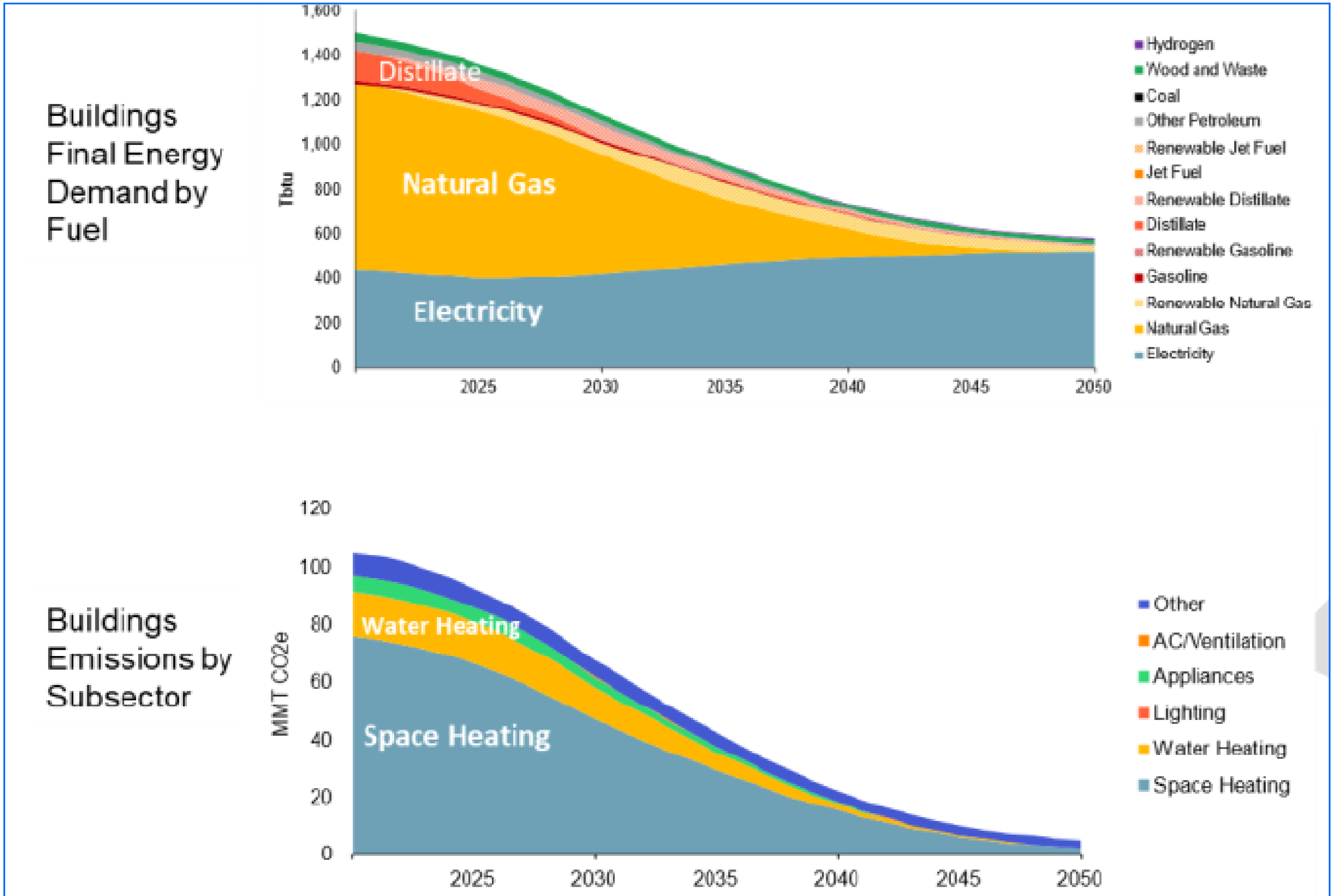
- **Prohibit gas & other fossil fuels in new single-family homes & low-rise residential (3 stories or less) construction by 2024 (2025?)**
- **Prohibit gas & other fossil fuels in large residential & all commercial building construction by 2027 (2028?)**
- **Undertake aggressive retrofitting of gas & other fossil fuel appliances with heat pumps & inductive stoves, starting in 2022 (2 million homes by 2030, out of total of 6 million single-family homes currently heated with fossil fuels in NY)**
- **"Strategically downsize" (dismantle) the gas distribution system, in an orderly way, from 2024 through 2045**
- **Encourage community-scale ground-source heating where appropriate.**

Heat pumps extract heat from environment (from air or groundwater), gaining 2.7 to 5 times more heat energy than electric energy consumed.

My home (1890's farm house) is 100% carbon neutral, with ground-source heat pump (since 2014) and renewable electricity.

Climate Action Council –draft of implementation plan (scenario #3)

Figure 15. Buildings' Energy Demand (top) and Emissions (bottom)



Briefing for the White House Office of Science & Technology Policy, May 27, 2016

Office of Science and Technology Policy
Dr. John Holdren
President's Science Advisor

Best way to reduce methane emissions from natural gas?

- Eliminate gas as a fuel as quickly as possible.
- Prohibit flaring & venting, but with independent verification (not industry self reporting).
- Urban delivery pipeline systems? Resources better spent on replacing gas than on fixing gas infrastructure.

The Methane Project at Cornell University

Questions?

The Methane Project at Cornell is funded by the Park Foundation and by an endowment given to Cornell by David R. Atkinson.

Further information available at Howarthlab.org