Methane: Sources and Reduction Opportunities

Ellen Baum and Joe Chaisson

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"Take Home" messages

- Global average atmospheric concentrations of methane have increased by 150 percent since 1750. Current atmospheric levels are as high as they have been in at least the last 650 thousand years.
- In the late 1990s, atmospheric methane concentrations stopped rising and have remained nearly constant since then.
  - Reduction measures may be contributing to this.
- Wetlands are a dominant source of methane emissions today and the trajectory of future wetland emissions is not clear (up? or down?).

Take Home message, II

- **Methane reductions lower tropospheric ozone concentrations.**
  - **Conventional "clean air" ozone reduction strategies focus largely on reducing NOx emissions and the resulting ozone reductions do not benefit climate.**
  - **Combining conventional NOx reduction strategies with methane reductions results in ozone reductions *that benefit climate*.**
- **Because methane is a well-mixed greenhouse gas, it does not matter where reductions occur.**
  - **This argues for targeting least-cost reductions to benefit global and Arctic climate.**
- **Because methane's atmospheric lifetime is less than ten years, methane reductions will have their full effect in reducing forcing within about a decade**

Take Home messages III

- Considerable analysis of methane emissions reduction potential has been conducted by the IEA, IIASA, EPA and others.
- These analyses largely rely on what has been demonstrated in the past, at a when the economic value of methane reductions has been typically quite low.
  - For example, commercial methane emissions reduction activities in the energy sector have increased over the past several years reflecting the recent significant increases in natural gas prices – but this recent experience has not been fully documented and used to update methane emissions reduction potential projections.
- CATF is currently working with NASA/GISS to identify plausible, accelerated reductions in methane and model resulting climate impacts.

Take Home messages: IV

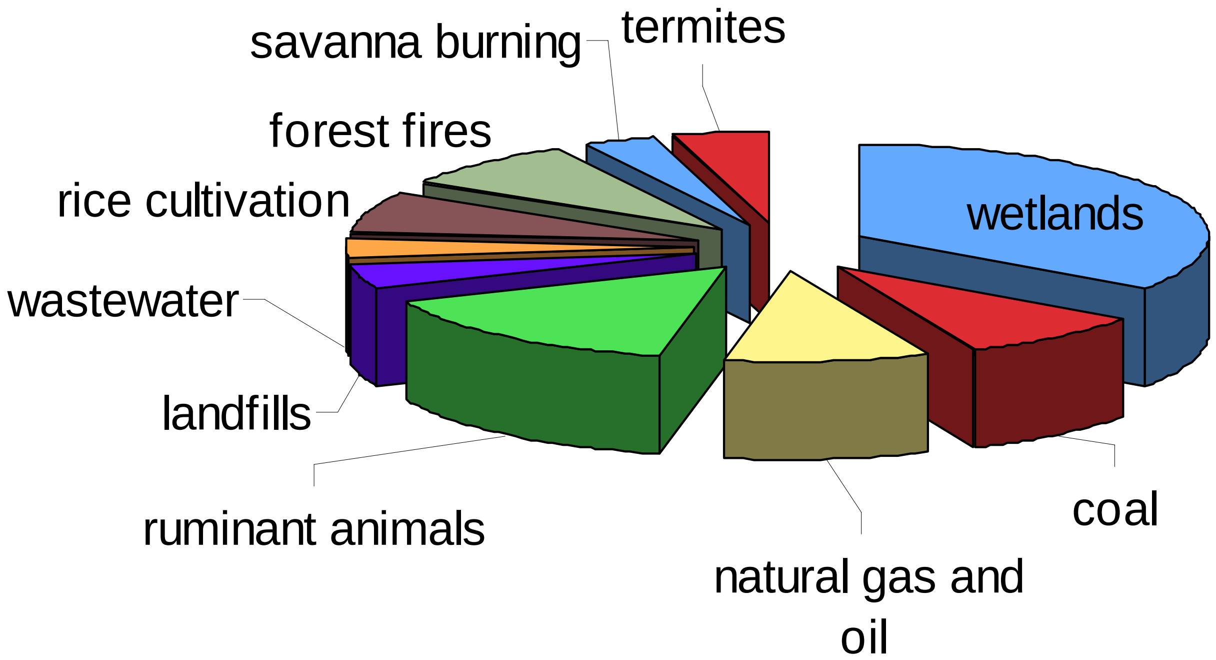
- **The "climate value" of methane emissions reductions could be large – as the potential for methane emissions reductions to relatively immediately (~10year) reduce atmospheric forcing is recognized.**

- **Potential to reduce anthropogenic methane emissions could be large:**

  - US Climate Change Technology Program estimates ***it is possible to achieve methane emissions reductions of 40 to 60 percent by 2050, and 45 to 70 percent by 2100***

- **Large-scale global methane emissions reductions also have human health benefits (by reducing ozone) – that could alone justify more aggressive reduction policies.**

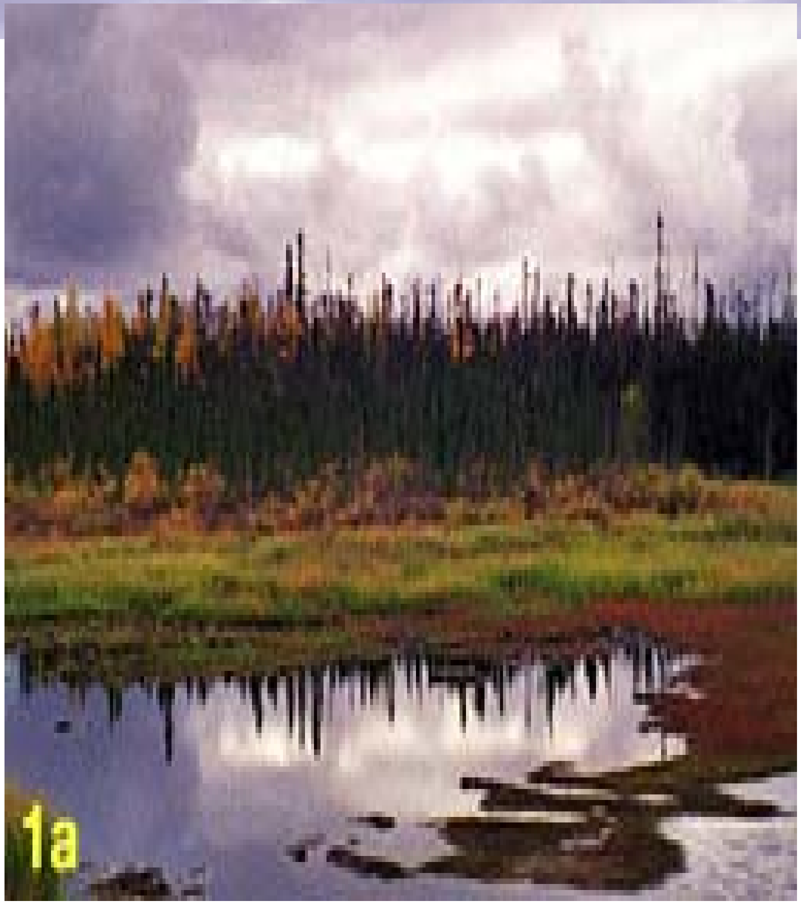
Global methane emissions



Matthews, GISS

Wetlands and Future Methane Emissions

- Natural wetlands are the world's largest methane source, produced when organic material in soils is broken down by microbes in the absence of oxygen. Methane is produced in sediments below the soil's water table and travels upward through the soil, through the stems of some plants or by bubbling through standing water.
- Wet peat soil will emit methane while the same soil, if dried, consumes methane.
- Sulfate deposition constrains wetlands methane production.
- Ice and snow melting starts things "cooking" and will release more (potentially MUCH more) methane.
- Our understanding of methane cycling in wetlands and measurements need to be improved.



Natural wetlands are found from the tropics to the arctic but are difficult to characterize due to their exceptional variability.

Northern boreal wetland, Matthews, GISS

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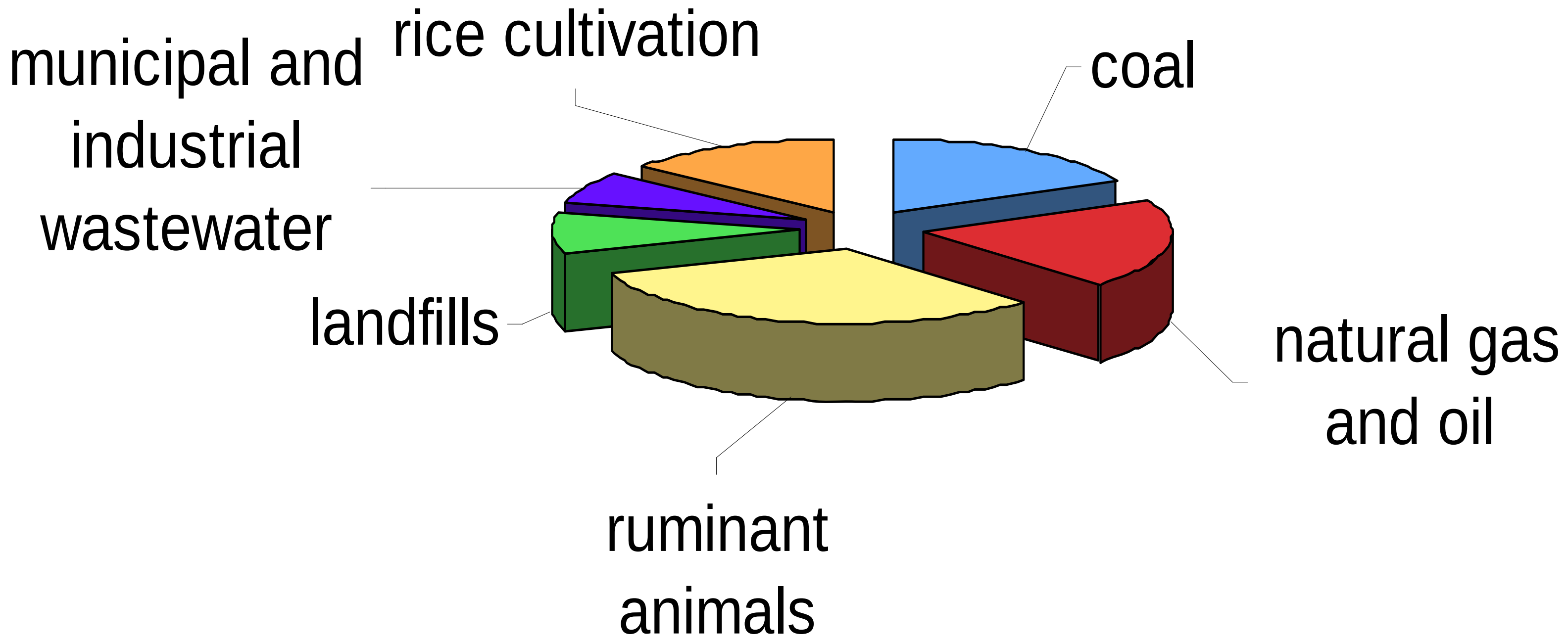
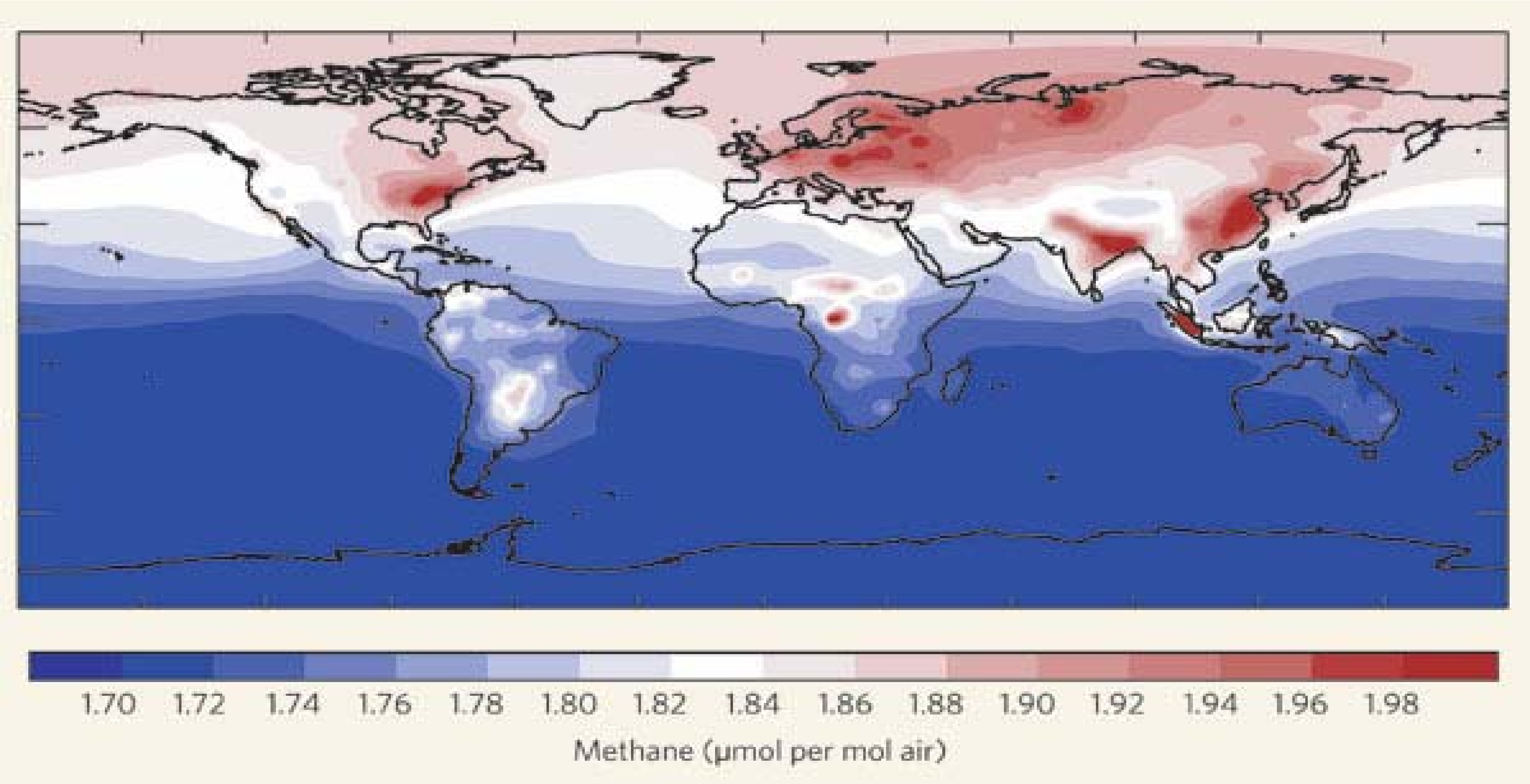
Anthropogenic sources of methane



Matthews, GISS

Most anthropogenic emissions occur in the Northern Hemisphere



Lelieveld, Nature, 2006

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Reduction target areas

- Coal mining
- Oil and gas extraction and energy systems
- Solid waste
- Wastewater treatment
- Ruminant animals
- Manure
- Rice culture

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Coal mining

- **Methane trapped in coal deposits and surrounding strata is released during mining operations in both underground and surface mines, with some (small) emissions also occurring from coal transportation and processing.**
- **Underground mines are the largest source of methane – because methane concentrations typically increase with coal depth – and offer the greatest reduction opportunities.**
- **Methane emissions reduction options include:**
  - **Degasification of coal seams before mining operations begin. This can occur –**
    - Through advanced coal bed methane recovery from the surface; or
    - Through operations conducted within the mine.
    - Methane captured through these processes will typically be used as fuel at the mine or injected into natural gas pipelines for sale.
  - **Catalytic conversion or recovery of of very low concentrations (<1%) of methane contained in ventilation air methane (VAM).**
    - Mine ventilation air is estimated to be about 80% of current coal mining methane emissions.
    - Technologies that could recover methane for use from VAM are challenging, but represent a large potential reduction opportunity.

Oil and gas

- Methane is emitted from global oil and gas energy systems (mostly gas) through routine operations (extraction, processing, transportation, distribution and end use) and unintentional events.
- At the current global market price of about $7/MMBtu, oil and gas systems losses equate to about $20 billion annual revenue loss.
- As gas prices increases, the incentives to prevent losses increases.

- Methane emissions reduction options include:
  - **Improved leak detection/reduction –**
    - New infrared camera has made leaks more visible and satellites may help even more with detection.
  - **Equipment upgrades and improvements**
    - Some very promising technologies are emerging, at affordable prices.

Examples of oil/gas methane emissions reduction measures & economics

Action	Volume of methane saved†, thousand cubic meters / year	Value of natural gas saved††, $ / year	Implementation cost, $	Payback, months
-------TANKS-------				
Vapor recovery units	109 to 2,142	30,300 to 606,800	35,738 to 103,959	3 to 19
-------COMPRESSORS-------				
Replacement of reciprocating compressor rod packing	19	6,055	540	2
Replacement of centrifugal compressor wet seals with dry seals	1,188	315,840	324,000	10
Keeping compressor pressurized when idle	116	30,800	0	Immediate
Routing compressor blowdown to fuel gas when idle	151	40,215	1,754	3
Routing compressor blowdown to fuel gas and install static seal when idle	183	48,615	4,210	7
-------INSTRUMENTATION AND CONTROLS-------				
High-bleed pneumatics: replacement	1 to 5	350 to 1,400	210 to 340	3 to 8
High-bleed pneumatics: retrofit	6	1,610	675	6
High-bleed pneumatics: improved maintenance	1 to 7	315 to 1,820	0 to 500	Immediate to 4
Replacement of pneumatics with instrument air systems	527	140,000	60,000	6

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US EPA, 2007

Oil/gas examples - II

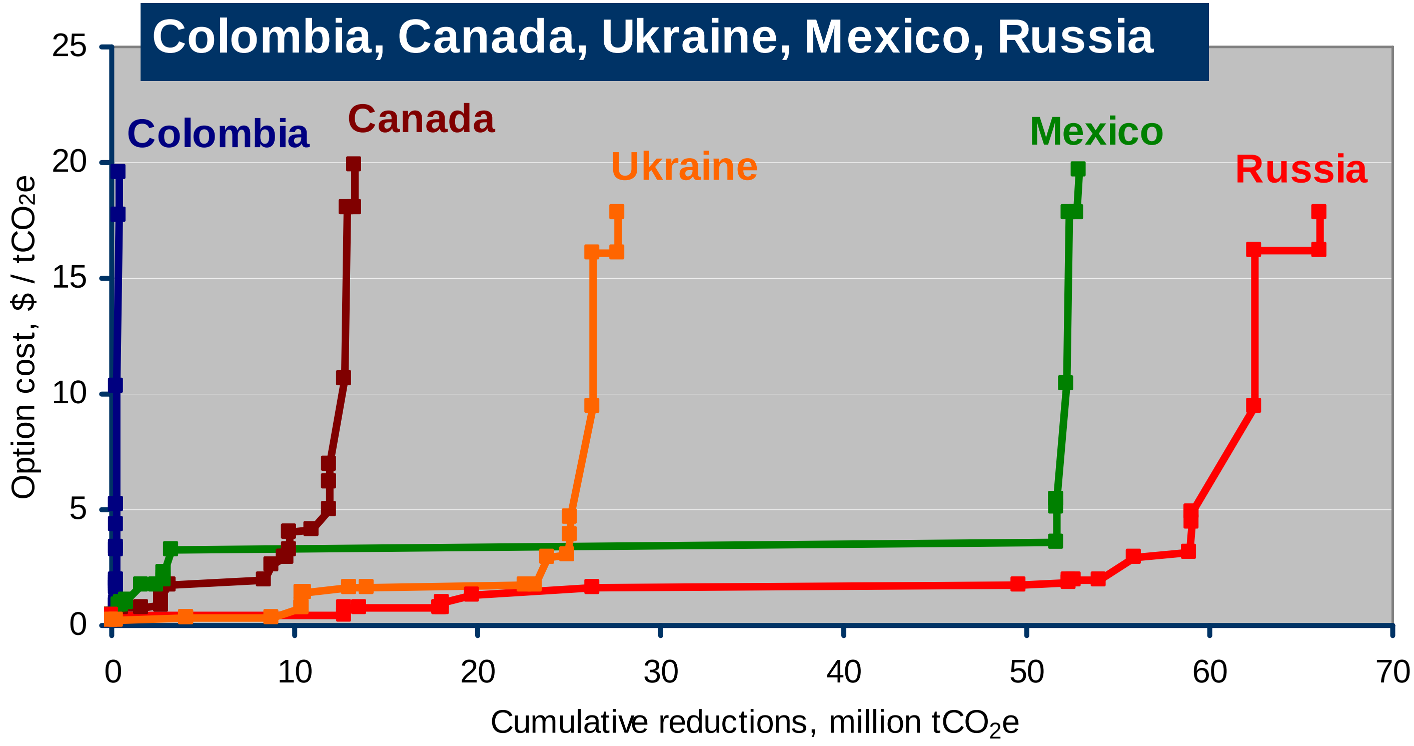
Action	Volume of methane saved†, thousand cubic meters / year	Value of natural gas saved††, $ / year	Implementation cost, $	Payback, months
-------COMPONENT LEAKS-------				
DI&M††† at compressor stations	775	205,889	47668	3
DI&M at gas processing plants	1,004 to 3,371	200,000 to 439,000	71,000 to 182,000	4 to 5
DI&M at gate stations	1 to 5	4,200	27 to 1,617	Immediate to 5
-------OTHER - PRODUCTION RELATED-------				
Reduced emissions completions	8,510	2,669,370	14,260	less than 1
Plunger lifts	105 to 407	32,900 to 127,750	2,591 to 10,363	2 to 14
-------OTHER - PIPELINE RELATED-------				
Composite wrap pipeline repairs	104	27,720	5,648	3
Pipeline pumpdown	5,268	1,400,000	98,757	1
-------OTHER - DEHYDRATOR RELATED-------				
Reducing glycol circulation rates	4 to 372	2,758 to 8,338	0	Immediate
Flash tank separator installation	7 to 201	8,338 to 75,019	6,500 to 18,800	4 to 11
Desiccant dehydrator installation	24	7,441	15,787	21

† Based on 78.8 percent methane in upstream natural gas and 93 percent methane in downstream natural gas.
†† Natural gas valued at $0.25 / cubic meter ($7 / thousand cubic feet).
††† DI&M = directed inspection & maintenance

Source: U.S. EPA Natural Gas STAR recommended technologies and practices, www.epa.gov/gasstar/techprac.htm

US EPA, 2007

Oil/gas emissions reduction potential "supply curve" example



Source: This analysis is based on country level methane emissions estimates (U.S. EPA. "Global Anthropogenic Non-CO2 Greenhouse Gas Emissions: 1990-2020," June, 2006, Appendix B-1.) and company-specific project results from implementation of a variety of top methane emission reduction technologies and practices (U.S. EPA Natural Gas STAR recommended technologies and practices, www.epa.gov/gasstar/techprac.htm).

Solid Waste

- Landfill methane emissions result from the decomposition of organic matter by bacteria in a non-oxygen (anaerobic) environment.
- Most landfill methane emissions come from countries with developed landfills (or that are likely to develop them in the future)
- The primary landfill emissions reduction options involve the collection and combustion (through flaring or energy use) of gas generated within the landfill.
  - Some promising techniques are being developed that could substantially increase the effectiveness of collection.
- Longer term reduction options include development of waste management alternatives:
  - Bioreactor (aerobic and anaerobic) landfills to promote organic waste decomposition and gas collection.
  - Better conversion of collected gas and better collection of gas.
  - Incinerators

Wastewater

- Methane emissions are generated from anaerobic pockets in municipal and domestic wastewater handling.

- Largest opportunities in the industrial sectors, in particular in food processing.

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Ruminant Animals

- Ruminant animals produce close to 20% of total annual methane emission. These are bovines (cattle and dairy cows), goats, sheep, pigs, camels, and water buffalo.
  - Bovines account for about 80% of ruminant methane emissions.
- Methane emissions occur through microbial fermentation in the digestive system.
- Methane release represents an economic loss to the farmer, because feed is converted into methane, rather than to the product output.
- Emissions reduction strategies include breed improvements, increased feeding efficiency through diet management, and strategic feed selection.
- *Significant* ruminant emissions reductions will only occur with reductions by reducing ruminant populations.

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Rice Cultivation

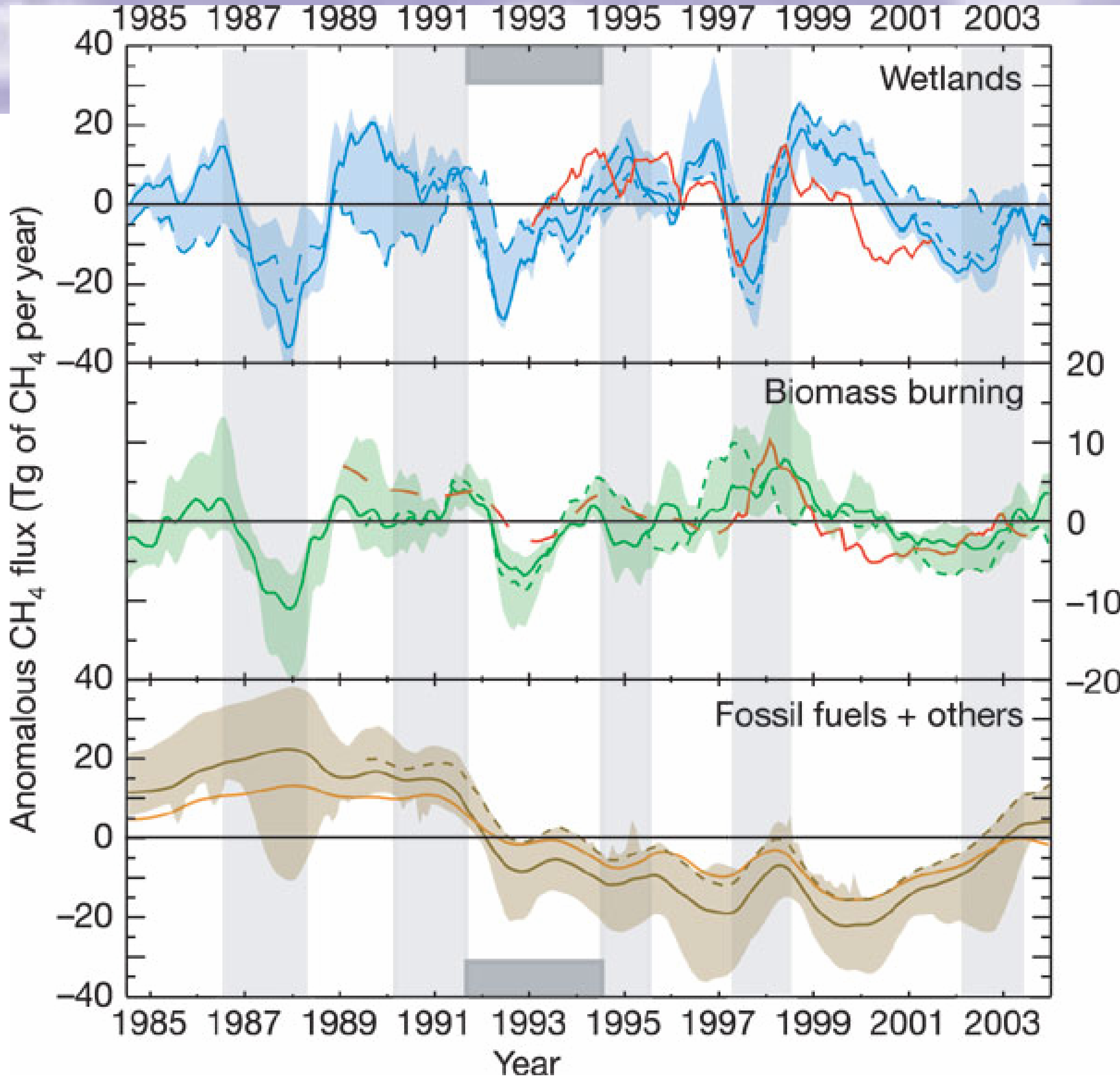
- Rice is generally grown in flooded paddy fields, where methane is generated by the anaerobic decomposition of organic matter in the soil.
- Rice cultivation emissions have leveled off in the past two decades, despite substantial increases in production and yield.
- In principle, opportunities exist to reduce rice cultivation methane emissions by 30-40 percent in the year 2020, but there are challenges, including.
  - Uncertainties as to how changes in cultivation management affects rice yield.
  - Developing feasible management that reduce methane emissions, without increasing nitrogen losses and reducing yields.

Livestock and poultry manure

- Management practices dictates whether manure is a source of nitrous oxide emissions or methane emission.
- Manure stored or treated in anaerobic conditions, such as lagoons and tanks, produce methane.
- Handled as a solid, such as ins tacks or deposited on pastures reduce methane emissions, but increasing nitrous oxide emissions.
- Technologies to reduce both will require developing
  - New types of digesters
  - Separation processes for solid and liquid fractions
  - Pyrolysis units

How much could we reduce anthropogenic methane emissions?

- **EPA estimates that methane emissions could be reduced 10% by 2030 at a net cost-savings using technology that is presently available.**
- **International Energy Agency (IEA) data, suggests a 29% reduction from baseline is possible by 2030, which keeps methane at today's emission levels through 2030.**
- **IIASA has developed an aggressive reduction scenario which immediately deploys all currently-available methane reduction technologies, but assumes no discovery of new abatement technologies in the future.**
  - **This scenario reduces emissions slightly below the IEA projections.**
- **The US Climate Change Technology Program estimates *it is possible to achieve methane emissions reductions of 40 to 60 percent by 2050, and 45 to 70 percent by 2100*.**
  - **This scenario assumes we will develop new emissions reduction measures, that we will "learn by doing" and that a much higher value will be placed on future methane emissions reductions.**
- **The CATF/GISS analysis should be available within a few months.**



Bousquet,Nature

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