From: Steve Hinchman
To: Bill.Storm

Dear Messers Storm and Hargis,

We wanted to be sure you were aware of issues that recently arose regarding a Potomac-Hudson lifecycle analysis of GHG emissions from a proposed coal gasification facility here in Maine [see accompanying pdf files]. I am happy to discuss further if you have any questions.

Steve

Steve Hinchman, Staff Attorney
Conservation Law Foundation
14 Maine St. Suite 200, PMB 38
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207/729-7733.13
shinchman@clf.org

November 15, 2007

Mr. A. Brook Crossan
Ms. Sarah M. Forbes
Potomac-Hudson Engineering, Inc.
106 Apple Street, Suite 102
Tinton Falls, NJ 07724

Re: Twin River Energy Center Mine-to-Wheels CO_2 Analysis

Dear Mr. Crossan and Ms. Forbes,

We are writing to express our very serious concerns with Potomac-Hudson's (P-H) recent analysis of lifecycle carbon dioxide (CO_2) emissions from the proposed Twin River Energy Center (TREC) coal gasification project in Wiscasset, Maine. A series of flaws in your analysis significantly underestimates the amount of global warming pollution the project will emit – and therefore the negative impact the project will have on Maine's efforts to reduce greenhouse gas emissions from the energy sector.

As we demonstrate below, the report includes a substantial mathematical error in the input data for two different stages in the lifecycle analysis. Similarly, the report uses outdated and inaccurate assumptions that conflict with the published data from similar projects. These flaws are fundamental to the outcome of the report and negate Potomac-Hudson's findings and conclusions.

We are equally concerned with the process that Potomac-Hudson and its client, Twin River LLC, used to present the analysis. This report's misleading conclusions were released shortly before a contested election while the underlying data and calculations used were kept secret. When those errors were pointed out to the study's principal author, she refused to timely correct or even acknowledge the mistakes.

Sadly, what could have been a scientific and objective look at a critical issue affecting the environment and public health has resulted in a biased and misleading report that has seriously misinformed Maine's residents. The record must be corrected. We ask that you immediately take steps to correct the clear errors in your draft analysis, provide a full and open disclosure of all data and input assumptions, revise inaccurate assumptions, and present the revised report for peer review.

SUMMARY OF ERRORS

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VERMONT: 15 East State Street, Suite 4, Montpelier, VT 05602-3010 • 802-223-5992 • Fax: 802-223-0060

In the TREC press release that accompanied the report, Ms. Forbes states the primary conclusion of the study is that by using wood biomass and carbon capture and sequestration, the TREC project would produce less CO_2 than a natural gas plant. CLF's subsequent review of the P-H analysis has identified the following errors which negate this primary conclusion and many other findings:

1. *The analysis of CO_2 emissions from coal production and transport is based on a major error. P-H modeled CO_2 emissions from mining and shipping 50,400 mmBtu of coal instead of the facility's design specification of 53,000,000 mmBtu as presented by TREC in several previous public forums and posted on their website. As a result, the study models the upstream CO_2 impacts from less than ½ of 1 day's supply of coal – or one-tenth of 1% of the total annual volume of coal needed to run this facility.*

2. *P-H's CO_2 emissions factor for upstream emissions is less than a third of published values from other lifecycle analyses. This results in a significant under prediction of TREC's upstream CO_2 emissions.*

3. *In comparing coal gasification to alternative fossil fuel technologies (coal combustion, coal gasification, and natural gas), P-H assumed the TREC project would simultaneously operate both the power plant and the refinery at peak production. This is contrary to the plant's design specifications and has the effect of significantly inflating TREC's energy output in comparison to alternative technologies.*

4. *P-H used CO_2 emissions factors for the alternative technologies that are significantly inflated. The emission rate for natural gas, for example, exceeds DOE's most recently published figures by 37% and exceeds emissions from Maine's existing natural gas plants by 22%. This results in a significant over prediction of emissions from competing technologies.*

5. *P-H's 25% carbon capture and sequestration scenario presumes sequestration is viable. It is not. As well established by other presenters at the Chewonki Foundation symposium, there is no known sequestration potential in Maine, nor any plan to identify or test carbon sequestration opportunities in the region. Therefore, any carbon captured by TREC must be immediately released. It is not a defensible assumption to deduct 25% of the facility's CO_2 pollution from its emissions profile.*

INPUT ASSUMPTIONS

Although, P-H has refused to release the data used in this study, the following specifications have been previously provided by TREC and/or are published on the company's website.[1]

- Coal Use: 2 million tons/year (US short tons, or 2,000 lbs) of coal per year.

[1] See http://www.twinriverenergy.com/images/pdf/08-22-07%20Westport%20Public%20Info%20Meeting.pdf

- Energy Balance:
  - 5.3×10^{13} Btu input = 2.7×10^{13} Btu internal use/losses + 2.6×10^{13} energy output
- Electricity Production:
  - 350-700 MW
  - 3.2 million MWh on an annual average
- Fuels Production:
  - 4,500 – 9,000 barrels FT diesel/day
  - 3 million bbl annual average

ANALYSIS

1. Annual Emissions from Coal Mining and Transportation:

To compute annual emissions from coal mining and transport,[2] P-H based its calculations upon the Btu content rather than weight of coal. Assuming 100% coal and zero biomass, P-H used a value of 50,400 million Btu (mmBtu).[3] According to P-H, this represents the total annual coal throughput for the TREC.

To check this figure, CLF compared it to TREC's previously published data on energy input (Table 1) and coal tonnage (Table 2). Both calculations show that P-H's Btu input data for upstream emissions is not only inconsistent with TREC's previously published data and with P-H's input data for TREC stack emissions (slide 10), but is off by three orders of magnitude.

Table 1. Energy input in Btu's.

Source	Energy Input	BTU	mmBtu
TREC - 8/22/2007	5.3×10^{13} Btu	5.3E+13	53,000,000
PH - 10/25/2007 (slide 6)	50,400 mmBtu	50,400,000,000	50,400

[2] See slides 6 & 8 of Ms. Forbes presentation at the Chewonki Foundation Carbon Symposium, Oct. 25, 2007.
[3] See id., slide 6.

Table 2._Coal input by weight compared to input by Btu's.

Source	Coal Input	Lbs coal	Btu/lb coal, PA 2007[4]	Btu	mmBtu
TREC - 8/22/2007	2 million tons (US)	4,000,000,000	12,618	50,472,000,000,000	50,472,000
PH - 10/25/2007 (slide 10)[5]	1.8 million tons (Metric)	4,141,718,087	12,618	52,260,198,816,719	52,260,199
PH - 10/25/2007 (slide 6)	Btu input				50,400

We further cross checked the data by comparing P-H's combined production and transportation CO_2 emission values – 54 metric tons CO_2 – to other modeling efforts. For instance, the financially-based lifecycle carbon analysis (EIO-LCA) model developed by Carnegie-Mellon University predicts CO_2 emissions from coal mining and transport to average 75,000 metric tons CO_2 per million tons of coal delivered. For a 2 million ton per year project, as here, this study would predict upstream emission of approximately 150,000 metric tons.[6]

Finally, P-H's results also conflict with carbon emissions from other related activities. For instance, P-H's estimated impact from shipping 1.8 million metric tons of coal per year 1,000 miles from western Pennsylvania to Wiscasset, Maine is a paltry 10 metric tons of CO_2 per year. This is one ton less than the estimated annual carbon emissions of a Hummer SUV (H3).[7] The H3 is big – but not that big.

The above comparisons make clear that P-H's input data is completely out of scale. Running P-H's numbers in reverse, the severity of the error is enormous: 50,400 mmBtu equates to 1,813 metric tons of coal, which is less than ½ of one day's coal supply for the proposed facility and one tenth of 1% of the total annual supply.

2. CO2 Factors for Upstream Emissions

Compounding this error, P-H used CO_2 emission factors for coal mining and transportation that are extremely low – between a third and a fifth of published values.

P-H's combined CO_2 emission factor for coal mining and transportation is 2.36 lbs CO_2/mmBtu (Table 3). This value is significantly less than the available published data for upstream

[4] See EIA Quarterly Report: Data for: 2nd Quarter 2007, Report Released: September 21, 2007, Next Release Date: December 2007.
[5] To compute TREC's stack emissions P-H assumed input of 1,878,671 metric tons of coal. Personal Correspondence with Sarah Forbes; 10/31/07.
[6] See Paulina Jaramillo, W. Michael Griffin, H. Scott Matthews, *Comparative Life Cycle Carbon Emissions of LNG Versus Coal and Gas for Electricity Generation*, Carnegie-Mellon University at 11 (2005).
[7] The annual carbon footprint of an H3 Hummer is 12.2 tons (11 metric tons) when driven 15,000 miles per year. See EPA website "fueleconomy.gov" at http://www.fueleconomy.gov/feg/bymanu.htm.

carbon emissions for coal power plants. For example, studies by the DOE's National Renewable Energy Laboratories have found upstream emissions for coal production (including transportation) from underground mines to average 15 lbs CO_2/mmBtu, while upstream coal emissions from surface mines average 9.9 lbs CO_2/mmBtu.[8] Similarly, data for mine-mouth coal gasification (IGCC) facilities (no transportation) show upstream impacts averaging 6.2 to 6.8 lbs CO_2/mmBtu.[9]

Table 3. Upstream CO_2 emission factors.

lbs CO2/mmBtu	**P-H**	**DOE - Surface Mine**	**DOE - Underground Mine**	**Mine-Mouth IGCC**
Mining	1.93			6.2 – 6.8
Transportation	0.43			--
Combined	**2.36**	**9.9**	**15**	**6.2 – 6.8**

The combined effect of the mathematical errors and the low upstream carbon emission factors is significant. Rather than the 54 MT/year of CO_2 reported by P-H, using the most conservative of the available published data upstream emissions should amount to 150,000 MT/year or more.[10]

3. Alternatives Analysis: The emissions profile of alternative fossil-fuel technologies is overestimated.

The core of the P-H study is the comparison of emissions from the TREC project to various other fossil fuel technologies, including pulverized coal (PC), coal gasification (IGCC) and natural gas turbines (NGCC). See slides 16 and 17. In developing this comparison, Potomac-Hudson assumed power plants and refineries equal in size to TREC's nameplate capacity (700 MW; 11,500 barrels/day). TREC, however, has previously explained that the facility cannot simultaneously produce at peak electric and fuels capacity. Rather, as publicly stated by TREC, output will range between 700 MW - 4,500 bbl/day when maximizing power production, and 350 MW - 11,500 bbl/day when maximizing fuels production.

This is confirmed by TREC's published energy balance and average annual output calculations. (Table 4). Based on this data, the electrical power station will operate at approximately 61% of nameplate capacity and the refinery will operate between 77-86% of capacity.

Table 4. Capacity Factors for alternate fossil fuel technologies

[8] See Spath, P. M.; Mann, M. K.; Kerr, R. R. *Life Cycle Assessment of Coal-Fired Power Production*, Department of Energy: National Renewable Energy Laboratory, 1999.
[9] See Southern California Edison, *Review of SCE's Clean Coal Activities ETAAC Meeting* at slide 14 (August 8, 2007); R. Ney & J. Schnoor, *Greenhouse Gas Emission Impacts of Substituting Switchgrass for Coal in Electric Generation: The Chariton Valley Biomass Project*, at 20 (May 20, 2002).
[10] The critical factor in determining the correct emission factor is coal mine methane emissions. In this case, barring an actual contract, the study cannot cherry pick among the most favorable coals but must use average regional values.

	Peak Production (85% CF)	Ave. Annual Production	% of Capacity	Ave. Annual mmBtu
Power (MWh)	5,212,200	3,200,000	61%	10,921,600
FT diesel (bbl)	2,792,250	2,400,000	86%	13,104,000
FT naptha (bbl)	775,625	600,000	77%	2,898,000
Energy output		26,000,000		26,923,600

P-H's use of peak production volumes for the TREC project inflates the energy output and therefore the size of comparative facilities by approximately 32 percent for power plants and 10 percent for refineries. Using inflated output volumes in turn inflates the CO_2 emission profiles of these comparative facilities by an equivalent amount. The net effect of this methodology makes the TREC project's emission rates look significantly lower in comparison to other available fossil-fuel technologies.

4. <u>The CO2 emission factors for alternative technologies are also significantly inflated.</u>

The effect of this error is again compounded by P-H's use of incorrect CO_2 emission factors. This time P-H used significantly inflated emission factors when calculating CO_2 pollution from PC, IGCC, and NGCC facilities. The error for NGCC is particularly significant, as it far exceeds both DOE's current baseline analysis for natural gas facilities and actual emissions from existing NGCC facilities in Maine (Table 5).

Table 5. CO_2 Emission Factors for alternative fossil fuel technologies.

CO_2 Emission Factors*	Potomac-Hudson	DOE 2007 Baseline[11] Study	Maine Actual 2006[12]
PC	2,000	1,830	
IGCC	1,800	1,714	
NGCC	1,100	797	908
* lbs CO2 per MWh			

In its primary conclusion, P-H found that the TREC project, with 5% biomass and 25% carbon capture would produce less CO_2 than a natural gas plant and refinery. But that conclusion is based on oversized facilities and inflated emissions factors. When the capacity and emission factors are

[11] DOE/NETL, *Cost and Performance Baseline for Fossil Energy Plants* (DOE/NETL-2007/1281) at Exhibit ES-2 (May 2007).

[12] 2006 CO_2 Emission Rates for all existing natural gas power plants in Maine, based on Maine 2006 Electricity Profile, DOE/EIA-0348, Date of Data: 2005, Data Release Date: March 2007 (available at http://www.eia.doe.gov/cneaf/electricity/st_profiles/maine.html)

corrected, this no longer holds true. Instead, the TREC project would produce more CO_2 than a natural gas plant plus a refinery under all scenarios.

5. <u>The Carbon Capture and Sequestration scenarios are based on an impossible hypothetical.</u>

By including a 25% carbon capture scenario in TREC's emission profile, Potomac-Hudson necessarily presumes that the captured carbon will be permanently isolated from the atmosphere. Otherwise, it is "catch and release." If the CO_2 is immediately released it cannot be deducted from TREC's total emission profile. Potomac-Hudson should clarify this problem by presenting scenarios for carbon capture and sequestration (CCS) based upon known CO_2 storage potential, as opposed to CCS that is contingent upon speculative future developments.

6. <u>Additional Issues:</u>

The New England and RGGI states measure CO_2 in US tons (1 ton = 2,000 lbs). The Potomac-Hudson study uses metric tons (1 ton = 2,204.6 lbs). This creates confusion and is misleading since, given the large numbers at issue, use of metric tons will generate a smaller overall number. We recommend that the study use US tons consistent with RGGI, or at a minimum use both measurements.

Additionally, assuming P-H resolves the errors noted in section 1 above (i.e. that 50,400 mmBtu is in fact 50,400,000 mmBtus), P-H is still using a figure that is 2,600,000 million Btus lower than those previously published by TREC. When combined with the use of metric tons, this explains the difference between Potomac-Hudson's numbers and the CO_2 emission rate of 5.488 million tons/year predicted by CLF based on TREC's prior published data. (Table 6).

Table 6. TREC's Direct and Indirect CO_2 Emissions using corrected data in Metric and US tons.

Thermal Input (mmBtu)	Eastern Bituminous Coal CO_2 Factor per pound	Total CO_2 -- Million MT	Total CO_2 -- Million US Tons
50,400,000	207.10	4.73	5.22
53,000,000	207.10	4.98	5.49

<u>CONCLUSION</u>

Each of the errors identified above is significant and warrants corrective action. In combination, however, these errors fundamentally change the analysis. Given the importance of the climate change issue – both to the TREC project and to Maine's future permitting and regulation of carbon emissions from power plants and refineries – it is incumbent upon Potomac-Hudson to address these issues and issue a revised report.

Although we are quite disappointed with the way this study was prepared and released, CLF is fully committed to working with you and other interested parties to ensure that, going forward, the most accurate information possible is provided to the public and state policy makers.

Sincerely,

Steve Hinchman,
Staff Attorney

cc: Kurt Adams, Maine PUC
Jeff Bielicki, Harvard Project on Energy Technology Innovation Policy
Rep. Lawrence Bliss
Jay Braitsch, US DOE
Grant Bromhal, US DOE
Jim Brooks, Maine DEP
Jack Cashman, Senior Economic Advisor
Joe Chaisson, CATF
Marc Cohn, Maine DEP
Joseph Cotter, National RE/sources
Leslie Haroun, Oak Foundation
William Hastings, Nova Atlantic, LLC
Howard Herzog, MIT
Rep. Jon Hinck
Ken Hnottavange-Telleen, Schlumberger
William Hopwood
Don Hudson, Chewonki Foundation
John Kerry, Office of Energy Independence and Security
Eric Larson, Princeton University
David Littell, Commissioner Maine DEP
Rep. Bruce MacDonald
Beth Nagusky, GrowSmart Maine
Sharon Reishaus, Maine PUC
John Richardson, Commissioner Department of Economic and Community Development
Willy Ritch, Back River Alliance
Jennie Stephens, Clark University
Michael Stoddard, Environment Northeast
Jeff Thaler, Bernstein Shur
Karin Tilberg, Senior Policy Advisor
Vendean Vafiades, Maine PUC

Dylan Vorhees, NRCM
Steve Wallace, TRC Environmental
David Wilby, Maine Independent Energy Producers Ass'n.
Elizabeth Wilson, Margaret Chase Smith Policy Center

Twin River Energy Center Mine-to-Wheels CO_2 Analysis

Sarah M. Forbes

Dorothy Peterson

A. Brook Crossan

POTOMAC-HUDSON ENGINEERING, INC.

Engineers* ■ *Scientists* ■ *Planners

Purpose of analysis

- Quantify mine-to-wheels emissions
  - Project emissions in an unbiased manner
- Compare TRE Center emissions
  - Existing fossil-fuel power plants
  - Traditional ways of producing diesel fuels
- Enable informed decision-making
  - Possible CO_2 storage or reuse opportunities
  - Impact of transportation options on CO_2

Outline of presentation

- Mine-to-wheels methodology
- Results
  - What are the TRE Center emissions?
    - From the stack
    - Mine-to-wheels
- Comparisons and displacement
- CO_2 reuse and storage opportunities

Mine-to-wheels includes CO_2 from:

- Mining the coal
- Transporting the coal and biomass
- Gasifying the coal to produce electricity and liquid fuels
- Transporting the TRE Center liquid fuels and other products
- End-use of TRE Center liquid fuels

GREET?

- *The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation* (GREET) Model
  - developed by Argonne National Laboratory
  - publicly-available online
  - spreadsheet based model that includes details on transportation and energy production emissions
  - the gold standard for vehicle/fuel analysis

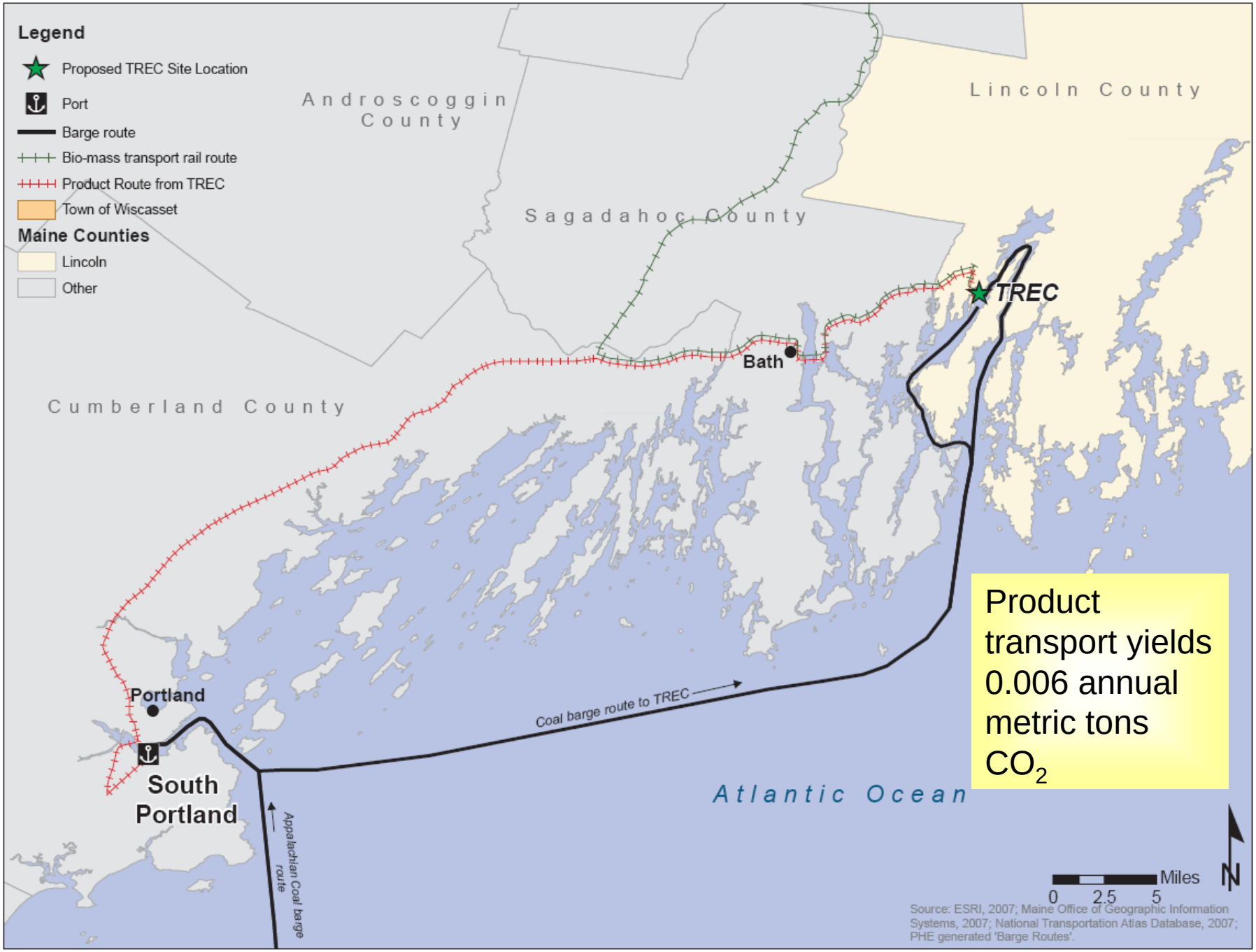
Annual emissions from coal mining

% Biomass	mmBtu Coal	Annual metric tons CO_2
0	50,400	44
5	47,800	42
10	45,400	40
15	42,800	38

Legend
Proposed TREC Site Location
Port
Coal mine
Barge Route
Railroad route:
PA to port - Route 1,2
PA to port - Route 1
PA to port - Route 2
South Portland Port to Proposed Site
CANADA
Lake Ontario
Lake Erie
NY
VT
NH
ME
MA
CT
RI
OH
PA
NJ
MD
DE
WV
VA
DC
South Portland Port
Appalachian coal
Port of Baltimore
ATLANTIC OCEAN
Miles
0
50
100
Source: ESRI, 2007; National Transportation Atlas Database, 2007; PHE generated 'barge routes'.

Coal and biomass transport annual metric tons CO_2

% Biomass	Rail to site	Barge to site
0	10	11
5	10	10
10	10	10
15	9	9



Product transport yields 0.006 annual metric tons CO_2

TRE Center stack emissions

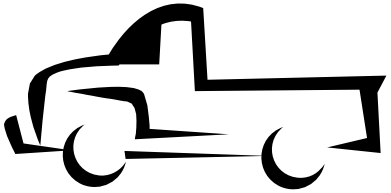
% Biomass	Million metric tons	Million metric tons -25% CO_2 captured
0	3.5	2.6
5	3.3	2.4
10	3.0	2.2
15	2.8	1.9

- 700 MW peak production
- 11,500 barrels of liquid fuel per day
- 85% capacity factor

Pump-to-wheels

Fuel Type 16.6 mmBTU/year	Annual Metric tons CO_2
F-T Diesel	1,256,423
Low Sulfur Diesel	1,340,290

Source: Assessment of Well-to-Wheels Energy Use and Greenhouse Gas Emissions of Fischer-Tropsch Diesel by Michael Wang (October 2002).



Mine-to-wheels emissions

% Biomass	Million metric tons CO_2/year	Million metric tons -25% CO_2 captured
0	4.7	3.9
5	4.5	3.6
10	4.3	3.4
15	4.1	3.2

How does TRE Center compare?

- TRE Center emissions were compared to:
  - Traditional coal plant (PC)
  - Integrated gasification combined cycle (IGCC)
  - Natural gas combined cycle (NGCC)
  - Oil refinery

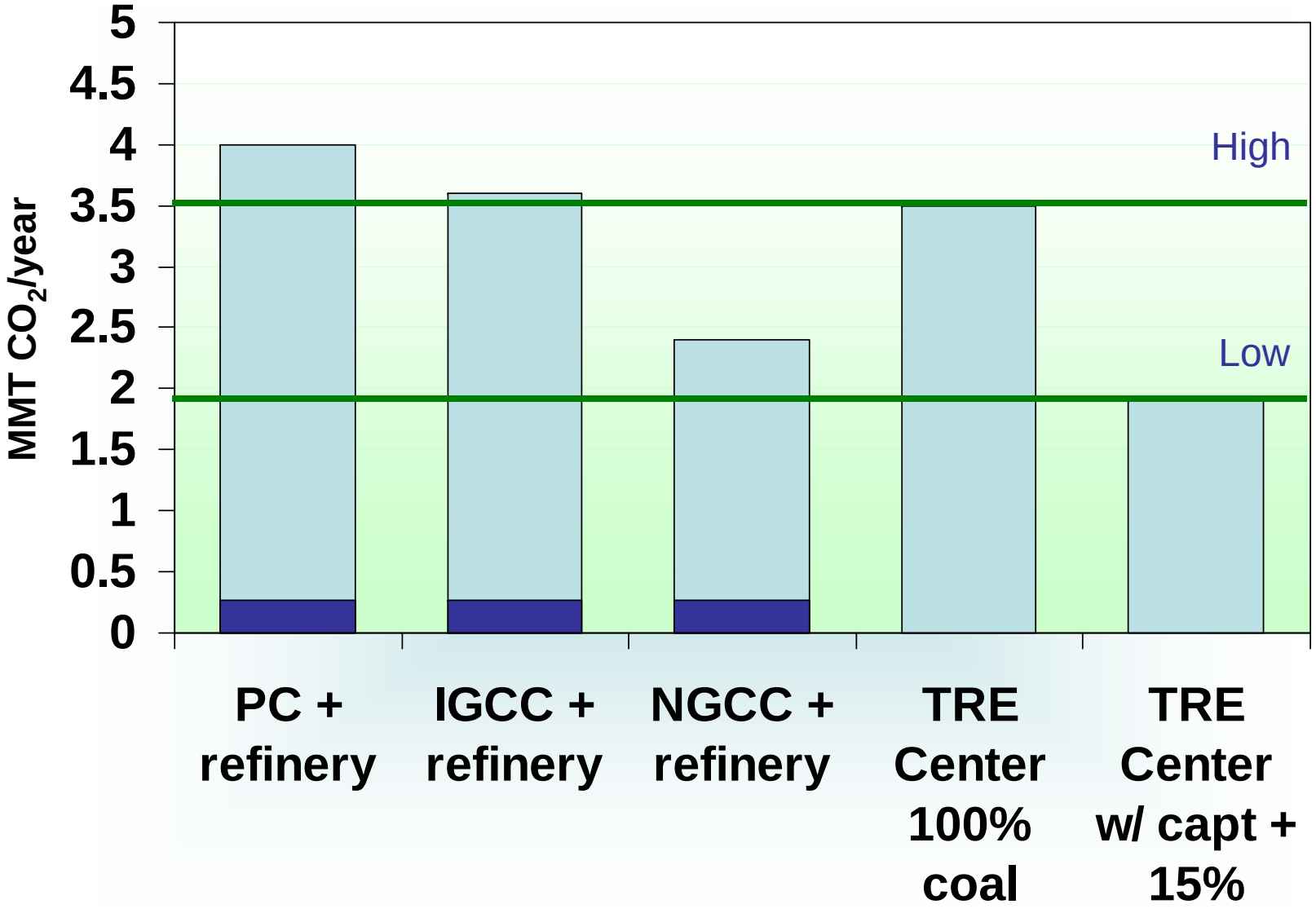
Calculations for comparison

- PC: 2,000 lb CO_2/MWh
  - Average rate of new coal plants
- IGCC: 1,800 lb CO_2/MWh
  - Average rate of existing and planned IGCC
- NGCC: 1,100 lb CO_2/MWh
  - Average emissions rate of new NGCC in RGGI states

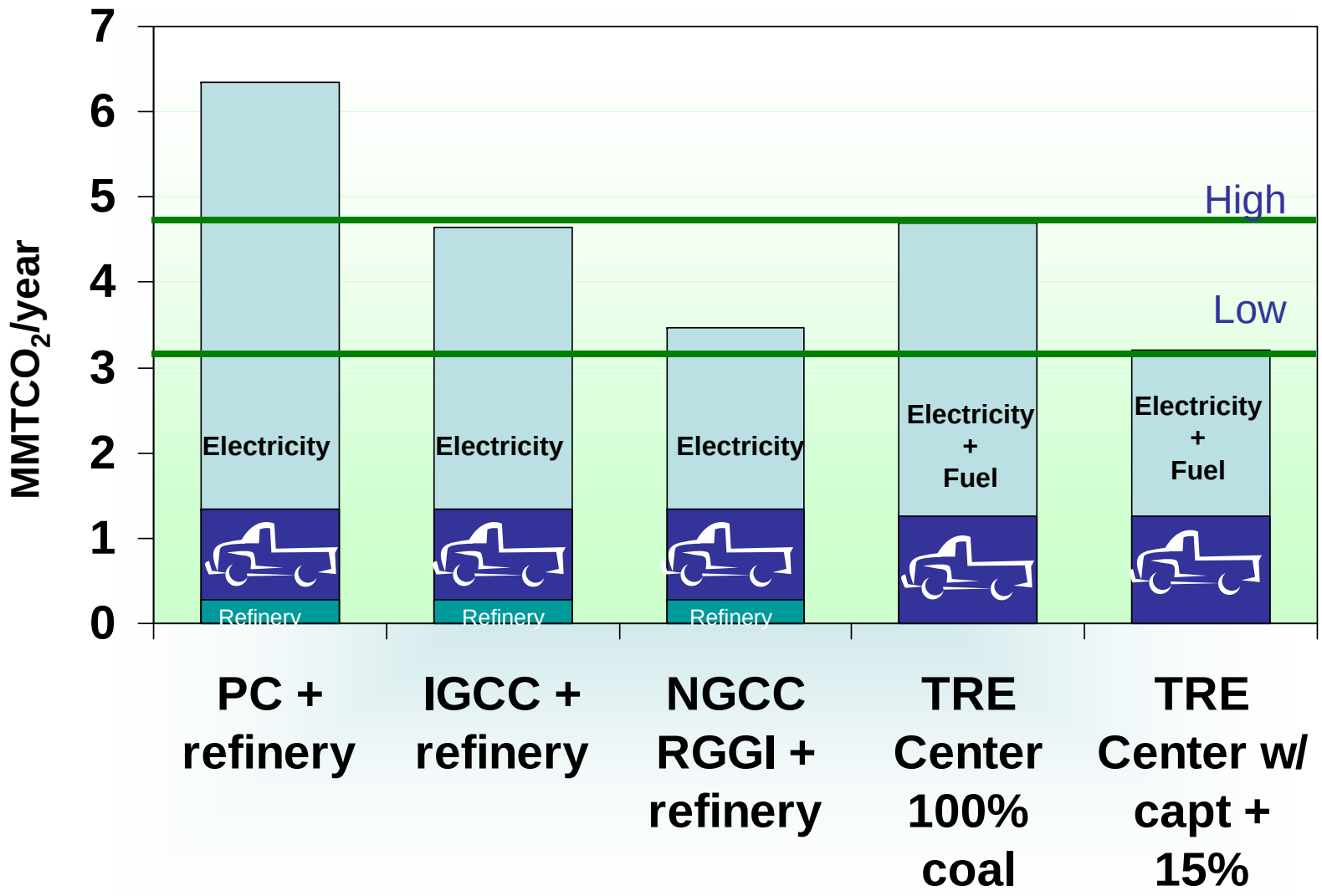
Calculations for comparison

- Oil refinery: 180 lb CO_2/barrel of liquid fuel, based on:
  - American Petroleum Institute GHG compendium emissions factors
  - Refinery production of equivalent fuels
  - Refinery production of equivalent volumes of diesel and naphtha produced

Total TRE Center stack emissions compared



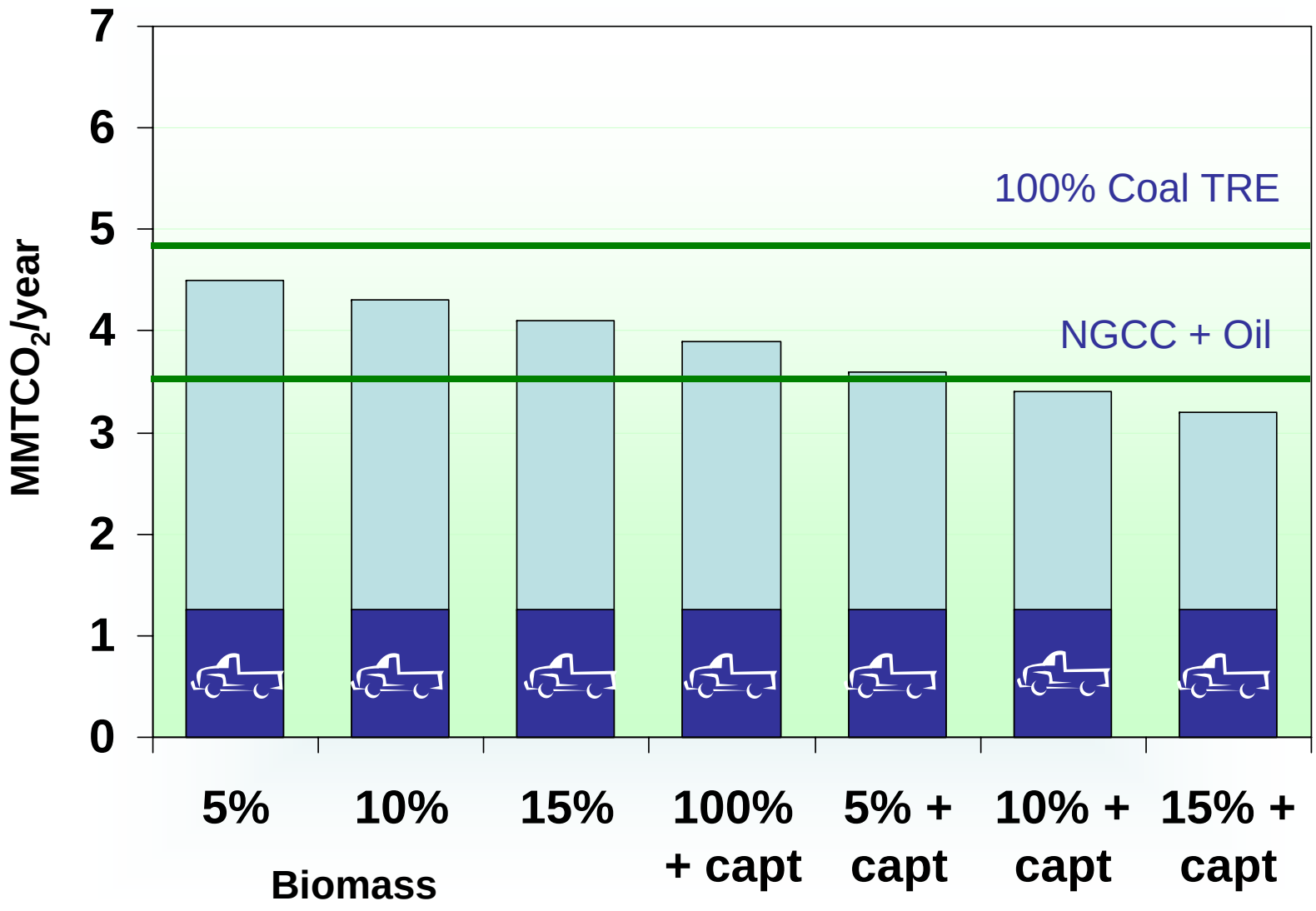
Mine-to-wheels emissions compared



TRE Center "net" emissions

- **When TRE Center comes online conventional plants and petroleum fuels will be displaced**
- **Net difference between TRE Center and NGCC + refinery life-cycle emissions can be reduced through biomass and carbon capture**

TRE Center emissions with capture and biomass



What can be done with captured TRE Center CO_2?

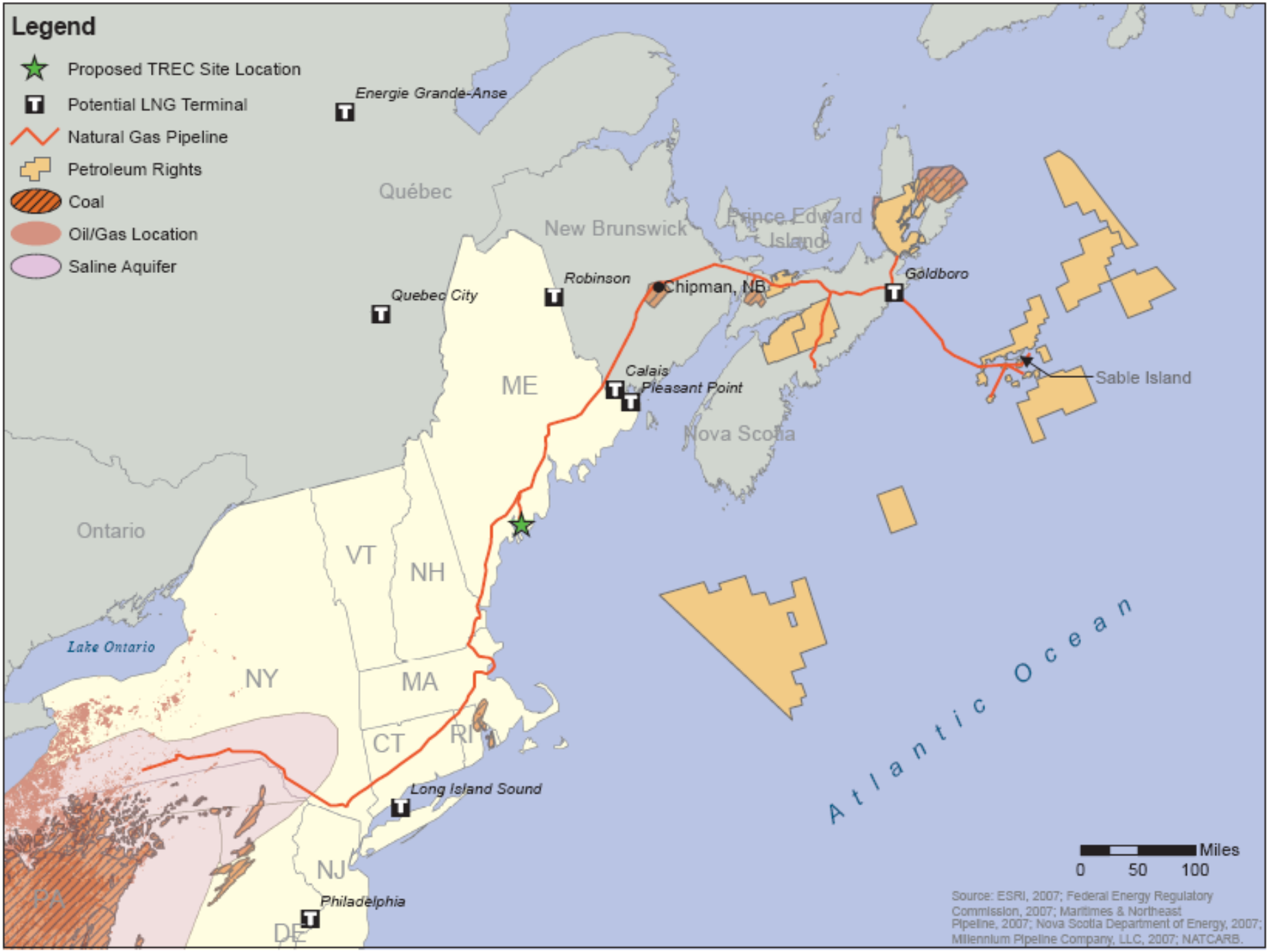
- **Onsite reuse**
- **Food-grade processes**
- **Urea production**
- **Industrial CO_2 supply**
- **Greenhouses**
- **Geologic storage**

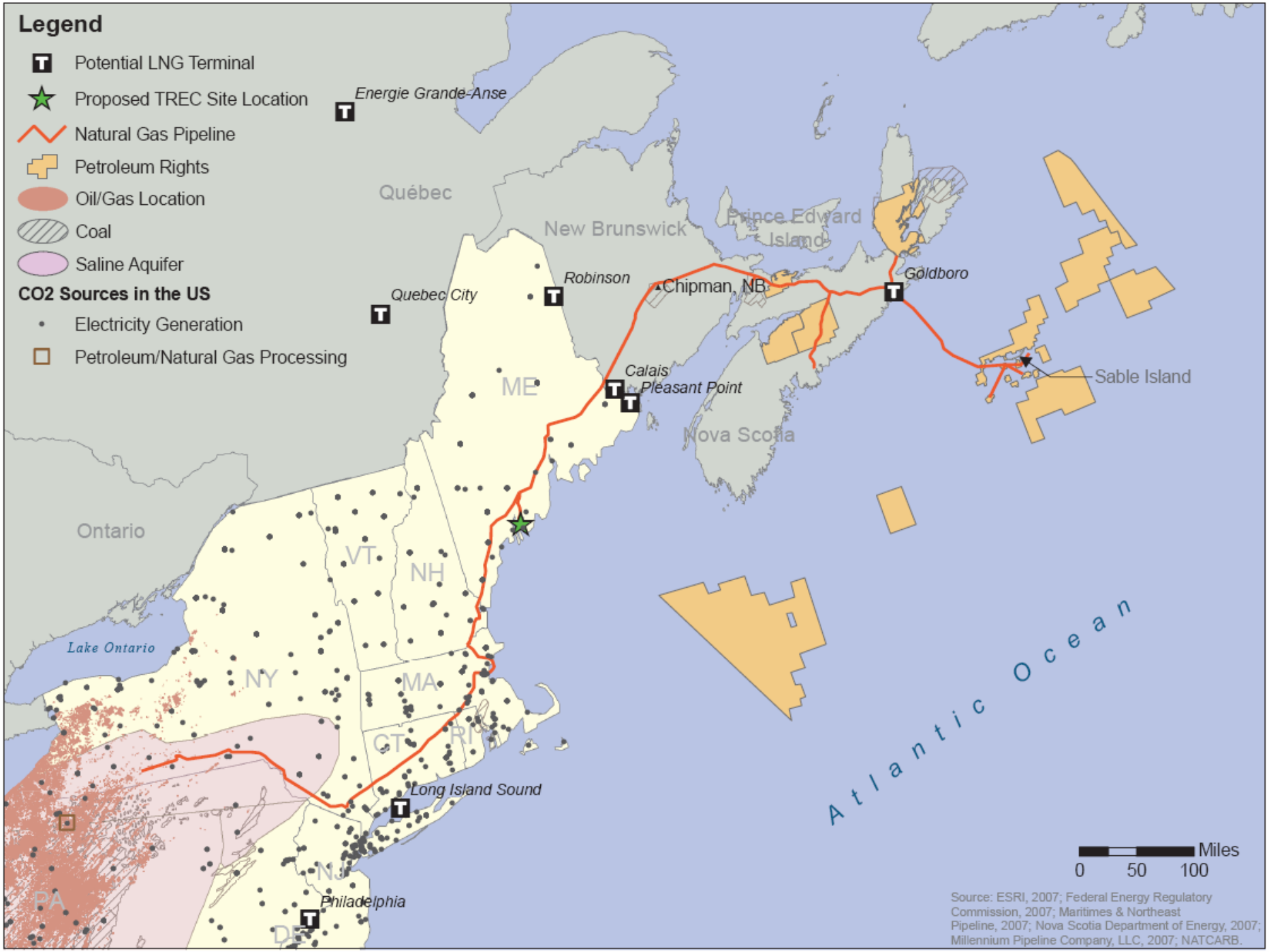
Examples of CO_2 reuse in the energy industry

- **Warrior Run plant coal plant in Cumberland, Maryland**
  - **Captures 5% of CO_2 for sale to beverage industry**
- **Irving Oil Refinery in Cape Breton, Nova Scotia**
  - **94,000 metric tons of CO_2 captured on average each year and processed for sale**

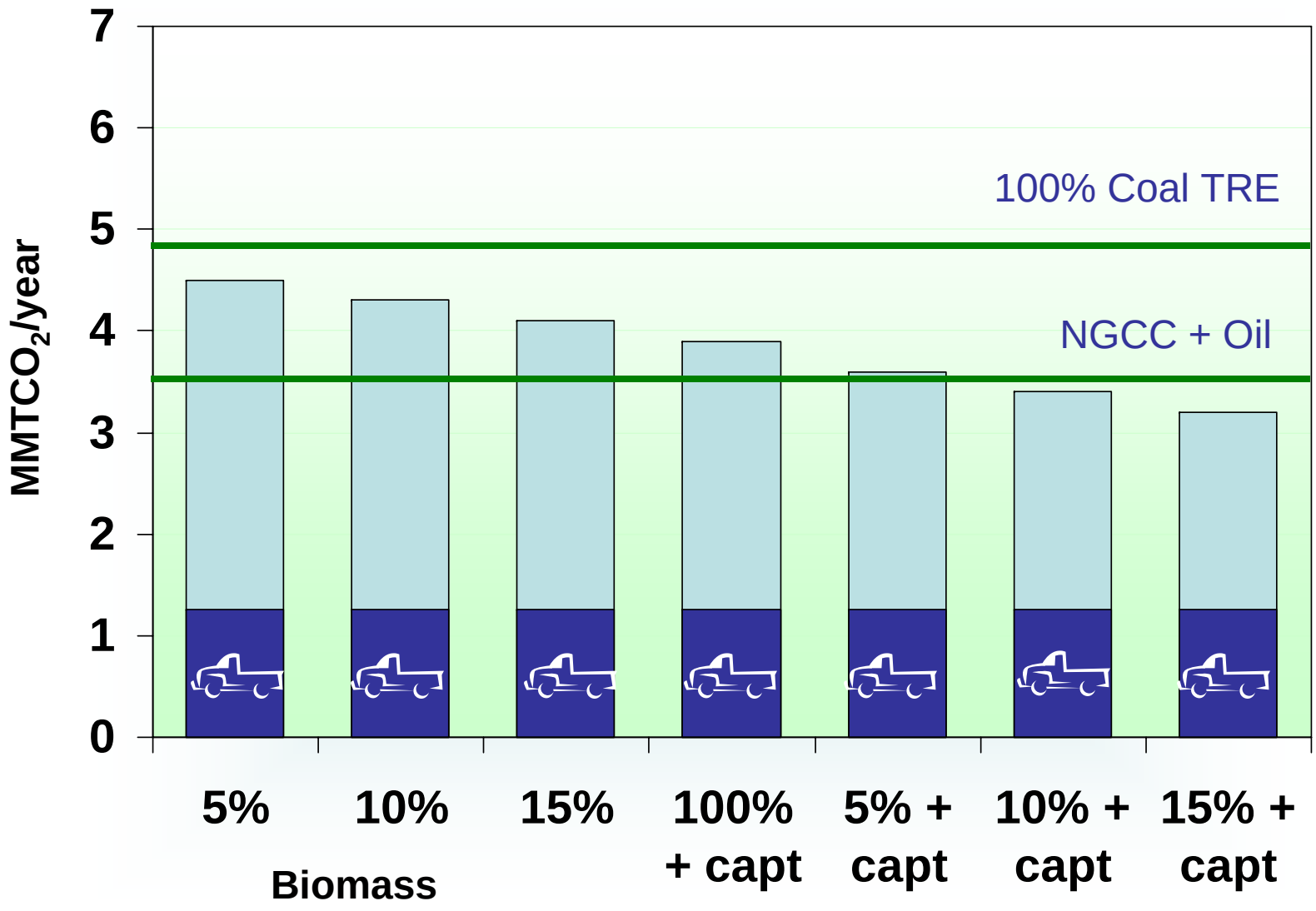
Geologic storage in Maine?

- **Assessed preliminary feasibility**
  - **Research needed to validate**
- **Potential opportunities within 500 miles of TRE Center**
  - **Sable Island gas fields**
  - **McCully gas fields**
  - **Nova Scotia unmineable coal seams**
  - **Saline formations in New York**


Legend
Proposed TREC Site Location
Potential LNG Terminal
Natural Gas Pipeline
Petroleum Rights
Coal
Oil/Gas Location
Saline Aquifer
Energie Grande-Anse
Québec
New Brunswick
Prince Edward Island
Robinson
Chipman, NB
Goldboro
Quebec City
Calais
Pleasant Point
Sable Island
ME
Nova Scotia
Ontario
VT
NH
Lake Ontario
NY
MA
CT
RI
Long Island Sound
NJ
PA
Philadelphia
DE
Atlantic Ocean
Miles
0 50 100
Source: ESRI, 2007; Federal Energy Regulatory Commission, 2007; Maritimes & Northeast Pipeline, 2007; Nova Scotia Department of Energy, 2007; Millennium Pipeline Company, LLC, 2007; NATCARB.


Legend
Potential LNG Terminal
Proposed TREC Site Location
Natural Gas Pipeline
Petroleum Rights
Oil/Gas Location
Coal
Saline Aquifer
CO2 Sources in the US
Electricity Generation
Petroleum/Natural Gas Processing
Energie Grande-Anse
Québec
New Brunswick
Prince Edward Island
Robinson
Chipman, NB
Goldboro
Quebec City
Calais
Pleasant Point
Sable Island
ME
Nova Scotia
Ontario
VT
NH
Lake Ontario
NY
MA
CT
RI
Long Island Sound
NJ
PA
Philadelphia
DE
Atlantic Ocean
Miles
0
50
100
Source: ESRI, 2007; Federal Energy Regulatory Commission, 2007; Maritimes & Northeast Pipeline, 2007; Nova Scotia Department of Energy, 2007; Millennium Pipeline Company, LLC, 2007; NATCARB.

Questions


7
6
5
4
3
2
1
0
MMTCO2/year
100% Coal TRE
NGCC + Oil
5%
10%
15%
100% + capt
5% + capt
10% + capt
15% + capt
Biomass

Contact Information

Sarah M. Forbes

Potomac-Hudson Engineering

207-557-5524

sarah.forbes@phe.com