Marine Emissions Reduction Opportunities

Cross Sound Ferry Repowering

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M.J. Bradley & Associates LLC
A Climate Change Capital Group Company

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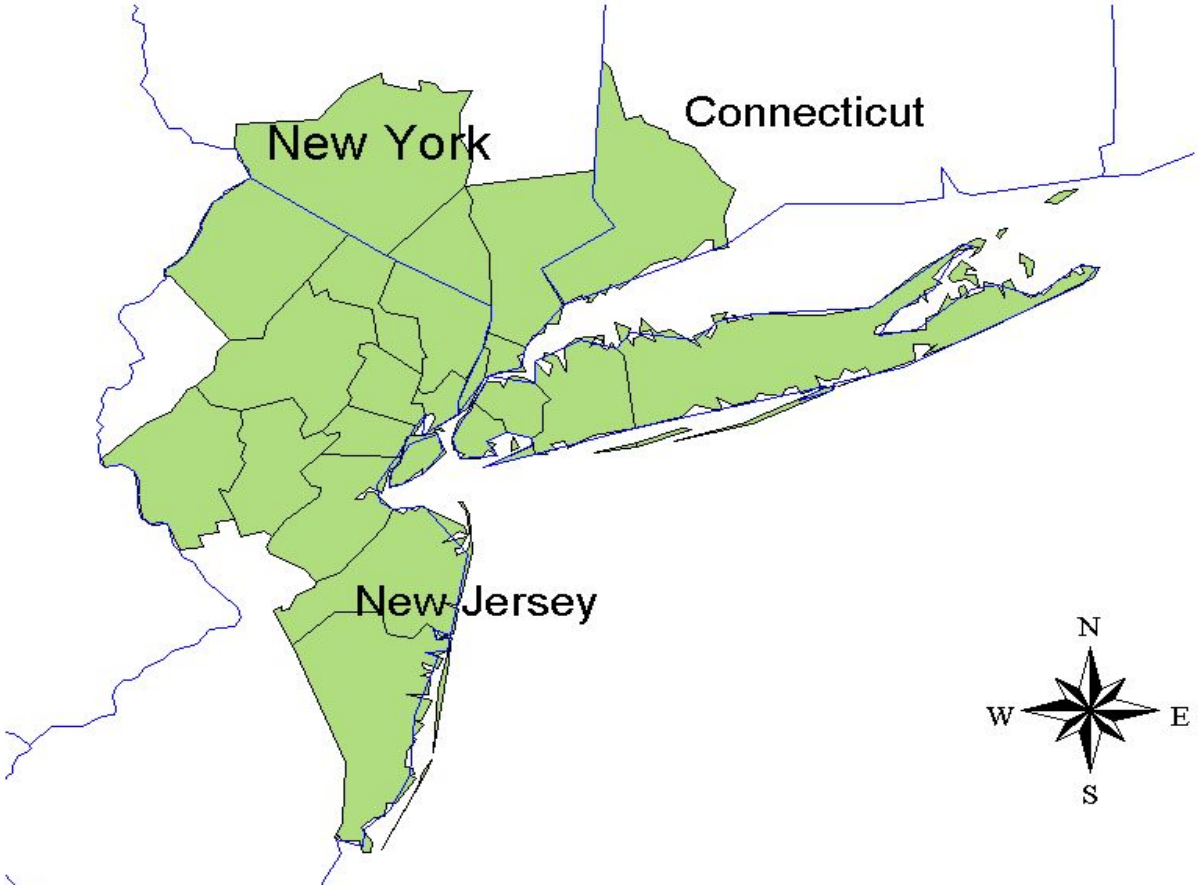
Today's Agenda

- The need for emissions reduction
- Marine vessel emissions
- Marine emissions reduction options
  - Retrofit
  - Repower
- Marine emissions reduction programs
  - PANYNJ
  - Cross Sound Ferry Repower

Need for Emissions Reductions

NY-NJ-CT-LI Nonattainment Area

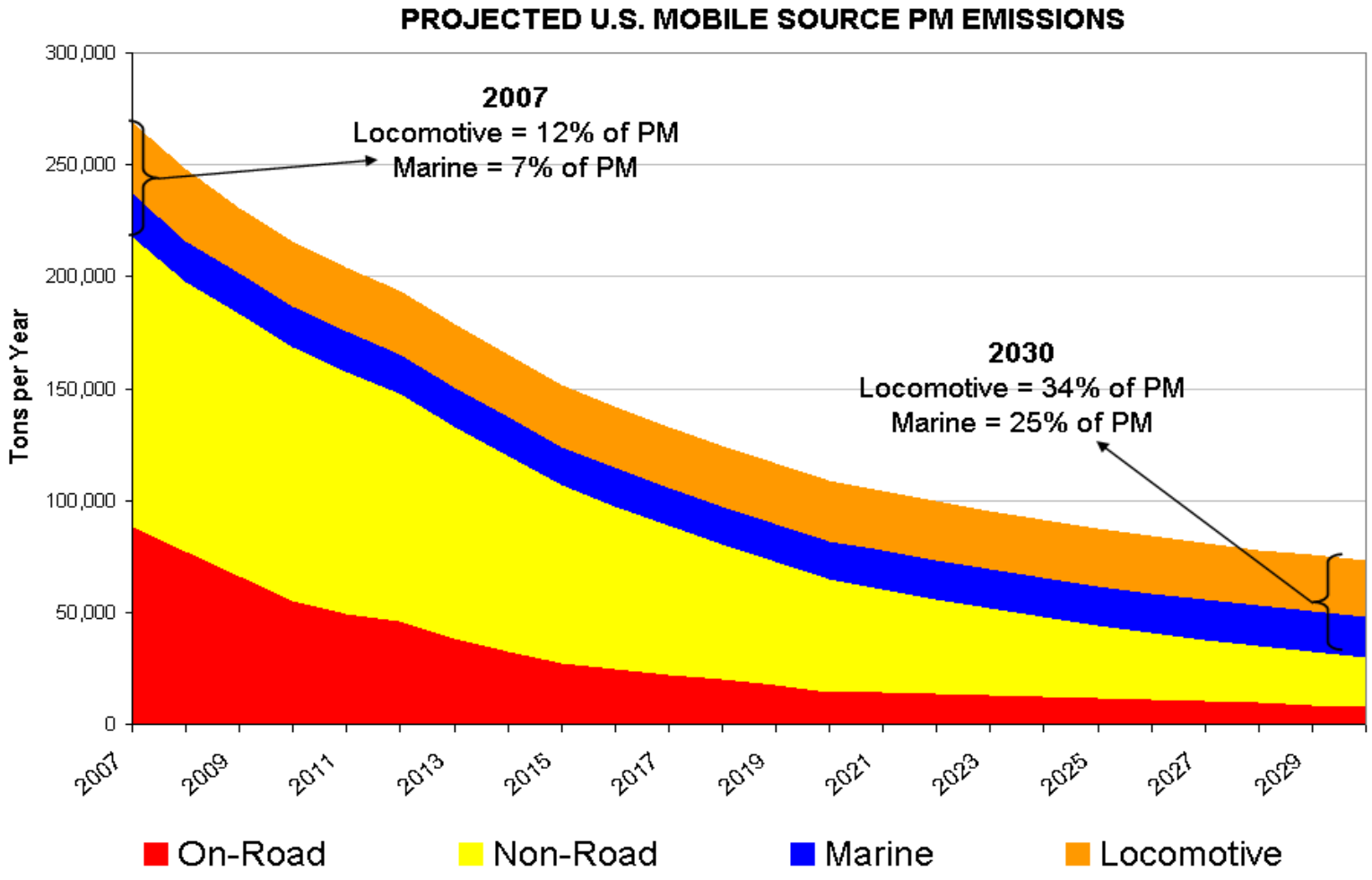


- Must reduce both NO_x and PM to achieve attainment with NAAQS
- Particular concern with diesel PM due to significant negative health effects
  - Asthma
  - Premature mortality

Why Focus on Marine Emissions?

NEXT 20 YRS:

Stricter Standards for onroad trucks and nonroad equipment will produce significant reductions as the fleets turn over



Marine & locomotive sectors will dominate remaining diesel PM sources

Types of Marine Vessels

Ocean-Going Vessels (Cruise Ships, Tankers, Cargo)

- Very large, unique diesel engines, 10,000 – 100,000 hp
- Burn heavy, residual “bunker fuel”
- *No emissions retrofit options exist for these vessels*

Coastal Vessels (Tugs, Ferries, Fishing/Work Boats)

- Use locomotive or large construction-type diesel engines, 500 – 4000 hp
- Typically burn #2 distillate fuel
- Can operate for 5,000 hrs per year or more, and burn more than 500,000 gallons of fuel annually
- Many in-use vessels have unregulated, Tier 0 engines
- *Both retrofit and repowering options exist for these vessels*

Marine Vessel Emissions Inventory

New York Harbor

CMVEI: New York Harbor Vessel Inventory, 2000

VESSEL TYPE		Number	Annual Emissions (tons)	
			NOx	PM
Ocean-going		1,425	4,139	234
Coastal Vessels	Ferries	42	1,484	38
	Tug Boats	122	5,024	191
	Excursion Vessels	25	871	22
	Government	25	168	5

Coastal vessels are less numerous but have greater effect on local air quality because they are generally captive to a region

Emissions Reduction Opportunities

Coastal Marine Vessels

- Many vessels with older, unregulated engines but significant remaining life
- Significant contributor to diesel emissions inventory in port cities (i.e. NYC)
  - Individual vessels are significant sources (High HP, high load factor, high annual usage)
  - Captive to a specific region
- Cost-effective reduction options are available
  - Repower and/or DOC retrofit
- Improved fuel economy of new engines (repower) provides significant CO_2/GHG co-benefits

Coastal vessels are some of the most effective and cost-effective targets for NO_x and PM reduction efforts

Cost Effective Emissions Reductions

TO REDUCE ~4 ANNUAL TONS OF PM:

Repower	1	3000 HP marine vessel:	$ 950,000
		or	
Retrofit	20	switcher locomotives with DOC:	$1,000,000
		or	
Retrofit	100 -200	construction engines with DPF:	$1,000,000+
		or	
Retrofit	200 - 400	onroad trucks with DPF:	$1,700,000+

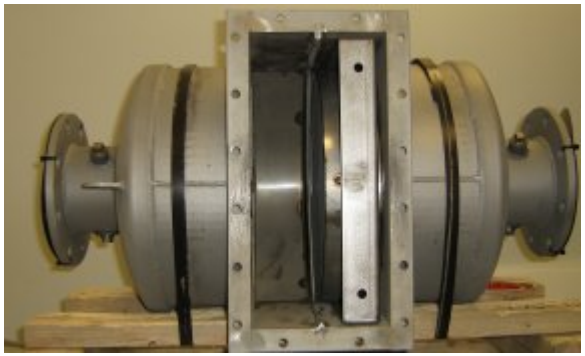
A marine engine repower will also reduce NO_x and CO_2 significantly, while the other approaches do not

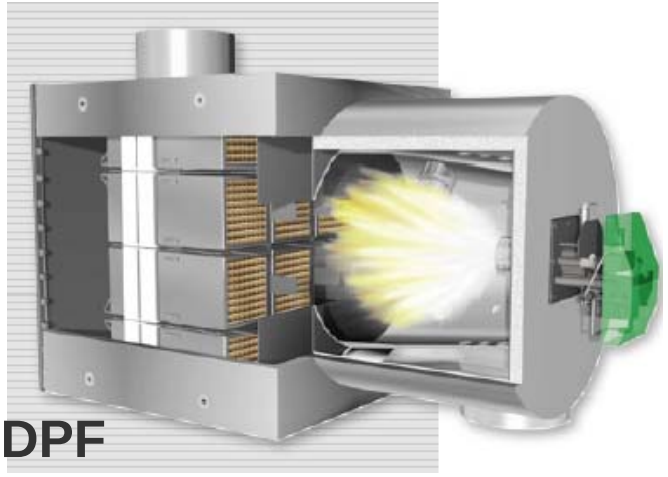
Coastal Marine Vessels

PM Retrofit Options

- Passive DPFs are generally not commercially available for marine engines
  - Active DPFs are available, but have mostly been installed in Europe, in conjunction with SCR
- DOCs are becoming available for marine engines, though there have been relatively few installations to date
  - A DOC will reduce PM by 25% and VOC by 25%
  - A DOC for a 3000 hp marine engine will cost approximately $50,000

Marine DOC





Active DPF

Coastal Marine Vessels

Changing EPA Emission Standards

Current availability of cleaner Tier 2 engines opens up an opportunity to achieve significant emissions reductions by repowering older vessels

Category 2 Marine Engines
<3700 kw & 7-15 liters/cylinder

New Engine Standard	First Applied (Model Year)	Emissions Limits (g/kwh)	
		NOx+HC	PM
Unregulated	Prior to 2004	~20.0	~0.70
EPA Tier 1 (IMO)	2004	11.5	~.50
EPA Tier 2	**2007**	**7.8**	**0.27**
EPA Tier 3	2013	6.2	0.14
EPA Tier 4	2016	1.8	0.04

New Tier 2 vs. Older Marine Engines

Technical changes yield lower emissions

- Electronic fuel control *(lower NO_x & PM; lower fuel consumption)*
- Better piston rings for lower lube oil consumption *(lower PM)*
- Improved turbocharger *(lower NO_x and PM)*
- Improved charge-air cooling *(lower NO_x)*

Tier 2 engines generally DO NOT use after-treatment.
Adding a DOC to a repower yields even greater PM reductions

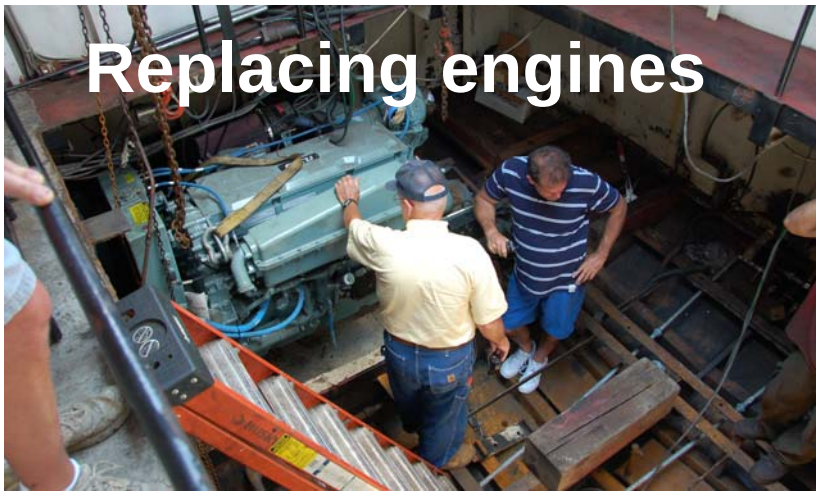
Coastal Marine Vessels

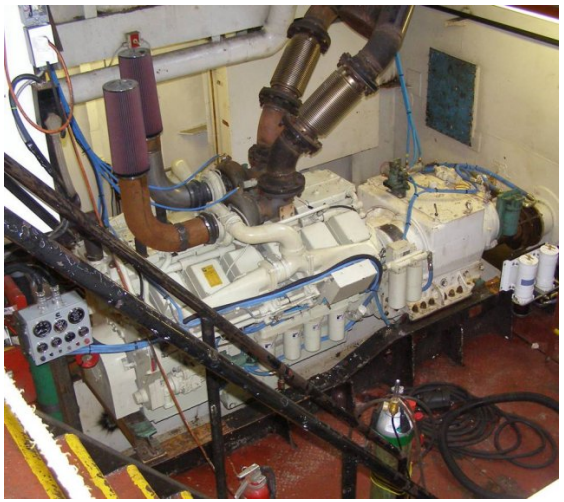
Repowering

- Many in-use marine vessels have unregulated Tier 0 engines
- Cleaner, Tier 2-compliant engines are now available
  - 66% lower PM and VOC emissions than Tier 0
  - 25% lower NOx emissions than Tier 0
  - 8 – 12% lower fuel use than Tier 0
- Repowering a marine vessel with a new 3000 hp Tier 2 engine will cost approximately $1,000,000
- Annual fuel savings for a large tug will pay back repowering costs in 7 – 8 years
  - Many vessel owners will repower if given a 50% capital subsidy (4 year pay back on owner's costs)

Coastal Marine Vessels

Repowering Process





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Comparing Emissions Reduction Projects

Project Type		Reductions [tpy/unit]			Project Cost [$/unit]	NOx & VOC Offset Value* [$/unit]	$PM_{2.5}$ Offset Cost [$/tpy]
		PM	NOx	VOC			
Vehicle Retrofit & Repower Options	Marine Repower + DOC	1.26	27.0	2.0	$350,000 **	$290,000	$47,000
	Marine Vessel DOC Retrofit	0.63	-	0.98	$50,000	$9,800	$64,000
	LH Locomotive DOC Retrofit	0.29	-	0.65	$50,000	$6,500	$150,000
	Switcher Loco DOC Retrofit	0.19	-	0.19	$50,000	$1,900	$250,000
	Gen-set Switcher Loco	0.73	12.1	0.73	$825,000	$128,300	$950,000
	Onroad Vehicle Retrofits	0.02	0.7	0.04	Up to $20,000	Up to $7,000	$0.3 - $29 mill
	Construction Retrofits	0.04	-	0.04	Up to $25,000	Up to $5,000	$0.3 - $2.8 mill
	Cruise Ship Shore Power	6.5	95.3	6.5	$8 - $16 mill	$1 million	$0.7 - $1.6 mill
Idle Reduction Options	Switcher Locomotive	0.04	1.3	0.04	$20,000***	$13,400	$165,000
	Sleeper Cab-equipped Truck	0.01	0.3	0.01	$5,000***	$3,100	$190,000

* Assumes that NOx and VOC offsets have a value of $10,000/tpy

** Assumes a capital cost subsidy high enough to provide vessel owner a 4-yr pay back based on annual fuel savings.

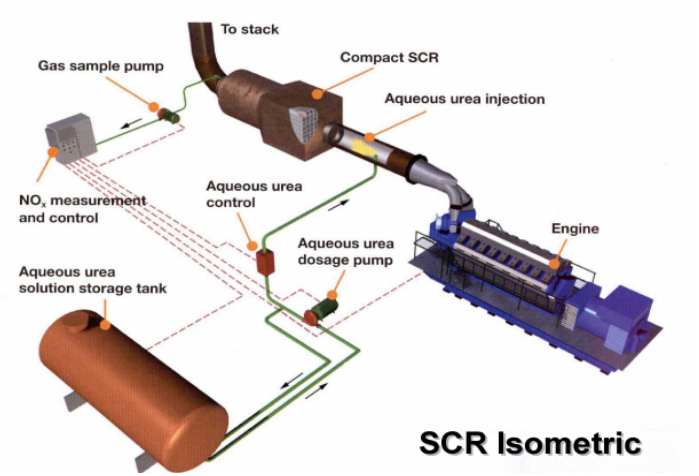
*** Assumes a capital cost subsidy high enough to provide vehicle owner a 1-yr pay back based on annual fuel savings

PANYNJ Marine Reduction Programs

- The Port of NY & NJ is located in an ozone Non-Attainment Area
- Dredging activities to deepen shipping channels will result in NOx emissions of ~100 tpy to ~700 tpy
- NOx reductions are required to offset the dredging emissions
- Desire to reduce emissions from sources geographically and chronologically coincident
- PANYNJ has funded marine emissions reduction programs
  - Staten Island Ferry Retrofit/Upgrade
  - Commercial marine engine replacements

Staten Island Ferry

Alice Austen SCR Demo



- Proof of concept demonstration
- Retrofit Alice Austen with
  - Selective Catalytic Reduction (SCR)
  - Diesel Oxidation catalyst (DOC)
- Applied to two CAT 3516 main engines
- Requires urea reductant
  - 32% solution in water
- ~70% NOx reduction and 25% PM reduction

Staten Island Ferry

Engine Upgrades

Vessel	Technology	NOx Reduction		PM Reduction	
		(tpy)	%	(tpy)	%
Barberi	Tier 1 upgrade	124	48%	0	0%
Newhouse	Tier 1 upgrade	124	48%	0	0%
Kennedy	Tier 1 upgrade w/ UL	96	42%	2.3	30%
Molinari	Tier 2 upgrade w/ UL	70	32%	4.0	44%
Marchi	Tier 2 upgrade w/ UL	70	32%	4.0	44%
Spirit of America	Tier 2 upgrade w/ UL	70	32%	4.0	44%
	TOTAL	**554**		**14.3**	

Completed **Planned**

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Marine Engine Replacement

Tugs & Excursion Vessels

Program	Number of Vessels	Annual NOx Reduction (ton)	Average Cost ($/ton)
KVK Tugs	2	51	$1,620
TERP	3	171	$1,170
MVERP	8	177	$1,550
MVERP2	10±*	240±*	$1,400±*
TOTAL	**23**	**643**	**$1,400**

** Currently projected totals; no awards have been made to date.*

PANYNJ pays for up to 100% of new engine cost – owner pays for installation

Potential Marine Vessel Projects

MAJOR FERRY & TUG FLEETS IN THE NORTHEAST

Requirements for a Successful Project

WILLING PARTNER

Cross Sound Ferry

VIABLE & COST EFFECTIVE TECHNOLOGY

Marine Repower

FUNDING

NYMTC?

Cross Sound Ferry

Proposed Repower Project

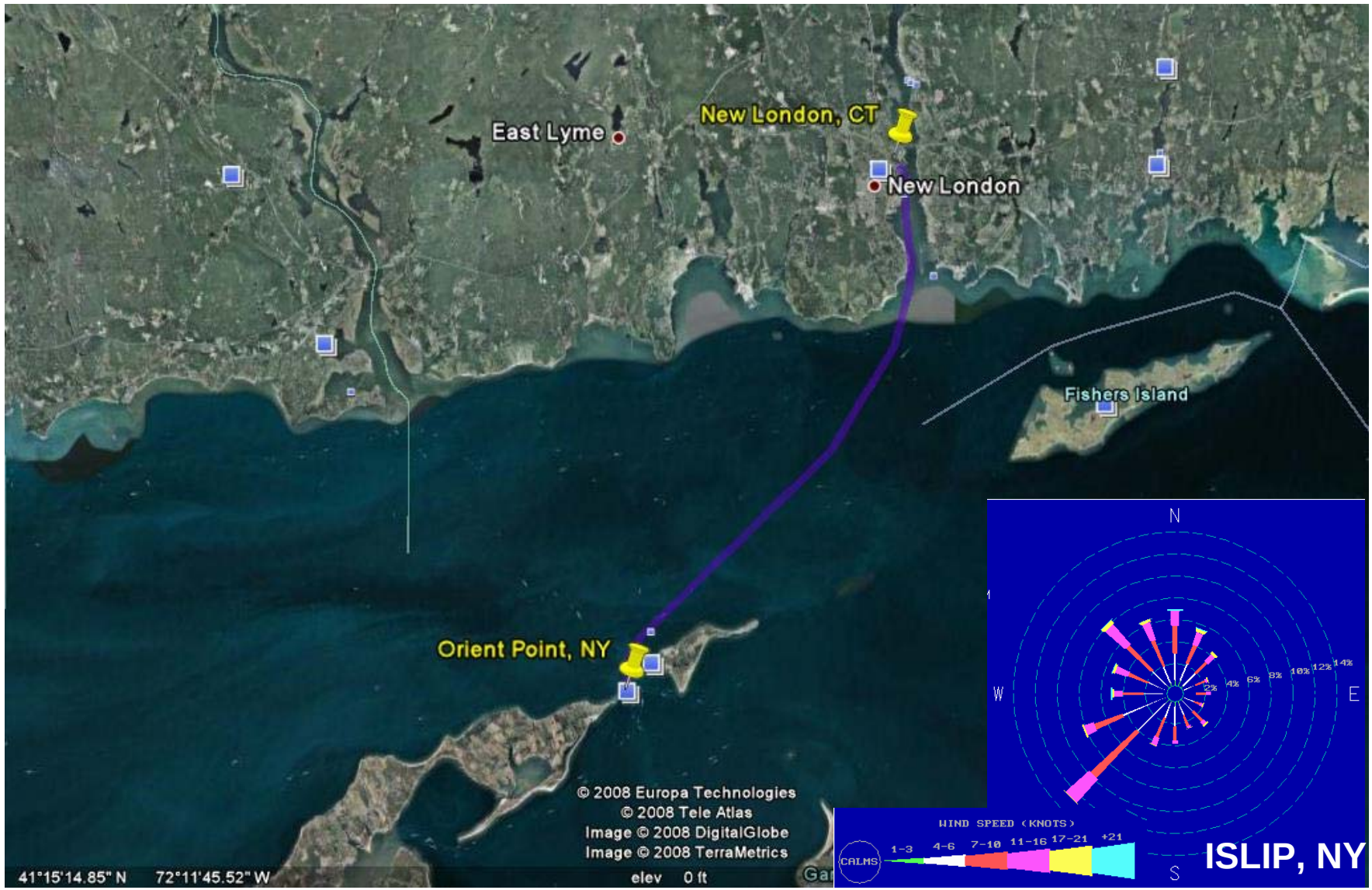
- Repower up to three vessels with new Tier 2+ engines
  - Include DOC as part of repower
- Total cost - $8 million
  - Cross Sound Ferry to provide 50% of total cost
  - Need to find $1 million in grant funding for each vessel
- Will significantly reduce annual emissions
  - 202 tons NO_x
  - 12.0 tons PM
  - 2,700 tons CO_2

Cross Sound Ferry - Overview

- Passenger and vehicle ferry service between New London, CT and Orient Point, NY
  - Carry passenger cars and heavy commercial trucks
- Fleet consists of 8 vessels
  - 7 passenger and vehicle service ferries
  - 1 high-speed ferry
- Each one-way trip covers a distance of 16 miles and takes approximately 1 hour and 20 minutes

- Over 12,000 annual one-way trips
- Over 2 million gallons of diesel fuel used annually

Cross Sound Ferry Service



Cross Sound Ferry Fleet

VESSEL NAME	ENGINES	HP	CAPACITY	
			CARS	PASS
MARY ELLEN	(2) Caterpillar 3516	1,550 each	85	675
SUSAN ANNE	(2) EMD 12-645E7B	2,300 each	80	840
CAPE HENLOPEN	(2) EMD 12-645E2	1,500 each	90	900
JOHN H	(2) EMD 12-645E2	1,500 each	120	1,000
NEW LONDON	(2) Cummins KTA38MZ	1,200 each	60	300
NORTH STAR	(2) Caterpillar D398	900 each	35	300
CARIBBEAN	(2) DDC 12-71	360 each	22	120
SEA JET	(2) Deutz 620	2,500 each	0	400

REPOWER CANDIDATES

CURRENTLY BEING REPOWERED

Cross Sound Ferry

Potential Repower Emissions Savings

VESSEL	NOx (tons/year)			PM (tons/year)		
	Current	After Repower	Savings	Current	After Repower	Savings
JOHN H	141	48	**93**	4.4	0.5	**3.9**
MARY ELLEN	58	31	**27**	3.2	0.3	**2.9**
SUSAN ANNE	58	31	**27**	3.2	0.3	**2.9**
CAPE HENLOPEN	84	29	**55**	2.6	0.3	**2.3**
TOTAL	**341**	**139**	**202**	**13.4**	**1.4**	**12.0**

Cross Sound Ferry

Repower Cost Effectiveness - Example

Vessel Mary Ellen :

Replace:

(2) EMD 12645H engines

with

(2) GE 1250 engines

$1,500,000	engines
$ 50,000	DOCs
$ 250,000	installation
$ 200,000	Project Mgmnt
$2,000,000	**TOTAL**

Annual Emissions Reductions:

NOx = 93 tons

PM = 3.9 tons

Cost of Reductions:

Project Cost:	$2 million
– Cost Share	$1 million
REQUESTED FUNDING:	$1 million
– Value of NOx*	$930,000
COST OF PM REDUCED	**$ 70,000**

$70,000 ÷ 2.9 tpy **= $24,000/tpy PM**

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** Assuming a market value of $10,000/tpy for NOx*

Cross Sound Ferry Repower

Reasons for NYMTC Support

- Enforceable, localized PM & NOx reductions
  - Repowered vessels will (can) not leave the region
- Manageable & cost effective
  - Large reductions from a small number of vehicles (similar to a stationary source)
  - Pay back to operator from fuel savings limits grant funding required to make a voluntary program work
- CSF supports CMAQ congestion mitigation goals
  - Reduced traffic through Manhattan to reach LI
- Not eligible for PANYNJ marine program funding
  - Not captive to NY Harbor

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