GHG Reduction Strategies for Connecticut

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Process

- NESCAUM is supporting CT DEP through a process to focus, prioritize, and assess the many good candidate measures that have been identified to date.
- Several key measures have been quantified in terms of GHG emission reduction potential
- Stakeholder feedback and information will help to analyze these measures in an integrated assessment framework to provide economic, environmental, and public health benefits, where feasible
- A list of recommended strategies to be published – based on these results – by July 2011

This is the focus of the current effort

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IRP Process

- IRP analysis is being conducted parallel to GWSA analysis
- Multi-stakeholder process focused on electric system cost, reliability, and environmental performance
- Products from this effort feed into the GWSA process

IRP Process

- 2008 IRP established an approach to planning process with near-term detail + long-term analysis
- 2010 IRP provides analysis of reliability, environmental and economic metrics
- Looks at objectives, drivers, and options
- Sound analytic basis for assessing power sector opportunities

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Current work : Identify Measures

- Initial list of measures has been developed though CT Climate Action Plan, stakeholder dialogue and review of NJ, NY, CA plans.
- Very broad list including about 150 measures spanning all sectors
- Identified key strategies with significant reduction potential that lend themselves to quantification (21 measures in all spanning many sectors)

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Scope of Analysis

- Identify and quantify several potential reduction opportunities…

BUT!

- Many of these identified opportunities overlap and therefore these measures are not necessarily additive
- Some represent sinks or reductions off future projected emissions and so reduction potential can be greater than current emissions

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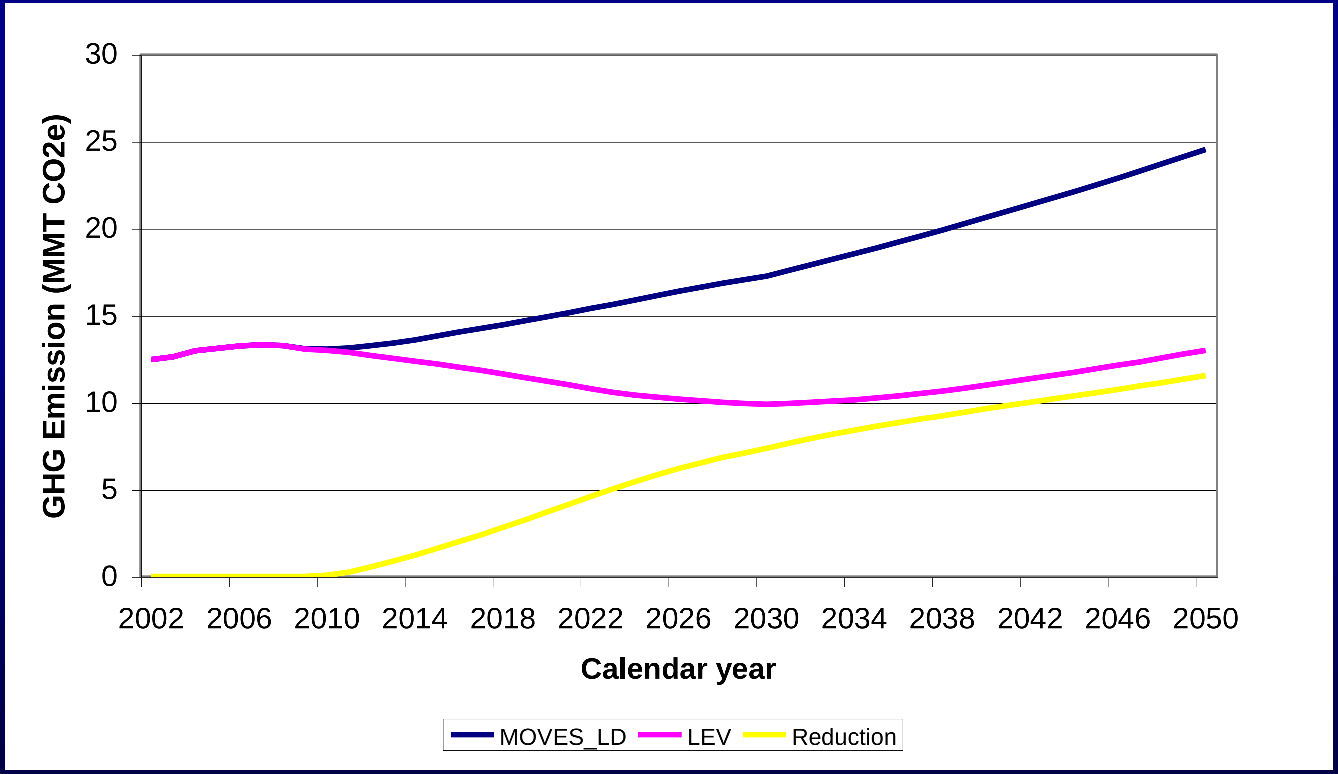
Transportation Measures

California Low Emission Vehicle Programs

- CA LEV II with LDV GHG Standard with extension
  - 27% reduction in fleetwide GHG emissions by 2016
  - Additional 4 percent/year reduction through 2022; then held fixed



2020 Reduction Potential: 3.7 MMT

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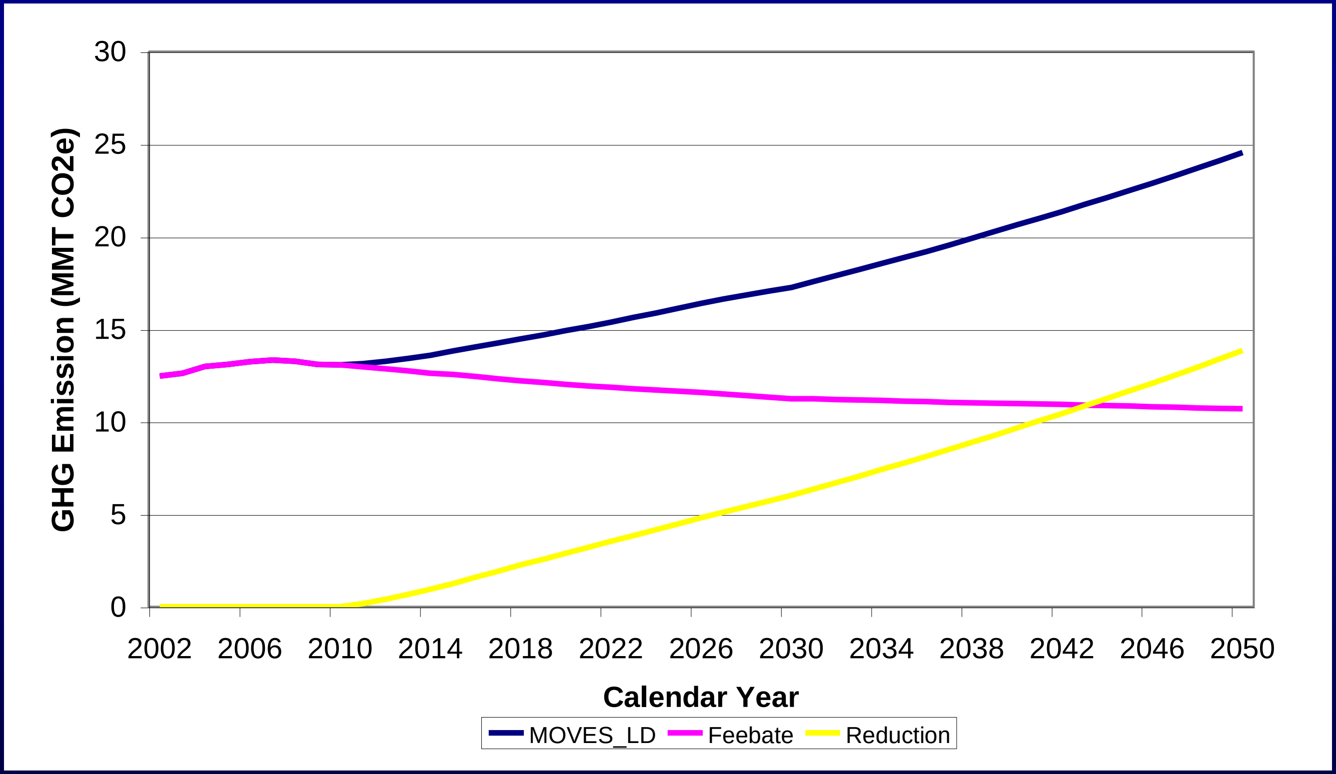
California Low Emission Vehicle Programs

- LDV Feebate Program
  - Based on CARB (U. of CA) analysis using CA-footprint (fleet mix) for revenue-neutral $20/g/mi feebate scenario for developing CT-specific reductions due to consumer response only



2020 Reduction Potential: 2.9 MMT

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Low Carbon Fuels Standard

- Region-wide 10 percent reduction in carbon intensity of transportation fuels; no set compliance path!
- U.S. DOE GREET model provides emission factors

•Analysis: bounding scenarios favor EVs, CNG, or renewable fuels (greatest to least benefit) but program is not determinative, so market outcome is unknown…

60% EV
20% Renewable Fuel
20% CNG

Point for comment:

How to credit upstream reductions?

2020 Reduction Potential: 0.6-1.2 MMT + 1.2-1.9 MMT upstream

20% EV
60% Renewable Fuel
20% CNG

20% EV
20% Renewable Fuel
60% CNG

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Smart Growth

- *Growing Cooler*
  - National review of program opportunities and potential applied to CT
  - Analyzed by type of measure and level of deployment

2020 Reduction
Potential: 0.04-0.2 MMT

VMT Reduction/Public Transit

- *Moving Cooler*
  - National review of program opportunities and potential applied to CT
  - Analyzed by type of measure and level of deployment

2020 Reduction
Potential: 0.04-0.12 MMT

Highway Speed Limit Reduction

- EPA analysis of emissions *increase* for speed limit increases in the 90s was applied to CT-specific highway VMT data by speed bin
  - 65 to 60 mph
  - 65 to 55 mph

2020 Reduction
Potential: 0.45-0.9 MMT

Clean Diesels

- 60 Auxiliary Power Units on long-haul CT fleets
- Potential DPF retrofit/replacement program for 50% of CT nonroad IC engines

2020 Reduction
APU Potential: 550 MT
nonroad Potential: 0.1-0.3 MMT

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Electric Power Generation

Renewable Portfolio Standard

- Current RPS calls for 27% of electric demand to be serviced by renewable generation by 2020
- Absolute generation – and therefore CO2 emissions – are dependent on demand forecasts; relative reduction still valid
- Updated forecasts may change reduction estimate

2020 Reduction Potential: 2.6 MMT

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RGGI

- Regional Greenhouse Gas Initiative calls for stabilization between 2009 and 2014; then 10% reduction in CO_2 cap by 2018
- Extend RGGI:
  - Additional 10% reduction of GHG cap by 2028
- Expand RGGI:
  - EGUs >15 MW (current limit is >25 MW)
  - ICI Boilers > 250,000 MMBtu/hr
  - 10% reduction in cumulative emissions between 2014 and 2023; implemented as single cap covering all sources

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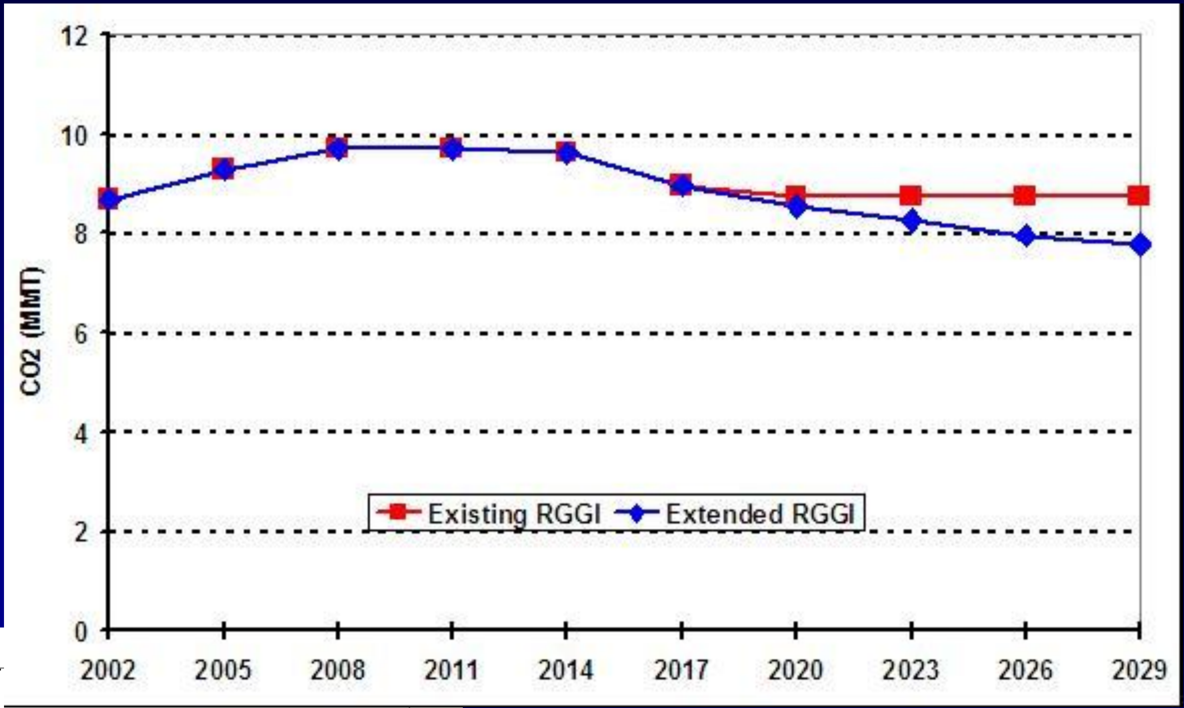
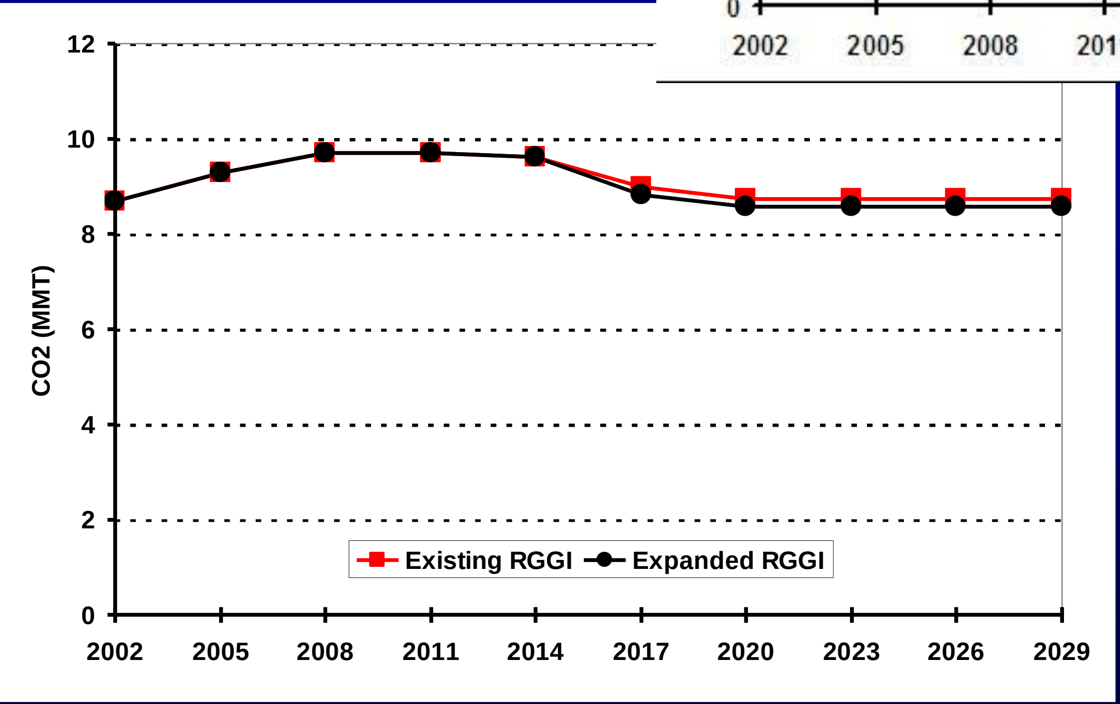
Extended RGGI

2020 Reduction Potential: 0.2 MMT (1 MMT in 2030)





Expanded RGGI

2020 Reduction Potential: 0.15 MMT

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CO_2 Performance Standard

	Integrated Gasification Combined Cycle						Pulverized Coal Boiler				NGCC	
	GEE		CoP		Shell		PC Subcritical		PC Supercritical		Advanced F Class	
	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 9	Case 10	Case 11	Case 12	Case 13	Case 14
CO_2 Capture	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Gross Power Output (kW_e)	770,350	744,960	742,510	693,840	748,020	693,555	583,315	679,923	580,260	663,445	570,200	520,090
Auxiliary Power Requirement (kW_e)	130,100	189,285	119,140	175,600	112,170	176,420	32,870	130,310	30,110	117,450	9,840	38,200
Net Power Output (kW_e)	640,250	555,675	623,370	518,240	635,850	517,135	550,445	549,613	550,150	545,995	560,360	481,890
Coal Flowrate (lb/hr)	489,634	500,379	463,889	477,855	452,620	473,176	437,699	646,589	411,282	586,627	N/A	N/A
Natural Gas Flowrate (lb/hr)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	165,182	165,182
HHV Thermal Input (kW_{th})	1,674,044	1,710,780	1,586,023	1,633,771	1,547,493	1,617,772	1,496,479	2,210,668	1,406,161	2,005,660	1,103,363	1,103,363
Net Plant HHV Efficiency (%)	38.2%	32.5%	39.3%	31.7%	41.1%	32.0%	36.8%	24.9%	39.1%	27.2%	50.8%	43.7%
Net Plant HHV Heat Rate (Btu/kW-hr)	8,922	10,505	8,681	10,757	8,304	10,674	9,276	13,724	8,721	12,534	6,719	7,813
Raw Water Usage, gpm	4,003	4,579	3,757	4,135	3,792	4,563	6,212	14,098	5,441	12,159	2,511	4,681
Total Plant Cost ($ x 1,000)	1,160,919	1,328,209	1,080,166	1,259,883	1,256,810	1,379,524	852,612	1,591,277	866,391	1,567,073	310,710	564,628
Total Plant Cost ($/kW)	1,813	2,390	1,733	2,431	1,977	2,668	1,549	2,895	1,575	2,870	554	1,172
LCOE (mills/kWh)[1]	78.0	102.9	75.3	105.7	80.5	110.4	64.0	118.8	63.3	114.8	68.4	97.4
CO_2 Emissions (lb/hr)	1,123,781	114,476	1,078,144	131,328	1,054,221	103,041	1,038,110	152,975	975,370	138,681	446,339	44,634
CO_2 Emissions (tons/year) @ CF[1]	3,937,728	401,124	3,777,815	460,175	3,693,990	361,056	3,864,884	569,524	3,631,301	516,310	1,661,720	166,172
CO_2 Emissions (tonnes/year) @ CF[1]	3,572,267	363,896	3,427,196	417,466	3,351,151	327,546	3,506,185	516,667	3,294,280	468,392	1,507,496	150,750
CO_2 Emissions (lb/MMBtu)	197	19.6	199	23.6	200	18.7	203	20.3	203	20.3	119	11.9
CO_2 Emissions (lb/MWh)[2]	1,459	154	1,452	189	1,409	149	1,780	225	1,681	209	783	85.8
CO_2 Emissions (lb/MWh)[3]	1,755	206	1,730	253	1,658	199	1,886	278	1,773	254	797	93
SO_2 Emissions (lb/hr)	73	56	68	48	66	58	433	Negligible	407	Negligible	Negligible	Negligible
SO_2 Emissions (tons/year) @ CF[1]	254	196	237	167	230	204	1,613	Negligible	1,514	Negligible	Negligible	Negligible
SO_2 Emissions (tonnes/year) @ CF[1]	231	178	215	151	209	185	1,463	Negligible	1,373	Negligible	Negligible	Negligible
SO_2 Emissions (lb/MMBtu)	0.0127	0.0096	0.0125	0.0085	0.0124	0.0105	0.0848	Negligible	0.0847	Negligible	Negligible	Negligible
SO_2 Emissions (lb/MWh)[2]	0.0942	0.0751	0.0909	0.0686	0.0878	0.0837	0.7426	Negligible	0.7007	Negligible	Negligible	Negligible
NOx Emissions (lb/hr)	313	273	321	277	309	269	357	528	336	479	34	34
NOx Emissions (tons/year) @ CF[1]	1,096	955	1,126	972	1,082	944	1,331	1,966	1,250	1,784	127	127
NOx Emissions (tonnes/year) @ CF[1]	994	867	1,021	882	982	856	1,207	1,783	1,134	1,618	115	115
NOx Emissions (lb/MMBtu)	0.055	0.047	0.059	0.050	0.058	0.049	0.070	0.070	0.070	0.070	0.009	0.009
NOx Emissions (lb/MWh)[2]	0.406	0.366	0.433	0.400	0.413	0.388	0.613	0.777	0.579	0.722	0.060	0.066
PM Emissions (lb/hr)	41	41	38	40	37	39	66	98	62	89	Negligible	Negligible
PM Emissions (tons/year) @ CF[1]	142	145	135	139	131	137	247	365	232	331	Negligible	Negligible
PM Emissions (tonnes/year) @ CF[1]	129	132	122	126	119	125	224	331	211	300	Negligible	Negligible
PM Emissions (lb/MMBtu)	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0130	0.0130	0.0130	0.0130	Negligible	Negligible
PM Emissions (lb/MWh)[2]	0.053	0.056	0.052	0.057	0.050	0.057	0.114	0.144	0.107	0.134	Negligible	Negligible
Hg Emissions (lb/hr)	0.0033	0.0033	0.0031	0.0032	0.0030	0.0032	0.0058	0.0086	0.0055	0.0078	Negligible	Negligible
Hg Emissions (tons/year) @ CF[1]	0.011	0.012	0.011	0.011	0.011	0.011	0.022	0.032	0.020	0.029	Negligible	Negligible
Hg Emissions (tonnes/year) @ CF[1]	0.010	0.011	0.010	0.010	0.010	0.010	0.020	0.029	0.019	0.026	Negligible	Negligible
Hg Emissions (lb/TBtu)	0.571	0.571	0.571	0.571	0.571	0.571	1.14	1.14	1.14	1.14	Negligible	Negligible
Hg Emissions (lb/MWh)[2]	4.24E-06	4.48E-06	4.16E-06	4.59E-06	4.03E-06	4.55E-06	1.00E-05	1.27E-05	9.45E-06	1.18E-05	Negligible	Negligible

[1] Capacity factor is 80% for IGCC cases and 85% for PC and NGCC cases
[2] Value is based on gross output
[3] Value is based on net output

DOE, NETL: "Cost and Performance Baseline for Fossil Energy Plants", August 2007

~1500 lb/MWh: Coal/Oil out, IGCC/Gas in…

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Residential, Commercial, Industrial Sector

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Conservation Funds

- Fiscal Incentives for Energy Efficiency
  - CT Energy Efficiency Fund, Natural Gas Efficiency Fund, and Fuel Oil Conservation Board
  - Assess CO_2 reduction achieved from 2008 expenditures; assume equivalent reductions for equal funding moving forward
  - Agnostic on source of future funding

2020 Reduction Potential:
CEEF: 1.0 MMT
NGEF: 6,250 MT
FOCF: 625 MT

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Appliance Standards

- Appliance Standards
  - 50% of new appliances sold in CT must meet EnergyStar™ or better efficiency ratings by 2014
  - All new appliances sold in CT must meet EnergyStar™ or better efficiency ratings by 2029

ENERGY STAR

2020 Reduction
Potential: 3.0 MMT

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Building Codes

- Architecture 2030 Challenge: All new buildings and major renovations meet a standard of 50% reduction in fossil fuel compared to regional average
  - 60% by 2010
  - 70% by 2015
  - 80% by2020
  - 90% by 2025
  - Carbon-neutral buildings by 2030

2020 Reduction Potential: ?? NEED INFORMATION RE: # Construction Permits

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"Top 20" from Study on CT Energy/Gas Efficiency Potential

- KEMA Consulting/Schlegel et al (2009): *Energy Efficiency Potential: Results of Studies by ECMB*
- *"Top 20" technologies surveyed for residential, commercial, and industrial sector*
- *Likely overlap with mechanistic approaches already listed (i.e. CEEF)*

2020 Reduction Potential:
Residential: 1.8 MMT
Commercial: 2.2 MMT
Industrial: 4.5 MMT

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Heat Pumps

- Heating and cooling consume 43% of residential and commercial energy
- Assume that 20% of residential and commercial heating and cooling demand satisfied by ground-source and air-source heat pumps by 2020

2020 Reduction
Potential: 2.3 MMT

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Weatherization

- Department of Energy eQUEST tool used to assess efficiency savings associated with upgrades to typical Hartford house
- Quantified GHG reductions associated with low-e double pane windows and improved insulation for 50,000 homes in the state

2020 Reduction Potential:
Windows: 0.13 MMT
Insulation: 1.16 MMT

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Smart Meters

- Northeast Utilities Pilot Program
  - 1000 smart meters deployed in 2009
  - Provides consumer information on usage
- National study used to assess potential benefits of 50% penetration

2020 Reduction
Consumer Info: 0.34 MMT
Smart Grid Diagnostics: 0.37 MMT
Advanced Voltage Control: 0.17 MMT

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High GWP Gas Measures

- Emissions are low now, but projected to grow as HFCs continue to be phased in
- Reductions relative to baseline through recycling and recovery programs in SIT model
- Assume that 50% of current emissions could be captured by 2020

2020 Reduction Potential: 1.5 MMT

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District Heating

- Connecticut Academy of Science and Engineering has examined potential for district heating and cooling and CHP
- Identified 11 EGUs in high density locations suitable for district heat/AC
- Assume that half of the waste heat from these facilities could be utilized to offset current heat/AC demand

$$$ 2020 Reduction Potential: 7.8 MMT

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Waste and Land Use

CT Solid Waste Management Plan

- Solid Waste Plan has 8 objectives and 75 strategies that result in diversion of up to 58 percent of solid waste by 2024
- Assess GHG reductions from four scenarios corresponding to different rates of solid waste diversion using EPA WAste Reduction Model (WARM)

2020 Reduction Potential: 1.6 MMT

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Forest and Ag Land Preservation

Terrestrial Carbon Sequestration in the Northeast

- The Nature Conservancy, 2007

- Land-use sector in CT is currently an emitter
- Report reviews a number of land-use options (including afforestation of agricultural land and restocking forest lands)
- Stratifies opportunities by cost/ton

Cumulative (over lifetime of forest) Reduction @ <$7/ton
Restocking Forest Land: 0.046 MMT
Cumulative (over lifetime of forest) Reduction @ <$20/ton
Agricultural Tillage: varies by county

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Summary

Measure	2020 Reduction (MMT CO_2e)
Transportation	
CA LEV II	3.7
Feebate Program	2.9
Low Carbon Fuel Standard	0.6-1.2 (+1-2 upstream)
Smart Growth	0.04-0.2
VMT Reduction/Public Transit	0.04-0.12
Speed Limit Reduction	0.45 (5 mph)/0.9(10 mph)
Clean Diesel Programs	0.0005 (APUs)/0.1-0.3(nonroad)
Power Generation	
Renewable Portfolio Standard	2.6
Extend RGGI	0.2 (1.0 by 2030)
Expand RGGI	0.15
Performance Standard	0 (backstop)
Residential, Commercial, Industrial Sectors	
Conservation Funds	1.2
Appliance Standards	3
Building Codes	??
"Top 20" efficiency opportunities (Residential, Commercial, Industrial)	1.8 (R), 2.2 (C), 4.5(I)
Heat Pumps	2.3
Weatherization	0.2(windows)/1.2(insulation)
Smart Meters	0.34
High GWP gas collection	1.5
District Heating	7.8
Waste/Land-Use	
Solid Waste Management Plan	1.6
Fields and Forests	[illegible]046 (cumulative)

Update Baseline Assumptions

Potential Overlap

Projected Reduction

Economic Analysis

Sink

∑ Re[illegible]ctio[illegible]

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Next Steps

- Identify emission targets (2009 GHG Inventory)
- Identify reduction strategies (This document)
- Analyze and recommend strategies (including economic analysis – July 2011)
- Report to Assembly on reductions achieved, schedule for policies, and scientific assessment (January 2012)
- Schedule of regulatory actions (July 2012)

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THANK YOU!

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