Connecticut Department of Energy and Environmental Protection

Connecticut Department of
ENERGY & ENVIRONMENTAL PROTECTION

GC3 Meeting

October 19, 2017
1:00 — 3:00 p.m.

Agenda

1:00	Welcome & Announcements *Mary Sotos, Deputy Commissioner of Energy*
1:05	Overview of mitigation scenarios and electric sector assumptions *Jason Rudokas, NESCAUM*
1:10	Review and discuss draft REMI analysis of combined buildings, transportation and electric sector scenarios *Stan McMillen, REMI Consultant*
1:35	Technology penetration rates by sector for 35%, 45%, 55%, and 55% +aggressive 2030 renewables scenarios *Jason Rudokas, NESCAUM*
1:50	Discuss mid-term GHG reduction target considerations *Facilitated by Commissioner Rob Klee, GC3 Chair*
2:45	Public comments

Overview of Mitigation Scenarios & Electric Sector Assumptions

Jason Rudokas, NESCAUM

Overview of Mitigation Scenarios

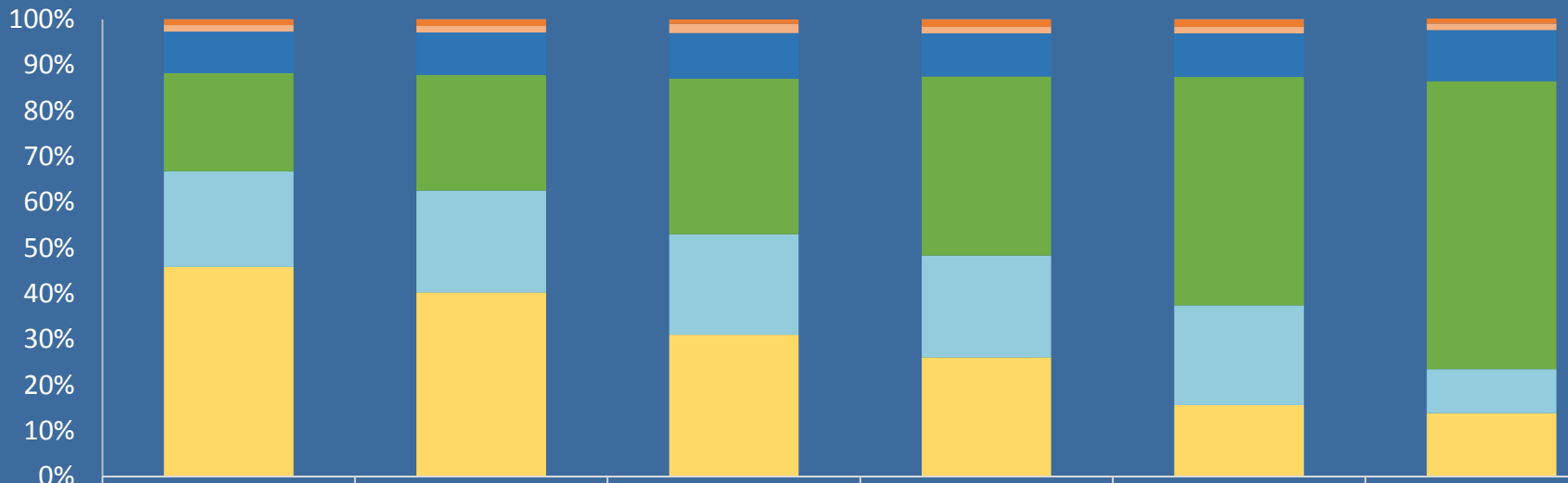
- This presentation documents the proposed input assumptions and mitigation wedges for mid-term target scenarios of 35%, 45% and 55% below 2001 levels by 2030.
- A sensitivity of high renewable penetration.
- Informed by GC3 guidance, the following set of slides outline the input assumptions for three sectors:
  - *Electric Sector*
    - Electric energy efficiency
    - Renewable and carbon free energy generation
  - *Buildings Sector*
    - Thermal energy efficiency
    - Renewable thermal
  - *Transportation Sector*
    - ZEV deployment
    - Heavy-duty electrification/alternative fuels
    - Passenger and freight rail electrification
    - Short haul trucks electrification/alternative fuels
    - VMT reductions

Electric Sector Inputs Assumptions

- Reference case electricity generation trends are based on the 2017 EIA Annual Energy Outlook (AEO) forecast for New England

- The AEO projections were scaled to CT electric load using the 2017 ISO-NE Capacity, Energy, Loads, and Transmission Report (CELT)

Scenarios for Electric Power Generation Mix



	2030 Reference Case	35% Mid-term Target	45% Midterm Target	55% Midterm Target	55% Midterm Target + Aggressive renewables	2050 Target
Oil	0%	0%	0%	0%	0%	0%
Coal	1%	1%	1%	2%	2%	2%
Biomass	1%	1%	2%	1%	1%	1%
Hydropower	9%	9%	10%	9%	10%	11%
Renewables	21%	25%	34%	39%	50%	63%
Nuclear	21%	22%	22%	22%	22%	10%
Natural Gas	46%	40%	31%	26%	16%	14%
	51% Zero Carbon	62% Zero Carbon	66% Zero Carbon	71% Zero Carbon	81% Zero Carbon	84% Zero Carbon

* Generation mix represents CT's portion of the regional electric grid.
* * Renewables are defined as CT Class I resources

Review and discuss draft REMI analysis of combined buildings, transportation and electric sector scenarios

Stan McMillen, REMI Consultant

Combined Sector REMI Output

Combined Sector Economic & Fiscal Impact (2020 – 2030)			
	35% Midterm Target	55% Midterm Target	55% +Aggressive 2030 Renewables
Economic or Fiscal Variable	**Average Level & % Change**	**Average Level & % Change**	**Average Level & % Change**
Total Employment (Jobs)	16,000 0.65%	26,000 1.0%	25,000 1.0%
State GDP (millions current $)	$2,000 0.6%	$3,800 1.0 %	$3,500 0.9%
State Revenue (millions current $)	$105 0.4%	$175 0.6%	$155 0.5%
State Expenditure (millions current $)	$120 0.5%	$160 0.6%	$180 0.7%

Key REMI Conclusions & Next Steps

Conclusions

- Economic and fiscal results are small fractions of the state economy and budget in each sector considered individually and combined…but not insignificant
- Very little economic difference between each scenarios.

Next Steps

- Complete economic and fiscal analysis report
- What else?

Review and discuss feasibility of technology penetration rates by sector for 35%, 45%, 55%, and 55 +aggressive 2030 renewables scenarios

Jason Rudokas, NESCAUM

Buildings Sector Technology Penetration Rates and Assumptions

Electric & Thermal Energy Efficiency Savings

- 35% Mid-Term Target Scenario:
  - Program spending remains at average 2014 – 2016 levels through 2050
- 45% Mid-Term Target Scenario:
  - Program spending is the average of 35% and 55% mid-term target scenario
- 55% Mid-Term Target Scenario:
  - Program spending is increased to remain a constant share of CT GDP through 2050
- Note: Based on input from members of the GC3 we have revised the cost escalation factor applied to EE measures – curves do not go completely flat

Residential & Commercial Renewable Thermal*

Residential RT	2020	2030	2050
35% below 2001 levels by 2030			
% of Thermal Load	10%	18%	87%
45% below 2001 levels by 2030			
% of Thermal Load	11%	26%	87%
55% below 2001 levels by 2030			
% of Thermal Load	13%	39%	87%
Sensitivity: 55% Case + Aggressive 2030 Renewables***			
% of Thermal Load		32%	87%

Commercial RT**	2020	2030	2050
35% below 2001 levels by 2030			
% of Heated Sq. ft.	5%	10%	69%
45% below 2001 levels by 2030			
% of Heated Sq. ft.	9%	20%	69%
55% below 2001 levels by 2030			
% of Heated Sq. ft.	17%	39%	69%
Sensitivity: 55% Case + Aggressive 2030 Renewables***			
% of Heated Sq. ft.		25%	69%

*Renewable thermal refers to air and ground source heat pumps.
**Percentages represent the % of heated floor space provided by heat pumps.
***Electric Grid is 50% Renewable by 2030

Transportation Sector Technology Penetration Rates and Assumptions

Electrification of Passenger Vehicles

	2020	2030	2050
35% below 2001 levels by 2030			
# of ZEVs	20,000	340,000	2,610,000
% of Fleet	1%	13%	95%
% of Sales	2%	44%	100%
45% below 2001 levels by 2030			
# of ZEVs	40,000	500,000	2,610,000
% of Fleet	2%	20%	95%
% of Sales	3%	56%	100%
55% below 2001 levels by 2030			
# of ZEVs	70,000	750,000	2,610,000
% of Fleet	3%	32%	95%
% of Sales	5%	72%	100%
Sensitivity: 55% case +Aggressive Renewables**			
# of ZEVs		600,000	2,610,000
% of Fleet		25%	95%
% of Sales		62%	100%

- In each scenario ZEV sales are ~ 100% by 2050
- # and % of ZEVs are rounded
- % of sales refers to annual sales
- **Electric Grid is 50% Renewable by 2030

Heavy-duty Vehicle & Rail Electrification

Heavy-duty Vehicle Electrification	2030	2050
Light Commercial Trucks and Transit Busses	30%	80%
School Busses & Refuse Trucks	30%	80%
Single Unit Short Haul Trucks	35%	80%

Passenger and Freight Rail Electrification	2030	2050
Passenger	45%	95%
Freight	45%	95%

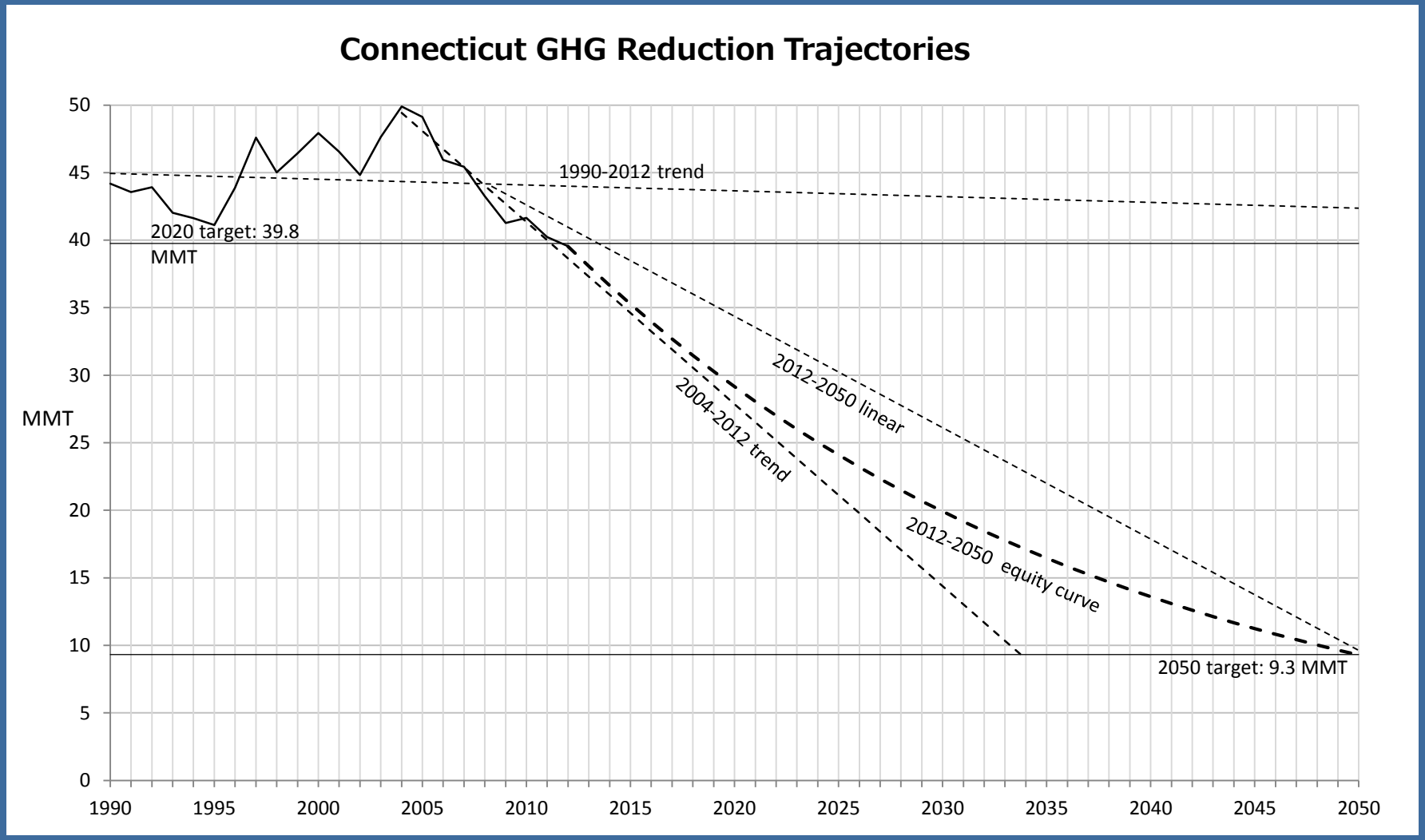
These mitigation wedges do not change based on the mid-term reduction target

CT VMT Reduction Scenarios

- VMT reduction scenarios apply only to passenger cars and passenger trucks
- **35% Mid-Term Reduction Scenario:** 2% reduction in VMT in 2050 relative to reference case.
- **45% Mid-Term Reduction Scenario:** 3% reduction in VMT in 2050 relative to reference case.
- **55% Mid-Term Reduction Scenario:** 4% reduction in VMT in 2050 relative to reference case.

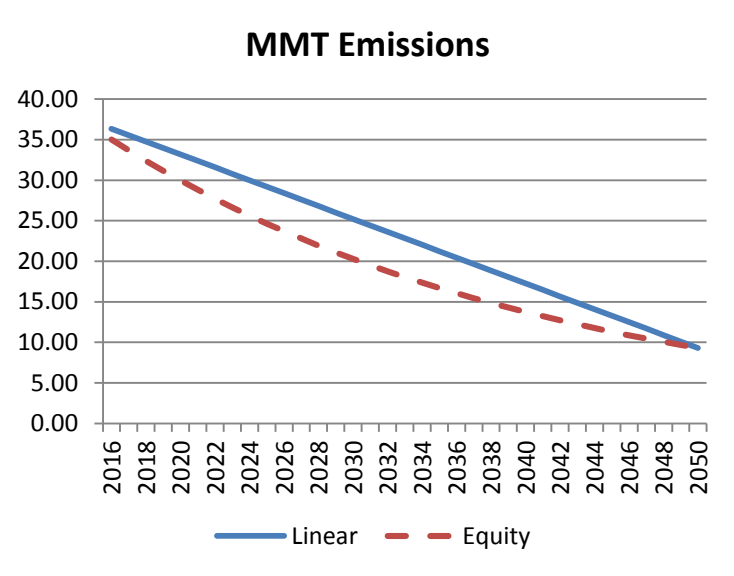
Discuss mid-term GHG reduction target considerations

Equity Curve



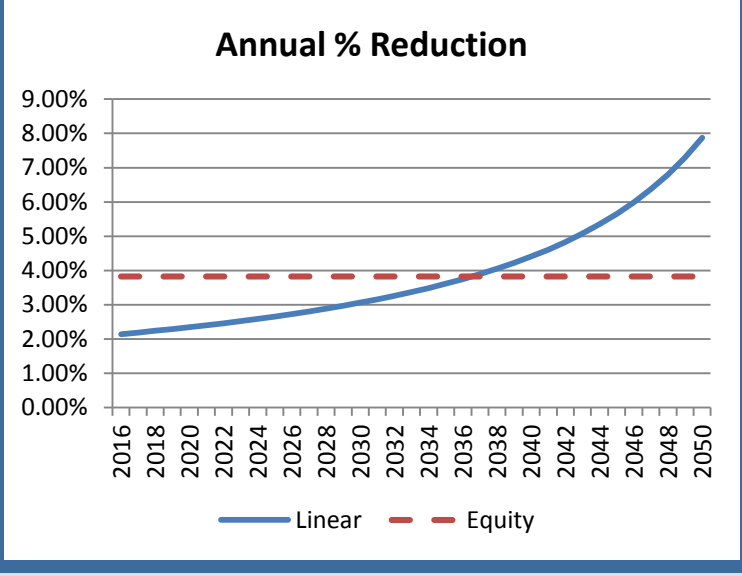
- This graph was based on the 2012 GHG Inventory as a starting point.
- 2012-2050 Linear Trajectory represents 0.8MMT annual reduction.

Equity Curve



Linear Trajectory

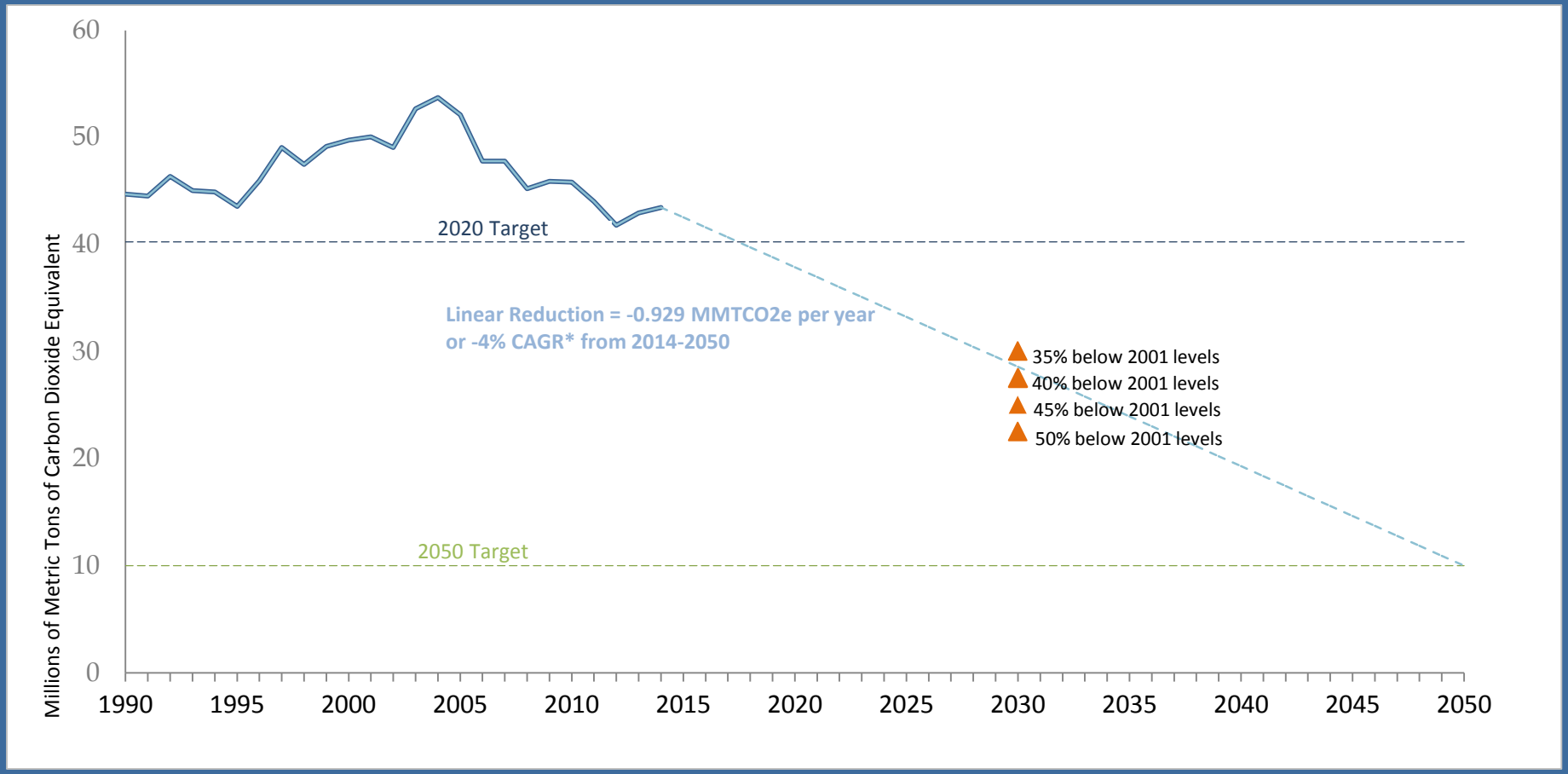
- the same volumetric (MMT) reduction in emissions each year
- increasingly higher proportional reductions from one year to the next
- 2030 level is 36% reduction from 2012
- 2050 level is 63% reduction from 2030



"Equity Curve"

- consistent year-to-year percentage reduction
- same proportional reduction between the years 2021 and 2022 as between 2036 and 2037
- percentage reduction for every ten-year period is also identical

Assessment of 2030 Interim GHG Reduction Targets for CT



*Compound Annual Growth Rate (CAGR)

GHG Reduction Targets

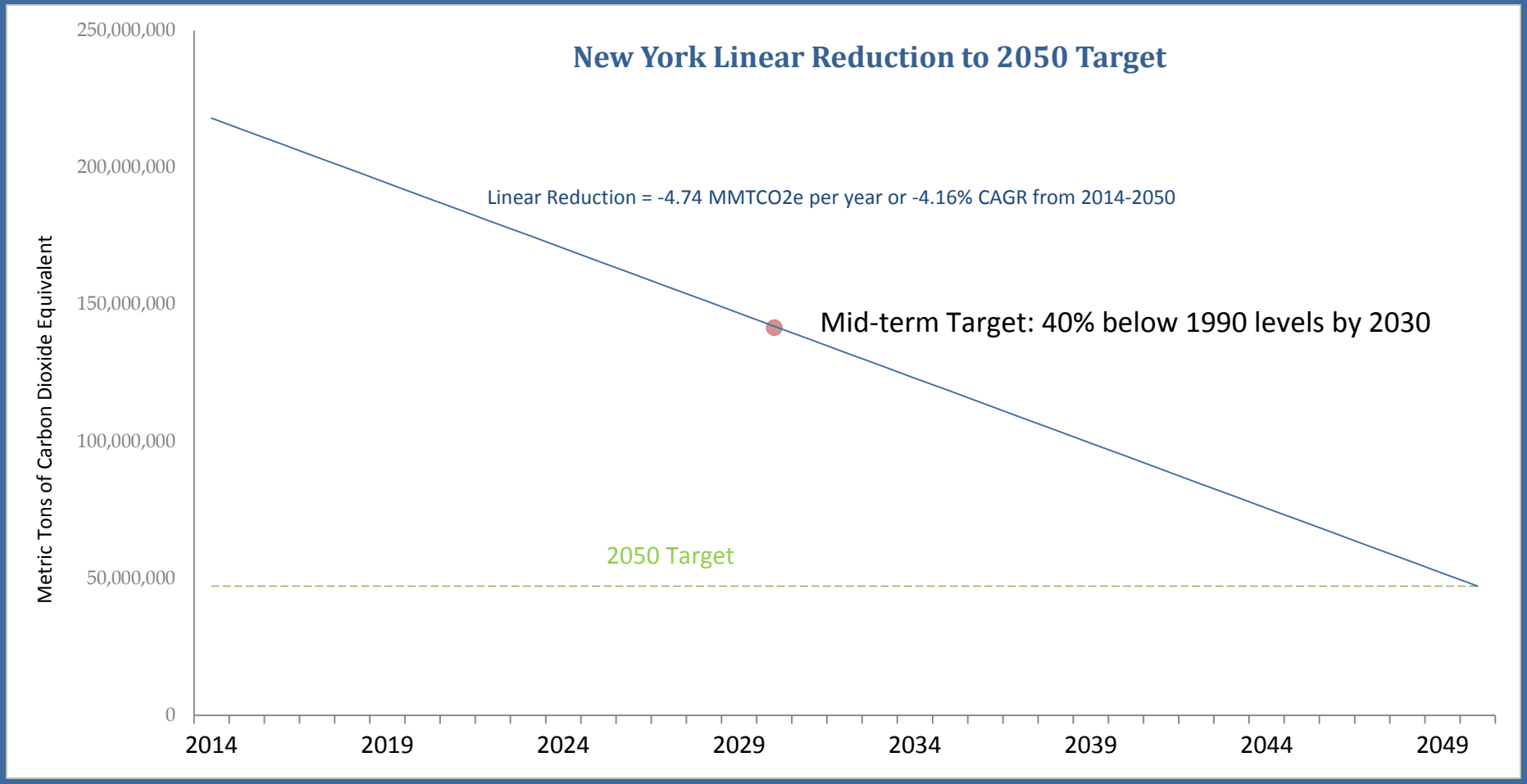
	2020	2025	2028	2030	2035	2050
CT	**10% below 1990 levels** (legislative mandate)					**80% below 2001 levels** (legislative mandate)
MA	**10-25% below 1990 levels** (legislative mandate)					**80% below 1990 levels** (legislative mandate)
NY				**40% below 1990 levels** (executive order)		**80% below 1990 levels** (executive order)
NH		**20% below 1990 levels** (aspirational)				**80%below 1990 levels** (aspirational)
RI	**10% below 1990 levels** (legislative mandate)				**45% below 1990 levels** (legislative mandate)	**80% below 1990 levels** (legislative mandate)
VT			**50% below 1990 levels** (aspirational)			**80-95% below 1990 levels** (aspirational)
CA	**A return to 1990 levels** (legislative mandate)			**40% below 1990 levels** (legislative mandate)		**80% below 1990 levels** (executive order)
MN		**30% below 2005 levels** (legislative mandate)				**80% below 2005 levels** (legislative mandate)
WA	**A return to 1990 levels** (legislative mandate)				**25% below 1990 levels** (legislative mandate)	**50% below 1990 levels** (legislative mandate)
NEG/ECP	**10% below 1990 levels** (aspirational)			**Marker Range 35-45% below 1990 levels** (aspirational)		**75-85% below 2001 levels** (aspirational)

Comparative Analysis of Mid-term Targets

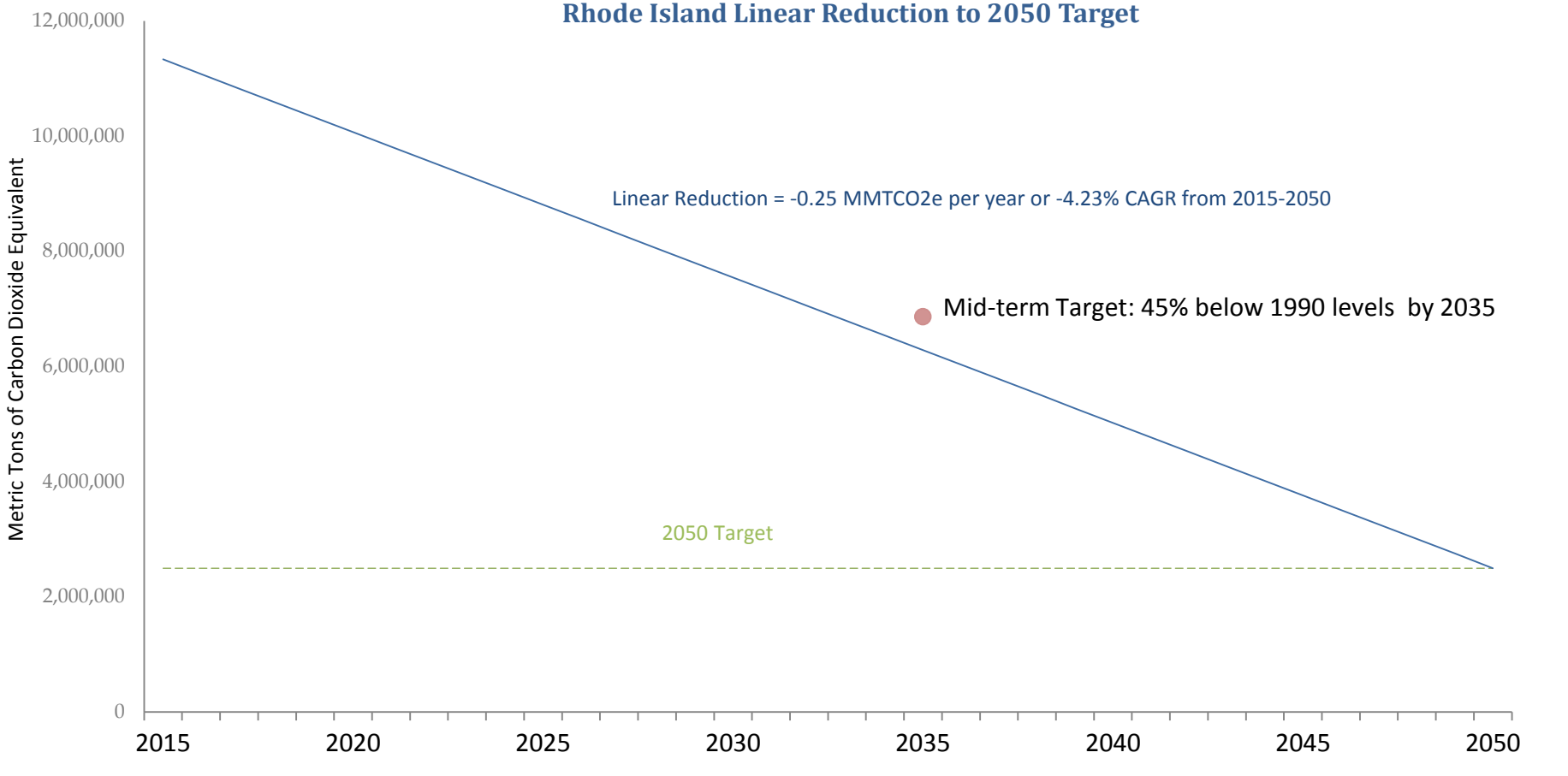
State	Baseline Year	Baseline total emissions (MMTCO2e)	Midterm Target Year	Midterm Target %	CAGR* reduction to meet mid-term target from 2014 baseline	CAGR reduction/increase from baseline to 2014
New York	1990	235,840,000	2030	40%	-2.66%	-0.3%
Rhode Island	1990	12,480,000	2035	45%	-2.47%	-0.4%
Vermont	1990	8,110,000	2028	50%	-4.36%	+0.1%
Minnesota	2005	150,000,000	2025	30%	-2.43%	+0.6%
California	1990	431,000,000	2030	40%	-3.29%	+0.1%
Connecticut	2001	50,065,141	2030	**35%**	-2.66%	-1.1%
Connecticut	2001	50,065,141	2030	**40%**	-3.14%	
Connecticut	2001	50,065,141	2030	**45%**	-3.66%	
Connecticut	2001	50,065,141	2030	**55%**	-4.87%	

*Compound Annual Growth Rate (CAGR)

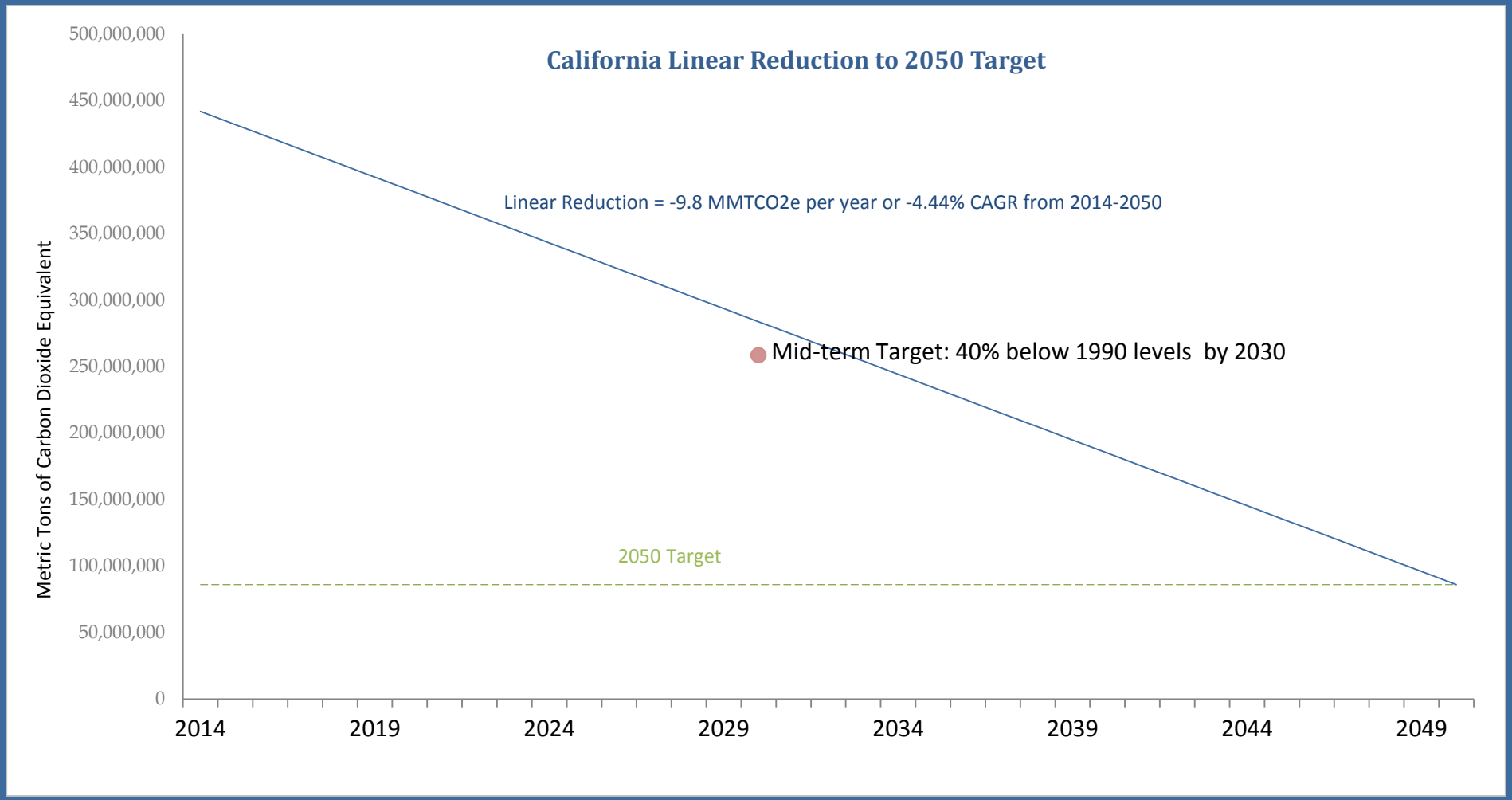
Comparative Analysis of Mid-term Targets



Comparative Analysis of Mid-term Targets



Comparative Analysis of Mid-term Targets



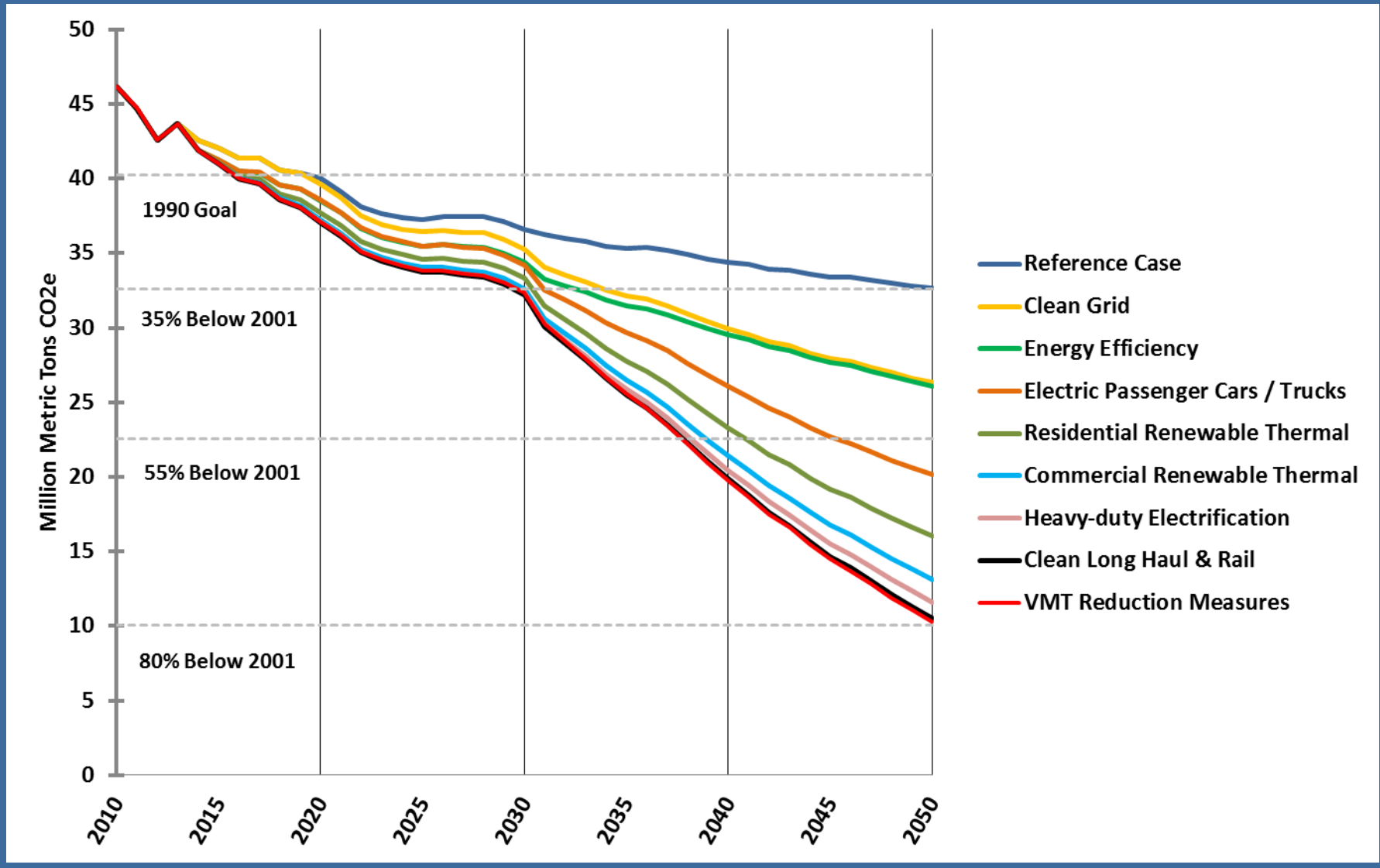
Mid-term Target Discussion

- Considerations?
  - Ambitious, stretch, achievable, flexibility, target range
- What, if any, additional information is needed?

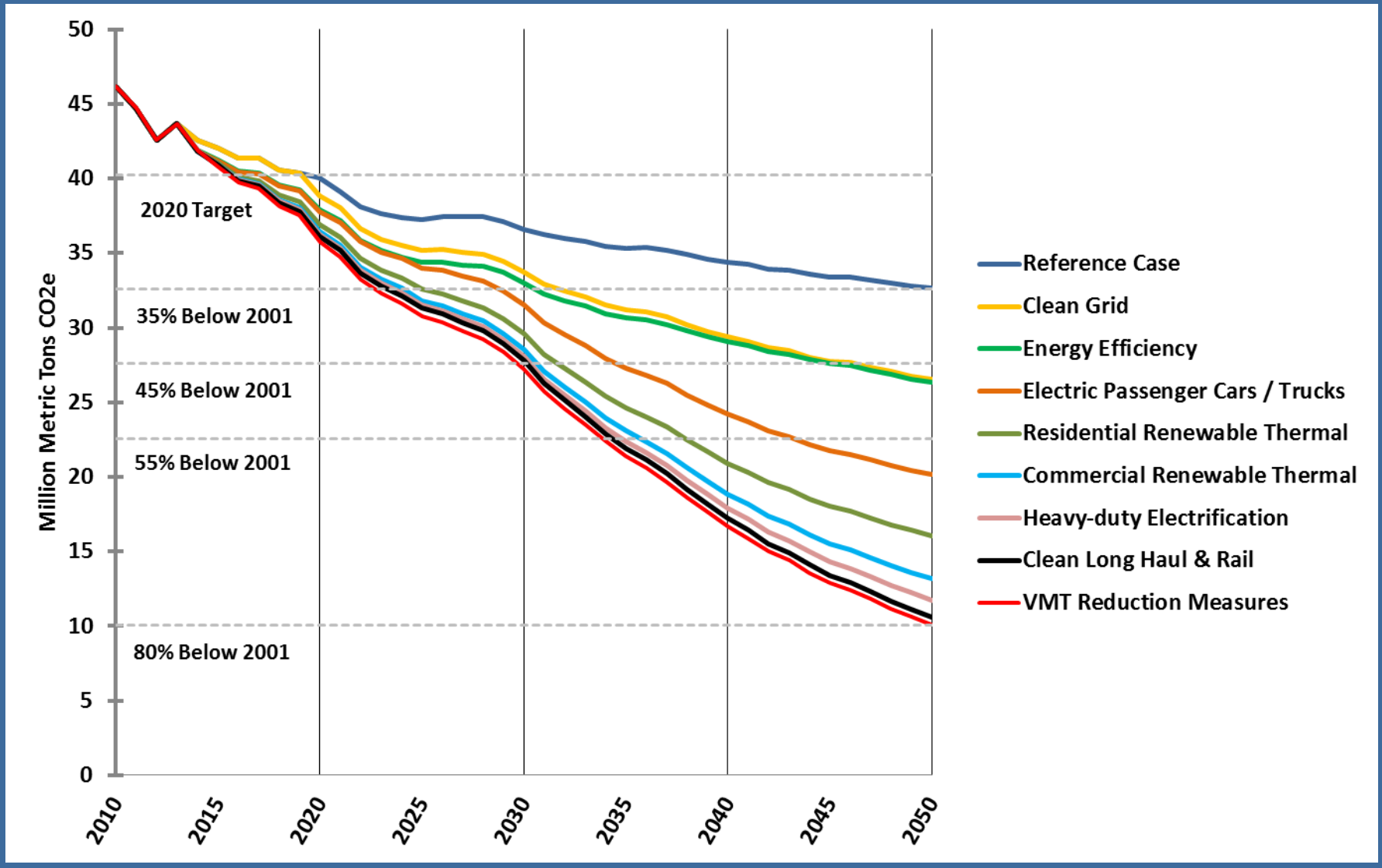
Public Comments

Appendix

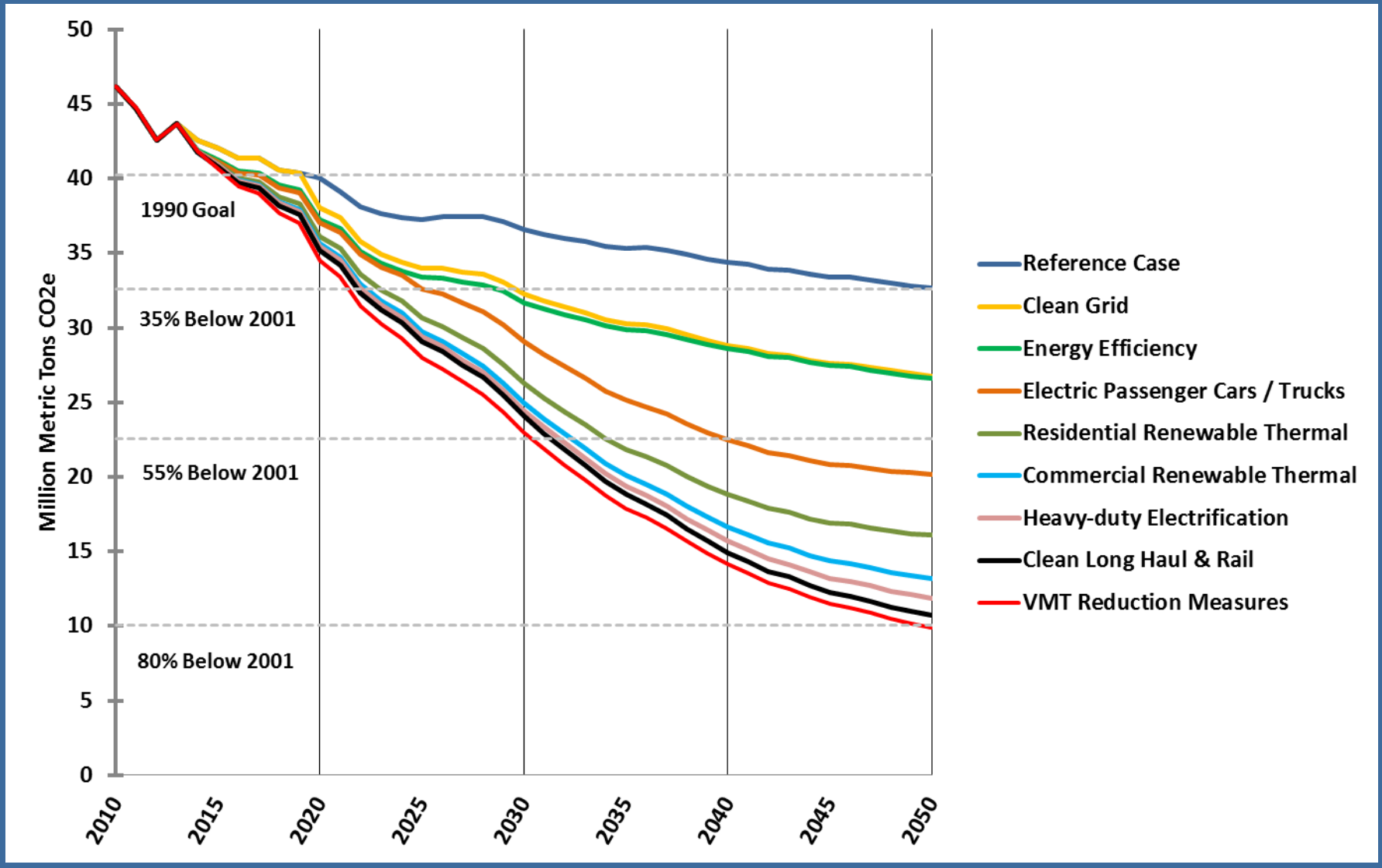
35% Reduction Target Mitigation



45% Reduction Target Mitigation

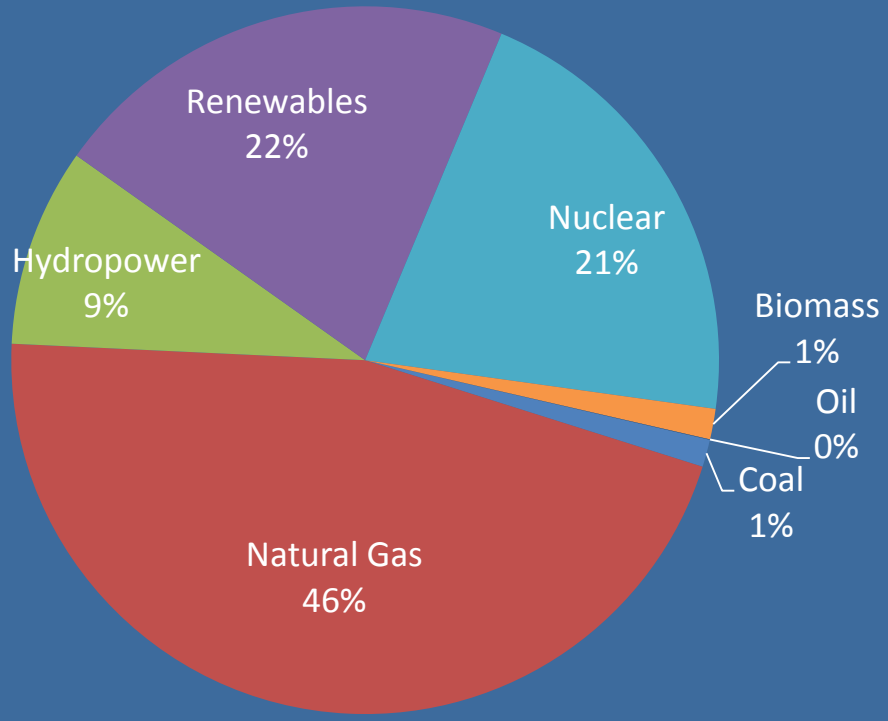


55% Reduction Target Mitigation



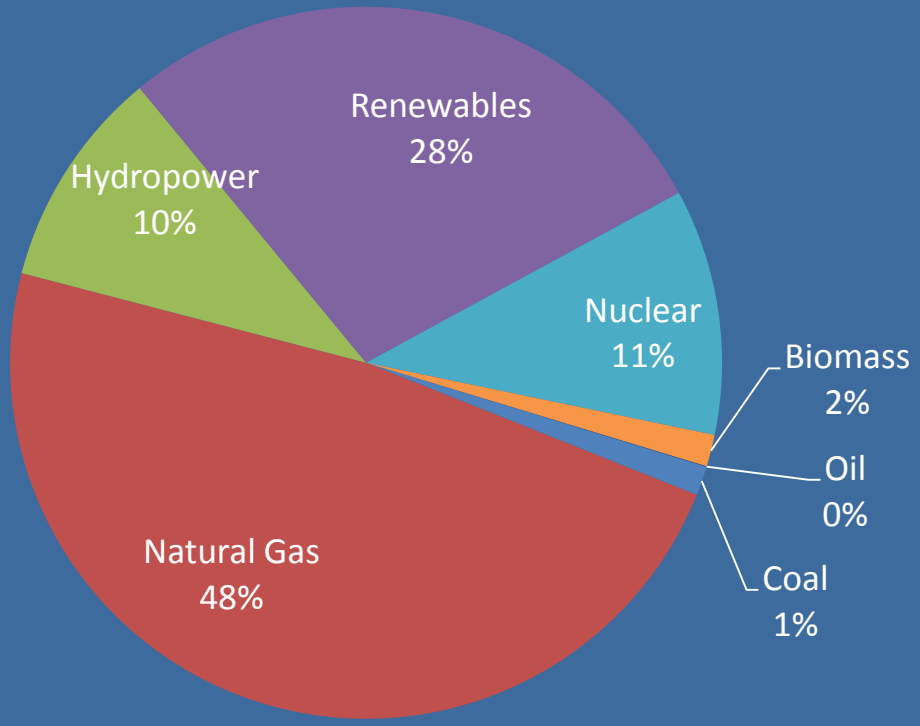
Electric Power Generation Mix for Reference Case

2030



Zero Carbon 2030: 51%

2050

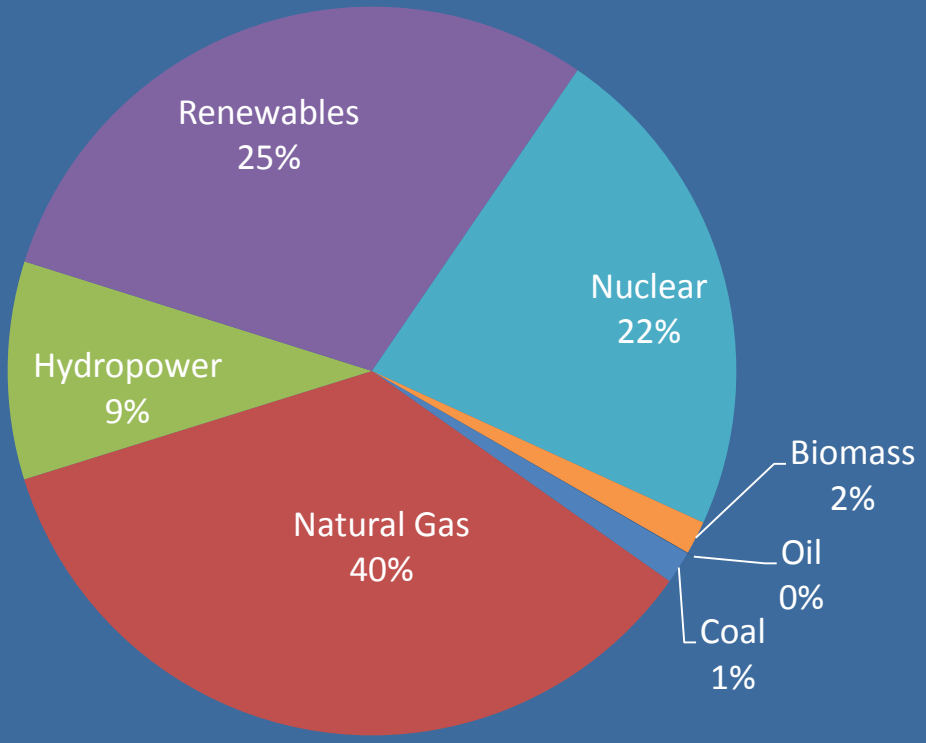


Zero Carbon 2050: 49%

* Generation mix represents CT's portion of the regional electric grid.
* * Renewables are defined as CT Class I resources

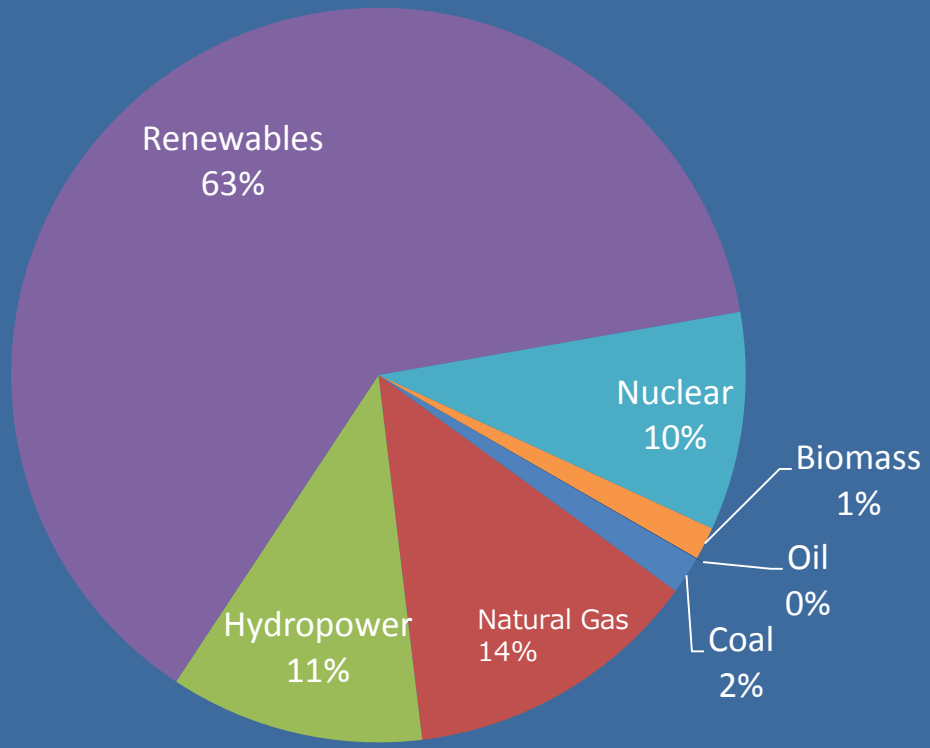
Electric Power Generation Mix for 35% Mid-term Target and 80% 2050 Target

2030



Zero Carbon 2030: 62%

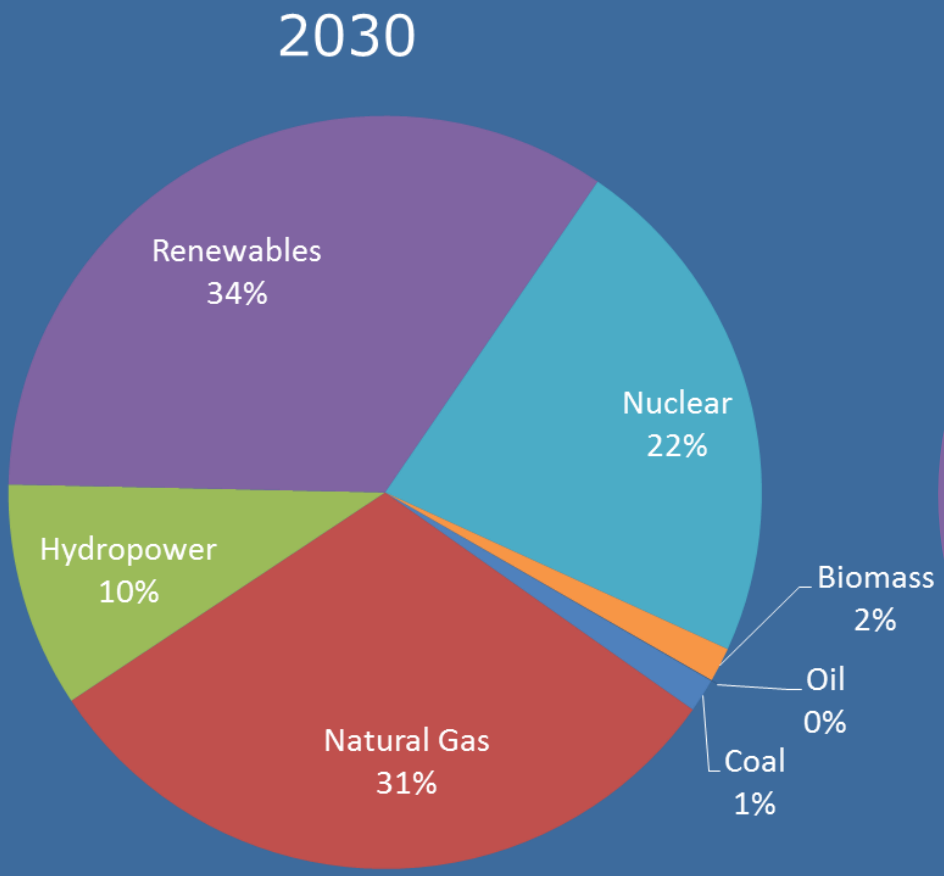
2050

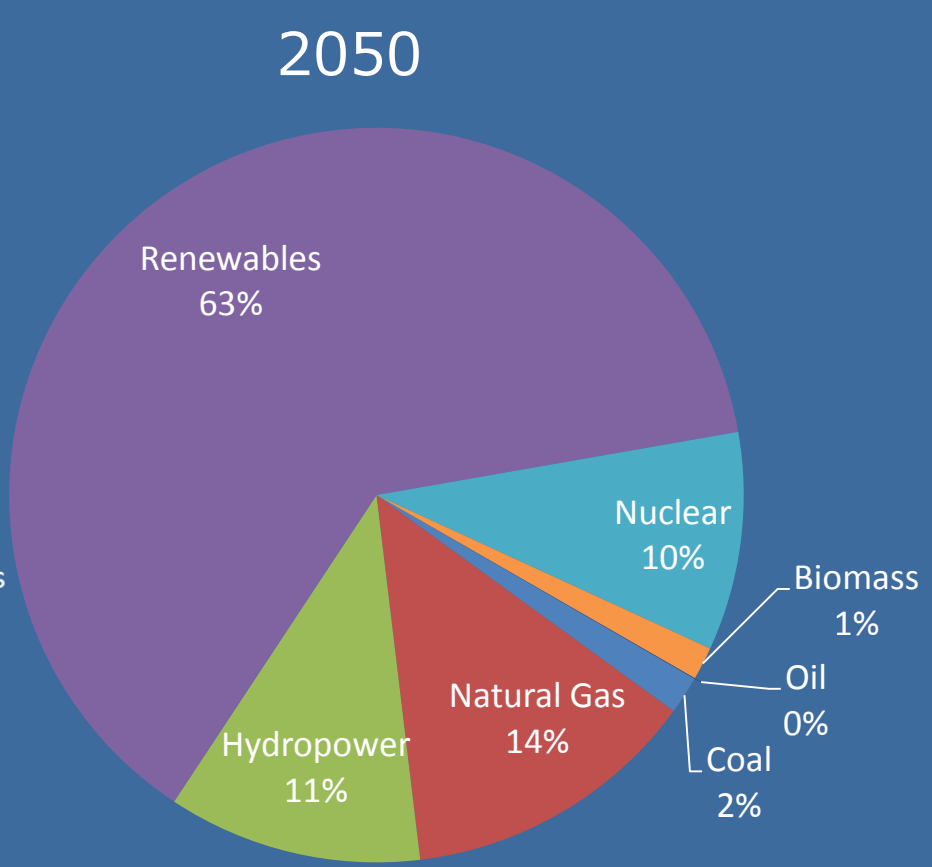


Zero Carbon 2050: 84%

* Generation mix represents CT's portion of the regional electric grid.
* * Renewables are defined as CT Class I resources

Electric Power Generation Mix for 45% Mid-term Target and 80% 2050 Target





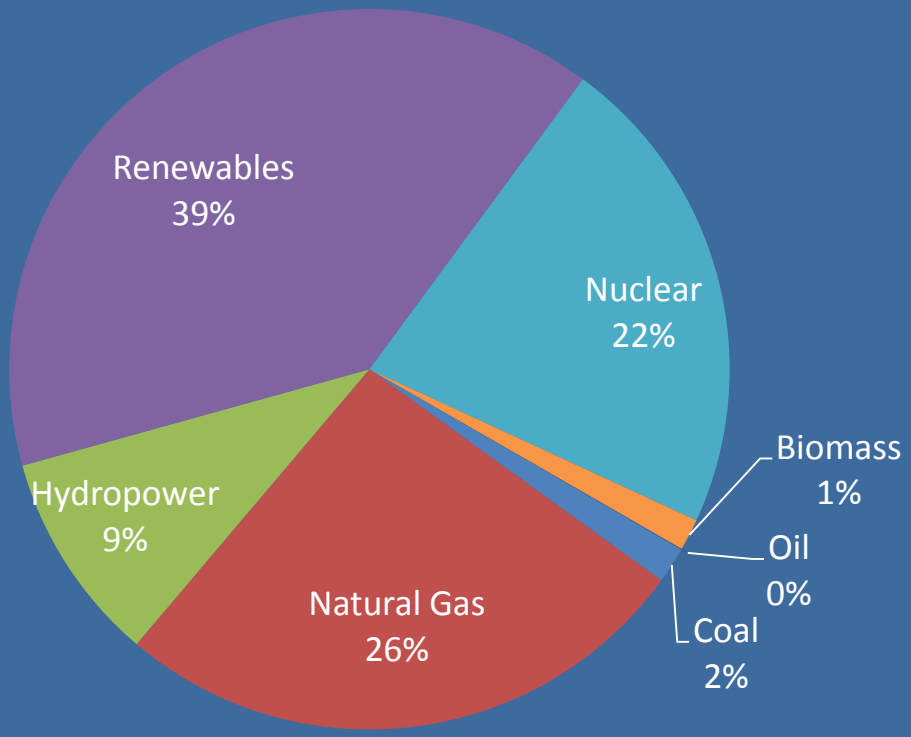
Zero Carbon 2030: 66%

Zero Carbon 2050: 84%

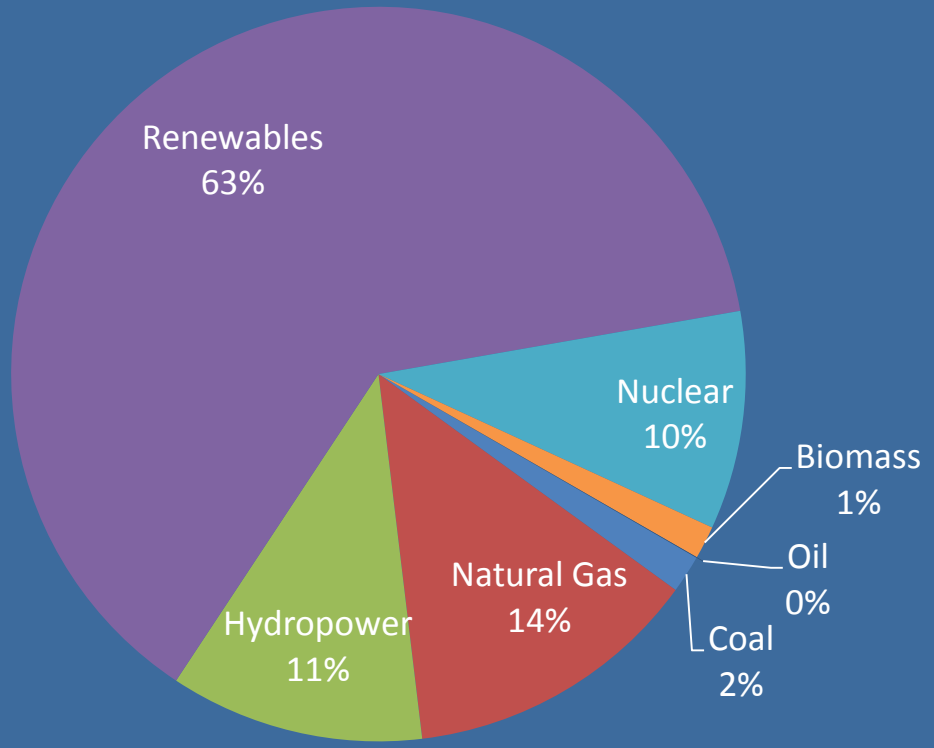
* Generation mix represents CT's portion of the regional electric grid.
* * Renewables are defined as CT Class I resources

Electric Power Generation Mix for 55% Mid-term Target and 80% 2050 Target

2030



2050



Zero Carbon 2030: 71%

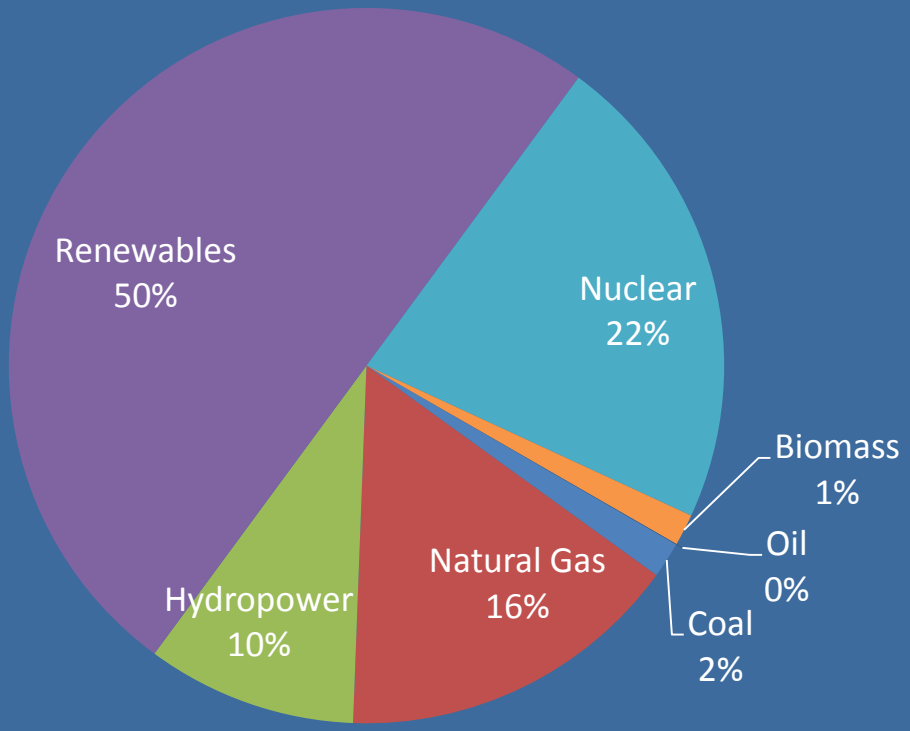
Zero Carbon 2050: 84%

* Generation mix represents CT's portion of the regional electric grid.
* * Renewables are defined as CT Class I resources

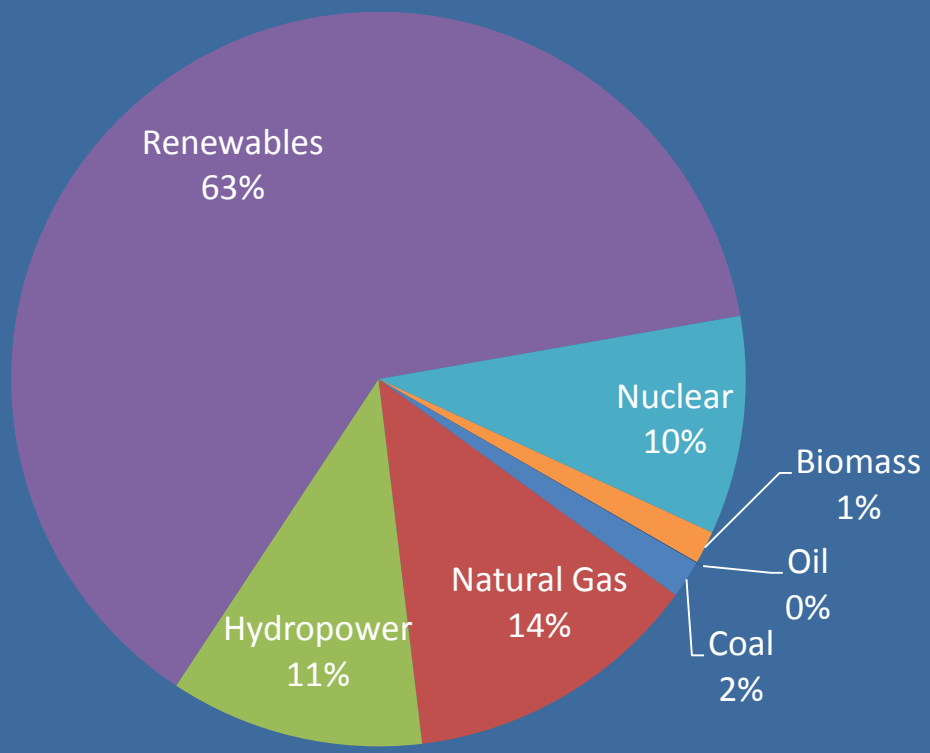
Electric Power Generation Mix

55% Mid-term Target +aggressive 2030 Renewables and 80% 2050 Target

2030



2050



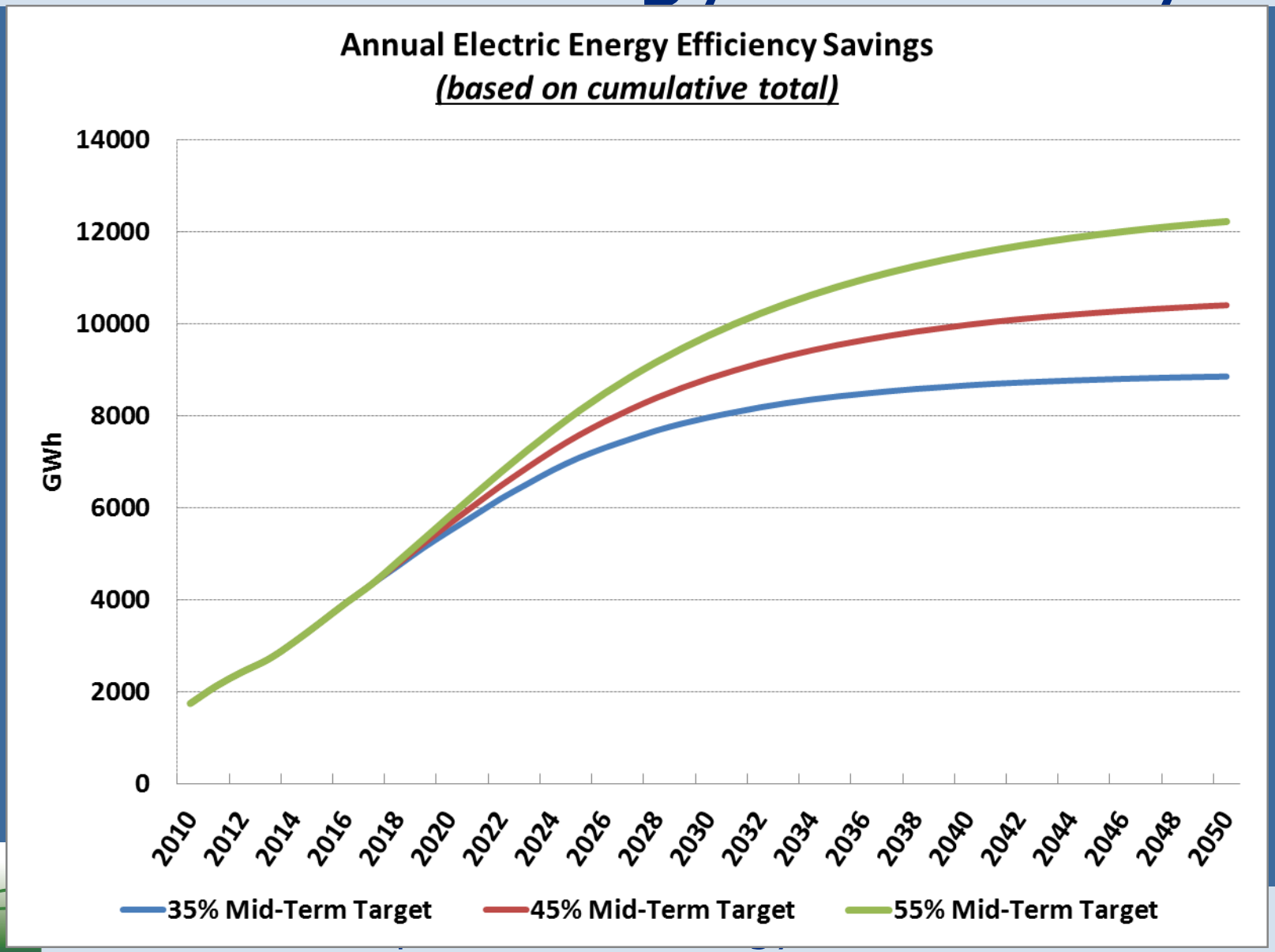
Zero Carbon 2030: 81%

Zero Carbon 2050: 84%

* Generation mix represents CT's portion of the regional electric grid.

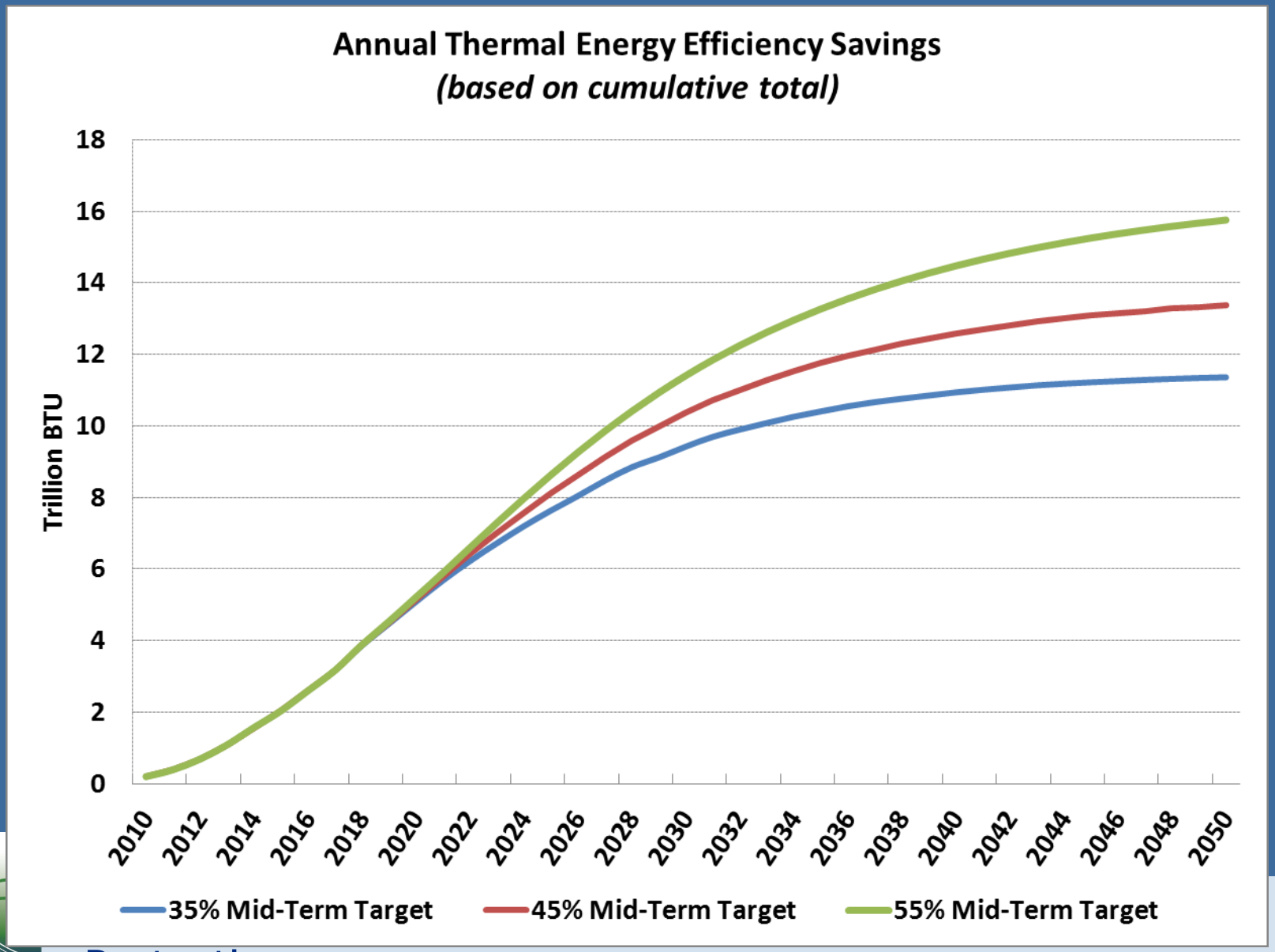
* * Renewables are defined as CT Class I resources

Electric Energy Efficiency



Protection

Thermal Energy Efficiency



Protection

Transportation Sector REMI Input

Key Transportation inputs include:

- Increased electricity demand as ZEVs increase
- Declining retail for fossil cars & trucks and complementary retail
- Increasing remediation expenditure for gas station exits
- Growing charger & H2 infrastructure
- Declining fuel tax revenue relative to reference case

Transportation Sector REMI Output

Transportation Sector Economic & Fiscal Impact (2020 – 2030)			
	35% Midterm Target	55% Midterm Target	55% +Aggressive 2030 Renewables
Economic or Fiscal Variable	**Average Level & % Change**	**Average Level & % Change**	**Average Level & % Change**
Total Employment (Jobs)	400 0.02%	1,400 0.06%	1,100 0.05%
State GDP (millions of current $)	$100 0.03%	$400 0.1%	$300 0.07%
State Revenue (millions of current $)	$6 0.02%	$20 0.07%	$15 0.05%
State Expenditure (millions of current $)	-$10 - 0.03%	-$40 -0.13%	-$20 -0.07%

Building Sector REMI Input

Key building sector inputs include:

- Increased investment for heat pumps outweighs electricity & fossil savings
- Increased EE spending offset by reduced electricity demand such that savings outweighs spending
- Consumer EE savings is spent on other goods
- C & I EE savings is invested in new plant & equipment

Building Sector REMI Output

Building Sector Economic & Fiscal Impact (2020 – 2030)			
	35% Midterm Target	55% Midterm Target	55% +Aggressive 2030 Renewables
Economic or Fiscal Variable	**Average Level & % Change**	**Average Level & % Change**	**Average Level & % Change**
Total Employment (Jobs)	15,000 0.6%	23,500 0.9%	23,000 0.9%
State GDP (millions of current $)	$2,000 0.5%	$3,300 0.9%	$3,200 0.8%
State Revenue (millions of current $)	$125 0.4%	$185 0.6%	$175 0.6%
State Expenditure (millions of current $)	$145 0.5%	$210 0.8%	$215 0.8%

Electricity Sector Input

Key electric sector inputs include:

- Increased investment for BTM & grid scale solar, wind, biomass & fuel cells
  - Lumps onshore, offshore wind
  - Statewide impact, not project-specific
  - Grid scale investment paid for by increased electricity cost to all sectors
- Reduced electricity demand from BTM deployment

Renewable Resource Mix
Electric Power Sector Scenarios

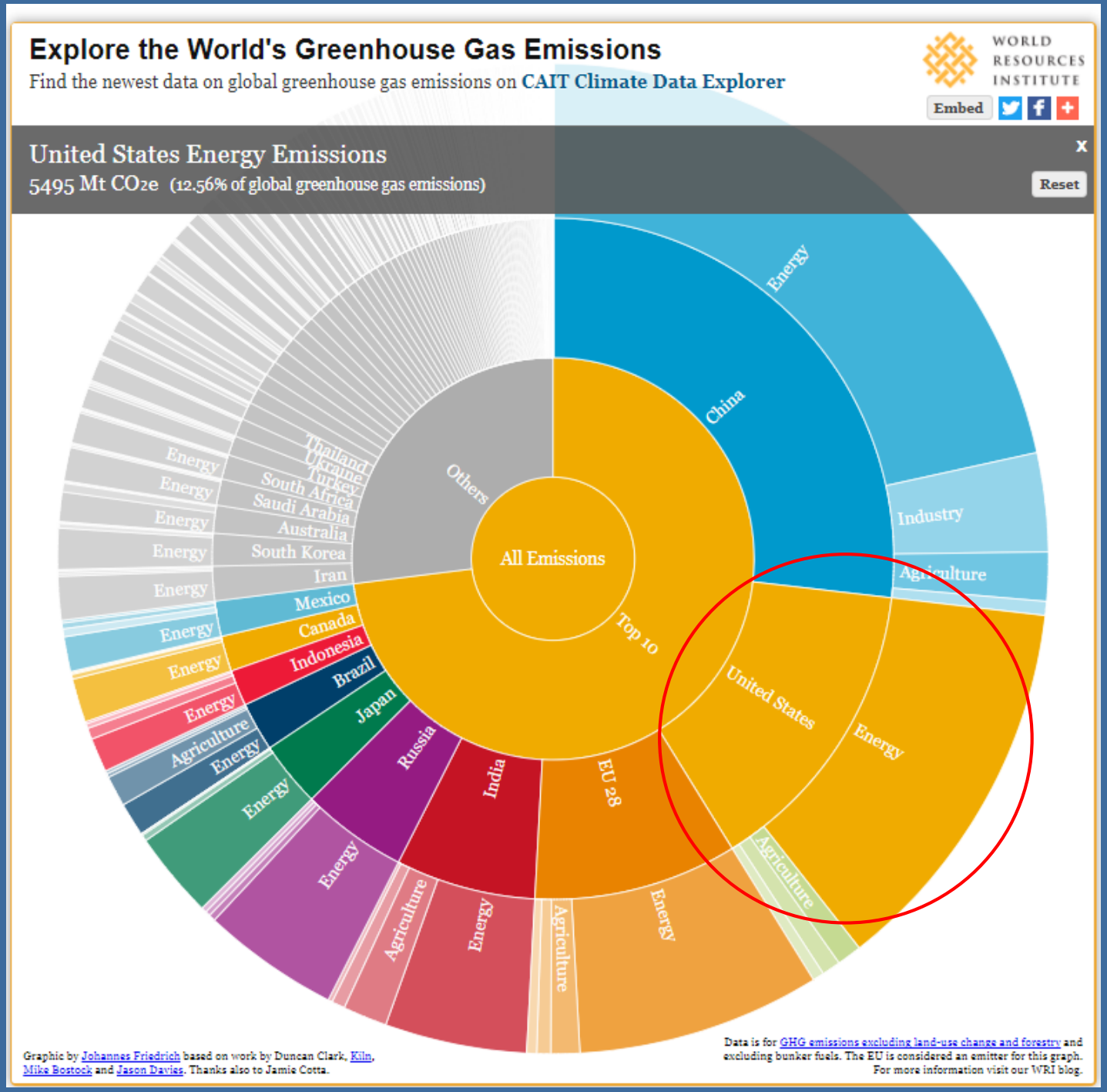
35% Case	2020	2030
Behind the Meter(BTM) Solar	5.9%	7.3%
Behind the Meter(BTM) Wind	0.0%	0.0%
Behind the Meter(BTM) Fuel Cells	2.0%	2.5%
Behind the Meter(BTM) Small Hydro	0.1%	0.1%
Total Behind the Meter (BTM)	**8.0%**	**9.9%**
In-state grid scale solar	2.4%	4.0%
In-state grid scale wind	0.2%	0.3%
In-state grid scale biomass	0.9%	1.5%
In-state grid scale fuel cells	1.7%	2.8%
Total Grid Scale In-state	**5.1%**	**8.6%**
Grid Scale Out of State	**6.9%**	**11.5%**
Total Renewables	**20%**	**30%**

55% Case	2020	2030
Behind the Meter(BTM) Solar	5.9%	9.0%
Behind the Meter(BTM) Wind	0.0%	0.0%
Behind the Meter(BTM) Fuel Cells	2.0%	3.0%
Behind the Meter(BTM) Small Hydro	0.1%	1.0%
Total Behind the Meter (BTM)	**8.0%**	**13.0%**
In-state grid scale solar	2.4%	5.5%
In-state grid scale wind	0.2%	3.5%
In-state grid scale biomass	0.9%	1.5%
In-state grid scale fuel cells	1.7%	3.0%
Total Grid Scale In-state	**5.1%**	**13.5%**
Grid Scale Out of State	**6.9%**	**13.5%**
Total Renewables	**20%**	**40%**

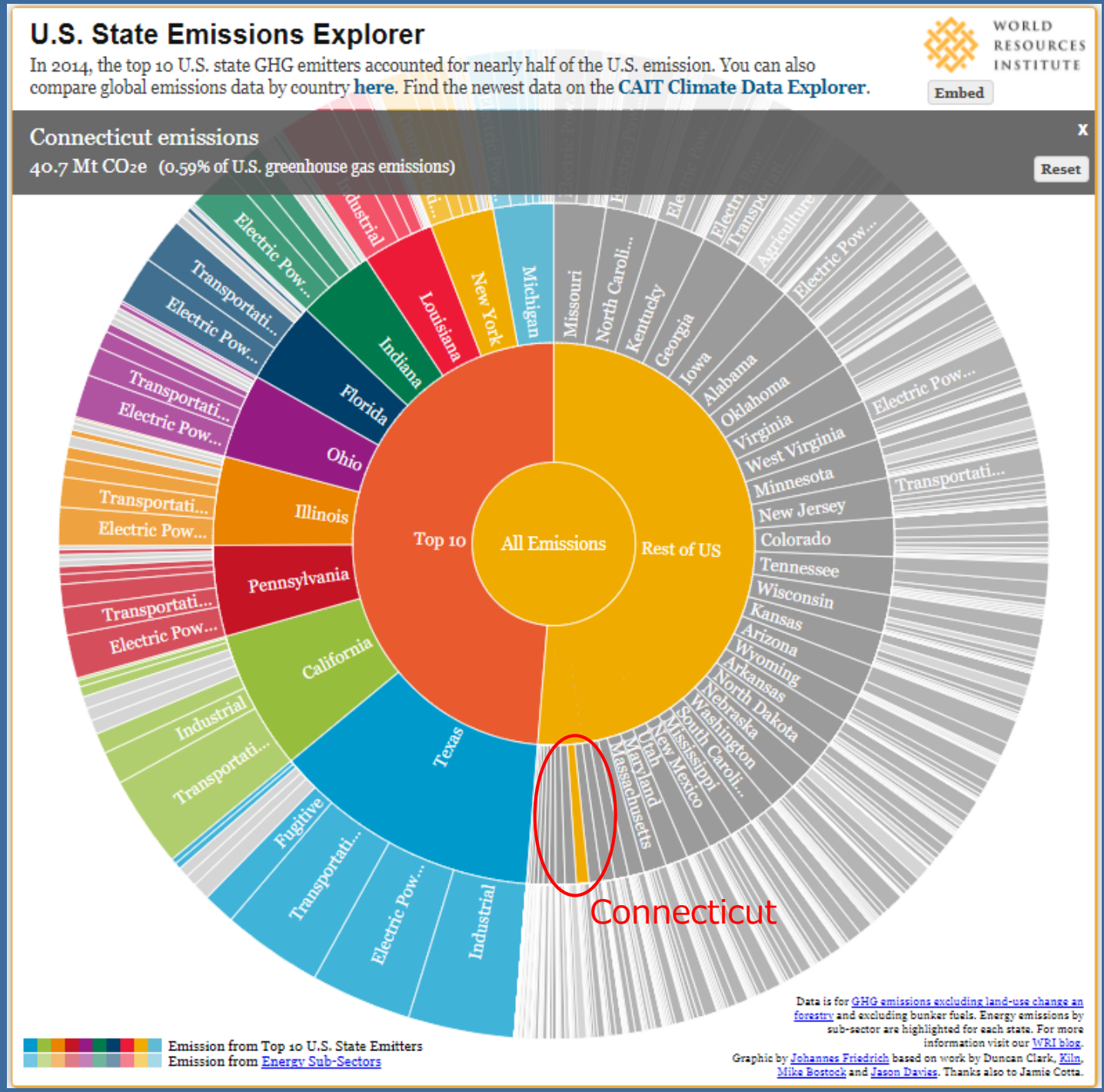
Aggressive 2030 Renewables	2020	2030
Behind the Meter(BTM) Solar	5.9%	10.0%
Behind the Meter(BTM) Wind	0.0%	0.0%
Behind the Meter(BTM) Fuel Cells	2.0%	3.5%
Behind the Meter(BTM) Small Hydro	0.1%	1.0%
Total Behind the Meter (BTM)	**8.0%**	**14.5%**
In-state grid scale solar	2.4%	6.5%
In-state grid scale wind	0.2%	5.5%
In-state grid scale biomass	0.9%	1.5%
In-state grid scale fuel cells	1.7%	3.5%
Total Grid Scale In-state	**5.1%**	**17.0%**
Grid Scale Out of State	**6.9%**	**18.5%**
Total Renewables	**20%**	**50%**

Electricity Sector REMI Output

Electricity Sector Economic & Fiscal Impact (2020 – 2030)			
	35% Midterm Target	55% Midterm Target	55% +Aggressive 2030 Renewables
Economic or Fiscal Variable	**Average Level & % Change**	**Average Level & % Change**	**Average Level & % Change**
Total Employment (Jobs)	600 .03%	1,200 0.05%	800 0.04%
State GDP (millions current $)	-$50 -0.021%	-$3 -0.008%	$35 0.017%
State Revenue (millions current $)	-$270 -0.9%	-$30 -0.1%	-$35 -0.1%
State Expenditure (millions current $)	-$95 -0.3%	-$7 -0.02%	-$12 -0.04%



Emissions from United States contribute 12.56% to global emissions



Connecticut's Emissions are equal to

0.59%

of U.S. greenhouse gas emissions