Environmental Update

Planning Advisory Committee

PATRICIO SILVA

LEAD ANALYST

Presentation Overview

- Key Points
- Federal Environmental Update
- New England Power System Trends
- New England Power System Estimated Emissions
- New England Air Quality
- Environmental Compliance Costs
  - Regional Greenhouse Gas Initiative Update
  - Massachusetts Global Warming Solutions Act Update
  - Impact of CO_2 Emissions on New England Energy Costs

Key Points

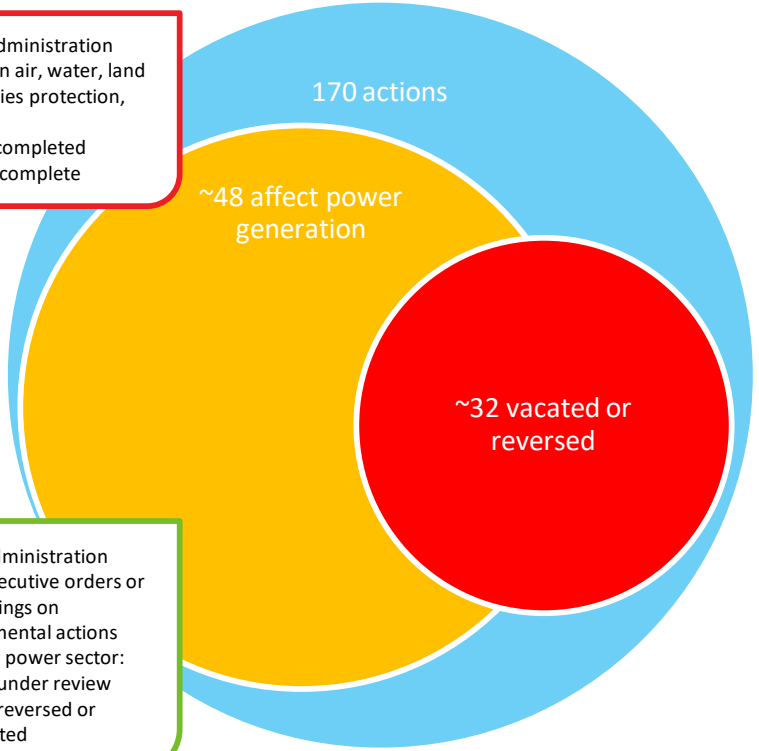
- In 2021, generating resources and transmission assets reported no issues with state or federal environmental compliance requirements
  - Various federal air, water, land use standards and rules under review
  - States pursuing reviews of greenhouse gas and other standards
- Preliminary data and estimates suggest New England power system carbon dioxide, nitrogen oxide and sulfur dioxide emissions remained near historic lows in 2021
  - Winter and summer air pollution spikes occurred due to continued reliance on fossil fired-generators for peaking service
  - Unhealthy ground level-ozone pollution increased over summer 2021 in New England compared to 2020
- Estimates suggest New England power system water use and wastewater discharges are near historic lows in 2021
  - Implementation of federal water standards for thermal and hydroelectric generators may require changes in operations
- Environmental compliance costs for emitting generators are increasing
- Environmental requirements in the siting, permitting and operation of energy infrastructure affect fuel supplies, generating resources, and transmission assets

FEDERAL ENVIRONMENTAL UPDATE

Shift in Federal Environmental Priorities

Many Prior Administration Actions under Review, Reversed, or Vacated by Courts

Trump Administration actions on air, water, land use, species protection, climate:
- 170 completed
- 40 incomplete



Biden Administration initial executive orders or court rulings on environmental actions affecting power sector:
- ~48 under review
- ~32 reversed or vacated

Shift in Federal Environmental Priorities Has Limited Impact on New England Power System

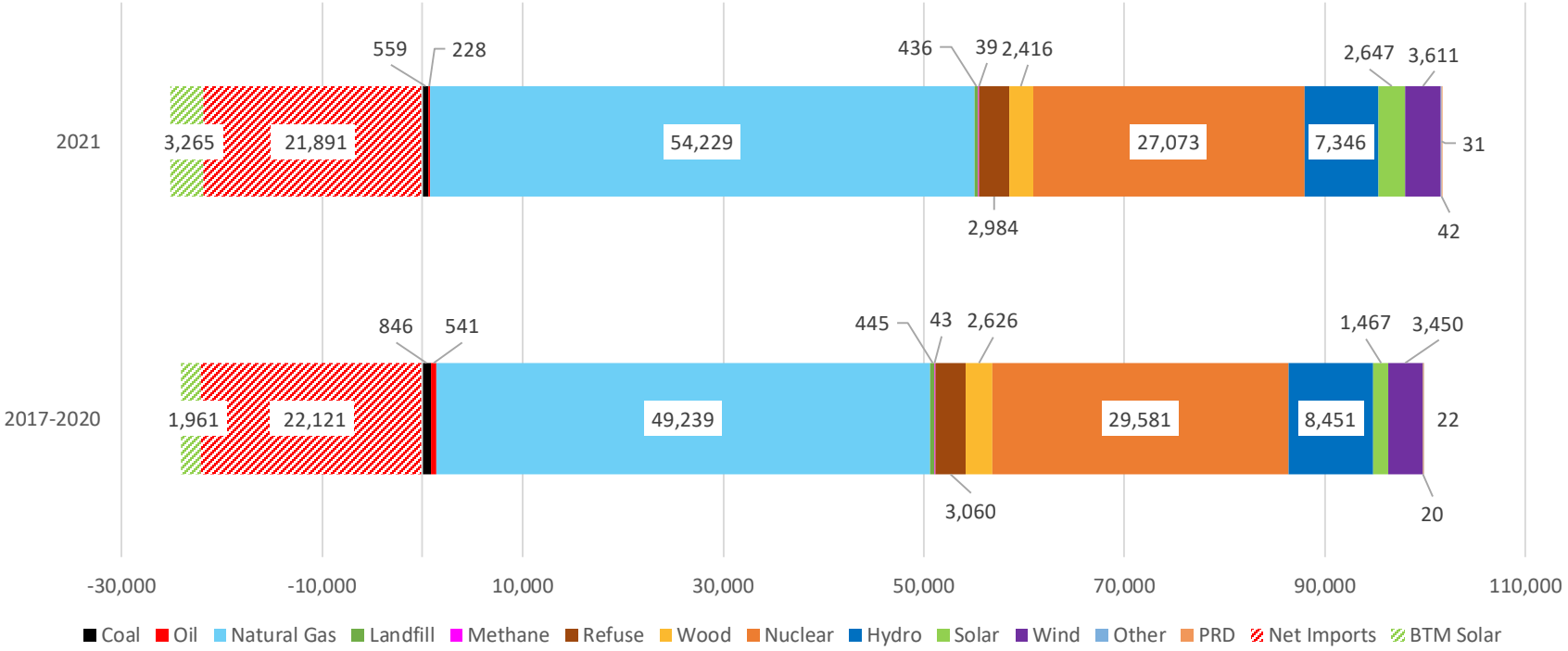
- EPA reviews of 2020 **ozone** and **fine particulate** standards potentially most impactful, but not before mid 2020s
- **Cross State Air Pollution Rule** (CSAPR), limiting long range air pollution (updated April 2021), some regional benefit
- **Power Plant Startup, Shutdown, and Malfunction Rule**, EPA withdrew 2020 guidance, reinstating 2015 policy (Sep 2021)
- **Mercury and Air Toxics Standards for Electric Generation Units**, EPA proposing overhaul (interagency review Aug 2021) of 2020 withdrawal of rule basis and residual risk standard, limited impact on regional generators
- **Cooling Water Intake Systems Rule** (Clean Water Act 316(b)), implementation continues through permit renewals
- **Steam Electric Power Generating Effluent Guidelines**, EPA rulemaking (July 2021) reviewing 2020 changes, limited risk for regional coal-fired generators
- **Coal Combustion Residuals Rule**, EPA reviewing requests for compliance extensions for ash storage sites, plans additional actions (January 2022), changes pose limited impact for regional coal-fired generators

Sources: White House; Harvard EELP; Washington Post

Sources: EPA, Unified Regulatory Agenda

NEW ENGLAND POWER SYSTEM TRENDS

2021 vs. 4-yr Avg Energy Supply by Fuel Type, BTM Solar & Net Imports (GWh)



In 2021, emitting generation (**fossil fuels, landfill, methane, refuse, and wood**) increased by **7.2**% (60,890 GWh) vs. the 4-year average (56,799 GWh); non-emitting generation (**hydro, nuclear, solar, and wind**) declined **-5.3**% (40,667 GWh) vs. the 4-year average (42,949 GWh). **Net imports** declined **-1**% in 2021 (21,891 GWh) vs. the 4-year average (22,121 GWh), and **behind-the-meter** (BTM) **solar** generation increased 66% in 2021 (3,265 GWh) vs. the 4-year average (1,961 GWh). Other, PRD omitted.

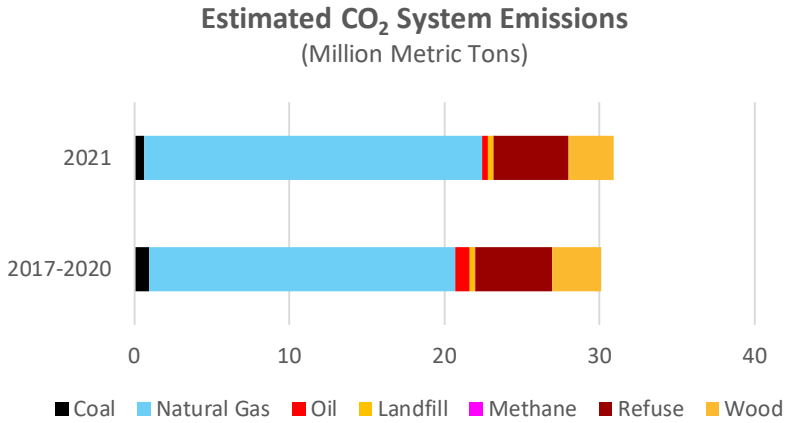
Sources: ISO-NE Market Analysis & Reporting, Markets & Operations, & Load Forecasting (BTM Solar)

2021 Energy Demand Yielding Higher Environmental Impacts, Carbon Intensity Up

Preliminary Data Shows 2021 Load Increased Compared to 4-year average (2017-2020)

- Preliminary 2021 generation data* shows New England power generation reached 101,640 GWh compared to a 4-year average of 99,784 GWh
- 2021 net imports* decreased to 21,891 GWh compared to the 4-year average of 22,121 GWh
- Compared to the 4-year average, generation in 2021 from emitting sources increased, while non-emitting generation and net imports both declined
- Estimated emission trends diverged in 2021:
  - New England power system carbon emissions increased
  - Sulfur dioxide (SO_2) and nitrogen oxide (NO_X) emissions declined compared to multi-year averages

Estimated 2021 Carbon Emissions Higher Than 4-year average



- 2021 estimated CO_2 emissions (30.9 million metric tons (MMT)) are **2.6**% higher than the 4-year average (30.1 MMT)
- 2021 CO_2 emissions from natural gas generation (21.8 MMT) 10% higher than the 4-year average (19.8 MMT)
- Other 2021 emitting fuel type CO_2 emissions are lower than 4-year averages

* 2021 daily generation data may be revised; December 2021 import data obtained from EIA Hourly Electric Grid Monitor

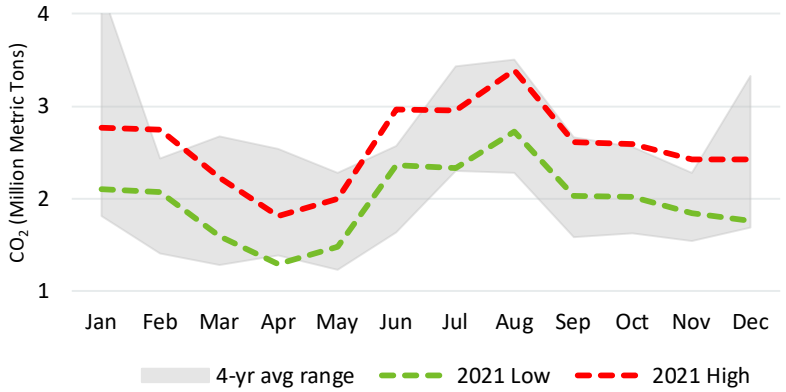
2021 CO_2 estimated emissions with EPA (eGrid 2021) balancing area fuel specific emission factors, with adjustments by ISO-NE (chart shows high range CO2 only)

NEW ENGLAND POWER SYSTEM ESTIMATED EMISSIONS

New England Power System Carbon Emissions

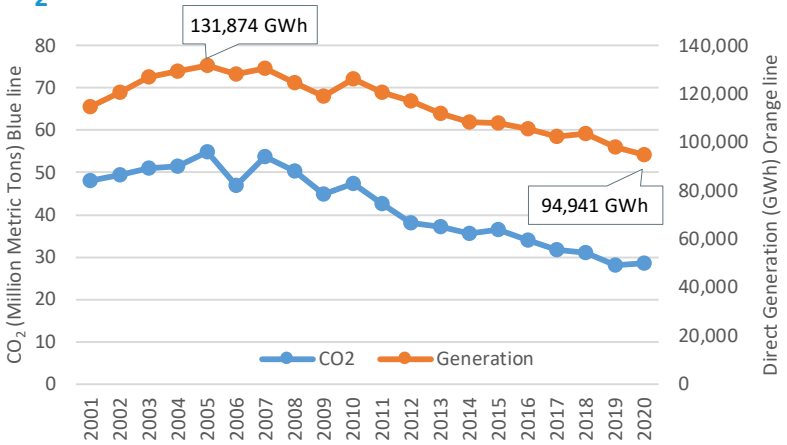
Long-term declines in direct carbon emissions, variability in recent year-to-year trends

2021 New England Power System Estimated Low & High Range Carbon Dioxide Emissions



- 2021 estimated system CO_2 emissions range between **23.6 – 30.9** million metric tons (MMT), 9% to 11% > than 2020
- 2021 estimated CO_2 emissions from natural gas generation range between **21.3 – 21.8** MMT, 7.7% to 8.2% > than 2020

New England Power System Direct Generation & CO_2 Emissions Near Historic Lows

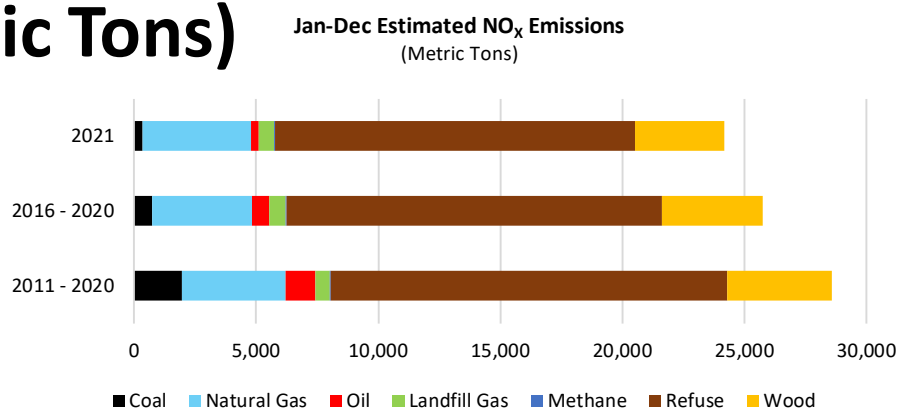


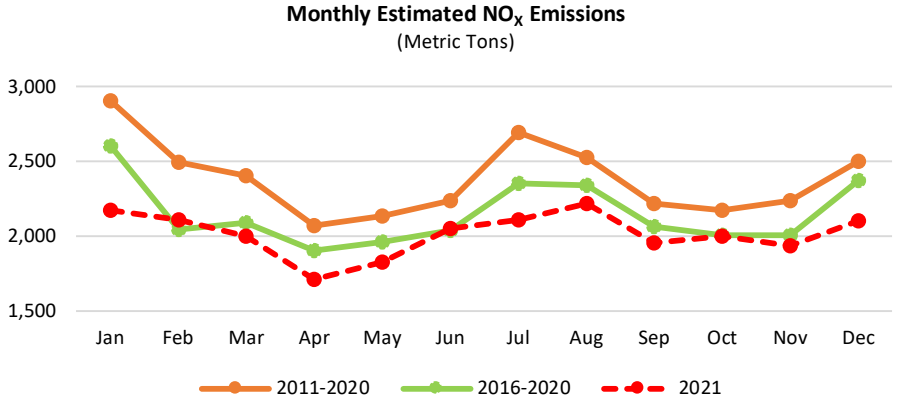
- CO_2 system emissions most recently peaked at **54.9** MMT in 2005, with total system generation reaching **131,874** GWh
- 2005 annual estimated system CO_2 emissions from fossil fuel generation ranged between:
  - **19.0-20.9** MMT for coal generation
  - **15.1 – 15.5** MMT for natural gas generation
  - **4.9 – 6.5** MMT for oil generation

2021 CO_2 estimated emissions with EPA (eGrid2019) balancing area fuel specific emission factors (2021 Low), with adjustments by ISO-NE for data gaps (2021 High)

2021 Estimated Nitrogen Oxide (NO_x) Emissions Trends by Fuel Type (Metric Tons)

- 2021 estimated nitrogen oxide (NO_x) emissions (24,177 metric tons) from power generation declined -**6**% compared to 5-year average (2016-2020) (25,758) and -**15**% compared to the 10-year average (2011-2020) (28,577)
  - Estimated 2021 NO_x emissions from natural gas generation (4,452 metric tons) increased **9**% compared to 5-year average (4,087) and **4**% compared to the 10-year average (4,278 metric tons)
  - Estimated 2021 YTD NO_x emissions from all other fuel categories decreased compared to 5- and 10-year averages
- NO_X emissions have direct and indirect adverse health and environmental impacts. Once emitted, NO_X reacts with other chemicals in the atmosphere, forming particles, ground-level ozone and nitric acid
  - According to EPA, nitrogen dioxide (NO_2) concentrations in the atmosphere have declined by an average of 37% and ground-level ozone concentrations by an average of 26% between 2000 and 2020 across the Northeast
  - In New England, most emitting generators are subject to specific NO_X emissions standards to limit local and regional impacts





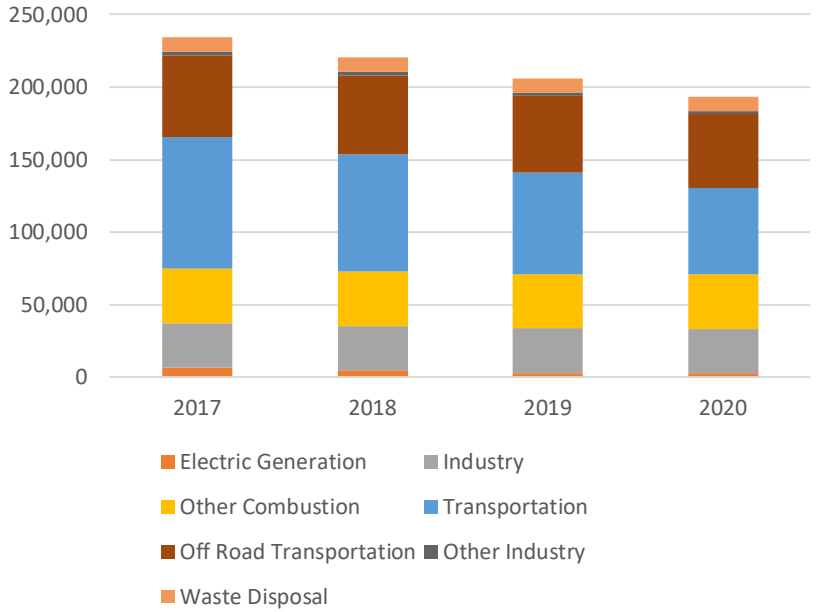
2021 NO_x estimated emissions with EPA (eGrid2019) New England balancing area fuel specific emission factors.

NO_X emissions from Electric Generation in New England Remain Low

New England NO_X emissions from Electric Generation

- Electric generation remains a declining source of NO_X emissions in New England
- Estimated daily NO_X emissions from all fuel types averaged 66 metric tons per day in 2021 for the year and the ozone season (May-Sep)
  - Estimated maximum daily emissions: 103 metric tons (1/29/21)
  - Estimated minimum daily emissions: 48 metric tons (5/9/21)

Major Sources of New England NOX Emissions (Metric Tons)

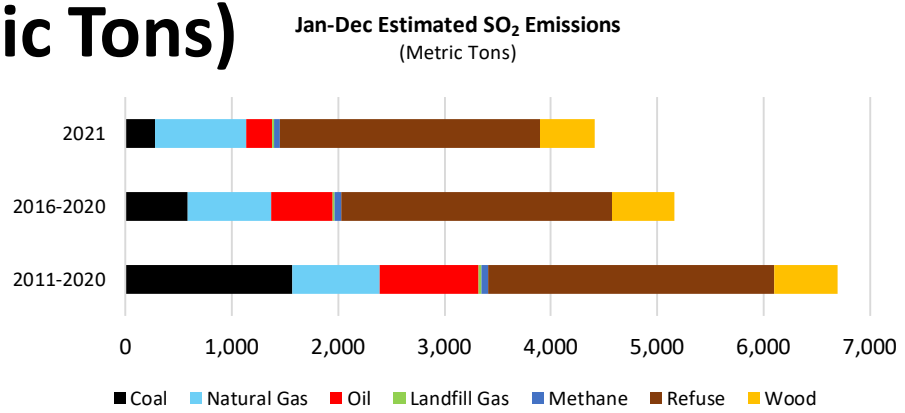


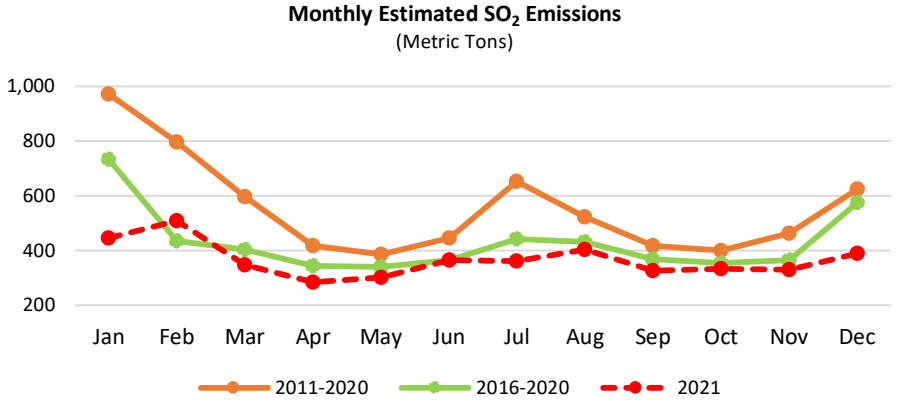
Source: 2021 NO_x estimated daily emissions with EPA (eGrid2019) New England balancing area fuel specific emission factors

Source: EPA NO_x emissions inventory for New England by fuel combustion activity (2017-2020)

2021 Estimated Sulfur Dioxide (SO_2) Emissions Trends by Fuel Type (Metric Tons)

- Estimated 2021 system sulfur dioxide (SO_2) emissions declined compared to the 5-year and 10-year averages
  - 2021 total emissions (4,408 metric tons) -**15**% lower than 5-year and -**34**% lower than 10-year averages
  - Estimated 2021 SO_2 emissions from natural gas generation sources increased **9**% (650 metric tons) compared to 5-year average (606 metric tons)
  - Estimated 2021 SO_2 emissions decreased from all other fuel categories
- SO_2 emissions have direct and indirect adverse health and environmental impacts. Once emitted, sulfur oxides react with other compounds in the atmosphere to form particles that can reduce visibility, increasing regional haze
  - According to EPA, SO_2 concentrations in the atmosphere have declined by an average of 91% between 2000 and 2020 across the Northeast
  - In New England, several generators are subject to specific SO_2 emissions standards to limit local and regional impacts





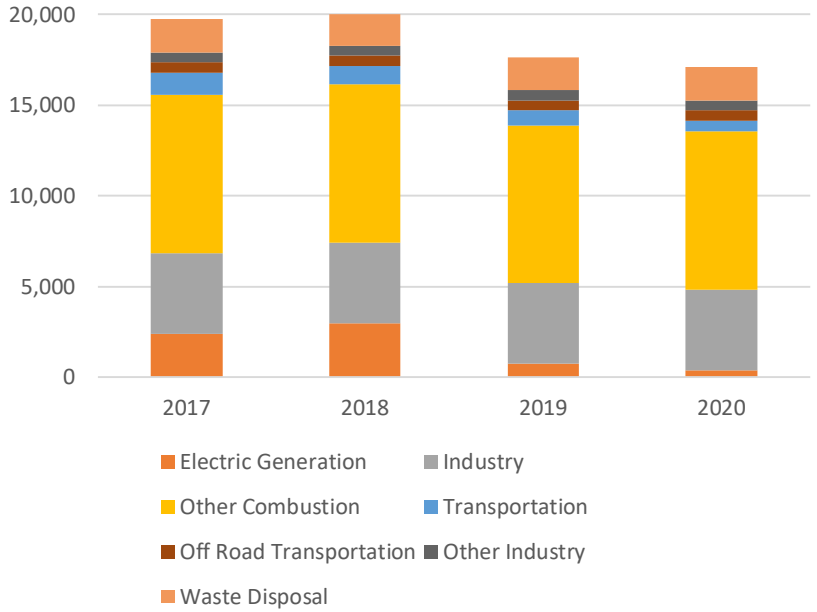
Source: 2021 SO_2 estimated emissions with EPA (eGrid2019) New England balancing area fuel specific emission factors.

SO_2 emissions from Electric Generation in New England Remain Low

New England SO_2 emissions from Electric Generation

- Electric generation remains a declining source of SO_2 emissions in New England
- Estimated daily SO_2 emissions from all fuel types averaged 12 metric tons per day in 2021
  - Estimated maximum daily emissions: 36 metric tons (1/29/21)
  - Estimated minimum daily emissions: 8 metric tons (5/9/21)

Major Sources of New England SO_2 Emissions (Metric Tons)



Source: 2021 SO_2 estimated daily emissions with EPA (eGrid2019) New England balancing area fuel specific emission factors

Source: EPA SO_2 emissions inventory for New England by fuel combustion activity (2017-2020)

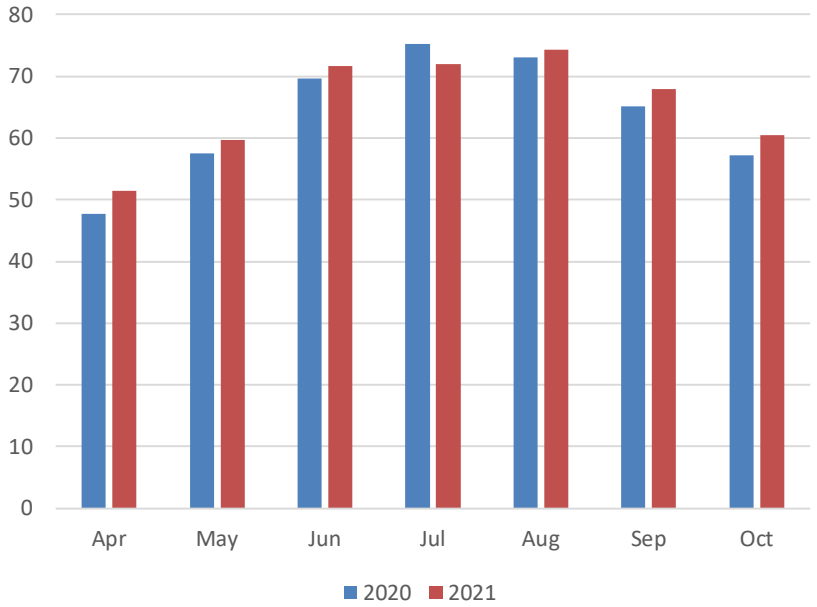
NEW ENGLAND AIR QUALITY TRENDS

Ground-level Ozone Increased in 2021

2021 Ozone Season More Robust, Generation Trends More Variable Due to Weather

- According to EPA and state monitoring data and reports, a mix of weather patterns, local and upwind air pollution contributed to an uptick in days with unhealthy ground-level ozone pollution in 2021 (23) compared to 2020 (18) across portions of New England
- In 2021, several ground-level ozone pollution episodes involved high pressure systems affecting the entire Northeast, overlapping with summer demand peaks for electricity in New England
  - In Summer 2021, loads averaged 15,298 MW, a **0.3**% increase from 2020 (15,253 MW) and a **2.2**% increase compared to Summer 2019 (14,968 MW)
  - Peak demand averaged 18,316 in summer 2021, a **-0.1**% decrease compared to summer 2020 (18,342)
  - Monthly peak demand during summer 2021 averaged: 17,894 MW in June 2021, a **9**% increase compared to June 2020 (16,397 MW); 17,632 MW in July 2021, a -**12**% decrease compared to July 2020 (20,064 MW), and 19,422 MW in August 2021, a **4.6**% increase compared to August 2020 (18,565 MW)

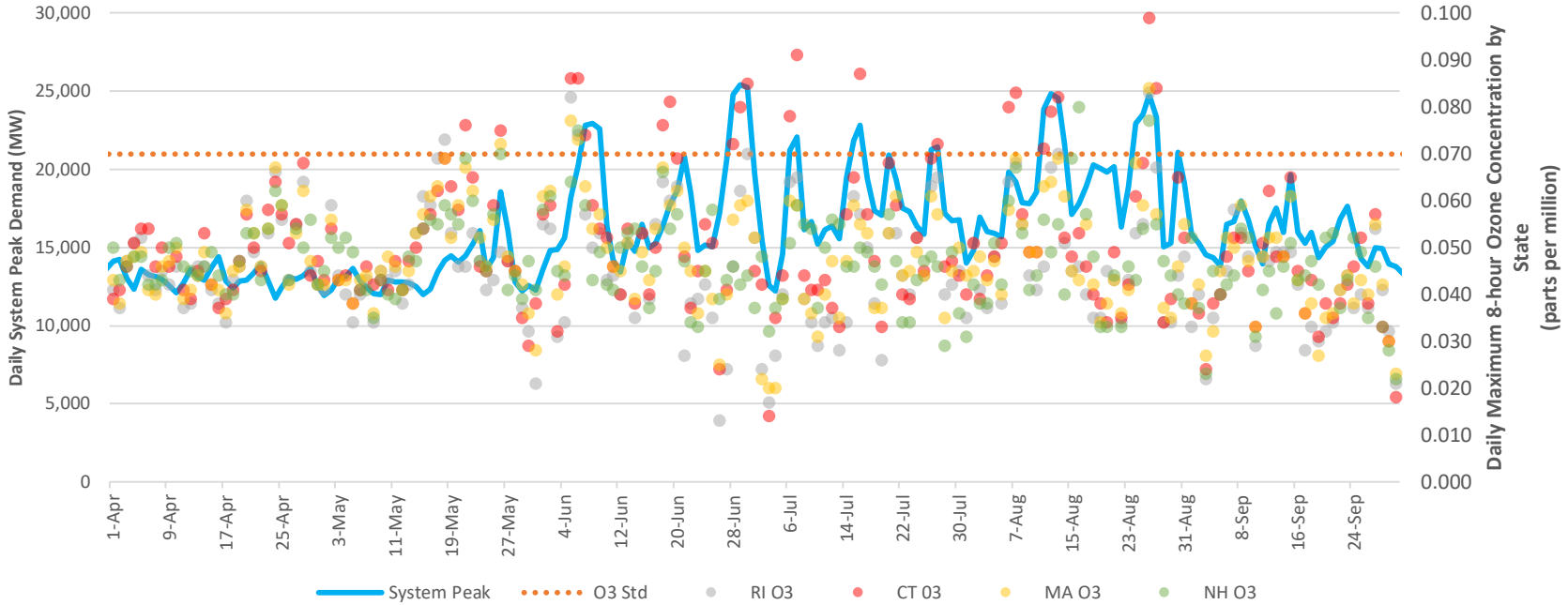
2020 vs. 2021 Monthly Weighted Average of Temperature Humidity Index at Peak Demand Hour



Sources: CT DEEP 2021 Ozone Season Summary; ISO-NE (generation, load data)

ISO-NE defines summer as June-August. EPA defines ozone season as April-Sept.

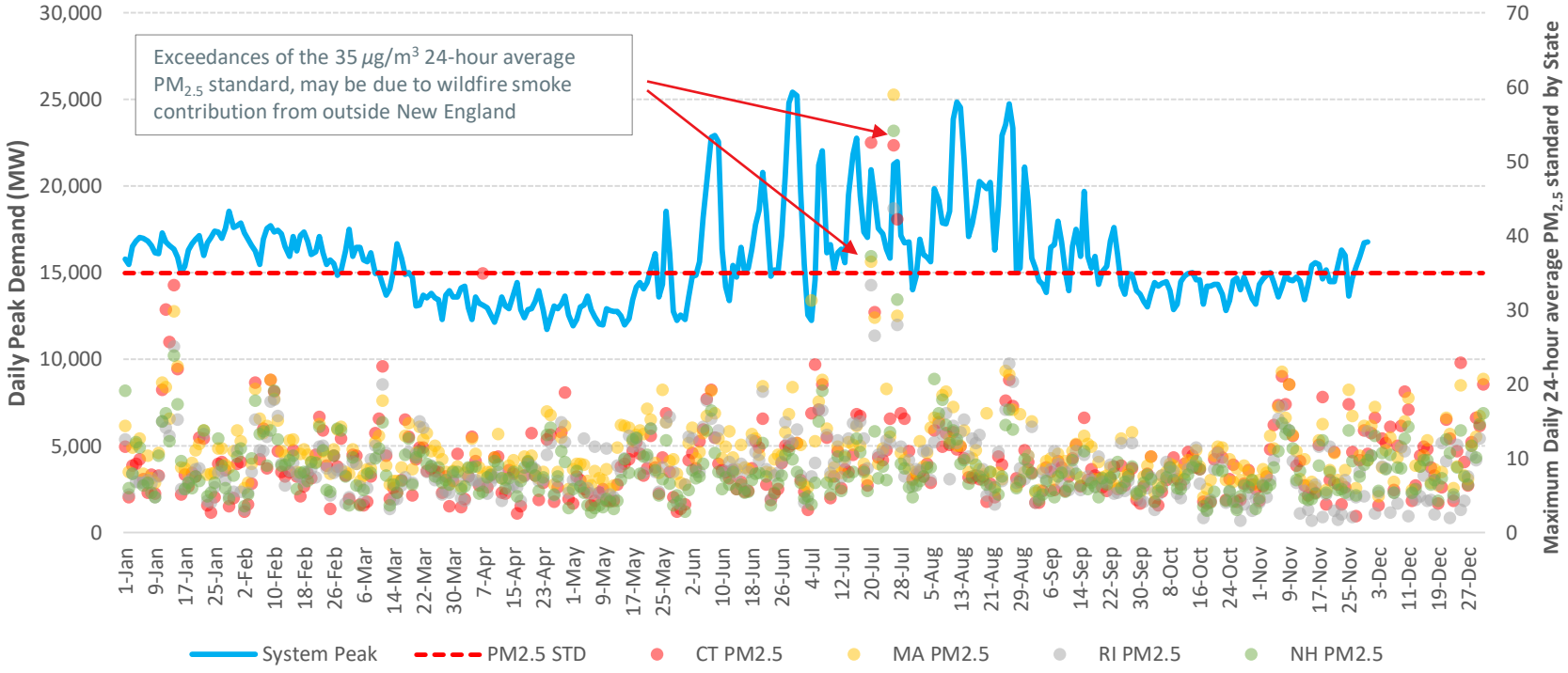
2021 Daily Peak System Load (MW) vs. Highest Daily Ground-level Ozone (ppm) in New England by State



In Summer 2021, loads averaged 15,298 MW, a **0.3**% increase from Summer 2020 (15,253 MW) and a **2.2**% increase compared to Summer 2019 (14,968 MW). Loads increased year over year due to increased humidity, lower behind-the-meter solar generation and increased electrification. Similar to Summer 2020, load levels remained elevated due to the COVID-19 pandemic, which attributed to increased residential air-conditioning demand, although less-utilized in 2020, office building demand remained relatively unchanged. Source: ISO-NE Internal Market Monitor

Sources: EPA (monitoring data); ISO-NE (generation data)

2021 Daily Peak System Load (MW) vs. Highest Daily Mean Fine Particulate Concentration by State



Sources: CT DEEP; EPA (monitoring data); ISO-NE (generation data)

REGIONAL GREENHOUSE GAS INITIATIVE UPDATE

Regional Greenhouse Gas Initiative Overview

- The Regional Greenhouse Gas Initiative (RGGI) is a cooperative effort among the States of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Vermont and Virginia to cap and reduce CO_2 emissions from the power sector:
  - Pennsylvania expected to begin participating in RGGI sometime in 2022
  - Virginia joined RGGI in January 2021; incoming administration reconsidering participation
  - New Jersey rejoined in January 2020 after an eight year hiatus
- RGGI is implemented through independently operated State CO_2 budget trading programs. The RGGI-wide CO_2 cap represents a regional budget for CO_2 emissions from the power sector, aggregating all the individual state program targets:
  - Each RGGI State accepts a valid vintage RGGI allowance from any RGGI State budget
  - RGGI cap declining at 2.275% annually through 2030
  - RGGI allowance = authorization to emit 1 short ton of CO_2
  - RGGI allowances are available in quarterly auctions (RGGI States pool their share of annual RGGI cap) or in the secondary market
- In 2021, RGGI affected 667 emitting electric generators at 222 facilities, across 11 States:
  - 97 boilers, 218 combined cycle units and 352 combustion turbines
  - 90 units in Virginia and New York modified its definition of affected RGGI units, adding 65 peaking units

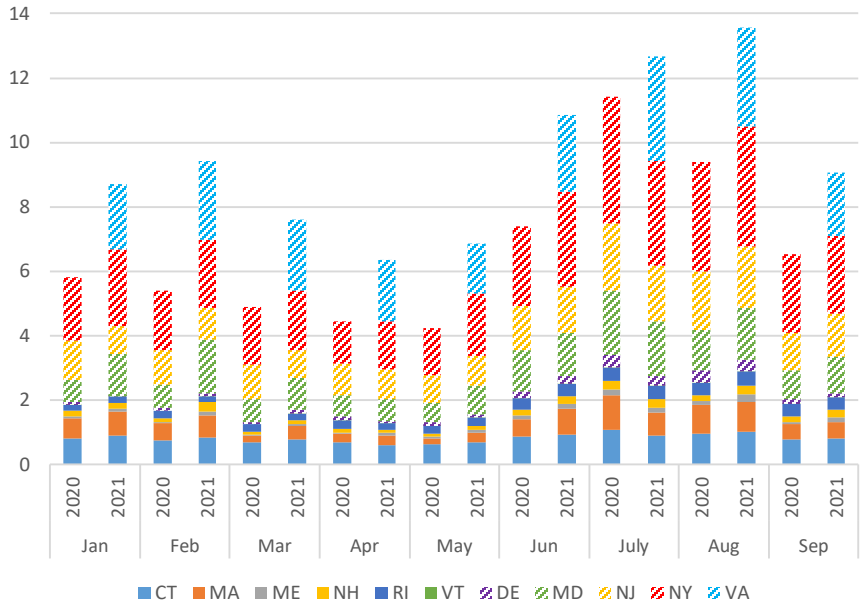
Source: RGGI

2021 RGGI Emissions Trends

2021 Year-to-date (Jan – Sep) CO_2 Emissions Fell for Most RGGI States

- Excluding Virginia, 2021 year-to-date RGGI CO_2 emissions increased by 4.6 million short tons (MT), to **64.2** MT in 2021, compared to **59.5** MT in 2020
  - January – September monthly data
  - New England RGGI States CO_2 emissions increased by 1.6 million short tons, **18.5** MT in 2021YTD, compared to **16.9** MT in 2020YTD
- Coal generation CO_2 emissions increased **3.3** MT across Connecticut, Delaware, Maryland and New Hampshire, **8.3** MT in 2021 vs. **5.0** MT in 2020
- Natural gas generation CO_2 emissions from natural gas generation increased **1.8** MT across Connecticut, Massachusetts, Maine, New Hampshire, New York and Vermont, **54** MT in 2021YTD vs. **52.2** MT in 2020YTD

Jan – Sep 2020, 2021 RGGI States CO_2 Emissions (Million Short Tons)



Source: EPA Air Monitoring Program Data

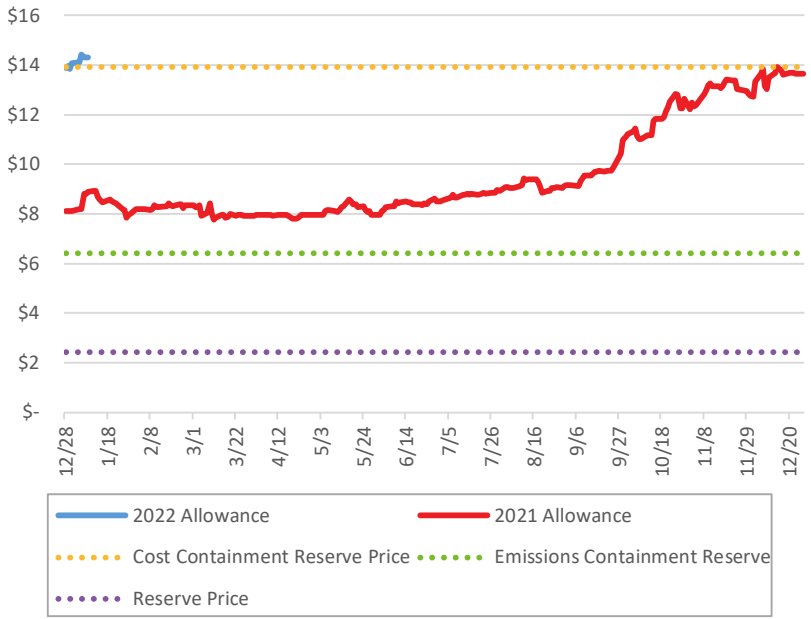
2022 RGGI Allowance Auctions

Compliance needs, speculation driving late year surge in secondary markets

RGGI Allowance Futures Prices Higher,

- Compliance costs increased in 2021 for all RGGI affected generators
- 2021 vintage RGGI allowance futures increased ~58% to **$13.91,** as of 12/27/21, from a low of **$8.11** in December 2020
- 2022 vintage RGGI allowance futures at $**14.17**, as of 1/13/2022
- 2022 RGGI auction price trigger thresholds:
  - **Cost containment reserve** price (**$13.91**): if auction clearing price reaches $13.91 or higher, releases 11.6 million additional allowance once during calendar year, (Mar. 2022 auction offering 21.7 million allowances)
  - **Emissions containment price** (**$6.42**): if auction clearing price falls below trigger, RGGI States participating would withdraw 10% of allowances from auction (11.3 million allowances in Dec. 2021 auction)
  - **Reserve price** (**$2.44** in 2022): auction clearing price floor

2021, 2022 RGGI Allowance, Auction Trigger Prices ($)



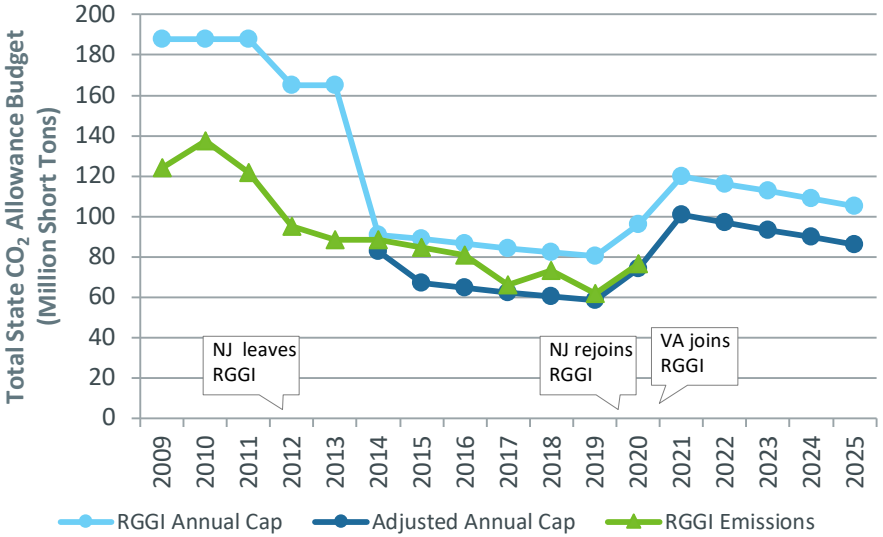
Sources: RGGI (auction details); S&P Capital IQ (allowance futures pricing)

RGGI Design Permits Adjustments in Model Rule & Annual Caps

RGGI CO_2 Emissions Target: 30% below the 2020 cap by 2030

- **2022** cap: **116.1** million short tons (MT) across all 11 participating States, adjusted down to **97** MT to account for banked CO_2 allowances
- RGGI States adjust the annual cap to account for banked allowances by auctioning fewer allowances:
  - 2022: **97** MT
  - 2021: **100.7** MT
  - 2020: **74.2** MT
- **166** million allowances in circulation at end of 2021 3rd quarter according to the RGGI market monitor
- **2014-2020** total interim adjustment withheld **139.5** million CO_2 allowances from auction

RGGI Multi-State Annual CO_2 Cap, Emissions & Adjustments for Banked Allowances



Note: RGGI model rule includes interim adjustments to the cap (2014-2020) to reduce CO_2 allowances early control periods. Other changes include total cap adjustments to account for privately held allowances, to reduce the bank of allowances by 2025.

Source: RGGI

MASSACHUSETTS GLOBAL WARMING SOLUTIONS ACT

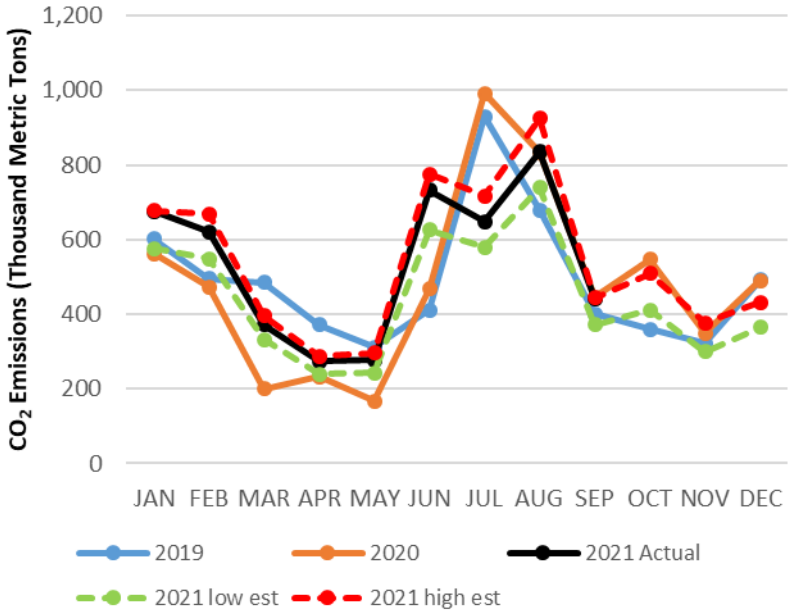
Generator Emissions Cap (310 CMR 7.74) Update

Massachusetts CO_2 Generator Emissions Cap

Electric Generation CO_2 Cap Estimated Emissions for 2021 following 2019-2020 Trends

- In 2021, estimated GWSA CO_2 emissions ranged between 5.3 and 6.5 million metric tons (MMT)
  - 64% to 79% of the 8.23 MMT 2021 cap
- Available GWSA allowances exceed estimated 2021 emissions range
- Latest GWSA auction cleared at $9.75 per metric ton of CO_2 for 2022 vintage GWSA allowances
- IMM estimated 2021 compliance costs by fuel type (based average GWSA emission/heat rates):
  - No. 2 fuel oil - $8.54/MWh
  - No. 6 fuel oil - $8.29/MWh
  - Natural gas - $2.39/MWh

2019-2021 Estimated, Past Monthly Emissions (Thousand Metric tons)



GWSA - Global Warming Solutions Act

Sources: ISO-NE (estimated emissions); EPA (actual emissions)

ENVIRONMENTAL COMPLIANCE COSTS

Impact of CO_2 Emissions Pricing on New England Energy Costs

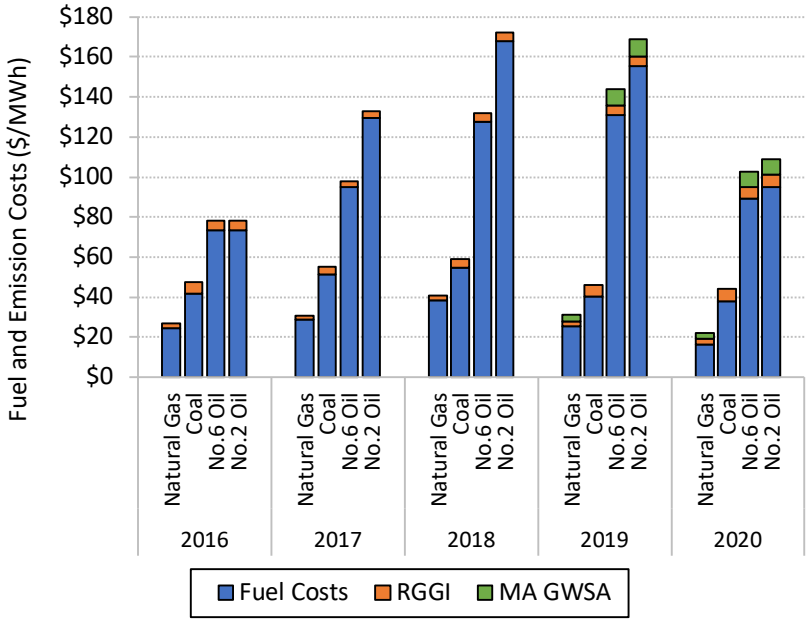
Generation & Environmental Compliance Costs

Carbon emissions costs have a relatively small, but increasing, impact on operating costs

Environmental Compliance Costs Remain Relatively Small Part of Operating Costs

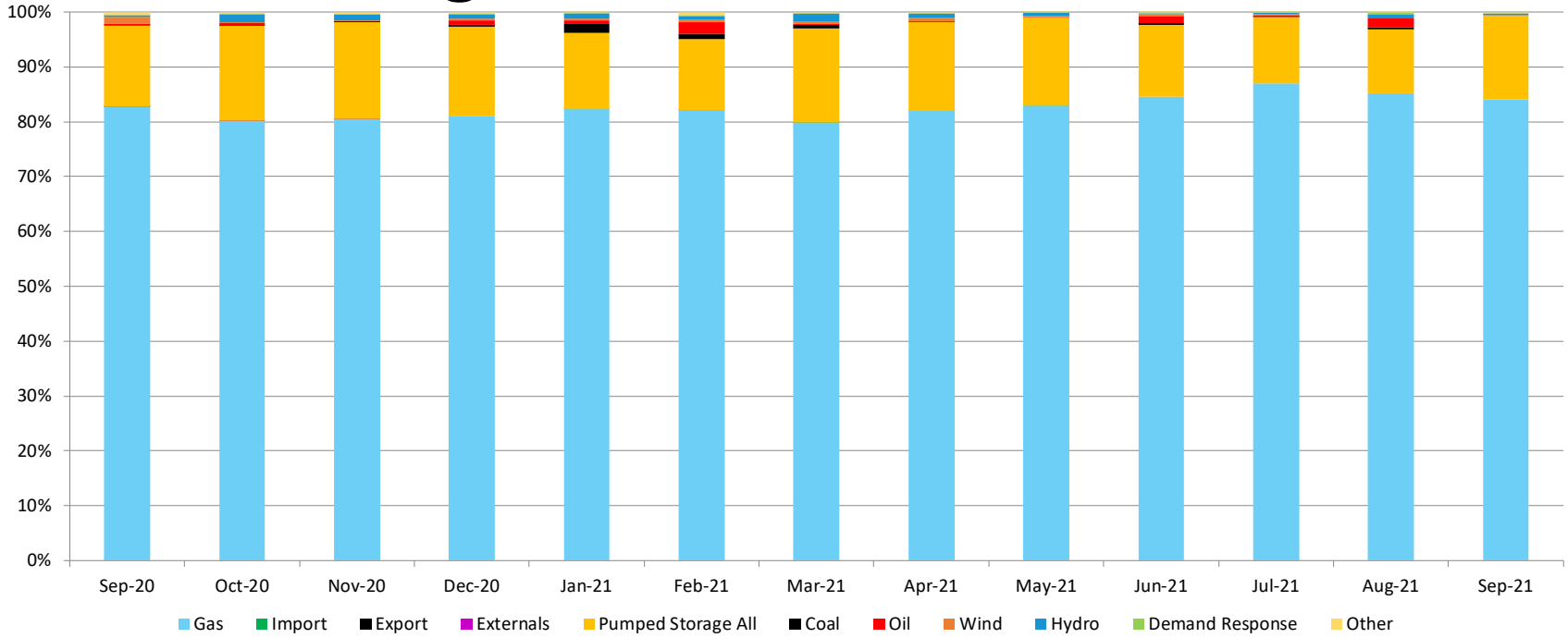
- The Internal Market Monitor finds that, at current price levels, RGGI and GWSA CO_2 compliance costs have a limited impact on the economic merit order of gas-, coal- and oil-fired generation compared to fuel costs in overall operating costs
- In 2020, RGGI compliance costs increased 15% year-to-year for affected units:
  - Natural gas: $2.51/MWh to $2.88/MWh
  - Coal: $5.67/MWh to $6.50/MWh
  - No. 6 Oil: $5.67/MWh to $6.50/MWh
  - No. 2 Oil: $5.19/MWh to $5.95/MWh
- RGGI allowance costs increased from an average of $5.51 in 2019, $6.31 in 2020 and $8.36 in 2021 (thru August 19, 2021)
- For combined cycle units average variable operating costs may range between $.10 - $1.20/MWh for environmental compliance costs

Annual Estimated Average Costs of Generation and CO_2 Emissions (2016-2020)



Source: ISO-NE Internal Market Monitor

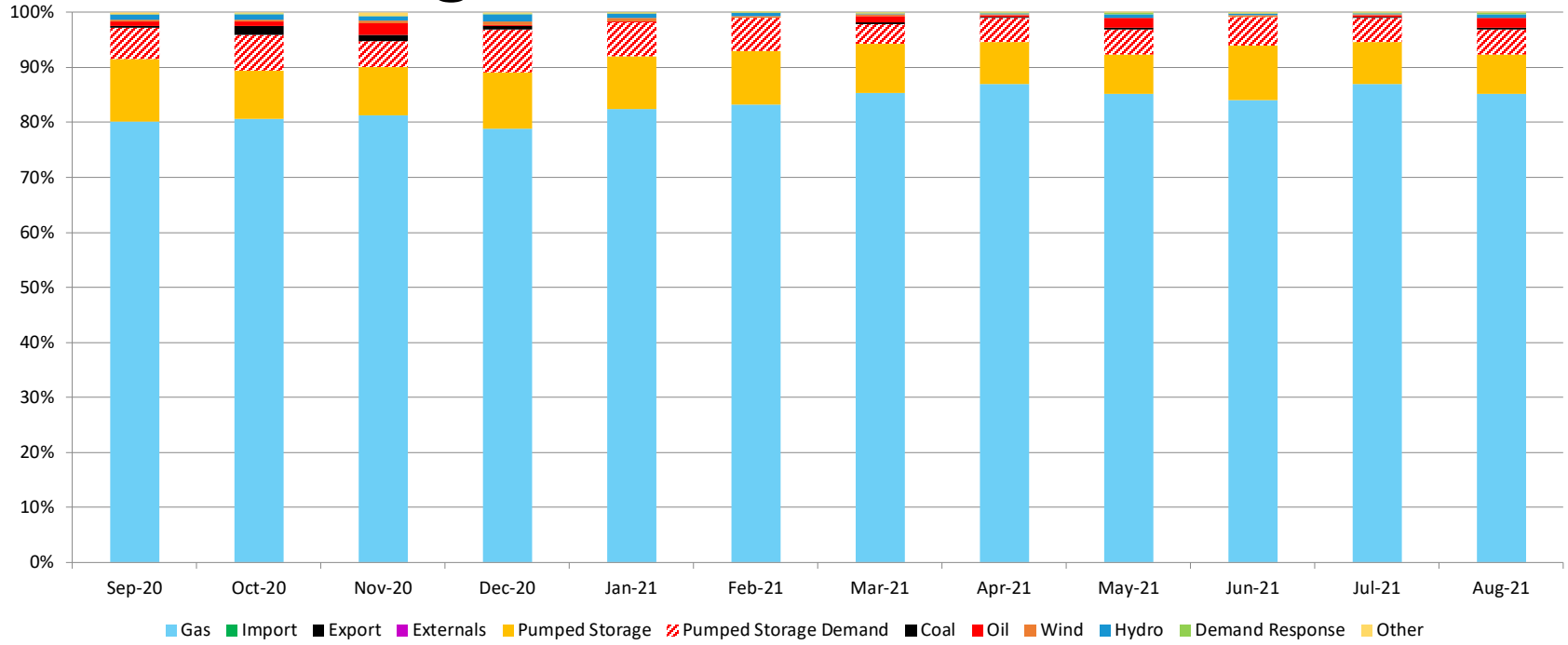
Summed Marginal Unit Emissions



Marginal emission rates are calculated using system data that identifies at least one locational marginal unit for each five-minute period, which is associated with meeting the energy requirements on the system during that pricing interval. Using system data on the magnitude and direction of power flows, load in constrained areas and the marginal generators in the same constrained areas are matched. Since these marginal generators can only serve load in the constrained area, weighting by the load in the constrained area against the overall load on the system provides a more accurate representation of the system impact of load weighted marginal units.

Source: ISO-NE Internal Market Monitor

Detailed Marginal Unit Emissions



Marginal emission rates are calculated using system data that identifies at least one locational marginal unit for each five-minute period, which is associated with meeting the energy requirements on the system during that pricing interval. Using system data on the magnitude and direction of power flows, load in constrained areas and the marginal generators in the same constrained areas are matched. Since these marginal generators can only serve load in the constrained area, weighting by the load in the constrained area against the overall load on the system provides a more accurate representation of the system impact of load weighted marginal units.

Source: ISO-NE Internal Market Monitor

Questions