United States Environmental Protection Agency

Analyzing air emission co-benefits of transportation decarbonization scenarios for New York City using City-based Optimization Model for Energy Technologies (COMET)

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What do we do? – A systems approach to energy

developing

energy systems models

- From resource extraction to power plants & refineries to all end-use sectors
- Multi-pollutant, multi-media, & multi-sector
- Forward-looking "What-if?“ and “How can I?” scenarios
- Environmental focus – particularly pollutant emissions, expanding to air quality and other endpoints

delivering

analyses, databases and decision support tools for…

- Anticipating future environmental challenges
- Evaluating existing & proposed air, climate, & energy regulations
- Identifying cost-effective strategies for achieving single & multi-pollutant emissions targets
- Examining additional endpoints, such as air quality & health

supporting

- EPA Program & Regional Offices
- EPA grantees
  - STAR, CACES-CMU
- Universities & NGOs
- Other federal, state & local government agencies
  - DOE/NETL, LBNL, NESCAUM

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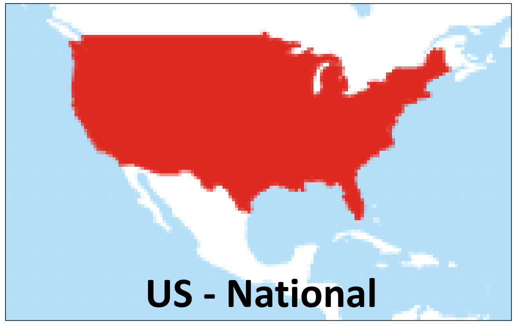
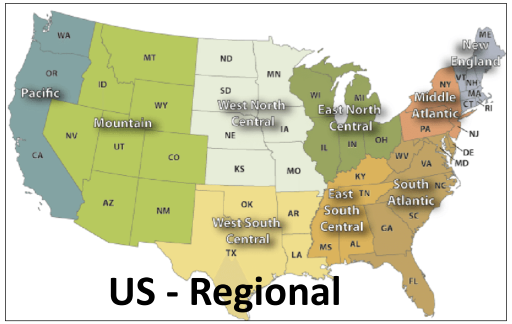
Geographic scope of models & select applications





COMET-NYC

Energy system optimization model

- Evaluation of transportation policies
- AQ attainment issues
- Decarbonization of buildings

EPAUS9r-TIMES

Energy system optimization models

- Starter model for developing countries (16 int'l universities, 13 developing countries)
- Scenarios for exploring deep decarbonization
- Assessment of hydrogen use in transportation
- Evaluation of decarbonization options in industry

GCAM-USA

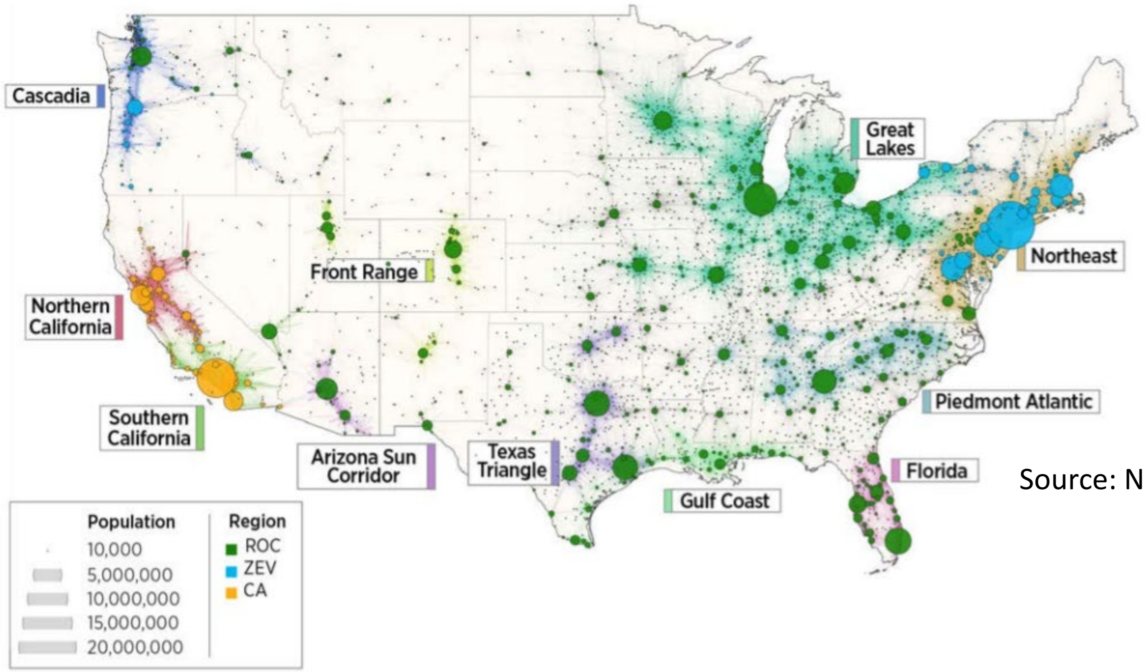
Human-Earth Systems simulation model

- Air pollutant emission impacts of alternative CO2 mitigation pathways
- State and regional EV emission impacts
- State-level NOx reduction potential of EE/RE

Why Cities? Regional, State and Local Analysis?

By 2050, almost 70% of the world population is expected to live in urban areas presenting a tremendous challenge for city governments

- To achieve greenhouse gas and air emissions reduction goals cost-effectively
- To meet growing energy, housing, and mobility demand,
- To provide clean air and water to their citizens
- To meet federal and state mandates environmental and energy standards and policies.



Source: NREL

Issues:

- Attainment of air quality standards
- Impact of climate change on air quality
- Urban heat island impacts and mitigation
- Aging transportation, building infrastructure
- Consequences of energy efficiency retrofits
- Proximity to industrial sources and mitigating climate change - decarbonization

Northeast region including NYC has one of the oldest infrastructures in the US
New growth in rest of the country specifically south could pose additional challenges in meeting AQ standards

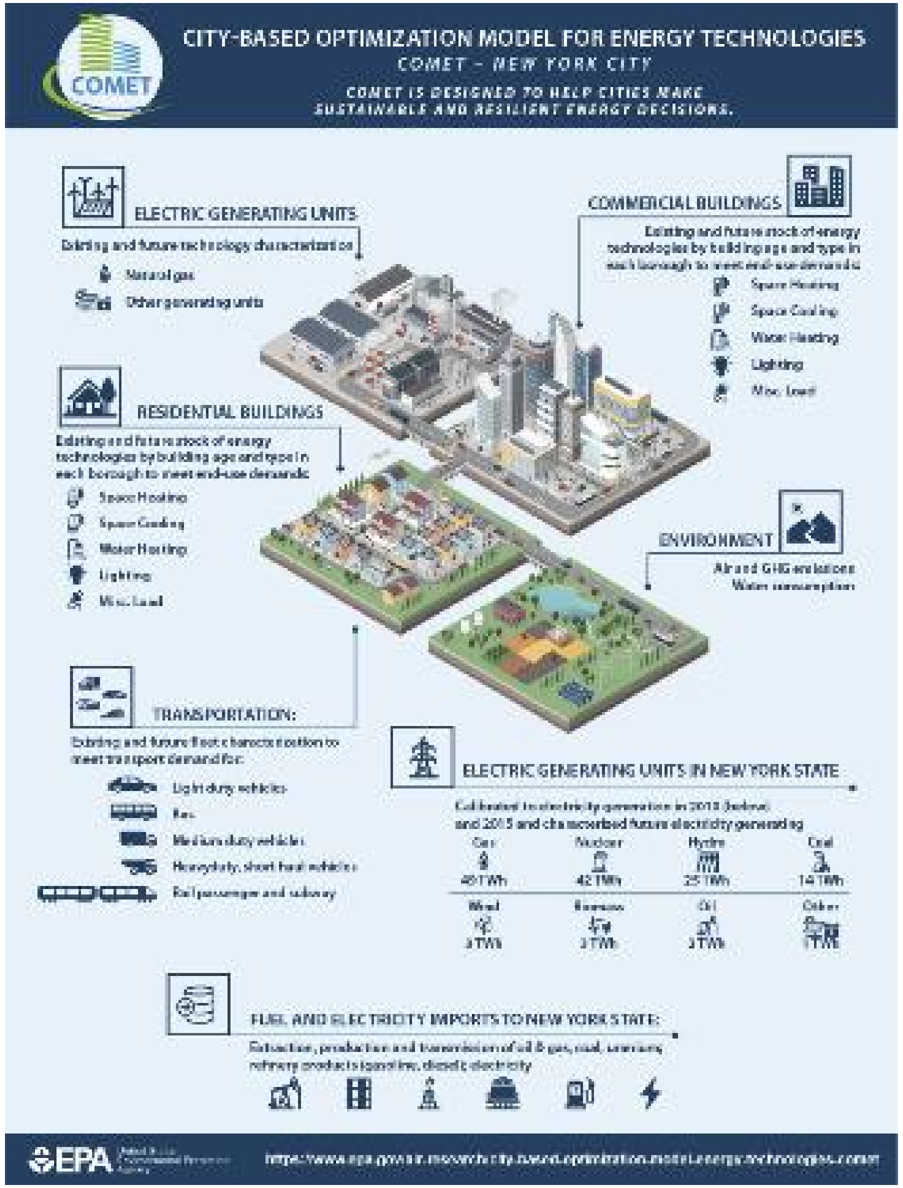
External stakeholder engagement focused on COMET

- We have been actively engaging and informing potential stakeholders across multiple organizations on development and application of ORD's energy systems modeling capabilities to their emerging energy planning related issues since 2016 including:

Academia	Government	Industry and NGOs
• City University of New York (CUNY) • Rutgers University	• EPA Region 2 • NJ Department of Environmental Protection • Board of Public Utilities • NYSERDA • NYC Department of Health and Mental Hygiene • NYC Department of Citywide Administrative Services • NYC Mayor's Office of Sustainability	• Public Service Enterprise Group • Regional Greenhouse Gas Initiative • C40

- Project is part of EPA Office of Research and Development's Air Climate and Energy research program

City-based Optimization Model for Energy Technologies



COMET is an analytical peer-reviewed technology evaluation tool for cities and states that can answer

- long-term planning questions (40+years of planning horizon) related to sustainability, resilience, equity, and growth in the energy sector.
- multipollutant and multi-media impacts, unintended consequences of the evolution of energy systems.

COMET can used in various applications such as

- **Pre-specify** an energy system scenario
  - Technology penetrations are determined *a priori*
  - Reports fuel use, GHG and pollutant emissions, water use
- **Prescribe** a least cost energy system
  - User provides constraints (e.g., emission limits, energy demands)
  - Identifies the least cost strategy while meeting the constraints
- Scenario framework to examine distinct **scenarios** of the future
- Scenario framework could be supplemented by **sensitivity** of the least cost pathway to the:
  - application of **new policies;** introduction of **new technologies;** changes to **fuel prices** or **fuel availability**

First application of COMET was piloted for New York City.

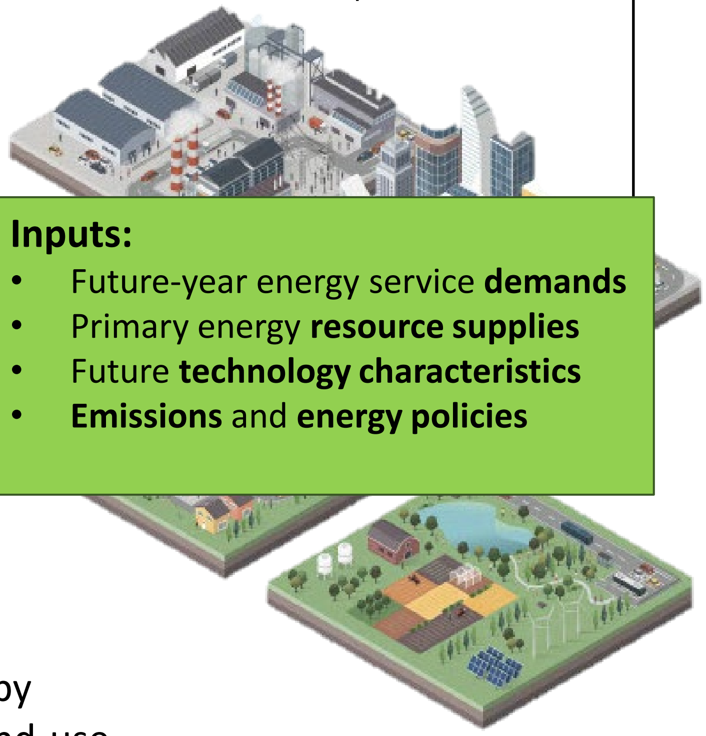
https://www.epa.gov/air-research/city-based-optimization-model-energy-technologies-comet

COMET - a partial-equilibrium technology rich, bottom-up optimization model

Allows user to analyze least-cost energy system technology portfolios to meet energy demands in buildings and transportation

Energy System for NYC+NYS

- Nearly 60 percent of the state's electricity is consumed in the New York City Metropolitan area (including Long Island)
- 64 natural gas plants (~50%)
- 4 nuclear reactors (33%)
- 180 hydroelectric plants (19%)
- 1 utility scale solar
- 16 peaking units near the city
- Centralized vs. distributed generation



Inputs:

- Future-year energy service **demands**
- Primary energy **resource supplies**
- Future **technology characteristics**
- **Emissions** and **energy policies**

Transportation

Existing and future fleet characterization to meet transport demand for

- Light duty vehicles
- Bus
- Medium duty vehicles
- Heavy duty short haul vehicles
- Rail passenger
- Subway

Residential and Commercial Buildings

Existing and future stock of energy technologies by building age and type in each borough to meet end-use demands:

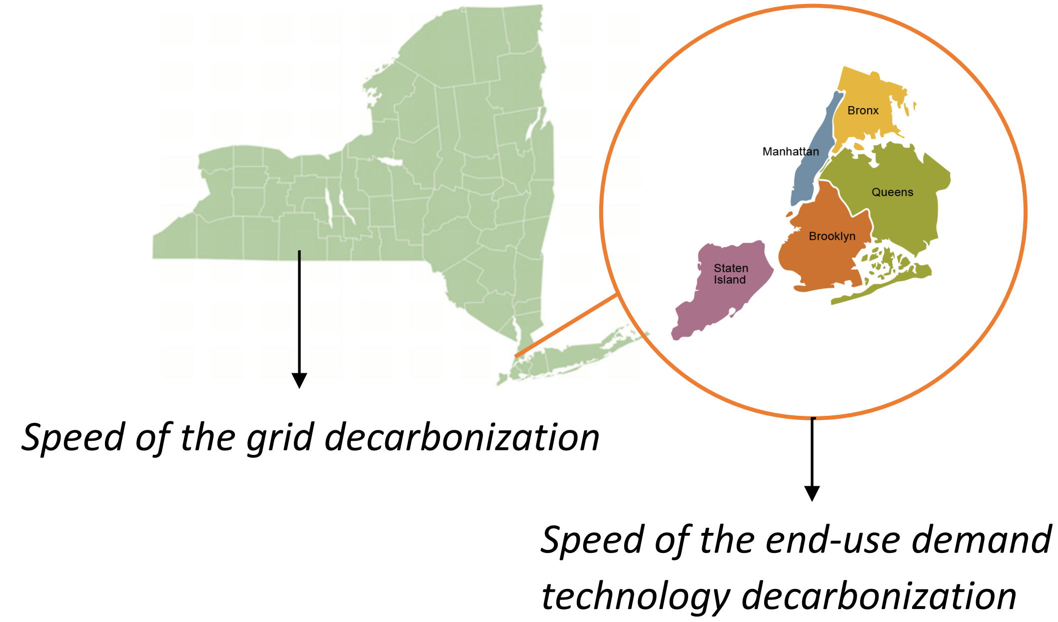
- Space Heating
- Space Cooling
- Water Heating
- Lighting
- Misc. Load

Outputs:

- **Technology portfolio** to meet end-use demands
- **Fuel use** by type and county
- **Emissions** (both sectoral and system-wide)
    - NO_x, SO_2, PM_{10}, $PM_{2.5}$, CO, VOC, CO_2, CH_4
    - water consumption in the utilities
- Marginal **prices**

A scenario framework helped us evaluate New York City's transportation policies with a focus on air emissions

Characterized the two most important uncertainties that can impact how cities could attain their goals



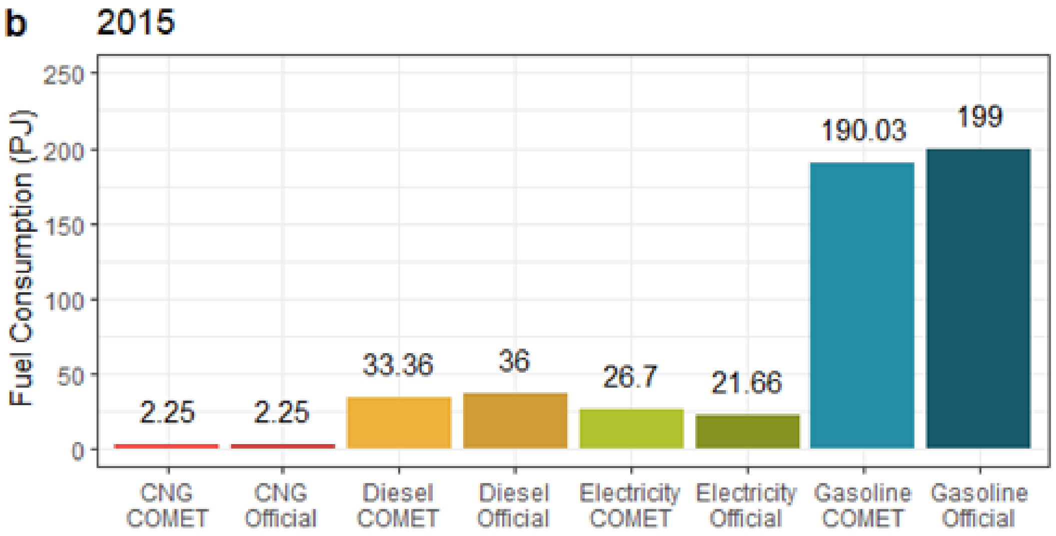
	Description	Goal
STEADY STATE	Business as usual trends	Least cost optimization with embedded technology turnover due to age and existing regulations, no carbon reduction
DEPENDENCE	Slower decarbonization of the grid	***The CO_2 intensity of electricity levels follow BAU trends***
REVOLUTION	Fast-paced decarbonization of the grid	***The CO_2 intensity of electricity levels follow State's goals on achieving electricity generation from renewables. "Clean Energy Standard"***

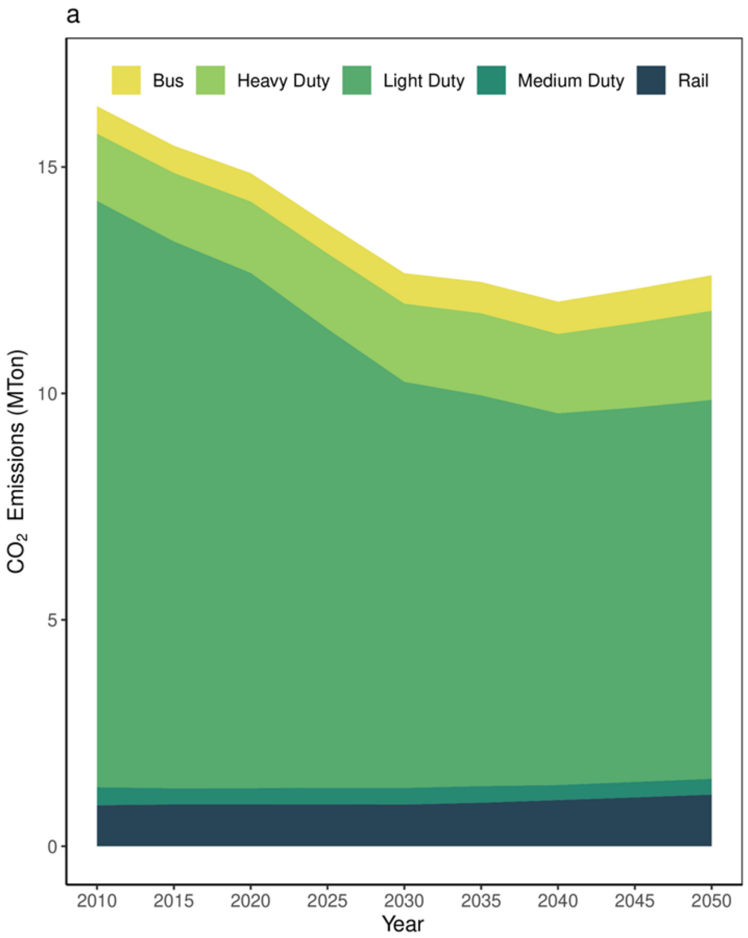
In addition, we conducted sensitivity analysis to explore implications of:

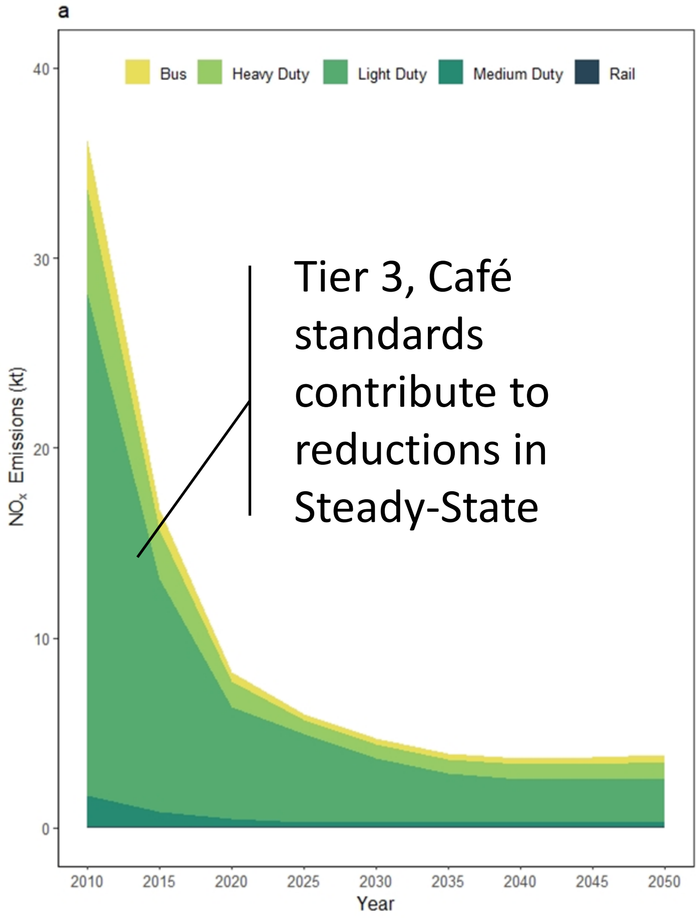
- Increased light-duty vehicle electrification (BATTERY),
- Increased use of ride-hailing services (TNC) leading to switch from public transit to ride hailing,
- Behavioral changes in transport mode choice (MODESWITCH) leading to decrease in vehicle miles traveled.

Isik, M., Dodder, R. & Kaplan, P.O. Transportation emissions scenarios for New York City under different carbon intensities of electricity and electric vehicle adoption rates. *Nat Energy* (2021). https://doi.org/10.1038/s41560-020-00740-2

Fuel consumption and transport related CO2 and NOx emissions







In 2015, majority of gasoline consumption is in light-duty sector, whereas diesel consumption is happening in the medium- and heavy-duty sectors.
NYC already has significant use of electricity in their transport system due to use of subways trains.

STEADY STATE carbon dioxide and NOx emissions reduce due to implementation of emission and fuel efficiency standards along with standard turnover of the fleet

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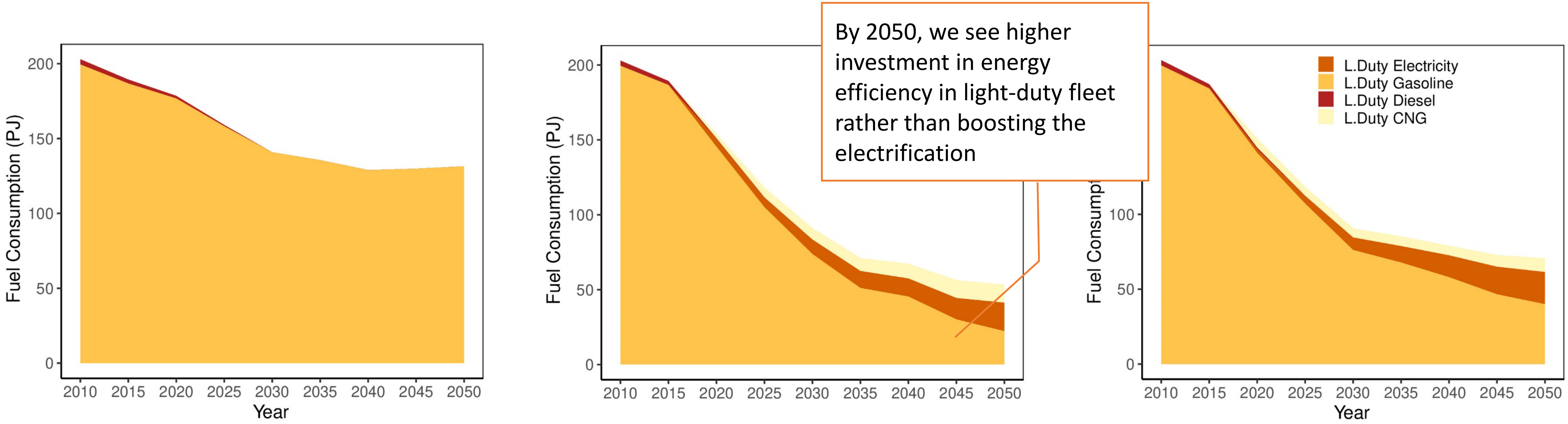
Light duty fuel consumption

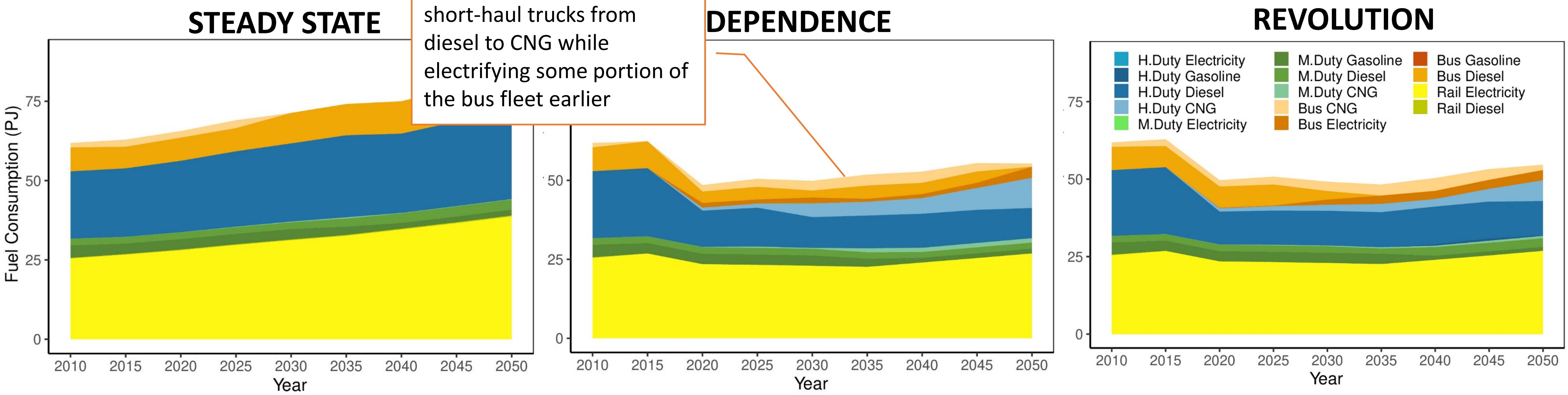
STEADY STATE | **DEPENDENCE** | **REVOLUTION**



- STEADY STATE light-duty vehicle fleet continues to rely on gasoline despite standard fuel efficiency improvements
    - 36% reduction in 2050 compared to 2010
- Gasoline consumption decreases by 79% and 83% in REVOLUTION and DEPENDENCE compared to STEADY STATE
- No investment in hydrogen-fueled vehicles were observed.
- High electrification of light-duty vehicles in both REVOLUTION and DEPENDENCE

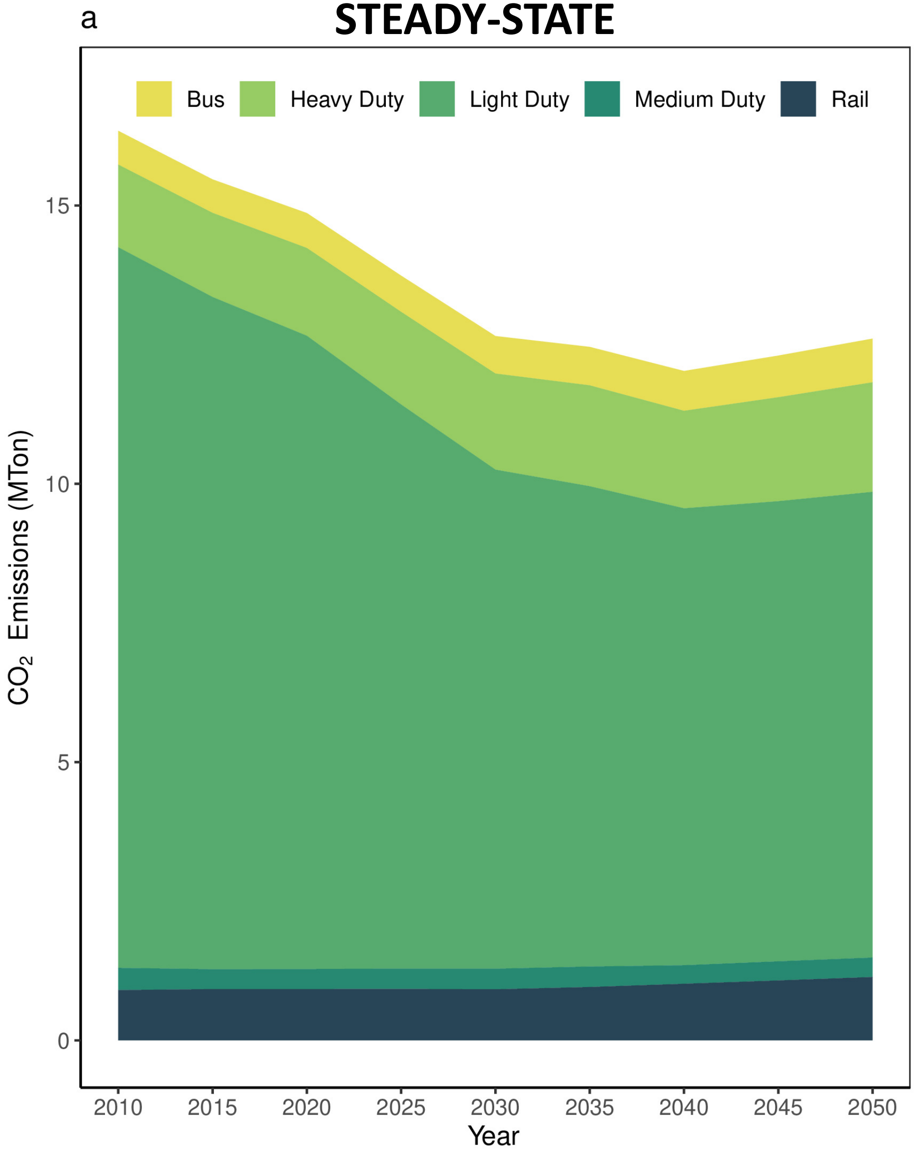
Heavy duty and other transportation fuel consumption

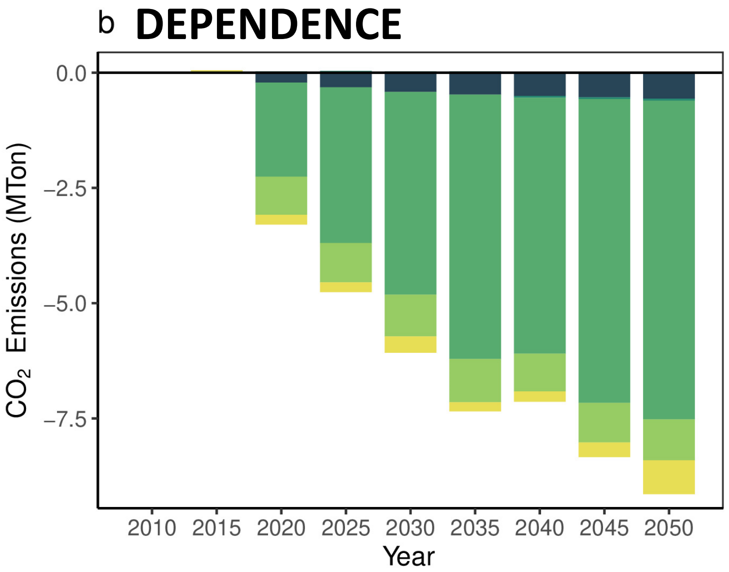
DEPENDENCE scenario converts more heavy-duty short-haul trucks from diesel to CNG while electrifying some portion of the bus fleet earlier

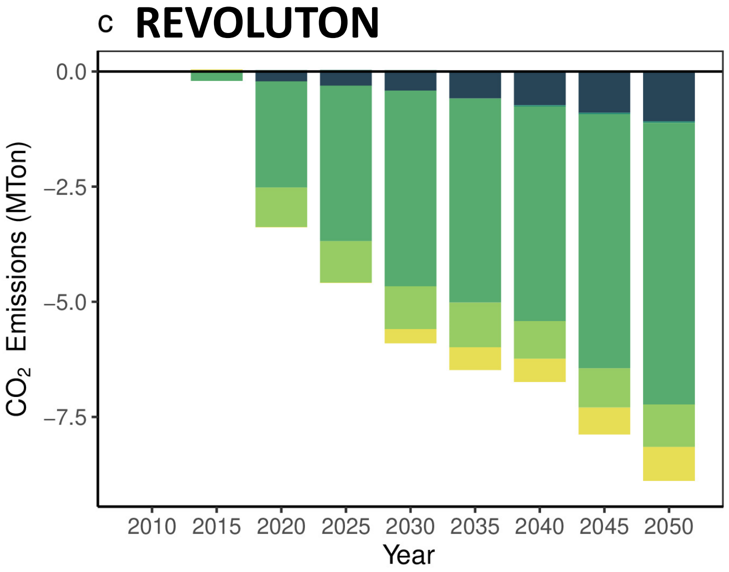


- New York City already has substantial electricity consumption due to subway system
- STEADY-STATE heavy-duty sector continues to rely on diesel.
- Electricity consumption increases by 33% and 26% for REVOLUTION and DEPENDENCE.
- DEPENDENCE consumes more electricity in the transportation sector than other scenarios in the near term

Transportation CO_2 emissions in Mton







- Most of these reductions were observed in the light-duty sector followed by short haul heavy-duty trucks.
- Both DEPENDENCE and REVOLUTION resulted in deeper cumulative reductions in CO2 emissions
- Majority of the near-term savings are coming from switching to newer vehicles with improved fuel efficiency
- We observe deepest reduction in a sensitivity scenario where light-duty sector is electrification is intensified (DEP_BATTERY)

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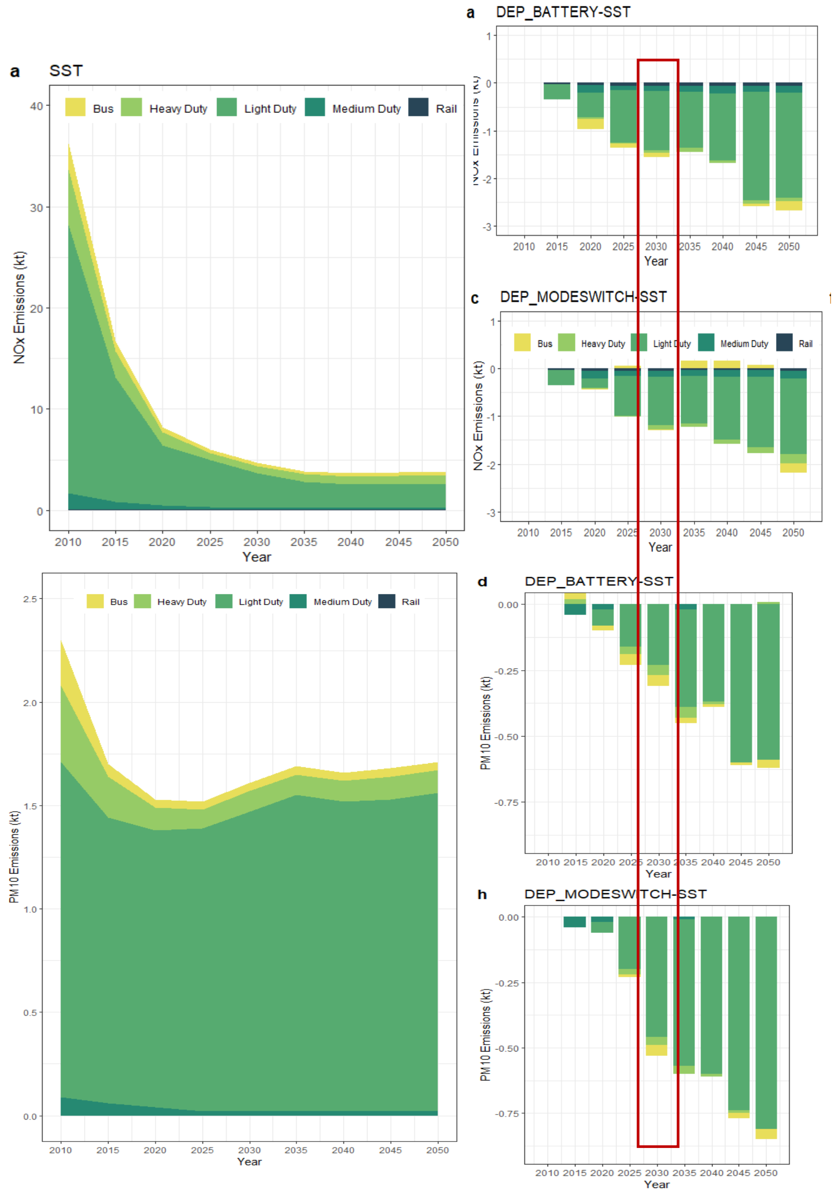
Transportation NO_x and PM10 emissions in kton



<u>Key Insight:</u> The fuel switching, especially buses and short haul freight modes, from diesel to CNG resulted in further reductions in NOx and PM10 emissions

<u>Key Insight</u>: The scenario with intense electrification of LDV fleet (i.e., all new LDV purchases to be 100% starting 2030) resulted in more NOx savings than the scenario where the passenger demand is reduced and replaced by public transit, walk and bike modes

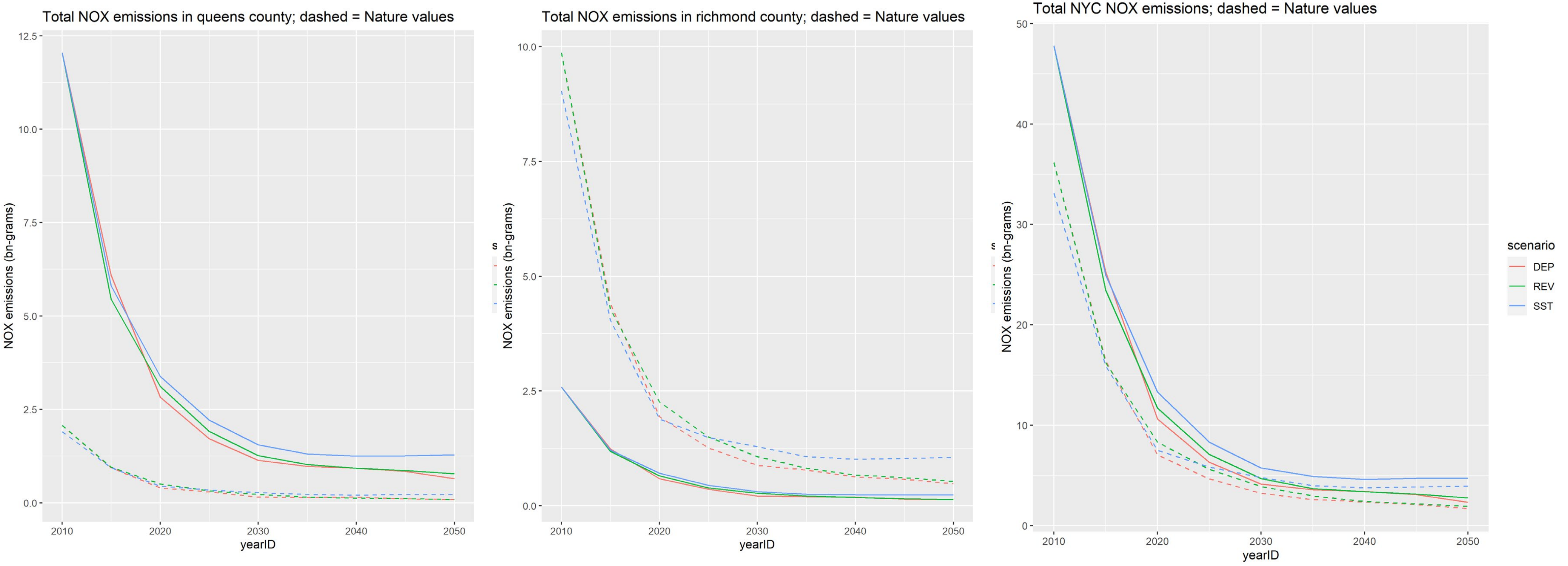
<u>Key Insight:</u> However, in the decarbonization scenarios, we observed more PM benefits when the LDV demand is reduced and switched to public transit, walk and bike modes.

Given the transit modes were moving towards clean fuels and electrification.

<u>Key Insight</u>: Grid carbon intensity highly influenced the resultant NOx emissions

- the deepest transport air emissions reductions were in the scenario, where the grid had higher carbon intensity

Further investigating the impact of localized emissions



We gathered new data to reflect city-driving conditions, and run MOVES at county-level

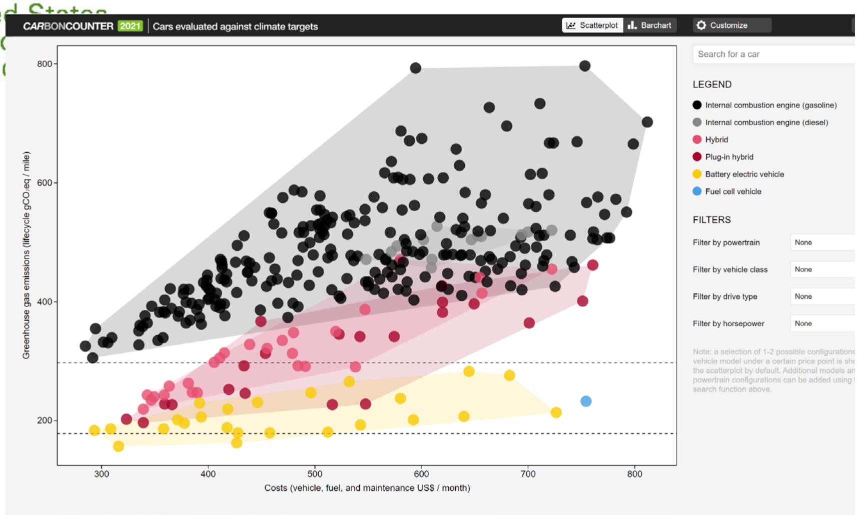
To update the emission factors – originally based on census region averages

Preliminary results show close values to regional emissions factors however,

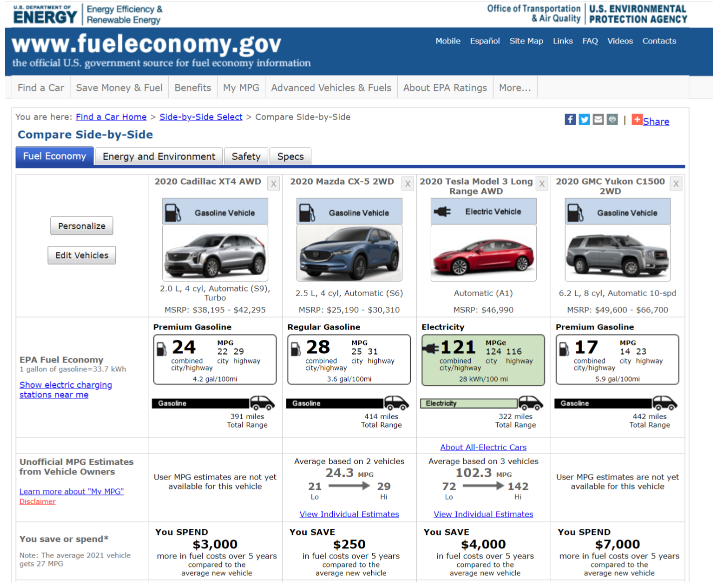
in some instances, over- and underestimation of local emissions per county per mode type

these preliminary results could have further implications on local air quality and health outcomes.

How can we reduce transportation emissions?



Clean fuels



Vehicle efficiency

How we move people and goods

Hard to decarbonize sectors - air, rail, freight

Implementing technological breakthroughs

How we build our cities

Better planning to reduce demand therefore yielding reduction in emissions

Encouraging use of public transit, walking and biking

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Thank you for your interest

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Bibliography

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