An analysis of Fuel Sulfur Content and Its Impact on Modeled Emissions and Projected NO_X Emissions Reductions

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For:

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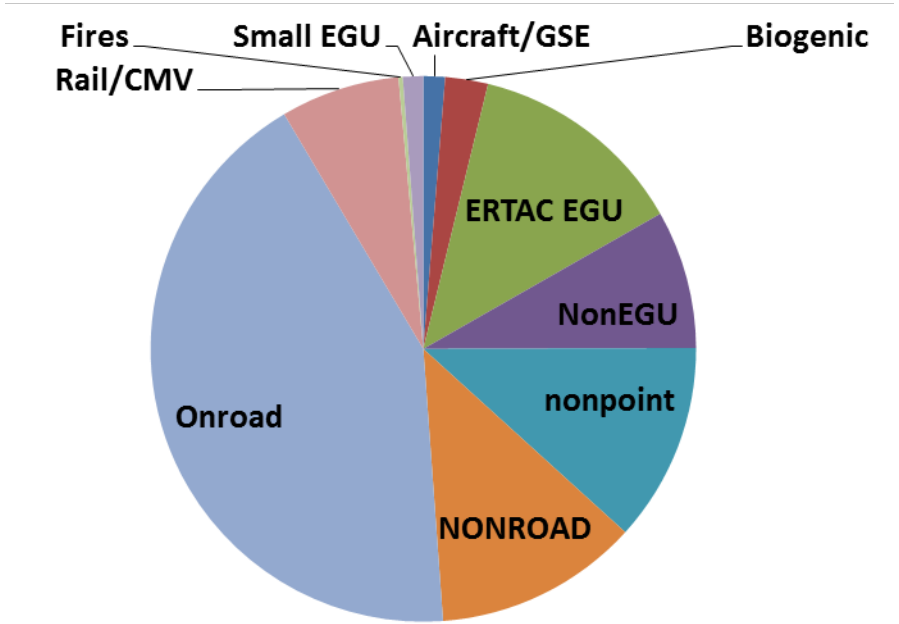
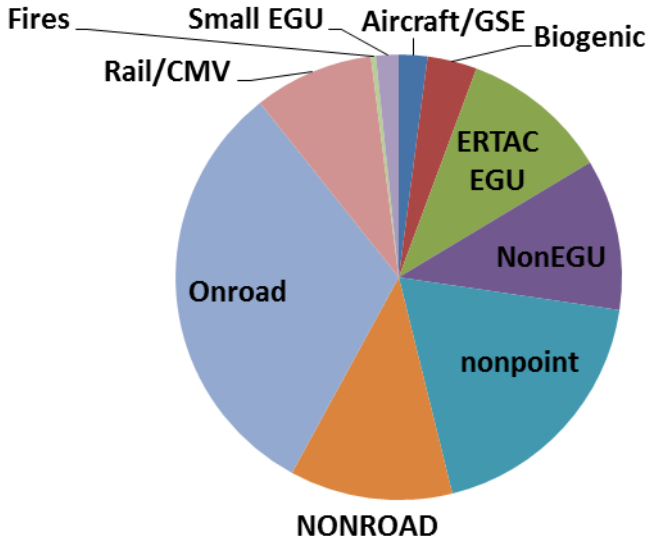
MARAMA

MARAMA Beta NOx Emissions



2011

Total: 2,600,000 TPY



2017

Total: 1,800,000 TPY

Overall a 29% NOX reduction from 2011 to 2017 is expected

MAJORITY (65%) OF THE REDUCTION IS FROM ONROAD

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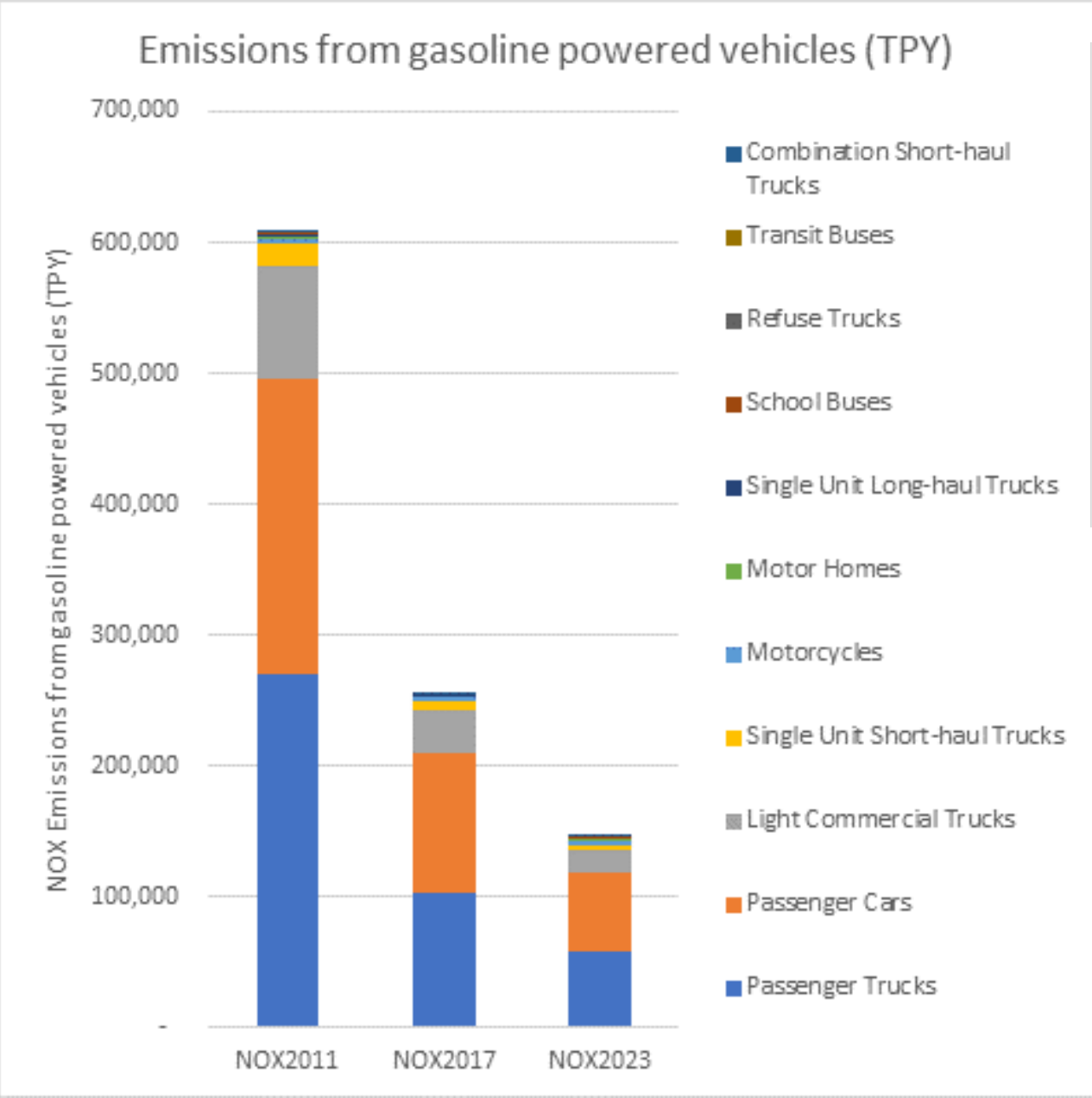
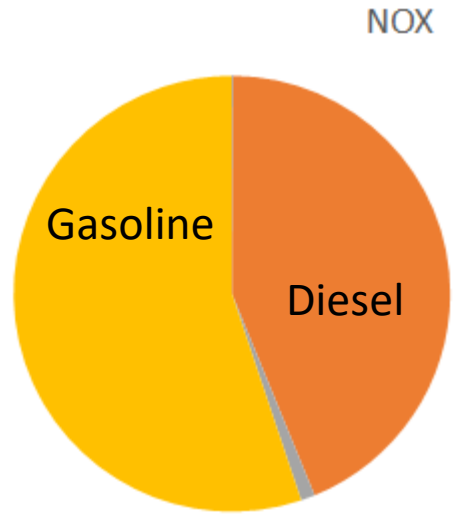




ANALYSIS OF THE EFFECT OF LOW SULFUR (TIER 3) FUEL ON EMISSIONS

CAN WE BELIEVE THE DRAMATIC MOBILE NO_X REDUCTIONS PREDICTED BY THE MOVES MODEL THAT ARE BAKED INTO OUR MODELING?

ANSWER: ????

Tier 3 Sulfur Standards for Gasoline Refiners and Importers (80.1603)

- Refiner and importer standards
  - Gasoline must contain no more than 10 parts per million (ppm) sulfur, on an annual average basis, beginning January 1, 2017
  - Gasoline must continue to contain no more than 80 ppm sulfur maximum, on a per-gallon basis
  - Standards apply to each refinery and each importer
- Small refiners and small volume refineries may delay compliance with the standards until January 1, 2020
- Refiners may request temporary relief if experiencing extreme hardship from economic factors or unforeseen circumstances
- Downstream of refineries and import facilities, gasoline must contain no more than 95 ppm sulfur

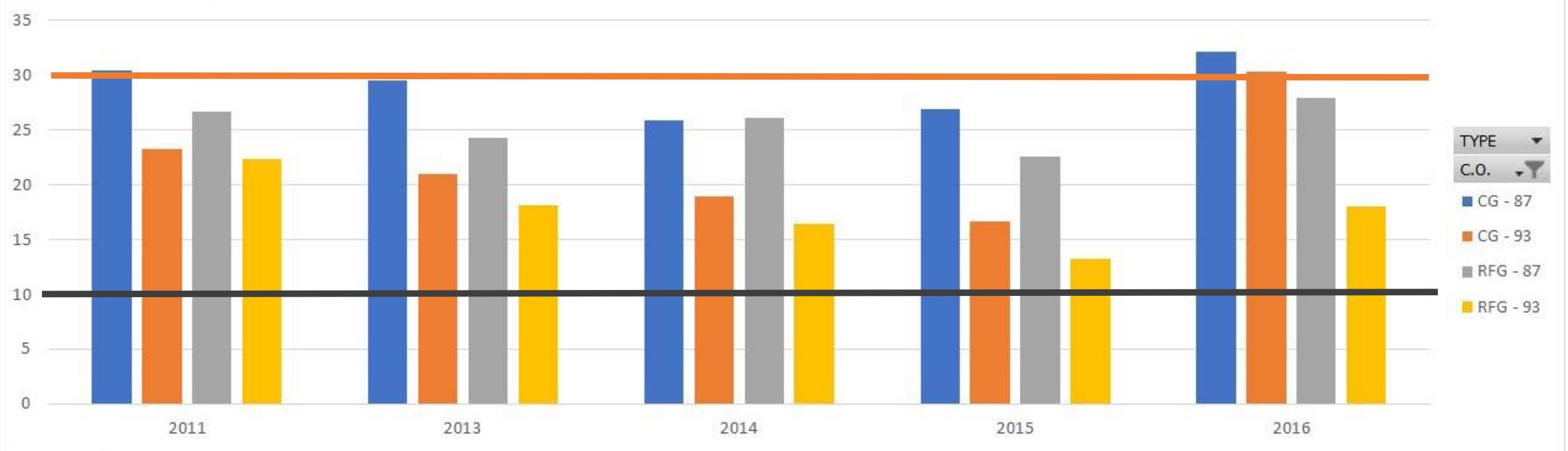
Averaging, Banking and Trading (ABT) Provisions (80.1615 & 80.1616)

- ABT provisions are similar to those in EPA's Tier 2 gasoline sulfur regulations, which established a 30 ppm annual average sulfur standard and 80 ppm per-gallon sulfur cap standard for refineries and importers beginning in 2004
- Beginning 1/1/2012, refiners and importers may generate gasoline sulfur credits which can be banked or transferred to other refiners and importers for compliance with either subpart H (Tier 2) through 2016, or subpart O (Tier 3) beginning in 2017
- Credits are measured in ppm-gallons
  - For example, beginning 1/1/2017, a refiner (non-small) or importer who produced or imported 1 gallon of gasoline containing 7 ppm sulfur could generate 3 ppm-gallon sulfur credits
  - A credit generator may bank credits for future usage, or transfer them to another refiner or importer who would use the credits if their annual average gasoline sulfur exceeded 10 ppm sulfur beginning in 2017
- Credits may only be transferred twice between refiners and importers

Gasoline Sulfur Credit Usage (80.1616)

- Credits are used by refineries or importers whose annual average gasoline sulfur exceeds 10 ppm beginning in 2017
- Credits are valid for use for 5 years after the year of generation, they expire if not used within this lifetime
  - For example, credits generated in 2012 may be used either for compliance with Tier 2's 30 ppm sulfur standard through 2016, or used for compliance with the 10 ppm sulfur standard in 2017 (2012 credits expire if not used through the 2017 compliance period)
- "Early" Tier 3 credits generated in 2014, 2015 and 2016 may be used no later than the 2019 annual compliance period, and expire by 3/31/2020 if unused
- Refineries or importers whose annual average gasoline sulfur exceeds 10 ppm beginning in 2017 are allowed to carry-forward a credit deficit for 1 year, but at the end of the subsequent year must meet the 10 ppm standard for both years

Annual Average Fuel Sulfur Content (PPM) by Octane and fuel type collected in ExampleState1



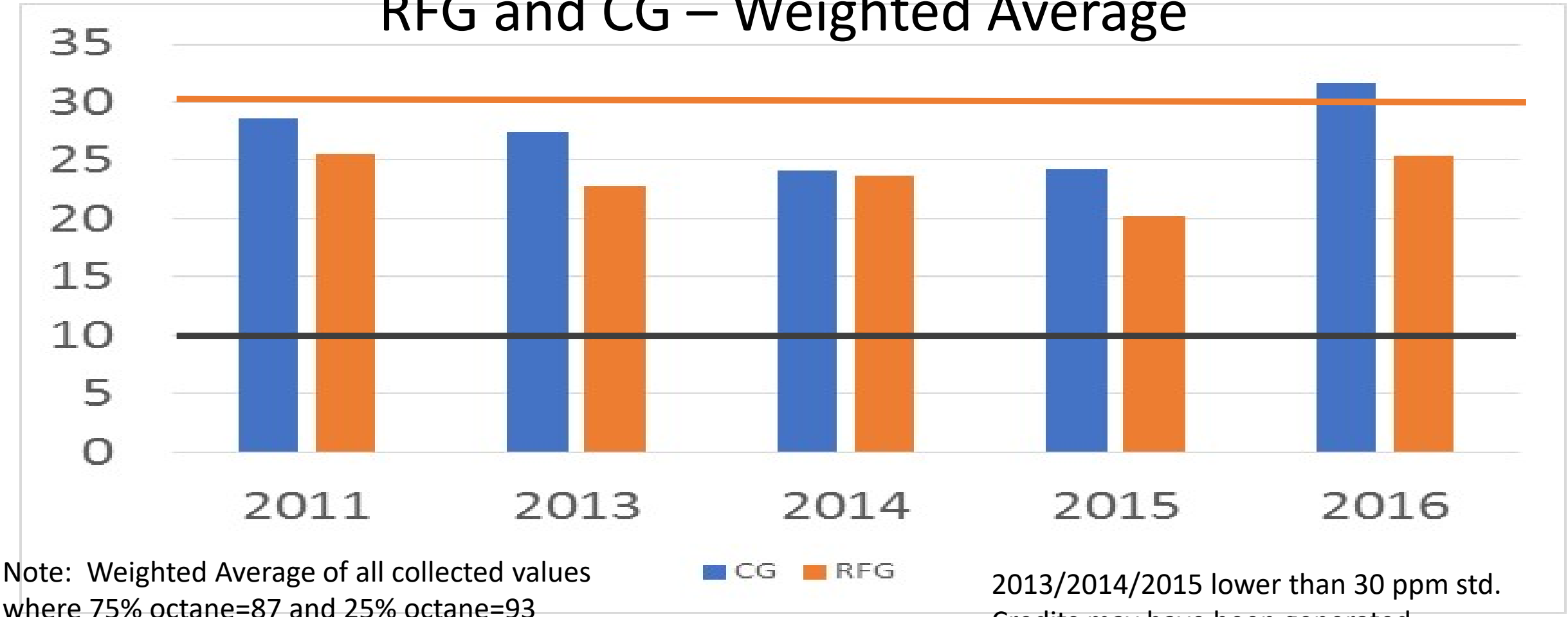
In general:

Sulfur content Conventional Gasoline (CG) > Reformulated Gasoline (RFG)

Sulfur content 87 octane > 93 octane

Annual Fuel Sulfur Content of fuel sold in ExampleState1 (PPM)

RFG and CG – Weighted Average



Note: Weighted Average of all collected values where 75% octane=87 and 25% octane=93
Some data is missing for some months.

2013/2014/2015 lower than 30 ppm std.
Credits may have been generated.

EPA MOVES Defaults Versus Measurements

- **Before 2017** - EPA default = 30 ppm (even though they have regional measured fuel sulfur contents which are somewhat lower than 30 ppm.)
- **Starting in 2017** - EPA default = 10 ppm (even though banking and trading program may keep fuel sulfur content higher than 10 ppm for several years, maybe until 2020 in some areas.)
- 10 ppm should be OK for 2023 as banked sulfur credits must be used by 2020.
- States are strongly encouraged in the guidance to use the default fuel sulfur content
- Most states use EPA MOVES default which is 30 ppm

How might this impact estimated NOX emissions?

- Sensitivity by two state agencies indicate a 35% NOX emission reduction from 30 ->10 PPM.
  - If impact is linear then a change of 1 PPM fuel Sulfur = 1.75% change in NOX emissions.
- **2011 – emissions over estimated:** If other state fuel sulfur content are similar to ExampleState1 then 2011 MOVES modeled NOX emissions are higher than actual:
  - 3-5% too high in 2011-2017 where CG is used
  - 8-9% too high in 2011-2017 where RFG is used
- **2017 – emissions under estimated:** If refineries exercise "credits"
  - Actual fuel sulfur may = 20 ppm, not 10 ppm (EPA Default).
  - MOVES Estimated emissions will be 1.75% X 10 = 17.5% under-estimated compared with use of actual sulfur content.

What does this mean for attainment demonstrations using NE 2011/2017/2023 AQ modeling?

- The AQ model (CMAQ & CAMX) is used in a “difference” mode to determine relative reduction from the base year.
- Actual reductions from base -> future year may be **less** than estimated in NE regional modeling platform because
  - 2011 emissions over-estimated and
  - 2017 emissions under-estimated due to banking
  - 2023 emissions correct because the opportunity for banking is past in 2020
- Other implication:
  - May contribute to difference between measured and modeled emissions noted in Discover AQ study

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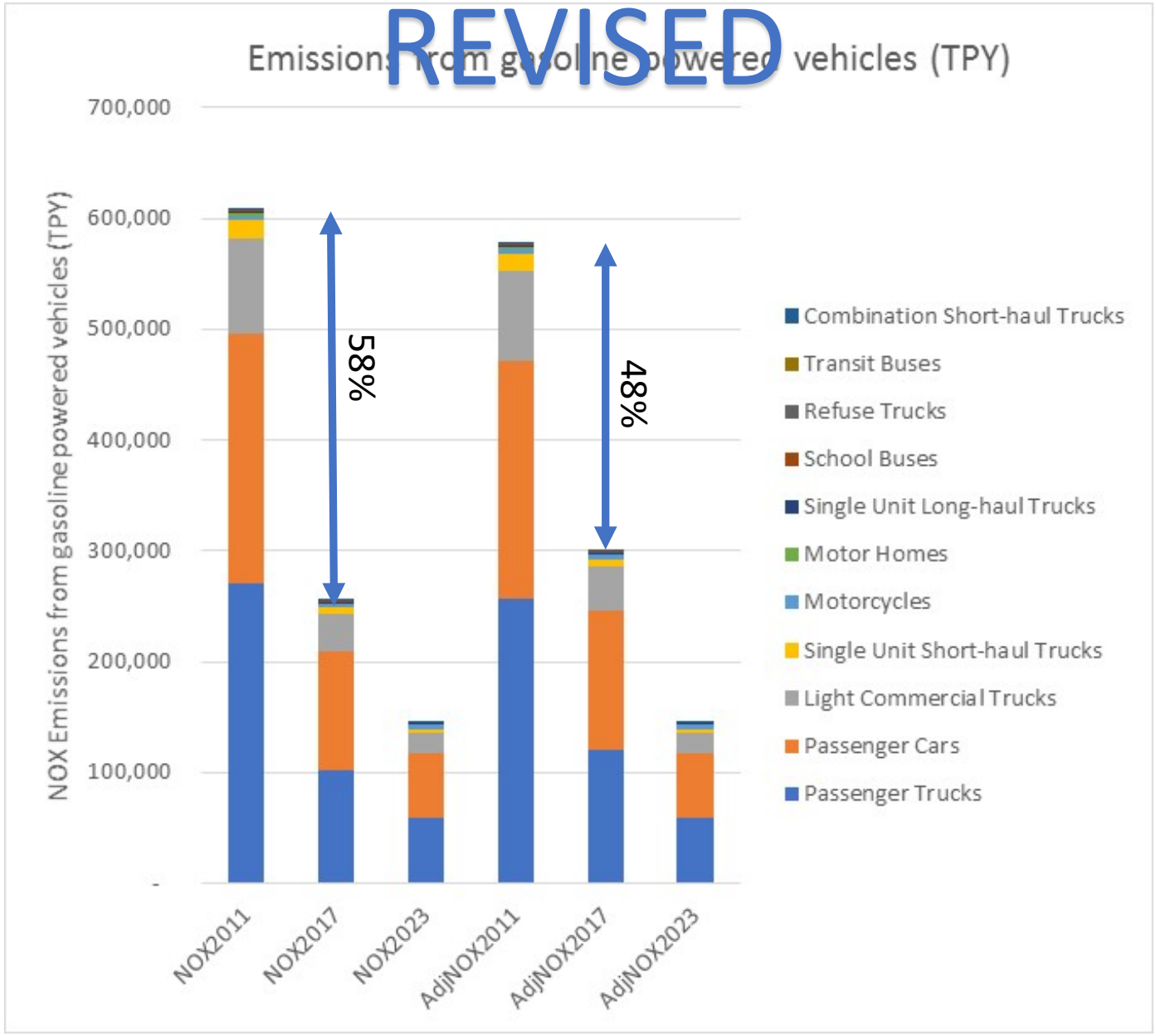

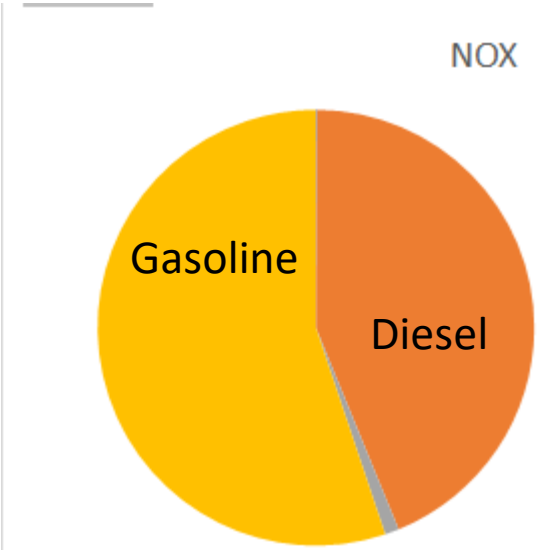

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ANSWER: NOT ENTIRELY

Preliminary Conclusions

- Official compliance with 10 PPM std starts 1/1/2017, but there is no legal reason to expect a step change in fuel Sulfur in 2017 as is the EPA default assumption.
- 2014/2015/2016 in ExampleState1 fuel sulfur was below 30 ppm so credits were banked. Banking occurred in many states.
- Credits expire at the end of 2019
- If banked credits are used they could delay regular usage of 10 ppb gas until 2020. Which would delay ambient NOX reductions to 2020
- Actual regional % NOX reduction due to low sulfur fuel may be less than was modeled in 2011/2017/2023 platform both because most states use default rather than actual fuel sulfur & use of banked credits
- Compliance is at the refinery or importer level for each “batch” of fuel, not at the filling station nozzle. Actual nozzle emissions may be higher because transport equipment is used for other high-sulfur products. This may have implications for emission factors

Follow on Questions

For states:

- What states have measurements of fuel sulfur and what do those measurements show?

For EPA:

- Have refiners actually banked emissions? Yes.
- What does EPA plan to use for defaults in subsequent MOVES modeling?
- What national data does EPA have about fuel sulfur concentrations?