# Understanding Reactivity

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# Agenda

1. Defining VOCs, Ozone & Reactivity
2. Reactivity – Uses, History, & Calculation
3. Example calculation
4. Update on fragrances
5. Timeline
6. Benefits of Reactivity

# What Is Reactivity?

# Volatile Organic Compound

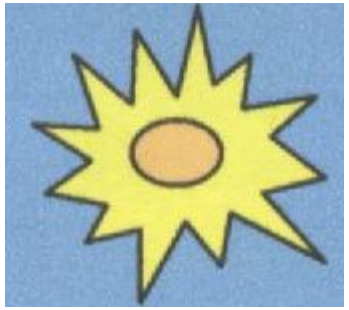
Any compound containing at least one atom of **carbon** excluding…

# VOC Exempts

Compounds determined not to react such as

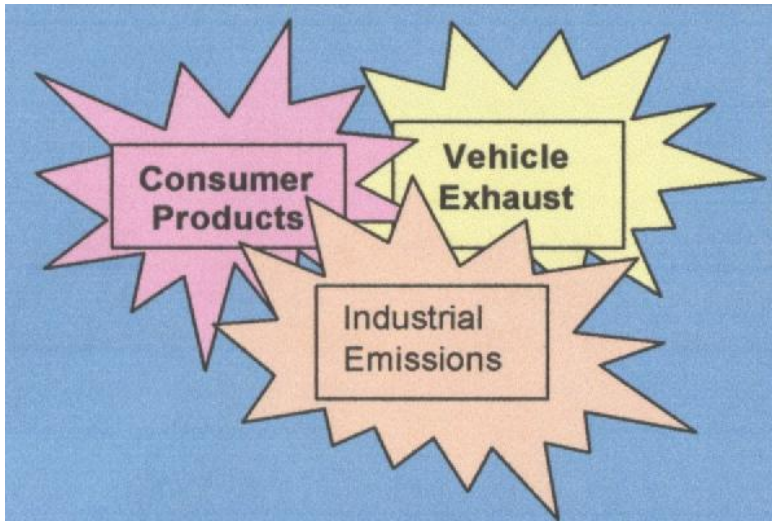
- HFC-152a
- HFO-1234ze
- Acetone
- $CO_2$

# VOCs
# are the precursors to
# OZONE



**Hot, sunny & calm weather promotes ozone formation.**

Ozone is formed in the atmosphere through chemical reactions between pollutants emitted from vehicles, factories, fossil fuels combustion, evaporation of paints, and many other sources. Key pollutants involved in ozone formation are hydrocarbon and nitrogen oxide gases.




**Hydrocarbons & Nitrogen oxide gases** → sunlight → **ozone**

# Photochemical Reactivity Concepts

- **Reactivity** - Measure of a **VOC's potential** to **react** in the atmosphere and **lead to the formation of ozone**
- Use of "lower reactive" VOCs may provide means for ozone reduction benefit where mass-based VOC reductions are not feasible
- Flexible approach that gives manufacturers more reformulation options
- May not be appropriate for all categories
  - products that contain only a few percent VOCs or contain compounds with the lowest MIR values

# What is Maximum Incremental Reactivity (MIR)?

"Maximum Incremental Reactivity" (MIR) means the maximum change in weight of ozone formed by adding a compound to the "Base ROG Mixture" per weight of compound added, expressed to the nearest hundredths of a gram (g $O_3$/g ROG).

MIR values for individual compounds and hydrocarbon solvents are specified in Title 17, California Code of Regulations Sections 94700 and 94701.

Reactive Organic Gas = ROG

# Why Are We Talking About MIR?

California's 2022 State Strategy for the State Implementation Plan (SIP) requires CARB to develop measures to reduce VOC emissions *or equivalent* from consumer products by **20 tpd Statewide** and **8 tpd in the South Coast** by the year 2037.

CARB will be proposing reductions in 2027 and is focused on reducing Ozone Forming Potential (OFP) rather than focused on reducing VOC emissions.

# Regulations Currently Using MIR

- CARB's Regulation for Reducing the Ozone Formed from Aerosol Coating Product Emissions
- EPA's National Volatile Organic Compound Emission Standards for Aerosol Coatings (40 CFR part 59, subpart E)
- Within the General Consumer Products Regulation:
  - Alternative Compliance Option for Multi-Purpose Lubricants
  - "Innovative Compressed Gas Propellant Product" and "Innovative Liquefied Propellant Product" in the aerosol "Hair Finishing Spray," "Dry Shampoo," or "Personal Fragrance Products

# Program Goals and Accomplishments

- The California Clean Air Act of 1988 established CARB's Consumer Products Program
- CARB adopts regulations to achieve the maximum feasible reduction in VOCs emitted by consumer products if the regulations are necessary to attain state and federal ambient air quality standards

## Overall Accomplishments

**26 Regulations**

**150+ categories regulated**

**250 tons per day (tpd) VOC reductions**


**0.24 million metric tons of CO2 equivalent reductions**

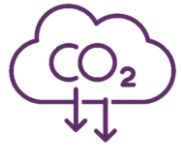
**13 tpd TAC reductions**

## 2021 Regulation

**7 categories regulated**

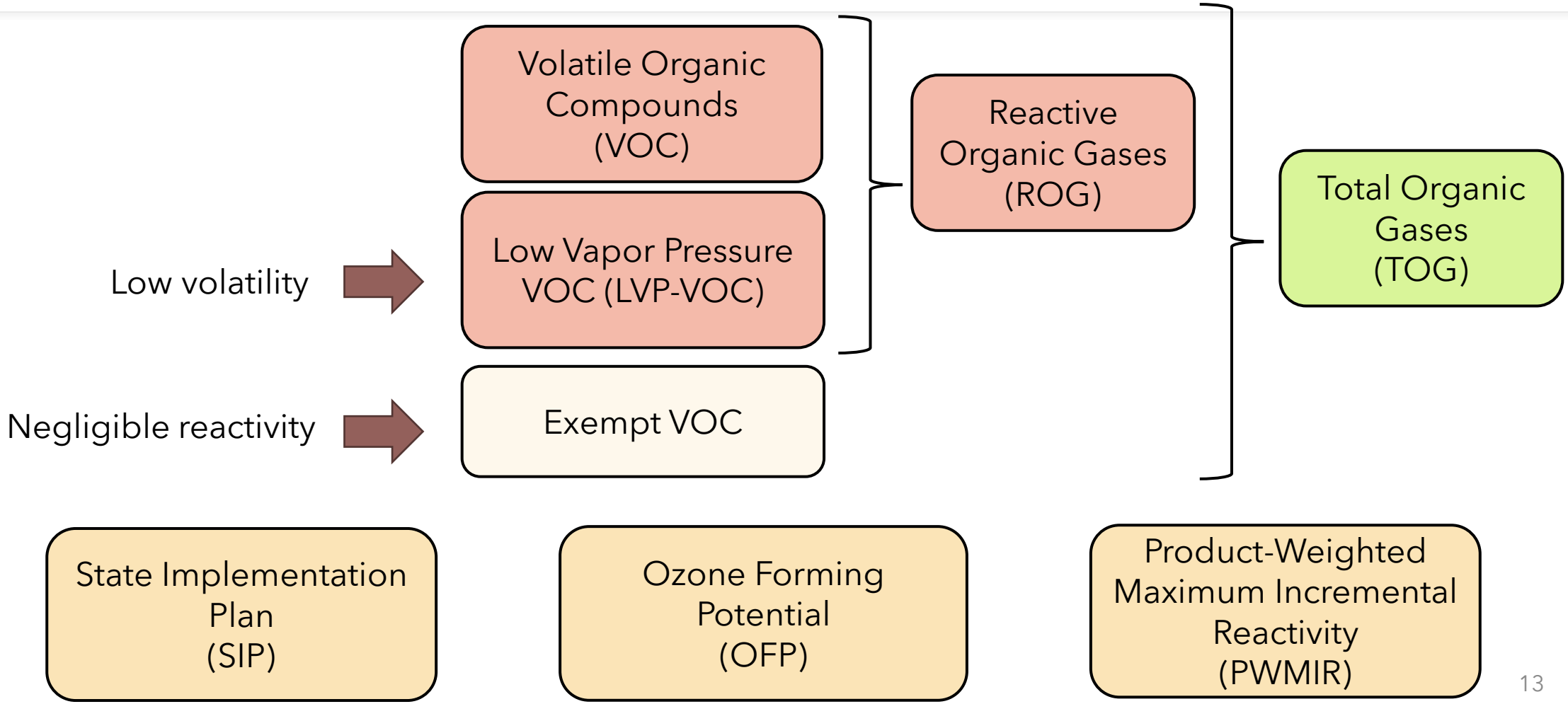
**9.8 tpd VOC reductions by 2031**

**3 tpd VOC reductions by 2031**

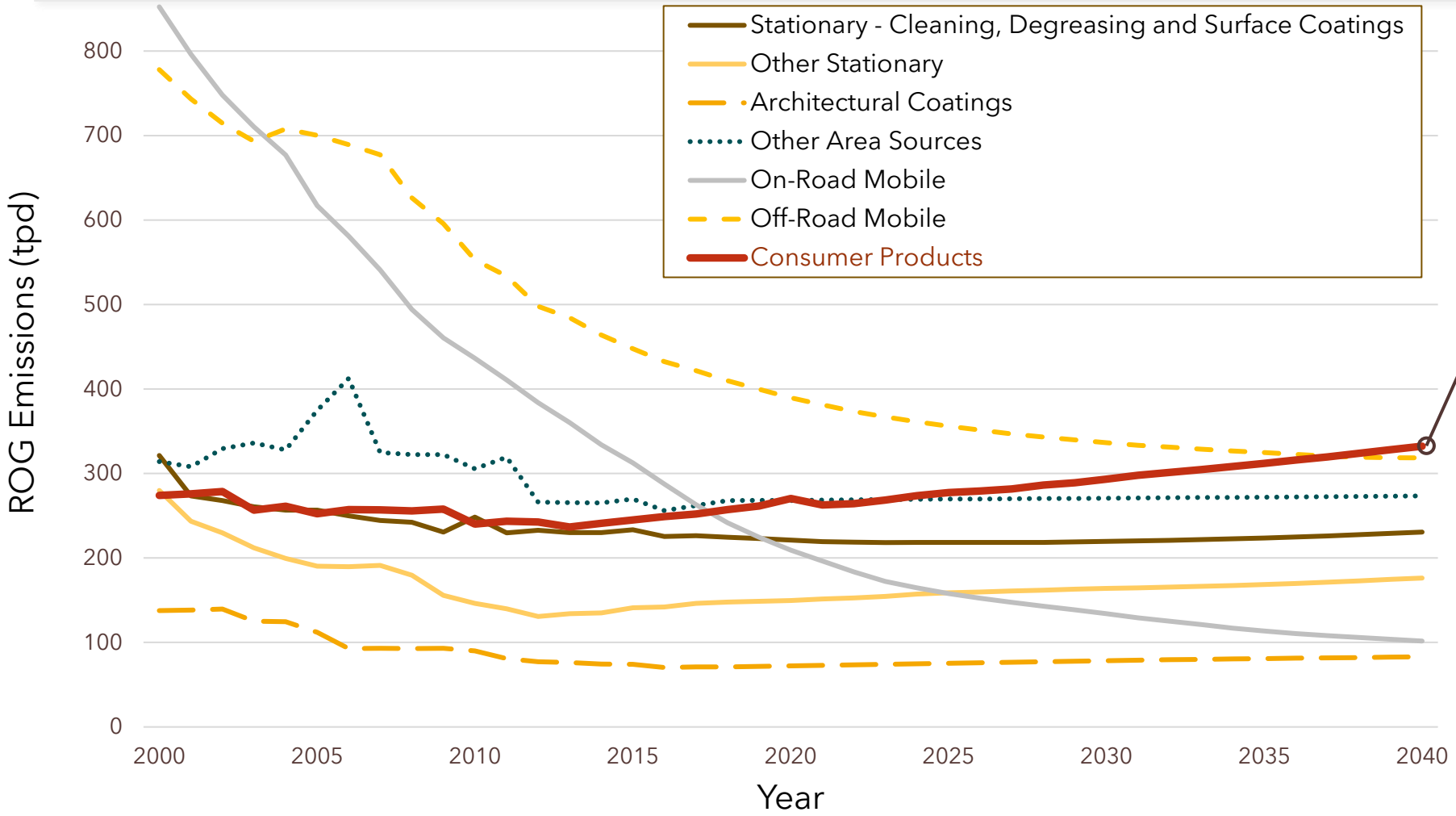



**0.039 - 0.32 million metric tons of CO2 equivalent reductions**

# Key Terminology



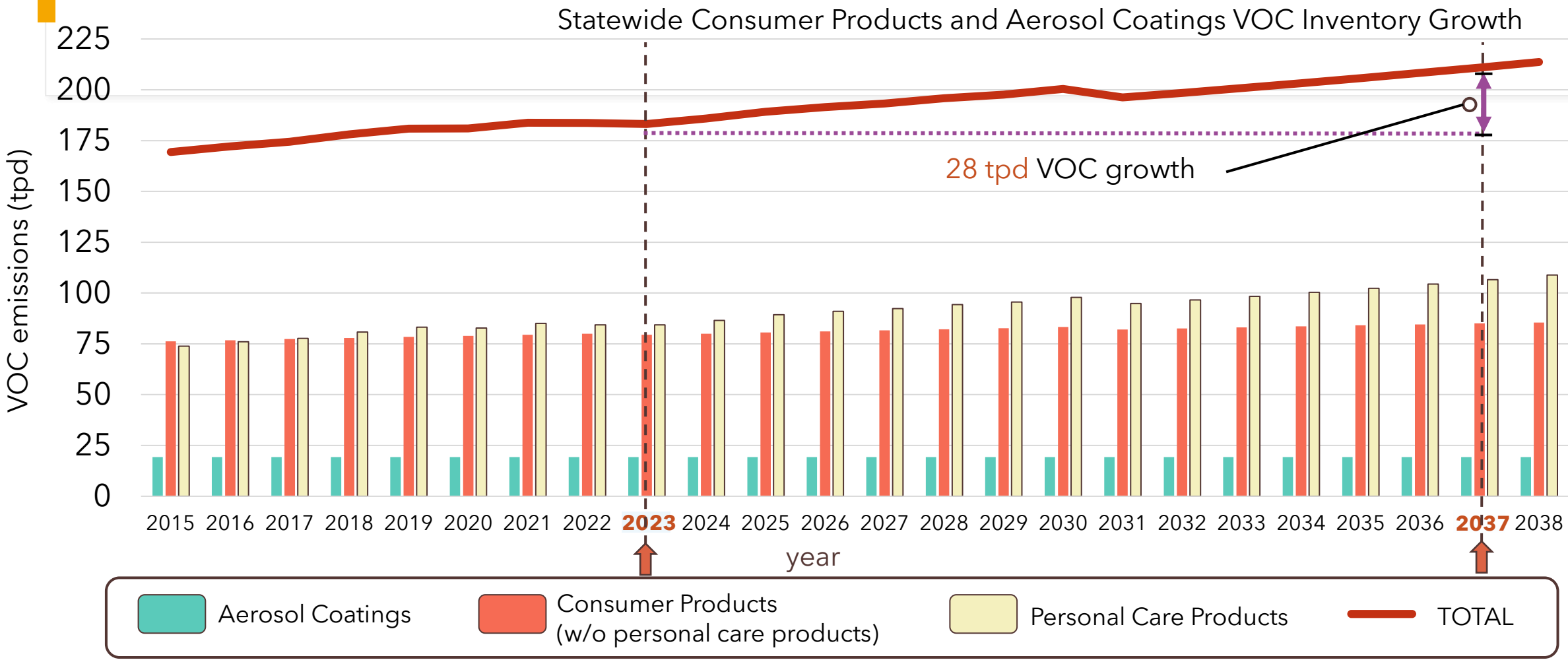
# Ozone-forming Emissions from Consumer Products are Rising




Consumer products will be the dominant contributor to ROG emissions in the future

Data from CEPAM 2019 v1.03 - Standard Emission Tool (Base Year 2017)

# 2022 SIP Commitment




SIP Reduction Commitment by 2037 = Remediate majority of 28 tpd VOC growth = 20 tpd Reductions

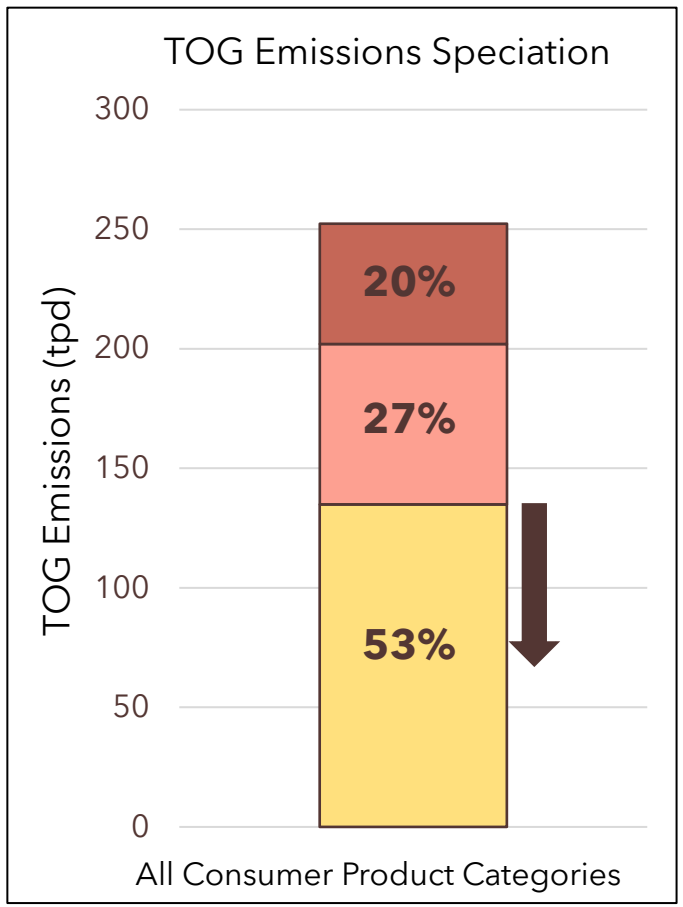
# Need to consider all TOG contributions to Ozone

Ultimate purpose of SIP Commitment: Ozone reduction for attainment

Over 30 years, the program aimed at reducing ozone by reducing VOC

Only ~ 1/3 of all categories have been regulated to date

But, there is a significant ozone contribution by LVP-VOCs

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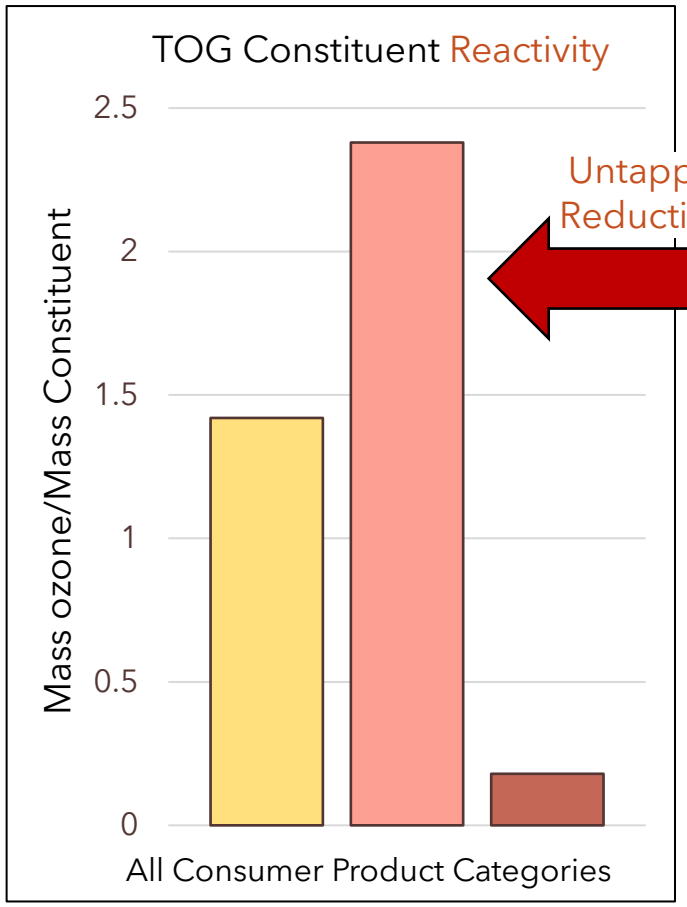


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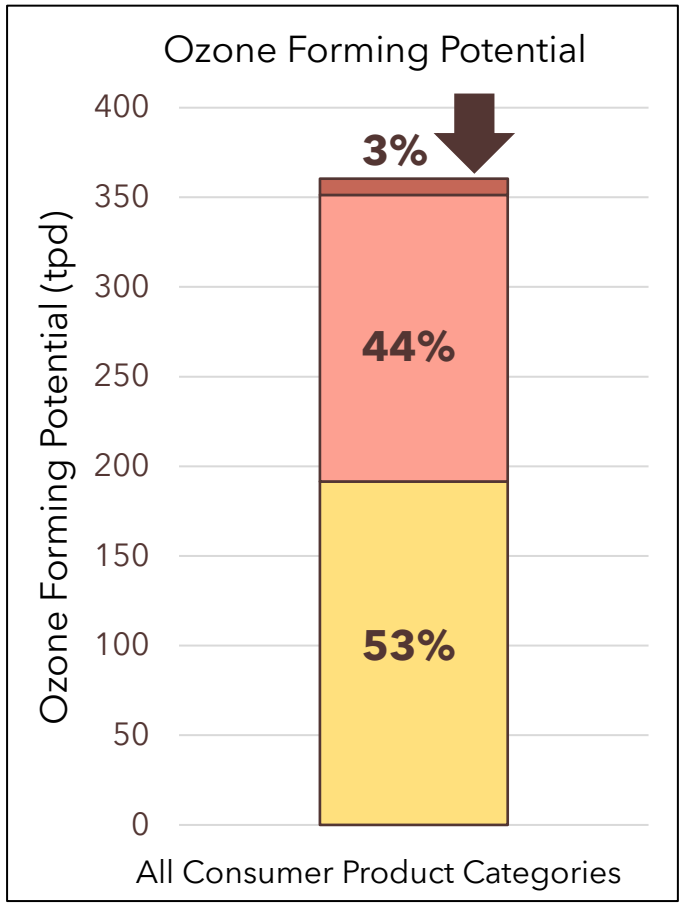
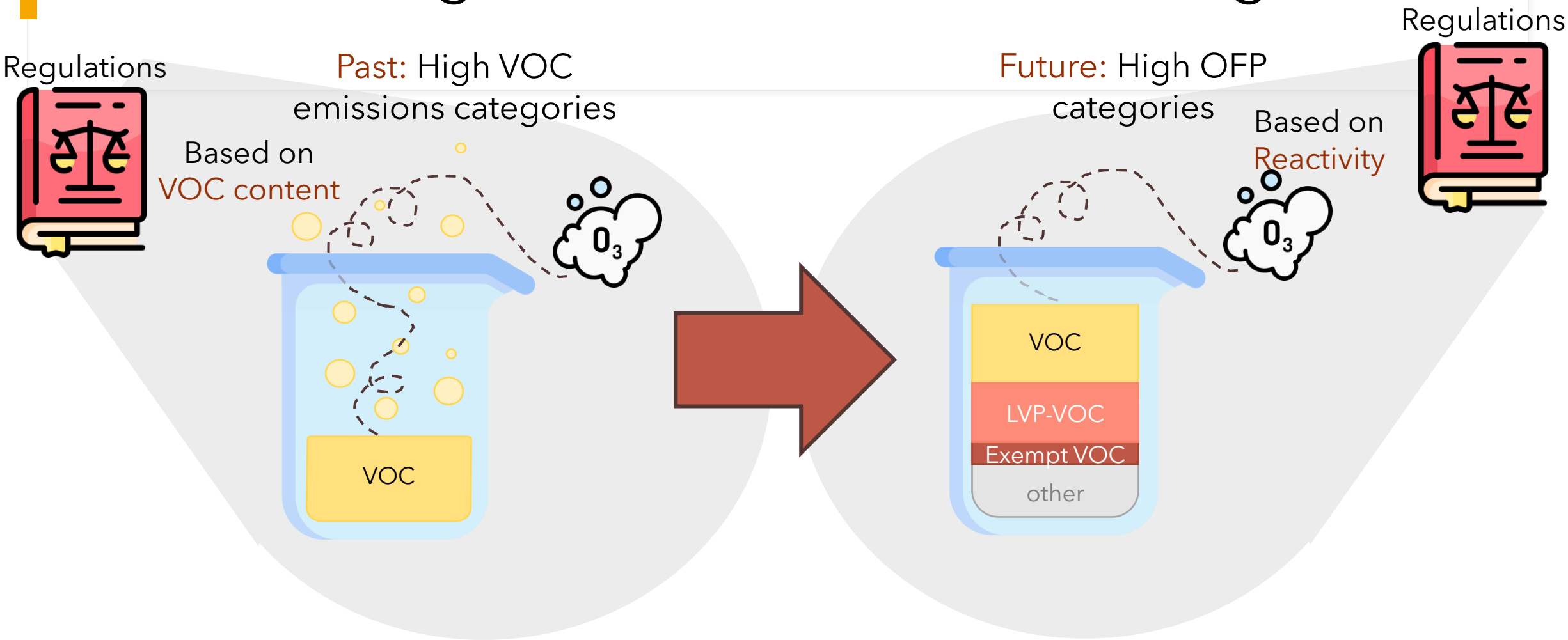



VOC LVP-VOC Exempt VOC

# Transitioning to a Holistic Ozone Forming Focus




After 30+ years of successfully reducing emissions from high-VOC categories, we are shifting focus to high ozone-contributing categories by focusing on reactivity

# How to Determine MIR of Substance

- Any Ingredient which does not contain at least One Carbon is Assigned an MIR value of 0.0.
- Carbon Dioxide is Assigned an MIR Value of 0.0.
- Ingredients that are Solid are Assigned an MIR Value of 0.0.
- MIR Values for Ingredients with at least One Carbon can be found at §94700
  - §94700 Table of MIR Values - Use 2010 Values
  - Be Careful with Nomenclature
    - Grouped by Various Structure

# Maximum Incremental Reactivity (MIR) Values

| Compound | MIR | Compound | MIR |
|---|---|---|---|
| m-Xylene | 9.75 | n-Docosane | 0.33 |
| d-Limonene | 4.55 | Acetone | 0.36* |
| Toluene | 4.00 | Ethane | 0.28* |
| Ethanol | 1.53 | AMP | 0.25 |
| Isobutane | 1.23 | p-DCD | 0.18 |
| Methanol | 0.67 | Methyl acetate | 0.07* |
| Isopropanol | 0.61 | HFC-152a | 0.02* |
| n-Tridecane | 0.53 | Cyclomethicone | 0.0* |
| Propane | 0.49 | Benzaldehyde | 0.0 |

* Exempted as negligibly reactive

# Image from MIR Table

| | Organic Compound | MIR Value (July 18, 2001) | New MIR Value October 2, 2010 |
|---|---|---|---|
| 603 | C19 naphthalenes* | 2.31 | 2.39 |
| 604 | C20 monosubstituted benzenes* | 1.05 | 1.10 |
| 605 | C20 disubstituted benzenes* | 2.29 | 2.36 |
| 606 | C20 trisubstituted benzenes* | 3.92 | 4.04 |
| 607 | C20 tetralins or indanes* | 1.39 | 1.44 |
| 608 | C20 naphthalenes* | 2.19 | 2.26 |
| 609 | C21 monosubstituted benzenes* | 1.00 | 1.05 |
| 610 | C21 disubstituted benzenes* | 2.18 | 2.25 |
| 611 | C21 trisubstituted benzenes* | 3.73 | 3.84 |
| 612 | C21 tetralins or indanes* | 1.32 | 1.37 |
| 613 | C21 naphthalenes* | 2.08 | 2.15 |
| 614 | C22 monosubstituted benzenes* | 0.96 | 1.00 |
| 615 | C22 disubstituted benzenes* | 2.08 | 2.14 |
| 616 | C22 trisubstituted benzenes* | 3.56 | 3.66 |
| 617 | C22 tetralins or indanes* | 1.26 | 1.31 |
| 618 | C22 naphthalenes* | 1.98 | 2.05 |
| | **Oxygenated Organics** | | |
| | **Alcohols** | | |
| 619 | methanol | 0.71 | 0.67 |
| 620 | ethanol | 1.69 | 1.53 |
| 621 | isopropyl alcohol | 0.71 | 0.61 |
| 622 | n-propyl alcohol | 2.74 | 2.50 |
| 623 | isobutyl alcohol | 2.24 | 2.51 |
| 624 | n-butyl alcohol | 3.34 | 2.88 |
| 625 | sec-butyl alcohol | 1.60 | 1.36 |
| 626 | tert-butyl alcohol | 0.45 | 0.41 |

# Instructions When MIR Value Not In Table

- First, Double-Check on Nomenclature
  - Most VOCs Have MIR Values in Table!
- If Your Specific Compound is Not Covered, but an Isomer is Listed, then the MIR Value for the Isomer Must Be Used.
  - If more than One Isomer is listed, the listed MIR Value for the Isomer with the Highest MIR Value must be used.
- If a Compound or Isomer is **not listed**, the MIR Value for Base Reactive Organic Gas (ROG) Mixture must be used to determine the weighted MIR of the compound

# Are New Ingredients Added to MIR Table?

- Yes!
- Need to Stay Up-To-Date on MIR Table
- If a New Ingredient is Added, the MIR Value for the New Ingredient Must be Used Rather than an Isomer or Base ROG Mixture

# What is Product-Weighted MIR (PWMIR)?

- Simply Put: the **weighted sum** of the MIRs of each ingredient in the product.

**Example Formulation**

| Ingredient | Percent | | MIR | | Partial Total |
|---|---|---|---|---|---|
| A | 40% | x | 2.0 | = | 0.8 |
| B | 30% | x | 1.0 | = | 0.3 |
| C | 20% | x | 0.5 | = | 0.1 |
| D | 10% | x | 0.0 | = | 0.0 |
| | | | | PWMIR = | 1.2 |

# Example Hairspray Reformulations

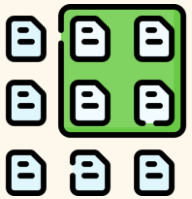
| Ingredient | Percent | MIR | Partial Total |
|---|---|---|---|
| **Ethanol** | 45 | 1.53 | 0.69 |
| HFC-152a | 45 | 0.02 | 0.01 |
| Fragrance | 0.1 | 6.36 | 0.01 |
| Other VOC or LVP-VOCs | 3.9 | 0.90 | 0.04 |
| Non-Volatiles | 6 | 0.00 | 0.00 |
| **Mass-Based Limit = 45** | | **PWMIR = 0.75** | |

| Ingredient | Percent | MIR | Partial Total |
|---|---|---|---|
| **Isopropyl Alcohol** | 45 | 0.61 | 0.27 |
| HFC-152a | 45 | 0.02 | 0.01 |
| Fragrance | 0.1 | 6.36 | 0.01 |
| Other VOC or LVP-VOCs | 3.9 | 0.90 | 0.04 |
| Non-Volatiles | 6 | 0.00 | 0.00 |
| **Mass-Based Limit = 45** | | **PWMIR = 0.33** | |

# Fragrances

- Currently, CARB's Rules for Determining the MIR Value of Fragrances is Using the MIR Value of Terpinolene.
  - Rules Currently Apply to Aerosol Coatings, Alternative Compliance Option for Multi-Purpose Lubricants, and IPEs for Hair Finishing Spray, Dry Shampoo, or Personal Fragrance Products
  - The MIR Value of Terpinolene is 6.36.
- During Last Rulemaking, Fragrance Industry Provided Input to Show that the Average MIR for a Fragrance Using Known Information is Significantly Less Than 6.36
  - Current Assumptions:
    - Terpene-Dominated Categories, MIR = 4.04
    - All Other Categories, MIR = 2.80

# 2025 Personal Fragrance Products (PFP) Technical Assessment



## Background

In 2021, the California Air Resources Board (CARB) amended the Consumer Products Regulation to further reduce VOC emissions from Personal Fragrance Products (PFPs)

≤7% fragrance

**VOC limit**
**75% → 70%**

The amendment lowered the VOC standard for non-aerosol PFPs containing ≤7% fragrance from 75% to 70% VOC

## Future Compliance Requirement

(Effective January 1, 2031):

Non-aerosol PFPs containing ≤10% fragrance

**50%**
VOC limit

Aerosol PFPs manufactured on or after January 1, 2031

**50%**
VOC limit

## Purpose of the Technical Assessment

Evaluate whether manufacturers can continue to meet the 50% VOC standard using current or new technology

# 2025 Personal Fragrance Products (PFP) Technical Assessment

**Submission Deadline**
March 31, 2026

**Applicability**

Companies listed on the product label of PFPs containing ≤10% fragrance sold in California are considered the Responsible Party and must report product information

**List of Categories for the 2025 PFPs Technical Assessment**

**Fragrance Products**

- Deodorant Body Spray
- Personal Fragrance Product with 20% or less fragrance

**Shaving Products**

- Aftershave Products

# Upcoming Work

**March 31, 2026**

Personal Fragrance Products reporting due for Technology Assessment

**Ongoing**

Discussions regarding definitions

Individual stakeholder meetings, Workgroup meetings and Workshops to explore emission reduction opportunities

**2026 - 2027**

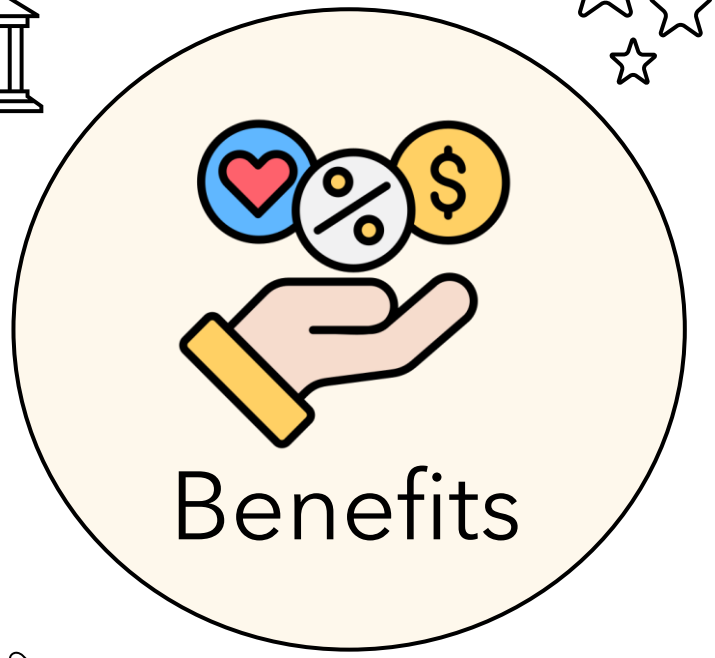
Regulatory Amendment Board Hearing

**Late 2027**

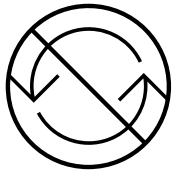
# Benefits of New Reactivity Limit Approach

Fewer new regulatory standards needed

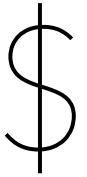
More effective products




Avoids the repeated regulation of categories with pronounced VOC content



More cost-effective products



Increases formulation flexibility for manufacturers

Enables technological advances by lifting exclusive VOC control

# Which Reduction Strategy is Best for your Products??

Check it Out!

# ANY QUESTIONS?

THANK

YOU

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