Overview of Air Quality Management and Workshop Organization

Dr. Elaine Chang

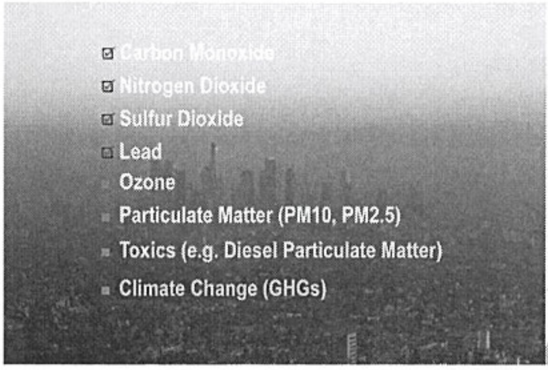
SCCAEPA - 11th Los Angeles Environmental Forum (LAEF)

August 7, 2018

Main Topics

- Overview of air quality management
- Air Quality Management Planning Program
- Workshop Organization

Key Air Quality Issues



- ☑ Carbon Monoxide
- ☑ Nitrogen Dioxide
- ☑ Sulfur Dioxide
- ☑ Lead
- Ozone
- Particulate Matter (PM10, PM2.5)
- Toxics (e.g. Diesel Particulate Matter)
- Climate Change (GHGs)

Integrated Multi-pollutant Approaches

- To derive the most efficient path to clean air for all pollutants, addressing
  - Different attainment deadlines
  - Common precursors between ozone, PM, air toxics, and climate change pollutants
  - Prioritization of policy choices if conflicts exist

Holistic Air Quality Management

Air Monitoring

- Purpose
  - To assess air quality conditions
  - To develop control programs
  - To evaluate effectiveness of control programs
  - To validate modeling performance
- Types of Monitoring
  - Regional
  - Community-based
  - Facility-based
  - Special Studies
  - Short, intermediate, and long term

Air Quality Management - Planning

Purpose

- Provide a methodical way to address air quality issues
- Provide policy choices
- Provide regulatory certainty
- Establish consensus among stakeholders

Air Quality Planning

Objectives

- Most Efficient Path to Clean Air
- Minimize Socioeconomic Impacts
- Promote Fair Share Responsibility
- Maximize Private/Public Partnership
- Equitable and Expeditious Progress

Air Quality Analysis

- Historical trend analysis
- Weather analysis
- Spatial and temporal analysis
- Characteristics of problems
  - Max
  - Frequency
  - Population exposure
  - Others

Air Quality Analysis(cont.)

- Speciation
  - Source apportionment
  - Photochemical reactivity

Air Quality Analysis(cont.)

- Performance index
  - Concentrations above the standard
  - Number of days exceeding the standard
  - Location(s) of exceedances
- Co-factors
  - Economy
  - Weather
- Speciation

Emission Inventory Development

- Emission trend analysis
  - Past, current, future
- Source contribution
- Spatial and temporal allocations
- Bottom-up vs. top down approach
- Inventory source categorization
- Inventory QA/QC
- Inventory uncertainty

Emissions Inventory Development(cont.)

- Stationary Sources
  - Point Sources
  - Area Sources
- Mobile Sources
  - On-Road Sources
  - Off-Road Sources
- Biogenic Sources

Emissions Inventory Development (cont.)

- Planning (seasonal) inventory
- Episodic (modeling) inventory
- Inventory forecast and backcast
- PM and VOC speciations

Emission Data Analysis

- Trend analysis
- Categorization
- Emission ranking

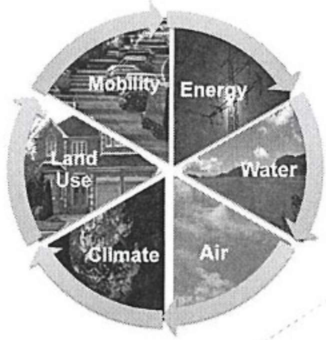
Inventory Methodology

- Continuous emission monitoring
- Calculated emissions
  - Recorded activity
    - Utility bills
    - Fuel flow meters
    - Invoices
    - Sales data
  - Emission rate
    - Source tests
    - Literature data

Agency Coordination/Integration

- MPOs
  - Demographic forecasts
  - Transportation projects
  - Transportation budgets
  - Land use: Job housing balance
- State agencies
  - Mobile sources
  - Consumer products
  - Waste disposal
  - Energy forecasts

Concerted Efforts



Workshop Organization

Topics

- Monitoring and data analysis(2)
- Planning
  - Control strategy (3)
    - Mobile sources (2)
    - Stationary sources (1)
- Permitting program
- Enforcement
- Socioeconomic assessments
- Air quality impact assessments and modeling
- Air toxics program

臭氧和挥发性有机物 (VOC) 监测简介
Introduction of Ozone and VOC Monitoring

Air Quality Chemist, Jianhang Lu, PhD

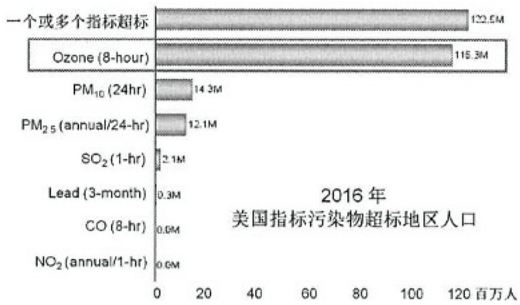
SCCEPA 洛杉矶环境论坛, August 07, 2018

内容概要

- 为什么监测臭氧和VOC
- 臭氧的监测
- 环境空气 VOC 监测
  - 光化学监测网 PAMS
  - 有毒物监测网 NATTS
- 污染源 VOC的测试
  - 污染源总VOC排放量测试
  - 污染源有毒VOCs测试
  - 工业和消费品中VOC含量测试

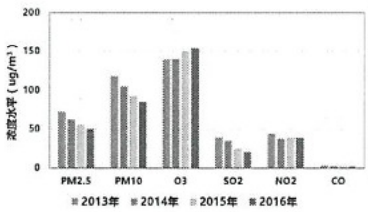
为什么要监测臭氧和VOC?

臭氧是影响人口最多的大气污染物



图片数据资料来源：美国 EPA 网站

2013~2016全国74城市指标污染物年际比较

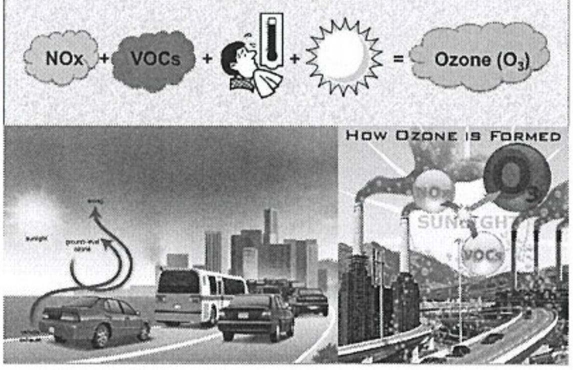


污染物	变化趋势
$PM_{2.5}$	↓30.56%
PM_{10}	↓27.97%
O_3	↑10.79%
SO_2	↓47.50%
NO_2	↓11.36%
CO	↓24.00%

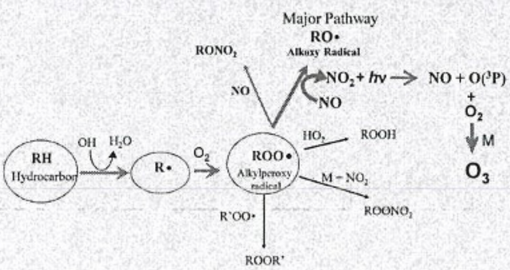
数据来源：2013~2016年中国环境状况公报

注：O_3 浓度为日最大8小时均第90百分位数；CO浓度为日均第95百分位数，单位 mg/m^3。

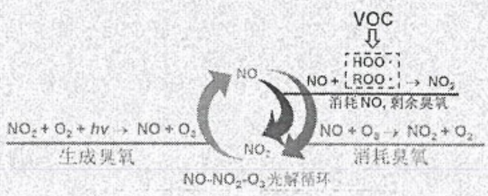
近地面臭氧的生成



臭氧生成反应途径

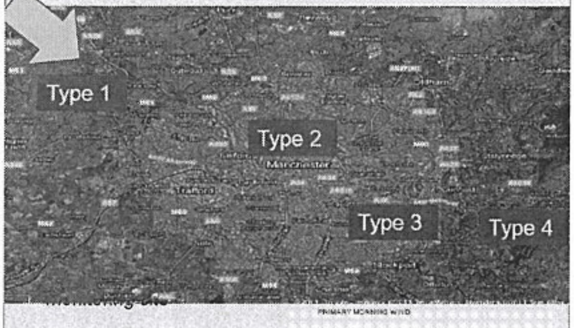


VOC如何造成 O_3 浓度上升?



氧化性: [O] > HOO· > ROO· > O_3 > O_2 > NO_2 > NO

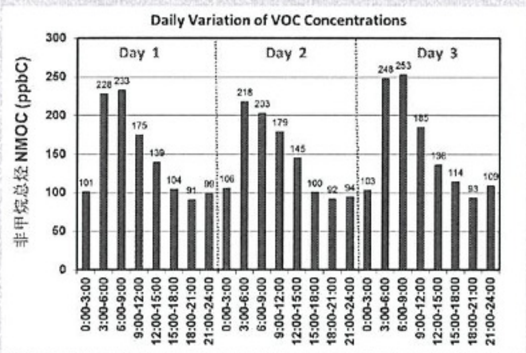
PAMS四类站点布点原则



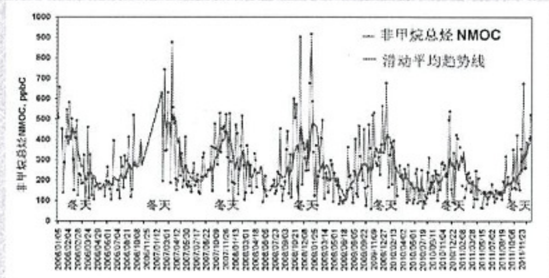
PAMS VOC 监测面临的问题 - 分析设备和技术

- 新增的目标化合物监测困难
  - 简单色谱仪器 (Auto GC类)一般用nafion dryer 除水，只适合烷烃类化合物，不适合乙醇和漩烯等极性化合物
  - 标准实验室设备，用于野外站点运维成本过高
    - 速冻除水法 – 设备成本高，某些化合物回收率仍有待验证
    - 三级冷阱法 – 野外站点液氮配给很不方便

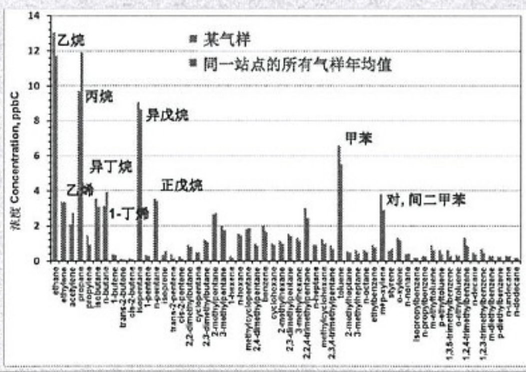
典型环境空气VOCs浓度的日变化图



典型环境空气VOCs 浓度季节变化图

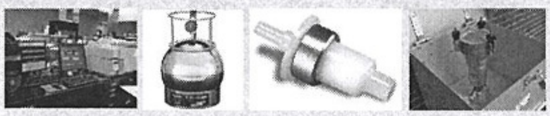


典型环境空气 VOCs 组分图



空气毒物趋势监测网 - NATTS (National Air Toxics Trends Stations)

- 网络大小: 全美27站点 (20个城市, 7个农村)，2001年开始
- 监测目的: 有毒污染物的浓度和变化趋势; 确定污染源
- 监测内容: 33个 (19个重点) 有毒污染物 (HAPS), 包含金属化合物, PAHs, VOCs, 羟基化合物Carbonyls等。
- 采样频率和要求: 每六天一个24小时混合样; 按季度算数据完整率 ≥85%; 准确度: ≤25% (多数分析物 ≤ 20%); 精确度 (重复或对比样): CV ≤15%



空气毒物趋势监测网 (NATTS)站点分布

空气毒物趋势监测网NATTS 19个重点有毒污染物

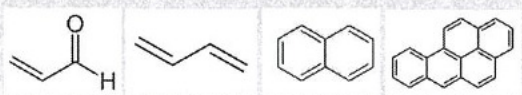
VOCs 挥发性有机物
- Acrolein 丙烯醛
- Benzene苯
- Chloroform 氯仿
- 1,3-butadiene 1,3-丁二烯
- Vinyl Chloride 氯乙烯
- Perchloroethylene 四氯乙烯
- Carbon Tetrachloride 四氯化碳
- Trichloroethylene 三氯乙烯

Carbonyls 羰基化合物
- Formaldehyde 甲醛
- Acetaldehyde 乙醛

PAHs 多环芳烃
- *Benzo(a)pyrene* 苯并(a)芘
- *Naphthalene* 萘

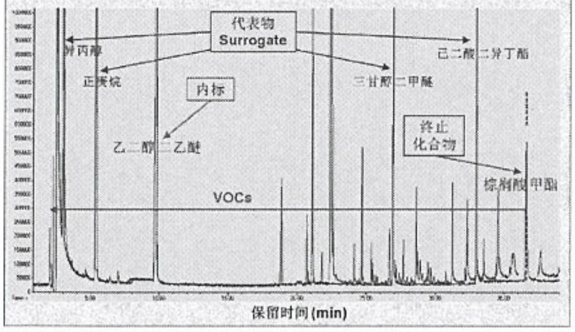
PM10 Metals 可吸入颗粒物中的金属
- Nickel compounds 镍
- Arsenic compounds 砷
- Cadmium compounds 镉
- Manganese compounds 锰
- Beryllium compounds 铍
- Lead compounds 铅

TSP Hexavalent Chromium 六价铬 Cr^{6+}
(2015年后改为选测污染物)



油漆涂料VOC测定方法 – SCAQMD Method 313

- 气相色谱, 低 VOC 含量 (<150g/L) 的油漆涂料的测试方法



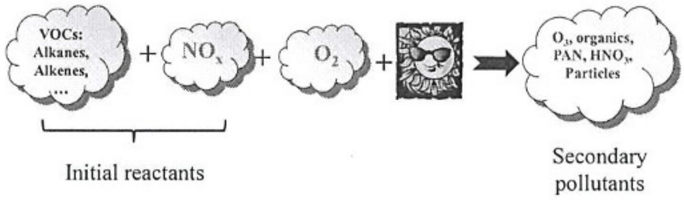
Jianhanglu@hotmail.com

WeChat: jianhanglu

Atmospheric Chemistry of Photochemical Smog:
Formation mechanism of ground-level ozone in smog

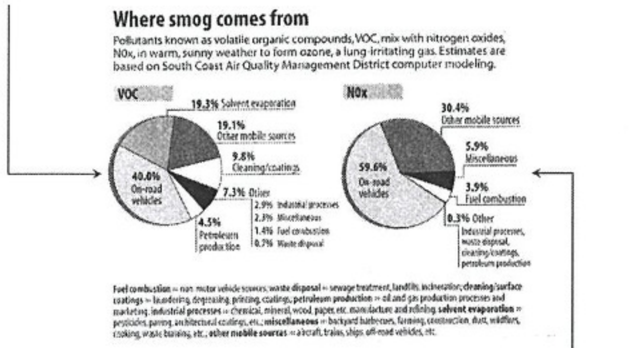
The overall reaction:

VOCs + NO + O_2 + sunlight → mixture of O_3, HNO_3, organics, particulate

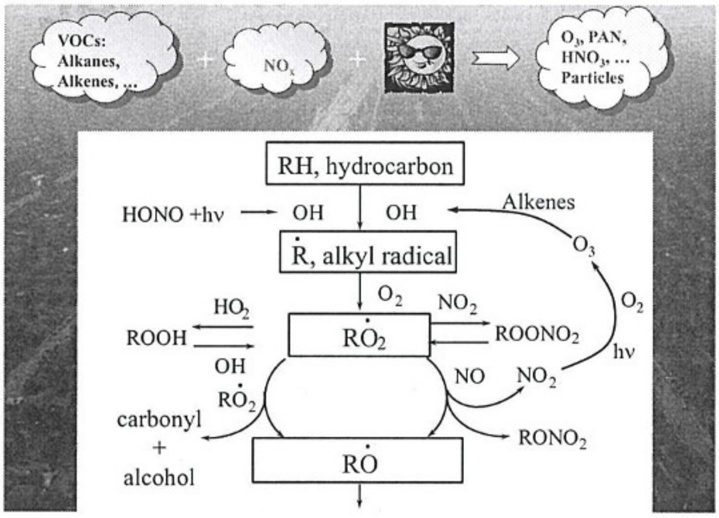


PAN: peroxyacetyl nitrate

VOCs: volatile organic compounds



$NO_x = NO + NO_2$
mainly from fuel combustion



Tropospheric chemistry: all the ingredients

$OH + RH \rightarrow H_2O + R^{\bullet}$	H abstracted, stable H_2O made.
$\dot{R} + O_2 \rightarrow ROO^{\bullet}$	Peroxy radical (ROO)
$RO\dot{O} + NO \rightarrow RO^{\bullet} + NO_2$	Peroxy radical → Alkoxy radical

$$NO_2 + h\nu \rightarrow NO + O$$

$$O + O_2 + M \rightarrow O_3 + M$$

$$\text{Net: } OH + RH + 2O_2 + h\nu \rightarrow H_2O + R\dot{O} + O_3$$

Net formation of ozone

Control strategy for ground-level ozone

Limiting VOC and NO emissions

Los Angeles: more NO_x than VOCs
Complicated by other reactions

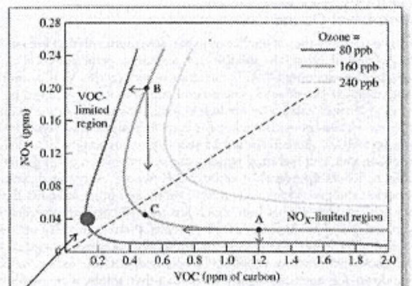
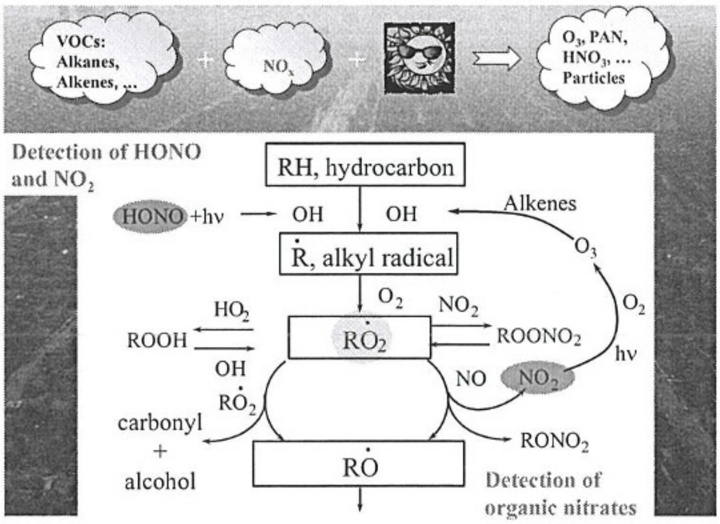


FIGURE 3-8 The relationship between NO_x and VOC concentrations in air and the resulting levels of ozone produced by their reaction. Points A, B, and C denote conditions discussed in the text. [Source: Redrawn from National Research Council, *Rethinking the Ozone Problem in Urban and Regional Air Pollution* (Washington, DC: National Academy Press, 1991).]

Eastern US: more VOCs than NO_x

Approax. current Los Angeles conditions



Ambient Air Quality Standards

Pollutant	Averaging Time	California Standards [1]		National Standards [2]		
		Concentration [3]	Method [4]	Primary [3,5]	Secondary [3,6]	Method [7]
Ozone (O_3)[8]	1 Hour	0.09 ppm (180 μg/m³)	Ultraviolet Photometry	—	Same as Primary Standard	Ultraviolet Photometry
	8 Hour	0.070 ppm (137 μg/m³)		0.070 ppm (137 μg/m³)		
Respirable Particulate Matter (PM10)[9]	24 Hour	50 μg/m³	Gravimetric or Beta Attenuation	150 μg/m³	Same as Primary Standard	Inertial Separation and Gravimetric Analysis
	Annual Arithmetic Mean	20 μg/m³		—		
Fine Particulate Matter (PM2.5)[9]	24 Hour	—	—	35 μg/m³	Same as Primary Standard	Inertial Separation and Gravimetric Analysis
	Annual Arithmetic Mean	12 μg/m³	Gravimetric or Beta Attenuation	12.0 μg/m³	15 μg/m³	
Carbon Monoxide (CO)	1 Hour	20 ppm (23 mg/m³)	Non-Dispersive Infrared Photometry (NDIR)	35 ppm (40 mg/m³)	—	Non-Dispersive Infrared Photometry (NDIR)
	8 Hour	9.0 ppm (10 mg/m³)		9 ppm (10 mg/m³)	—	
	8 Hour (Lake Tahoe)	6 ppm (7 mg/m³)		—	—	
Nitrogen Dioxide (NO_2)[10]	1 Hour	0.18 ppm (339 μg/m³)	Gas Phase Chemiluminescence	100 ppb (188 μg/m³)	—	Gas Phase Chemiluminescence
	Annual Arithmetic Mean	0.030 ppm (57 μg/m³)		0.053 ppm (100 μg/m³)	Same as Primary Standard	
Sulfur Dioxide (SO_2)[11]	1 Hour	0.25 ppm (655 μg/m³)	Ultraviolet Fluorescence	75 ppb (196 μg/m³)	—	Ultraviolet Flourescence; Spectrophotometry (Pararosaniline Method)
	3 Hour	—		—	0.5 ppm (1300 μg/m³)	
	24 Hour	0.04 ppm (105 μg/m³)		0.14 ppm (for certain areas)[11]	—	
	Annual Arithmetic Mean	—		0.030 ppm (for certain areas)[11]	—	

2016

TABLE 11.2 Detection Limits for Some Trace Gases in Air by FTIR,[a] TDLS[b], and Matrix Isolation IR[e]

Gas	FTIR detection wavenumber (cm^{-1})	FTIR detection limit[c] (ppb at L ~ 1 km)	TDLS detection wavenumber (cm^{-1})	TDLS detection limit[d] (ppb at L ~ 150 m)	Matrix isolation detection limit[e] (ppb)
SO_2	1133	25[g]	1360.7	0.5	0.01
NH_3	931 967.5 993	4 3 4	1065	0.025	
HCHO	2779, 2781.5	6	2781	0.05	0.03
HCOOH	1105	2	1107	1.0	0.02
HNO_3	896	6	1720	0.1	0.01
N_2O_5	740, 1248	4			0.02[f]
HONO	791 (*trans*) 853 (*cis*)	10			0.01
PAN	1162	3			0.05
H_2O_2	1251	40	1285.7	0.1	

[a] From Tuazon *et al.* (1980).
[b] From Schiff *et al.* (1994b).
[c] Resolution 0.5 cm^{-1}.
[d] 150 m, integration time 3–5 min.
[e] From Griffith and Schuster (1987); for a 15-L air sample.
[f] Based on laboratory spectra only.
[g] From E. Tuazon, personal communication, 1996.

4. Absorption spectroscopy (in situ)

(3) UV-vis absorption spectroscopy (in situ)

- gas absorption spectroscopy by Beer-Lambert law $I = I_0 e^{-\sigma \ell n}$
- strong absorption in UV-vis region for sensitivity
- long path for sensitivity

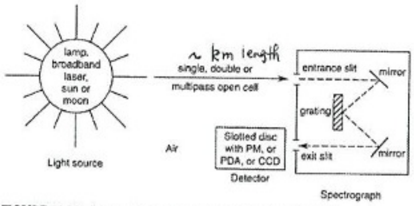


FIGURE 11.11 Schematic diagram of components of a DOAS system.

4. Absorption spectroscopy (in situ)

(3) UV-vis absorption spectroscopy (in situ)

- gas absorption spectroscopy by Beer-Lambert law $I = I_0 e^{-\sigma \ell n}$
- strong absorption in UV-vis region for sensitivity
- long path for sensitivity
- DOAS – differential optical absorption spectrometry (differential absorption cross sections: *sharp features* on top of broad feature)
- O_3, NO_2, SO_2, NO_3, HONO, etc (see table)
- sensitive but expensive

Differential absorption cross sections: *sharp features*

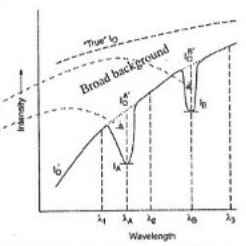


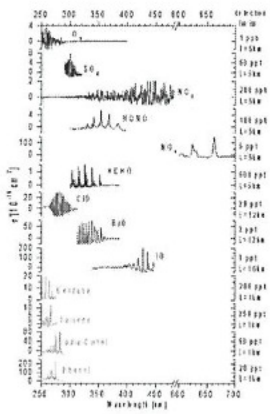
FIGURE 11.10 Light intensities relevant to DOAS spectrometry.

Finlayson-Pitts, B.J., and Pitts, J.N. (2000) *Chemistry of the Lower Atmosphere: Theory, Experiments and Applications*

TABLE 11.3 Detection Limits for DOAS Measurements of Some Gases of Atmospheric Interest Using the Slotted-Disk or Photodiode Array (PDA) Techniques[a,b]

Gas	Technique	Path length	Detection limit: Platt *et al.*[a]	Detection limit: Plane *et al.*[b]
O_3	Slotted disk	5	2 ppb	2 ppb
	PDA	5	0.17–1.4 ppb	
	PDA	15	0.2–0.45 ppb	
SO_2	Slotted disk	5	100 ppt	10 ppt
	PDA	5	50–100 ppt	
	PDA	15	16–33 ppt	
NO_2	Slotted disk	5	200 ppt	50 ppt
	PDA	5	100–200 ppt	
	PDA	15	33–66 ppt	
HCHO	Slotted disk	5	500 ppt	50 ppt
	PDA	5	200–500 ppt	
	PDA	15	66–166 ppt	
HONO	Slotted disk	5	60 ppt	30 ppt
	PDA	5	30–60 ppt	
	PDA	15	10–20 ppt	
NO_3	Slotted disk	5	2 ppt	0.4 ppt
	PDA	5	1–3 ppt	
	PDA	15	0.33–1 ppt	
OH	PDA	5	$1.5 \times 10^6\ cm^{-3}$ (0.06 ppt)	$3 \times 10^6\ cm^{-3}$ (0.12 ppt)
ClO	PDA	5	1 ppt	20 ppt
BrO	PDA	5	0.5 ppt	30 ppt
IO	PDA	5	0.4 ppt	10 ppt

[a] Adapted from Stutz and Platt (1997) and Platt and Hausmann (1994).
[b] From Plane and Smith (1995) for L = 5 km and a minimum optical density of 10^{-4}.



Atmospheric Measurements of Criteria Gaseous Air Pollutants

TABLE 11.1 Reference and Equivalent Methods Designated by the U.S. Environmental Protection Agency for Monitoring Criteria Gaseous Air Pollutants

Gas	Reference or equivalent method
NO_2	Ozone chemiluminescence Differential optical absorption spectrometry Sodium arsenite
O_3	UV absorption Chemiluminescence Differential optical absorption spectrometry
CO	Nondispersive infrared
SO_2	UV fluorescence Differential optical absorption spectrometry Pararosaniline

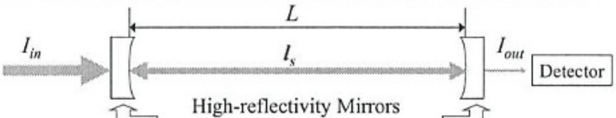
4. Absorption spectroscopy (in situ)

(4) CRDS

- **Cavity Ringdown Spectroscopy (CRDS)**
  - **Ultra-sensitive absorption technique**
  - **km effective absorption path with a table-top setup**
- **Application of CRDS in Ambient and Smog Chamber Measurements**
  - **HONO, Ambient NO_2, SO_2, NO_3, aerosol**
  - **RO_2 by PERCA**

Cavity Ring-Down Spectroscopy

Measure Rate of intensity decay instead of Magnitude of attenuation



High-reflectivity Mirrors
R ≥ 99.99 %

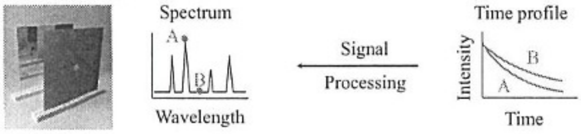
$I_{out}(t) = I_{out}^0 \cdot \exp(-t/\tau)$

$\frac{1}{\tau} = \frac{c}{L}[(1-R) + \alpha l_s]$ (on resonance with sample: A)

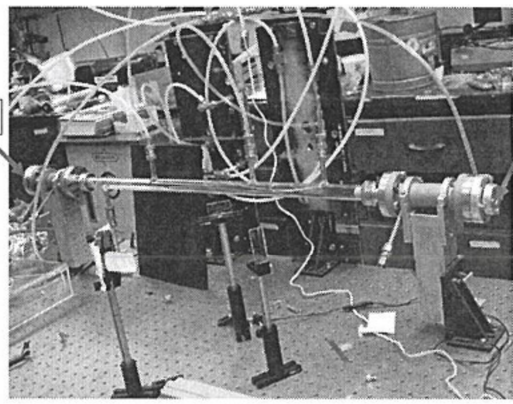
$\frac{1}{\tau_0} = \frac{c}{L}[(1-R)]$ (off resonance or without sample: B)

$\alpha = \frac{1}{c}(\frac{1}{\tau} - \frac{1}{\tau_0}) = \sigma n$ *(absorption coefficient)*

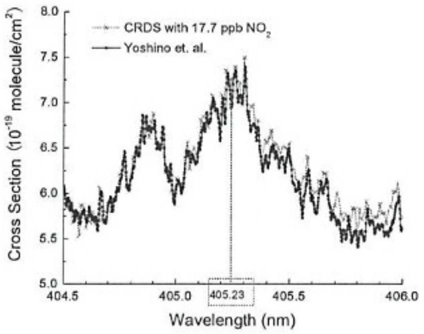
τ_0: Ringdown time without sample
τ: Ringdown time with sample
c: Speed of light
R: Cavity mirror reflectivity
αl_s: Single trip absorbance
l_s: Single path absorption length



Cavity Ringdown Spectrometer

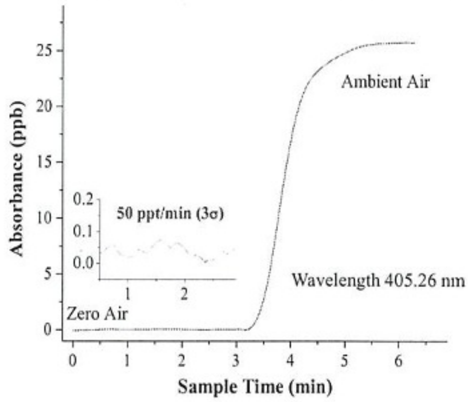


NO_2 Absorption Spectrum



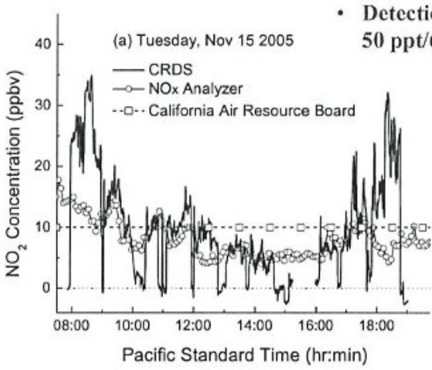
Hargrove et. al., Environ. Sci. Technol., **2006**, 40, 24, 7868

CRDS Detection Sensitivity for NO_2



Ambient Measurements of NO_2

- Detection sensitivity 50 ppt/60 s (3σ)



Hargrove et. al., Environ. Sci. Technol., **2006**, 40, 24, 7868

NO_2 and RNO_2 organic nitrate measurements

Chin. J. Chem. Phys., Vol. 30, No. 5 — NO_2 and RNO_2 by Two-Channel Thermal Dissociation CRDS

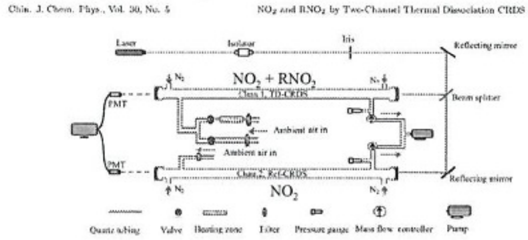
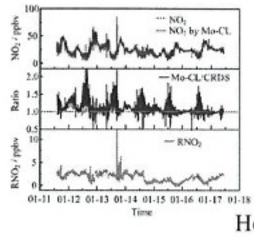


FIG. 1 Configuration of two-channel CRDS set-up.

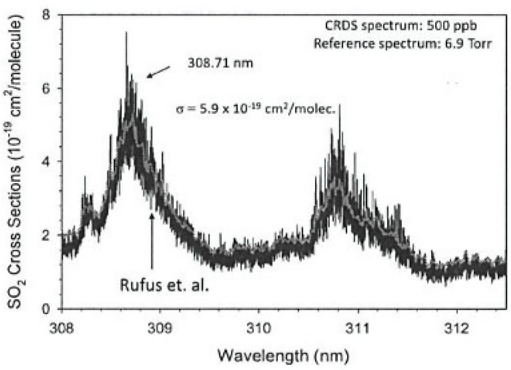
Monitoring of RNO_2

Positive bias in NO_x Chemiluminescence analyzer



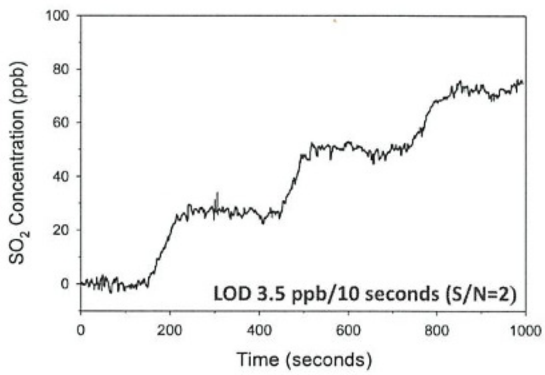
Hefei, China

SO_2 Spectrum



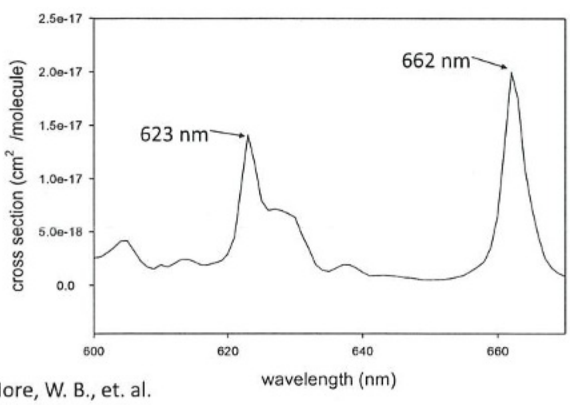
Medina, D. S. et. al, Environ. Sci. Technol., 2011, 45, (5), 1926-1931

SO_2 Step Dilution



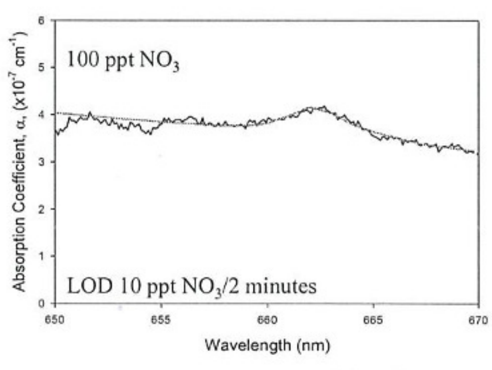
Medina, D. S. et. al, Environ. Sci. Technol., 2011, 45, (5), 1926-1931

NO_3 Absorbance Spectrum



DeMore, W. B., et. al.

Low Concentration NO_3 Spectrum



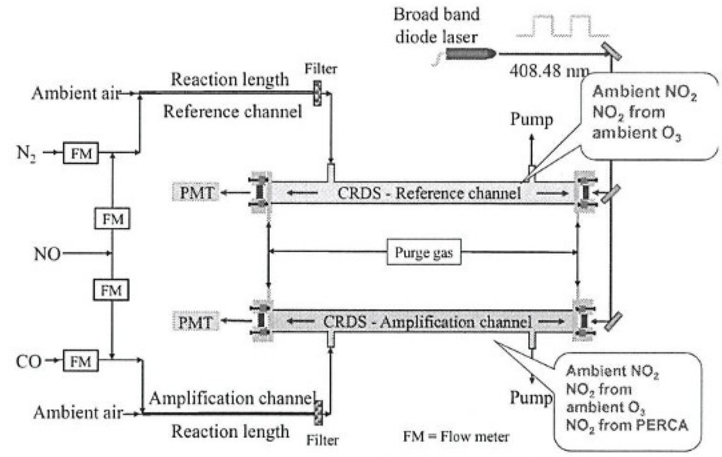
$\alpha(\lambda) = \sigma(\lambda)\, n + a_1 \lambda + a_2 \lambda^2 + b$

PERCA: background and interferences in ambient measurements

- Ambient NO_2
- Ambient ozone ($NO + O_3 \rightarrow NO_2 + O_2$)
- Ambient peroxyacetyl nitrate ($CH_3C(O)O_2NO_2$, PAN) and peroxy nitric acid (HO_2NO_2, PNA): decomposing to NO_2.

Modulation of NO

Cantrell, Stedman, Hastie, Clemitshaw, Sadanaga, Green, etc.



Y. Liu and J. Zhang, Analytical Chemistry, 2014

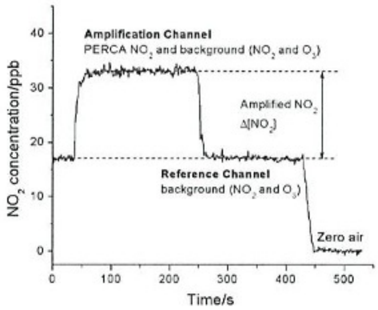
Dual-channel PERCA CRDS

Improvements from single channel:

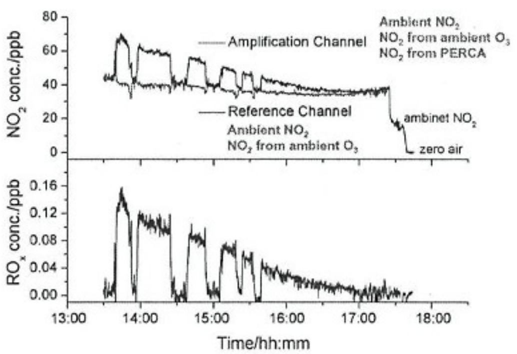
Liu, Y. et, al. Environ. Sci. Technol **43**, 7791 (2009)

- dual inlets/channels replacing upstream and downstream modulation → faster time response (~ 1 sec)
- real-time subtraction of the background → better accuracy and sensitivity and faster time response
- diode laser based CRDS → portable PERCA instruments

RO_x detection sensitivity: 4 ppt/10s (3σ)
(CL = 180)

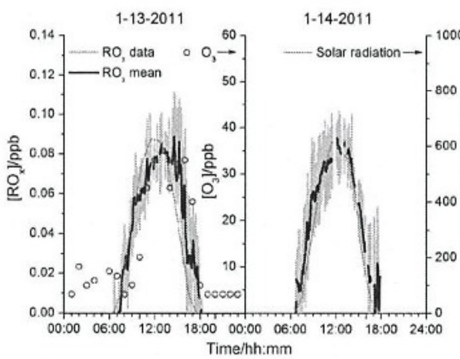


Typical ambient air measurement



Y. Liu and J. Zhang, Analytical Chemistry, 2014

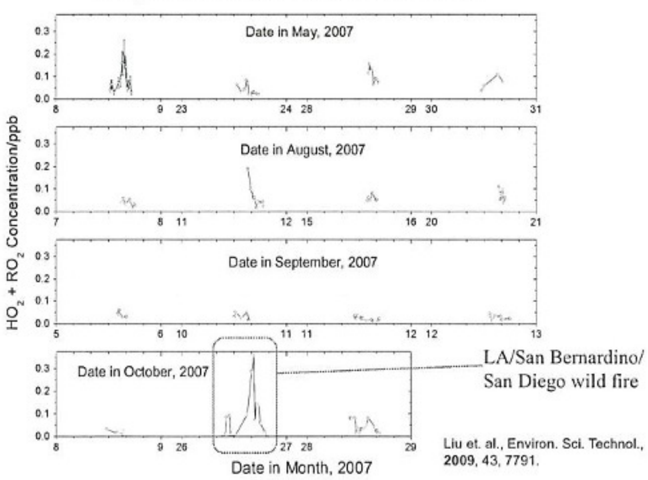
Ambient Measurements



$RO_x = \Delta[NO_2]/CL$
CL=180

Y. Liu and J. Zhang, Analytical Chemistry, 2014

RO_x Ambient Concentrations in 2007



Liu et. al., Environ. Sci. Technol., **2009**, 43, 7791.

Summary

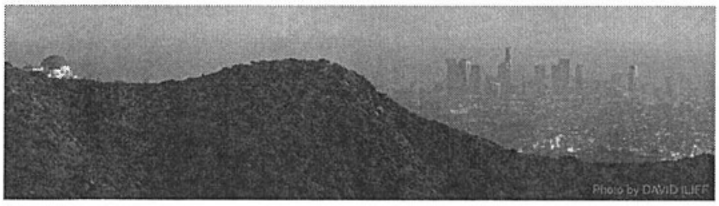
- PERCA-CRDS: a new method to measure peroxy radicals HO_2 and RO_2
- Detection sensitivity for peroxy radicals: ~4 pptv/10 s (3σ).
- Ambient measurements of peroxy radicals at Riverside were carried out.

加州移動源污染控制概述-道路機動車

Overview of Mobile Source Emission Controls in California – On-Road Motor Vehicles

李偉

August 7, 2018



Discussion Topics

- On-Road Motor Vehicles
  - New vehicle / engine emission standards
  - In-use vehicle regulations and emission tests
  - Old vehicle repair / retirement programs
  - Emission inventory
  - A few new topics
- Off-Road Road Equipment
- Facility-based Mobile Sources

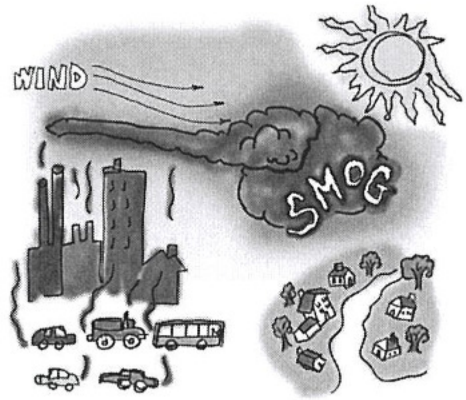
Motor Vehicle Emission Problems

Mobile Source Emission Problems

Motor Vehicle Emission Problems

Why Vehicle Emissions A Problem?

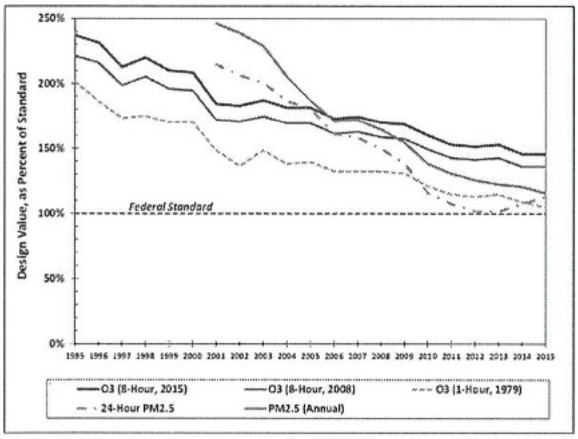
One of the Largest Sources of Smog Formation



Motor Vehicle Emission Problems

Why Vehicle Emissions A Problem?

Trends of Ozone and PM2.5 in LA Region



Motor Vehicle Emission Problems

Why Vehicle Emissions A Problem?

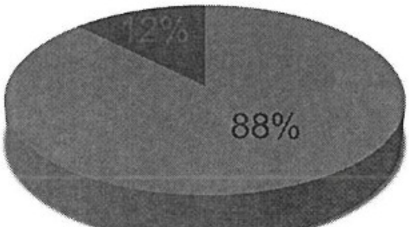
Ozone and PM2.5 Attainment Targets in LA Region

Standard	Concentration	Classification	Latest Attainment Year
2015 8-hour Ozone	70 ppb	Extreme	?
2008 8-hour Ozone	75 ppb	Extreme	2031
1997 8-hour Ozone	80 ppb	Extreme	2023
1979 1-hour Ozone	120 ppb	Extreme	2022
2012 Annual PM2.5	12 μg/m³	Serious	2025
2006 24-hour PM2.5	35 μg/m³	Serious	2019

Motor Vehicle Emission Problems

Why Vehicle Emissions A Problem?

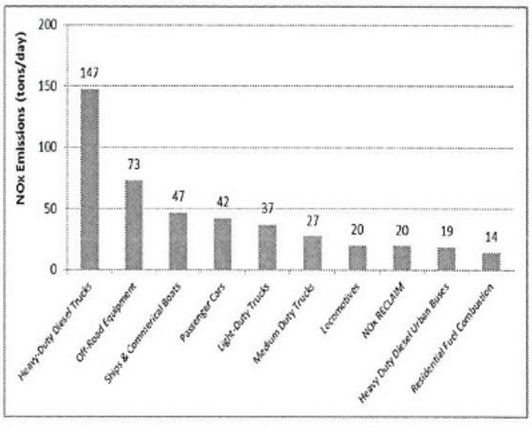
Source of NOx in LA Region: Stationary vs. Mobile



Motor Vehicle Emission Problems

Why Vehicle Emissions A Problem?

Top NOx Emissions Sources in LA Region (2012)



Motor Vehicle Emission Problems

In-Use Regulations and Emission Test Programs

California Smog Check Program

- ❖ Traditional Tailpipe Test
  - ❖ ASM test (HC,CO and NO)
  - ❖ Two-speed idle test for HC and CO
- ❖ On-Board Diagnostic (OBD) Only
  - ❖ Gasoline vehicles: model-year 2000 and newer
  - ❖ Diesel vehicles: model-year 1998 and newer
- ❖ Remote OBD?

In-Use Regulations and Emission Test Programs

Truck and Bus Regulation

Lighter Trucks and Buses (14,000 < GVWR ≤ 26,000 lbs) Compliance Schedule

Existing Engine Model Year	Replace with 2010 Engine by
1995 & older	January 1, 2015
1996	January 1, 2016
1997	January 1, 2017
1998	January 1, 2018
1999	January 1, 2019
2003 and older	January 1, 2020
2004 - 2006	January 1, 2021
2007 - 2009	January 1, 2023

In-Use Regulations and Emission Test Programs

Truck and Bus Regulation

Heavier Trucks and Buses (GVWR > 26,000 lbs) Compliance Schedule

Existing Engine Model Year	Compliance Date	
	Install PM Filter by	Replace with 2010 Engine by
1993 & older	N/A	January 1, 2015
1994 – 1995	N/A	January 1, 2016
1996 – 1999	January 1, 2012	January 1, 2020
2000 – 2004	January 1, 2013	January 1, 2021
2005 – 2006	January 1, 2014	January 1, 2022
2007 or newer	January 1, 2014 if not originally equipped	January 1, 2023

In-Use Regulations and Emission Test Programs

Heavy-Duty Vehicle Periodic Smoke Inspection Program (PSIP)

- ❖ Diesel and bus fleet owners conduct annual smoke opacity inspections of their vehicles and repair those with excessive smoke emissions to ensure compliance.
- ❖ The ARB randomly audits fleets, maintenance and inspection records and tests a representative sample of vehicles.
- ❖ All vehicles that do not pass the test must be repaired and retested.
- ❖ A fleet owner that neglects to perform the annual smoke opacity inspection on applicable vehicles is subject to a penalty of $500.00 per vehicle, per year.

Old Vehicle Repair / Retirement Programs

Old Vehicle Repair / Retirement Programs

Old Vehicle Repair / Retirement Programs

Light- and Medium-Duty Vehicles

- ❖ Statewide: Consumer Assistant Program (CAP)
- ❖ South Coast Air Quality Management District
  - ❖ High Emitter Repair Or Scrap Program I & II
  - ❖ Enhanced Fleet Modernization Program (EFMP) or Replace Your Ride
  - ❖ Rule 1610 Program

Old Vehicle Repair / Retirement Programs

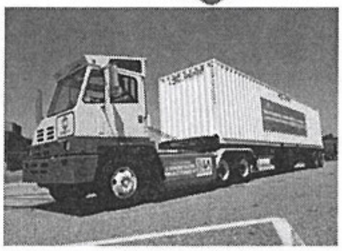
Heavy-Duty Vehicles

- ❖ Carl Moyer Memorial Air Quality Standards Attainment Program (Carl Moyer Program)
- ❖ Proposition 1B - Goods Movement Emission Reduction Program
- ❖ Clean Transportation Funding from the Mobile Source Air Pollution Reduction Review Committee (MSRC)

Emission Inventory

Emission Inventory

Zero / Near Zero Emission Engines/Trucks



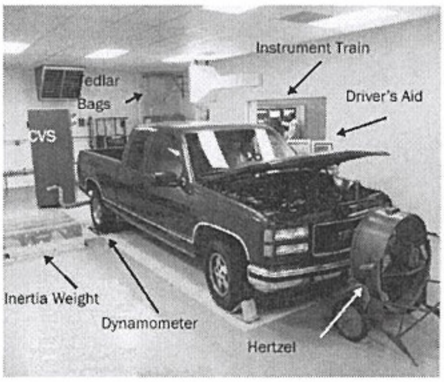
New Topics to Watch

Hot Topics

- U.S. EPA Repeals Emission Standards on Glider Kits for Heavy Trucks
- U.S. EPA Prepares to Roll Back CAFE Standard
- Proposed Heavy-Duty Engine Zero/Near-Zero Standards
- ARB Advanced Clean Truck Regulation
  - Innovative Clean Transit
  - Zero-Emission Airport Shuttle Buses
  - Last-Mile Delivery
  - Potential Zero-Emission Drayage Trucks
- SCAQMD Fleet Rule Amendment
- SCAQMD Facility Based Control Measures

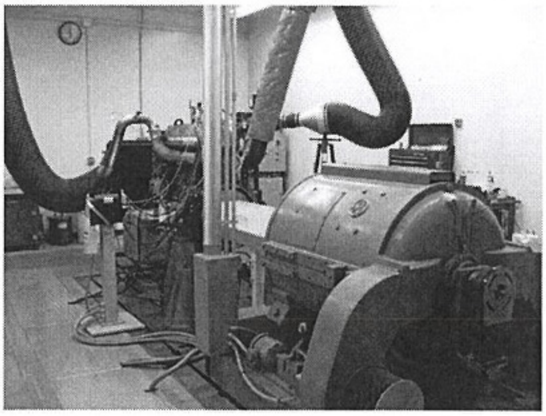
Emission Certification vs. Real-World Emissions

Chassis Dynamometer + CVS + Analyzer



Source: CARB's Emission Inventory Series, Vol.1,Issue 9

Heavy-Duty Engine Dynamometer



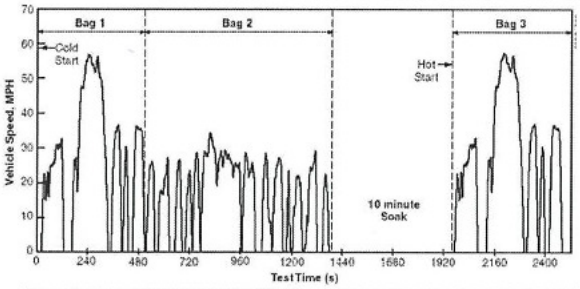
Heavy-Duty Chassis Dynamometer

Study Methods for Real-World Emissions

- Portable Emission Measurement System (PEMS)
- Mobile Emission Laboratory
- Remote Sensing
- Tunnel Study
- Chase Study
- Other Study Methods

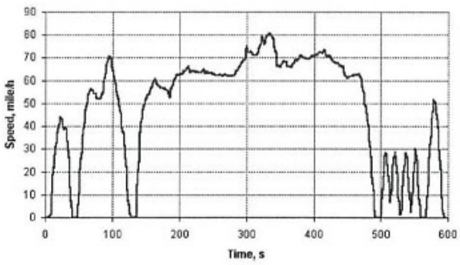
Supplemental Material

United States: FTP-75 Cycle



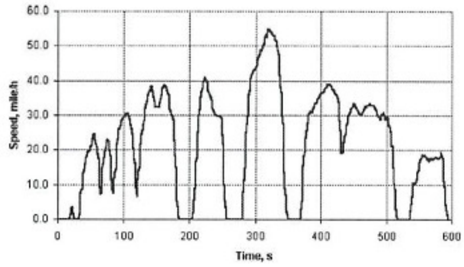
Distance	17.77 km (11.04 miles)
Duration	505+864+505=1874 sec (soak time not included)
Average Speed	34.1 km/h (21.2 mph)
Maximum Speed	91.2 km/h
Maximum Acceleration	1.6 m/s²

SFTP: US06



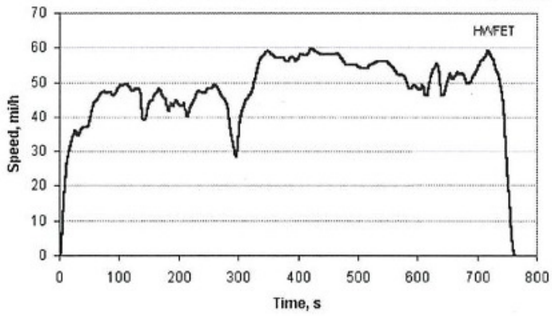
Distance	12.8 km (8.01 miles)
Duration	596 sec
Average Speed	77.9 km/h (48.4 mph)
Maximum Speed	129.2 km/h (80.3 mph)

SFTP: SC03



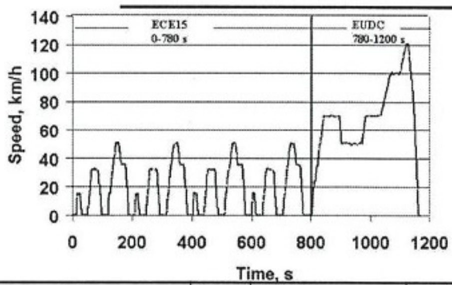
Distance	5.8 km (3.6 miles)
Duration	596 sec
Average Speed	34.8 km/h (21.6 mph)
Maximum Speed	88.2 km/h (54.8 mph)

Highway Fuel Economy Test (HWFET) Cycle



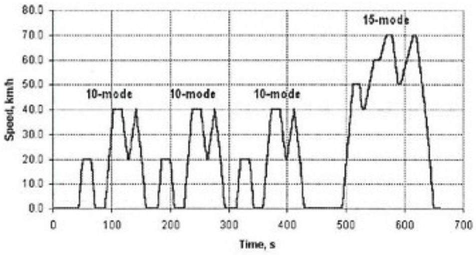
Distance	10.26 miles (16.45 km)
Duration	765 sec
Average Speed	48.3 mi/h (77.7 km/h)

European Union: ECE15-04+EUDC Cycle



Characteristics	Unit	ECE15	EUDC
Distance	km	4×1.013=4.052	6.995
Duration	sec	4×195=780	400
Average Speed	km/h	18.7 (with idling)	62.6
Maximum Speed	km/h	50	120
Maximum Acceleration	m/s²	0.487	0.395

Japan: 10-15 Mode Cycle



- Distance traveled: 4.16 km
- Duration: 660s
- Average speed: 22.7 km/h

Source: http://www.dieselnet.com/standards/cycles/ (all above 3 charts)

USEPA Tier 3 Standards

Bin	NMOG+NOx	PM*	CO	HCHO
	mg/mi	mg/mi	g/mi	mg/mi
Bin 160	160	3	4.2	4
Bin 125	125	3	2.1	4
Bin 70	70	3	1.7	4
Bin 50	50	3	1.7	4
Bin 30	30	3	1.0	4
Bin 20	20	3	1.0	4
Bin 0	0	0	0	0

Source: DieselNet

California Ports Emission Reduction Near-Zero Emission and Zero Emission Technologies

Eddy Huang, Ph.D.
August 7, 2018

Outline

- California Ports Emission Sources
- Near-Zero Emission (NZE) and Zero Emission (ZE) Technologies
  - Low NOx and Renewable Natural Gas
  - Hybrid CNG/LNG/Battery
  - Battery Electric
  - Hydrogen and Fuel Cells

2016 Port of Los Angeles Emission Sources

	PM_{10} tons	$PM_{2.5}$ tons	DPM tons	NO_x tons	SO_x tons	CO tons	HC tons	CO_2e MT
2016								
Ocean-going vessels	60	56	47	3,200	106	273	128	207,693
Harbor craft	27	25	27	751	1	487	78	58,348
Cargo handling equipment	6	6	5	435	2	752	69	159,658
Locomotives	28	27	28	780	1	191	44	67,387
Heavy-duty vehicles	8	8	8	1,857	4	139	36	388,411
Total	130	121	115	7,023	114	1,842	355	881,496

NZE and ZE Strategies

- Heavy Duty Vehicle (HDV):
  - NZE - Low NOx/Renewable Natural Gas, battery-electric hybrid with an LNG range extender fueled by RNG
  - ZE - Battery Electric, Hydrogen and Fuel Cells
- Cargo Handling Equipment (CHE):
  - NZE - Low NOx/Renewable Natural Gas, Hybrid Electric
  - ZE - Battery Electric, Hydrogen and Fuel Cells
- Ocean Going Vessel (OGV):
  - ZE - Shore Power
- Locomotive:
  - NZE - Low NOx Natural Gas, Hybrid CNG/Battery

NZE Technologies for HDV

- CUMMINS WESTPORT 2018 ISX12N
  - Ultra Low NOx emission
  - Low NOx standard of 0.02 g/bhp-hr

- Hybrid Electric
  - Battery-electric
  - With a LNG range extender fueled by RNG

ZE Technologies for HDV

- Battery Electric
  - BAE Systems
  - BYD
  - Orange EV T-Series
  - Tesla
  - TransPower

- Hydrogen Fuel Cells

Advanced Yard Tractor Demonstration

- Low NOx Natural Gas Yard Tractors 低氮氧化物排放瓦斯场车
  - Capacity yard tractors equipped with the Cummins-Westport near-zero 0.02 gram/bhp-hr NOx engine 备有Cummins-Westport近零排放0.02g/bhp-hr的引擎

- Battery Electric Yard Tractors 电池驱动场车
  - BYD Yard Tractors 比亚迪电池电动场车
- Battery Electric Top Handlers电池驱动集装箱正面吊运机
  - Taylor Top Handlers Taylor正面吊运机

Advanced Yard Tractor POLA Estimated Benefits

- LNG Yard Tractors (3): RNG fuel ⇒ 100% PM and 97% NOx emission reductions 液化瓦斯场车使用再生瓦斯燃料，可达100%颗粒物减排,97%氮氧化物减排
- Electric Yard Tractors (2): 100% reduction of all pollutants 电动场车：各种空气污染物100%减排
- Projected total emission reductions 预估总减排量
  - 1,099 tons per year (TPY) CO2e 年减1,099吨二氧化碳
  - 240 LB diesel particulate matter (DPM) 240磅柴油颗粒物
  - 12,820 LB nitrogen oxides (NOx) 12,820磅氮氧化物

ROLE OF ATTORNEYS AT SCAQMD AND AIR QUALITY LITIGATION

Daphne Hsu, Esq.
South Coast Air Quality Management District

August 7, 2018

AIR QUALITY MANAGEMENT

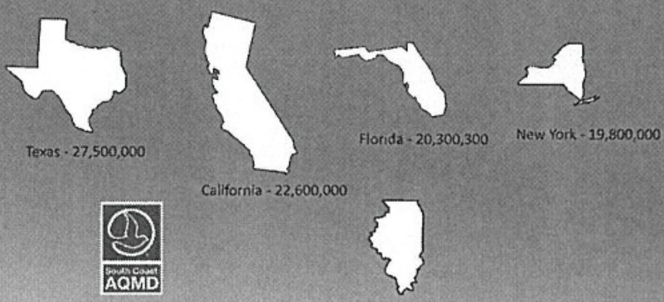
U.S. Environmental Protection Agency	*California Air Resources Board*	*Local Air Districts*
• Adopts health-based national air quality standards • Adopts tailpipe emission standards for out-of-state mobile sources (trucks, trains, buses) and in-state trains • Oversees state clean air plans	• Adopts health-based state air quality standards • Adopts in-state tailpipe emission standards for cars, trucks and busses. • Approves local air district clean air plans	• Monitor air quality; Issue health alerts • Prepare clean air plans • Primary responsibility for all sources of air pollution, other than tailpipe emission standards for motor vehicles • Respond to nuisance complaints

LOCAL AIR DISTRICTS

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

South Coast Basin:
4-county region
10,000 sq. miles
Almost 17 million residents
Millions of gasoline vehicles
Hundreds of thousands of diesel vehicles

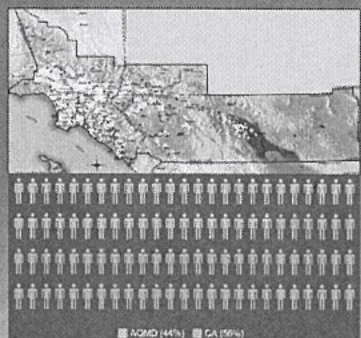
SCAQMD POPULATION



SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

4 Counties of
- Los Angeles
- Orange
- San Bernardino
- Riverside

44%
State's population in South Coast



SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT GENERAL COUNSEL'S OFFICE (法務辦公室)

- Perform in-house work (執行內部工作)
- Assist in rulemaking (協助制定法規)
- Ensure compliance with laws that apply to government agencies (確保政府組織內有符合法規)
- Pursue violators (追查違規者與違規事項)
- Represent the agency in civil matters (民事事務上代表本機關)

COMPLIANCE WITH LAWS THAT APPLY TO GOVERNMENT AGENCIES 政府組織裡的法規符合性審查

- Review potential conflicts of interest (檢查是否有利益衝突的可能性)
- Ensure open meetings laws are followed (確保會議公開流程)
- Assist in fulfilling public records requests (協助公共資訊索取申請)

HEARING BOARD RESPONSIBILITIES
聽證會的責任

- Appeals of denials of applications for ERC
  ERC申請被拒絕的上訴案件
- Permit appeals
  許可的上訴案件
- Petitions for variances
  暫時性寬限申請的請願案件
- Petitions for orders for abatement
  強制減排的請願案件

VARIANCES
暫時性的寬限申請

If a facility is out of compliance (or will be in the future) due to circumstances out of its control, it may request temporary relief from specific regulations and permit conditions.

如果某個設施在它無法控制的情況下而不符合法規時，它可請求在特定法規和許可條件裡暫時性的寬限。

VARIANCES

- Emergency
- Short
- Regular
- Interim
- Product

SIX FINDINGS REQUIRED FOR A VARIANCE
暫時性寬限申請的六項裁決要素

(1) Petitioner is or will be in violation.
(2) The violation is beyond a petitioner's reasonable control or will result in an unreasonable taking. Whether the petitioner is providing an essential public service is considered.
(3) Closing or taking would not have a corresponding benefit in reducing air contaminants.
(4) The petitioner considered curtailing operations instead of applying for a variance.
(5) Petitioner will reduce excess emissions to the maximum extent feasible.
(6) Petitioner will monitor and quantify emissions.

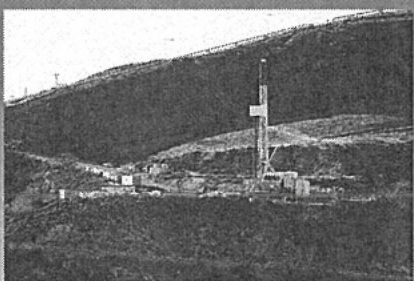
FIVE FINDINGS REQUIRED FOR A PRODUCT VARIANCE
暫時性寬限申請結果的五項裁決要素

(1) The manufacture, distribution, offering for sale, sale, application, soliciting the application, or use of the product is, or will be, in violation of a rule, regulation, or order of the district.
(2) Due to conditions beyond the reasonable control of the petitioner, requiring compliance would result in either (A) an arbitrary or unreasonable taking of property, or (B) the practical closing and elimination of a lawful business.
(3) The taking or closing would be without a corresponding benefit in reducing air contaminants.

FIVE FINDINGS REQUIRED FOR A PRODUCT VARIANCE (CONT'D)
暫時性寬限申請結果的五項裁決要素

(4) The petitioner exercised due diligence in attempting to locate, research, or develop a product that is in compliance with district rules and regulations.
(5) During the period that the product variance is in effect, the petitioner shall quantify any excess emissions to the maximum extent feasible and report the emission levels to the district, if requested by the district.

GAS LEAK AT ALISO CANYON



Aliso Canyon gas leak site, photo by Scott L / CC by 2.0

SIX FINDINGS REQUIRED FOR A VARIANCE
暫時性寬限申請的六項裁決要素

(1) Petitioner is or will be in violation.
(2) The violation is beyond a petitioner's reasonable control or will result in an unreasonable taking. Whether the petitioner is providing an essential public service is considered.
(3) Closing or taking would not have a corresponding benefit in reducing air contaminants.
(4) The petitioner considered curtailing operations instead of applying for a variance.
(5) Petitioner will reduce excess emissions to the maximum extent feasible.
(6) Petitioner will monitor and quantify emissions, if requested by the District.

CLEAN AIR ACT AND CALIFORNIA HEALTH AND SAFETY CODE SETTLEMENTS
清潔空氣法和加州健康和安全法和解協議內容

- More than $15 billion
  - Includes $3 billion in environmental mitigation projects
- Offer buyback or lease termination
- Corporate governance reforms
- Vehicle testing

FUNDS TO REDUCE NOx EMISSIONS
NOx 減排基金

- Volkswagen to invest $800 million in ZEV projects in California over a 10-year period
  - Installing ZEV fueling infrastructure (electric- and hydrogen-powered cars), funding brand-neutral consumer awareness campaigns to grow the ZEV vehicle market, and investing in projects such as car-sharing programs to increase access to ZEVs for all consumers in California
- Volkswagen Environmental Mitigation Trust provides about $423 million for California
  - Focused on scrap and replace projects in heavy duty sector
  - SCAQMD to implement $150 million in projects

CRIMINAL PLEA
刑事訴訟

- $2.8 billion criminal penalty
- Independent compliance monitor during 3-year probation
- Cooperation in ongoing investigation

CONSUMER LITIGATION
消費者訴訟

- Most American owners agreed to take part in a $25 billion settlement
- About 2,000 owners opted out

QUESTIONS

Daphne Hsu
dhsu@aqmd.gov

Economic Incentive Program

Discussion of Lessons Learned from a Cap-and-Trade Program

Susan Tsai

Program History

- Economic Recession in Early 1990's
- High Abatement Cost for Command and Control Rules
- Time & Resources for Adopting each Command and Control Rule
- Alternative Compliance Strategy Options:
  - Emission Taxes/Fees
  - Emission Trading

Program History

REgional Clean Air Incentive Market Program (RECLAIM)

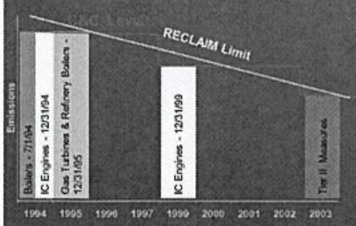
- Adopted in October 1993
- Started in January 1994
- Included largest NOx and SOx sources
- Specifies facility declining annual emissions caps
- Allows facilities options to reduce emissions or buy RECLAIM Trading Credits (RTCs)

Program Objectives

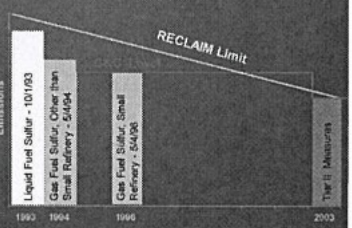
- Meet Same Level of Emission Reductions
- Enhance Emission Monitoring for Higher Compliance Confidence
- Providing Additional Flexibility to Lower Compliance Cost

Program Objectives
Same Level of Emission Reductions

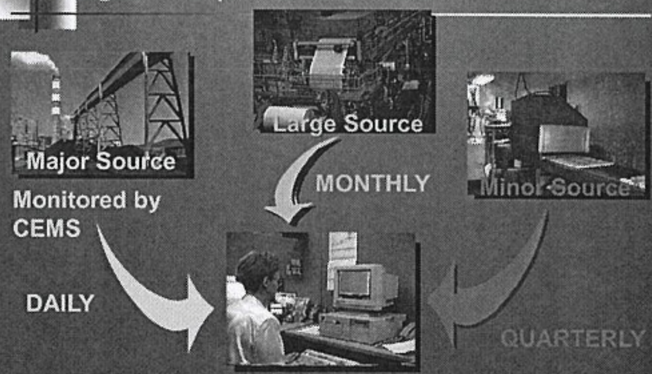
C&C NOx Emission Reduction Measures



C&C SOx Emission Reduction Measures



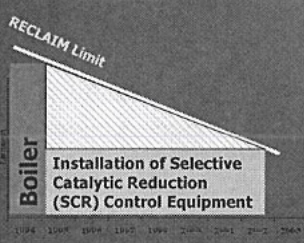
Program Objectives
Higher Compliance Confidence

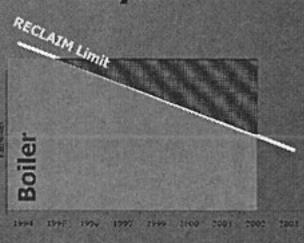


*Process Units and Rule 219-Exempt Equipment

Program Objectives
Same or Lower Cost

Seller ⟷ **Buyer**





- Emission reduction = Financing for technology
- Emission exceedance for which RTC's need to be purchased

Program Benefits

- For Facilities
  - Maximum Flexibility
  - Lower Compliance Costs Through Credit Trading
  - Replaced 30+ Adopted and 12 Potential Rules
- For Environmental Quality
  - Equivalent or Better Emissions Reductions
  - Promotes Control Technology Development
  - Enhanced Emission Monitoring
  - Control on Alternative Sources

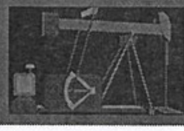
Market Participants

- RECLAIM Facilities
- Brokers
- Commodity Traders
- Individual Investors
- Mutual Funds

Participation
Major NOx Traders

Buyers:
- Utilities
- Large Refineries
- Asphalt Batch Plants
- Metal Processing

Sellers:
- Small Refineries
- Utilities
- Shut Down Facilities

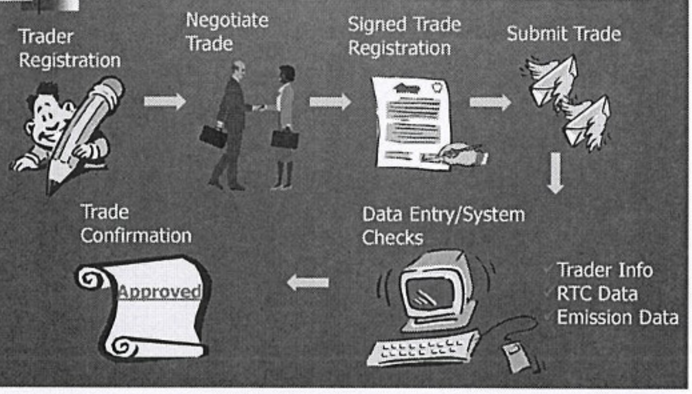


Participation
Major SOx Traders

Buyers:
- Large Refineries
- Utilities

Sellers:
- Small Refineries
- Malt Manufacturing
- Shut Down Facilities

Trading Steps

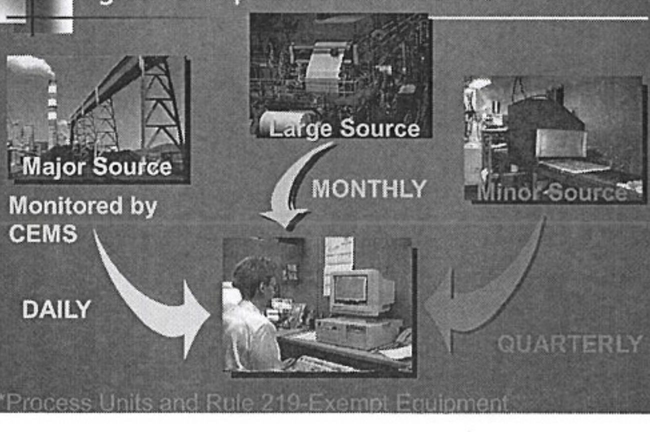


RTC Trades

- Over $1.48 billion RTCs traded since inception of RECLAIM in 1994
- Over $6.86 million of RTCs traded in Calendar Year 2017 (compared to $118.6 million in Calendar Year 2016, decrease of 94%)

Monitoring, Reporting, and Recordkeeping (MRR)

Program Objectives
Higher Compliance Confidence



Major Sources

- Major Sources–devices with greatest emission potential.
- Examples:
  - External combustion device with max. capacity ≥ 40 mmbtu/hr and annual heat input > 90 billion btu
  - External combustion device with max. capacity ≥ 500 mmbtu/hr
  - Internal combustion engine ≥ 1000 bhp and operated more than 2,190 hrs/year

Facility Audit

- Annual Audit of Each Facility
- Review Operational Records
- Check CEMS Operations
- Review Test Results

Facility Audit

- Emission Calculation Verifications
  - Gather Raw Emission Data
- RECLAIM Inspection Points
  - Equipment Inspection
  - Emission Monitoring
  - Emission Reporting
- Command and Control Inspection
  - Equipment Inspection
  - Operations Conform to Permit Conditions

Facility Audit

- Compliance Actions
- Facility Audit Report
- Data compiled for Annual RECLAIM Report

Annual RECLAIM Report

Annual Audit Report

- RECLAIM Elements
  - Universe
  - Programmatic Compliance
  - Facility Compliance
  - Job Impacts
- RTC Allocations and Trading
- Interaction with Other Programs
  - New Source Review Activity
  - Air Quality and Public Health Impacts

RECLAIM ELEMENTS
Universe

Universe Changes

- Inclusions
- Exclusions
- Facilities Permanently Ceasing Operations

RECLAIM Universe Changes	NOx Facilities	SOx Facilities
Universe – January 1994	390	41
Universe – June 30, 2017	262	30

RECLAIM ELEMENTS
Facility Compliance

- Allocation Compliance
  - Compliance Status
  - Impact of Missing Data Procedures
- Emissions Monitoring
  - CEMS Compliance Status
  - Semiannual and Annual CEMS Assessments
- Emissions Reporting

RECLAIM ELEMENTS
Job Impacts

Job Impacts

- Based on Employment Survey
- Number of Job Gains and Losses attributed to RECLAIM
- Reasons for Job Gains and Losses

California Energy Crisis
Background

- Southern California relied on imported electricity except for summer peaks
- High demand for local power generation
  - 17 power-producing facilities
- Operation of plants above permitted levels
  - Governor's Executive Order
- Power plants were not fully controlled
- Old uncontrolled units put online

California Energy Crisis
Effects

- Accelerated demand for credits
- Skyrocketing credit prices
- Ability of Power Plants to pass-on costs to consumers
- Non-power producing facilities
  - in violation due to credit shortages
  - forced to compete for remaining credits at inflated prices

California Energy Crisis
Effects

- Emissions exceeded allocations for 2000
- Prices exceeded threshold set in Rule 2015 - Backstop
- Initiated program review
- Rule amendment adoption (May 11, 2001)

California Energy Crisis
Amendments to the Program

- Required power plants to file compliance plans on installation of controls (Best Available Retrofit Control Technology - BARCT)
- Temporary exclusion of Power Plants from market participation
- Set up Emission Mitigation Program for Power Plants

Program Adjustments

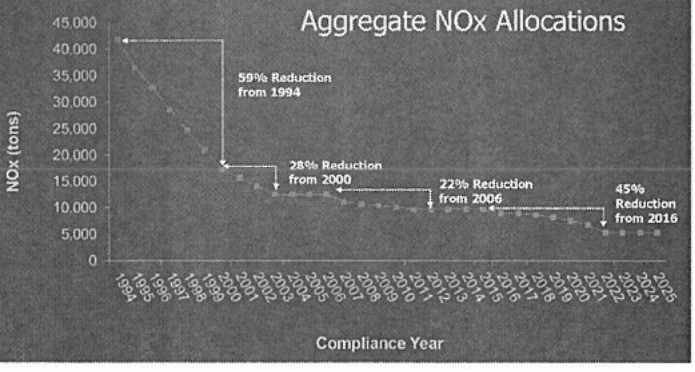
RECLAIM Rules Amended 24 Times Since Adoption in 1993

- Implementation Issues (examples):
  - Time allowed for monitor installations
  - Emission calculation methodologies
  - Source test requirements and frequency
  - Reporting methodologies
  - Allocation calculation methodologies

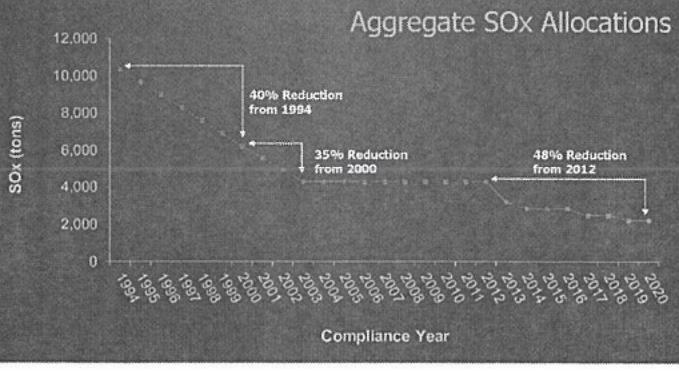
Program Adjustments

- Program Detail
  - Extend program beyond 2010
  - Address the RTC pricing issue during energy crisis
  - Allow facilities to exit program
- Allocation Reductions
  - NOx shave of 22.5% implemented in 2011
  - SOx shave of 48.4% implemented in 2013 – 2019
  - Additional NOx shave of 45.2% implemented in 2016 – 2022

Program Objectives
Same Level of Emission Reductions



Program Objectives
Same Level of Emission Reductions



美国与加州空污排放许可证制度简介

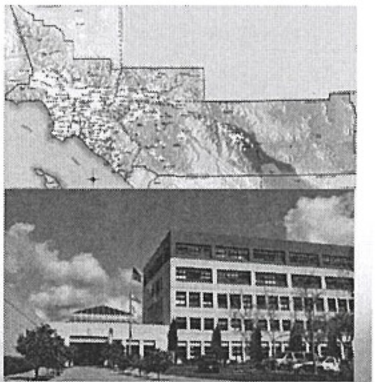
Jay Chen (陈 爵), P.E.
2018年8月7 - 8日
南加華人环保协会空气质量讲座

加州空气质量管理机构

- 州政府:
  - 空气资源委员会(Air Resources Board)
  - 监管机动车排放及消费品
  - 监督区域和地方机构
- 区域与地方政府:
  - 共35个独立的空气质量管理局
  - 监管固定污染源
  - 南海岸空气质量管理局(SCAQMD)是最大的机构

南海岸空气质量管理局(SCAQMD)

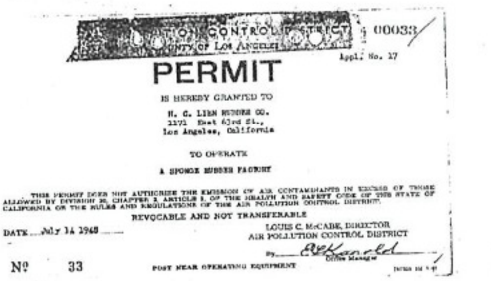
- 美国加州的区域空气污染治理机构(管理区域覆盖橙郡以及洛杉矶, 河滨与圣贝纳迪诺等郡非沙漠区)
- 全美空气质量最差(臭氧&PM 2.5)
- 1千7百万 居民
- 26,000平方公里
- 下辖27,000固定源
- 每年处理近10,000件许可证申请
- 13位理事会委员, 约800位员工



加州空气污染管控系统

- NAAQS
  - 国家与州环境空气质量标准
- SIP
  - 州执行计划(包含区域空气质量管理计划&移动源管控措施)
- AQMP
  - 空气质量管理计划(包含管控措施&监测系统)
- 法规
  - 实施管控措施 & 国家排放标准
- 许可证
  - 执行法规,登记排污设备&收费
- 执法
  - 确保达标&公平的竞争环境

洛杉矶郡空气污染管制局于1947年实施许可证制度，图为1948年發出的許可证


PERMIT

IS HEREBY GRANTED TO

H. C. LIEN RUBBER CO.
1171 East 63rd St.,
Los Angeles, California

TO OPERATE

A SPONGE RUBBER FACTORY

THIS PERMIT DOES NOT AUTHORIZE THE EMISSION OF AIR CONTAMINANTS IN EXCESS OF THOSE ALLOWED BY DIVISION 20, CHAPTER 2, ARTICLE 1, OF THE HEALTH AND SAFETY CODE OF THE STATE OF CALIFORNIA OR THE RULES AND REGULATIONS OF THE AIR POLLUTION CONTROL DISTRICT.

REVOCABLE AND NOT TRANSFERABLE

DATE July 14 1948

LOUIS C. McCABE, DIRECTOR
AIR POLLUTION CONTROL DISTRICT

By ________ Office Manager

№ 33

POST NEAR OPERATING EQUIPMENT

加州于1975年立法制订空污排放许可证制度

Health and Safety Code Section 42300(a):

Every district board may establish, by regulation, a permit system that requires, except as otherwise provided in Section 42310, that before any person builds, erects, alters, replaces, operates, or uses ***any article, machine, equipment, or other contrivance*** *which may cause the issuance of air contaminants, the person obtain a permit to do so from the air pollution control officer of the district.*

What Requires California Air Permit?

- Any equipment, the use of which may cause the issuance of air contaminants (a.k.a. the Basic Equipment)
- Any equipment, the use of which may eliminate, reduce, or control the issuance of air contaminants (a.k.a. the Control Equipment)
- Exempt equipment is clearly defined and includes:
  - Self-propelled mobile equipment
  - Small combustion equipment (e.g., engines < 50 HP, natural gas fired boilers < 2 MMBtu/hr)
  - Comfort air conditioning systems
  - Fuel Cells
  - Equipment exclusively for dwellings of up to 4 families

加州空污许可证制度特色

- 由区域空气质量管理局进行管理
- 以设备为基础的许可证（也叫许可单元）和相关法规
  - 空气污染物排污设备
  - 空气污染物防治设备
- 许可程序分成两步
  - 建设许可 (Permit to Construct, P/C)
  - 操作许可 (Permit to Operate, P/O)
- 收费用于支持清洁空气行动，包括：
  - 用于许可项目而收取的许可证手续费
  - 用于现场监察项目而收取的每年许可费
  - 用于监测、规划和法规制定而收取的每年排污费

许可证审批规定重点二
- 新源审核 (续)

- Key Requirements for Non-Attainment Air Pollutants (a.k.a. NA-NSR or NSR):
  - BACT /LAER Analysis
    - Major Source: achieved-in-practice or transferable technologies
    - Minor Source: published guidelines or cost-effectiveness analysis
  - Dispersion Modeling to demonstrate compliance with State and National AAQS (not required for VOC)
  - Emissions Offset
- Key Requirements for Attainment Air Pollutants (a.k.a. Prevention of Significant Deteriation, PSD):
  - BACT/LAER
  - Dispersion Modeling to demonstrate compliance with NAAQS and PSD increments (not required for VOC & GHG)

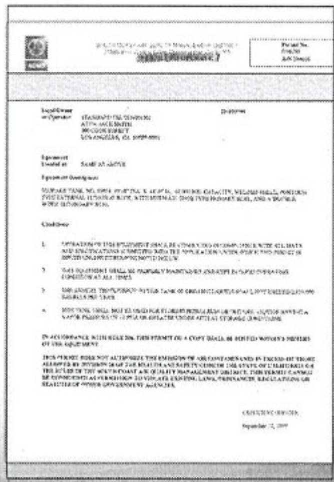
许可证审批规定重点三
- 有毒/有害污染物新源审核

- Apply to New or Modified Equipment (Permit Unit) with increase in toxic emissions
- Based on standardized Health Risk Assessment approach, instead of limiting individual compounds
- Health Risk Limits (for each Permit Unit):
  - Max. Individual Cancer Risk
    - 1 in a million (10^{-6}) without using BACT for Toxics (T-BACT)
    - 10 in a million (10^{-5}) with T-BACT
  - Cancer Burden: 0.5 cancer cases
  - Hazard Indices: 1.0 based on Reference Concentrations

许可条件

- 许可条件有四大主要类别
  - 排放限值
  - 替代参数（例如过程速率、参数以及其他变量）
  - 合规核查（监测和检测）
  - 保管记录和报告
- 其他许可条件，例如
  - 一般管理条件
  - 大污染源管理条件
  - 排放交易（RECLAIM） 监测和检测要求
  - 联邦有毒污染物管控条例的额外要求

设备许可证示例 (储缶)



Questions or Comments?

Jay Chen, P.E.
Contact Information
Email:
jaychen49@yahoo.com
Phone:
(626) 617-8811

整厂许可证示例（封面，共465页）

Benefit-Cost Considerations in Air Quality Management

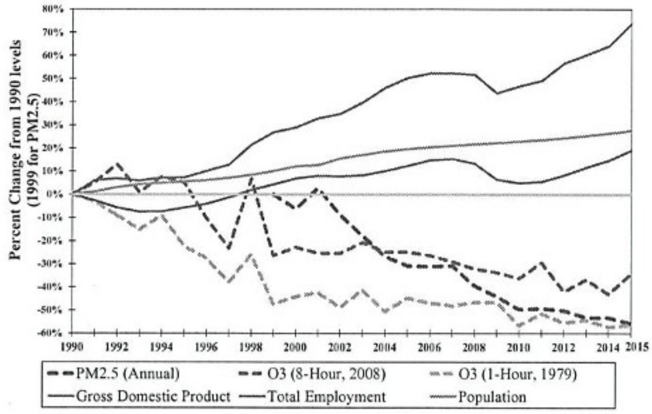
South Coast AQMD

Elaine Shen, Ph.D.
Program Supervisor – Mobile Source/ISR
Planning, Rule Development and Area Sources

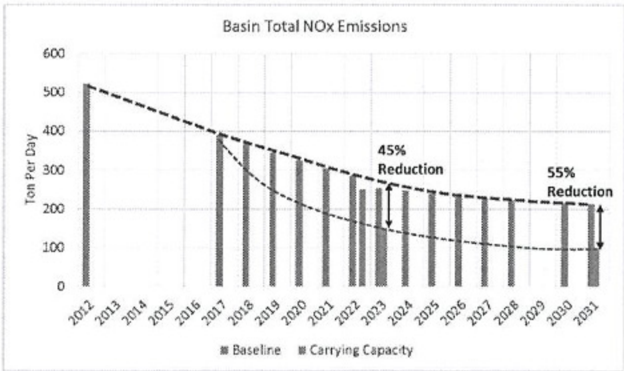
SCCAEPA Los Angeles Environmental Forum
Air Quality Workshop
August 8, 2018

Cleaning The Air That We Breathe...

Air Quality Improved Amid Population and Economic Growth



Air Quality Challenges Over Next Decade and a Half



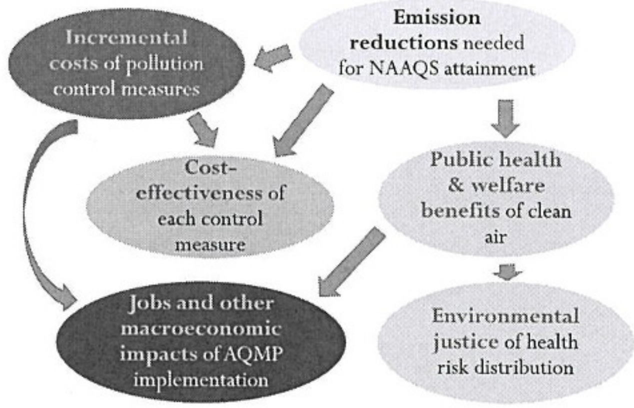
California Health & Safety Code

- Socioeconomic impact assessment:
  - Type of affected industries, including small businesses
  - Impact on employment and the regional economy
  - Range of probable costs, including costs to industry or business
  - Availability and cost effectiveness of alternatives
  - Emission reduction potential
  - Necessity of adopting, amending or repealing rule/regulation to attain state and federal ambient air quality standards
- Governing Board shall:
  - Actively consider socioeconomic impacts
  - Make a good faith effort to minimize adverse socioeconomic impacts

Extensive Public Process

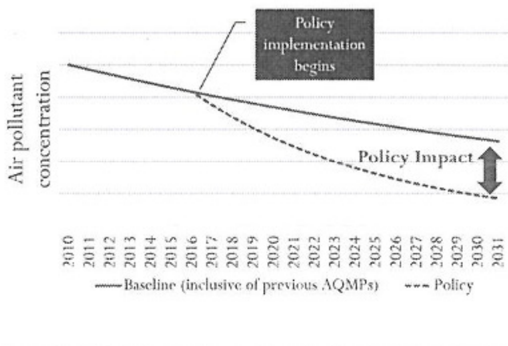
- Individual Rules:
  - Draft Socioeconomic Impact Assessment released for public review and comment at least 30 days before Public Hearing
  - Method and cost assumptions discussed at working group meetings and public workshop
- 2016 Air Quality Management Plan:
  - Chapters released for review and comment as drafted
  - Socioeconomic methods and results discussed at:
    - 9 Scientific, Technical & Modeling Peer Review (STMPR) Advisory Group meetings between October 2014 and November 2016
    - 4 AQMP Advisory Group meetings in 2015 and 2016
    - 3 Socioeconomic Assessment EJ Working Group meetings in 2016
    - 8 regional public workshops and hearings in 2016
    - Additional presentations to various stakeholders

AQMP Socioeconomic Analysis



Policy Impact Assessment

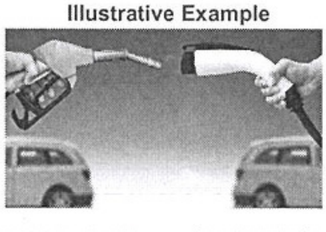
- Difference between projected outcomes under policy and baseline scenarios



Incremental Costs

- Cost/cost-savings otherwise would not occur *sans* Policy

Illustrative Example



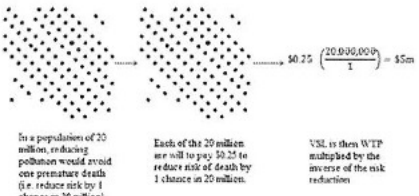
A representative **conventional** model
- Capital Cost: $20K
- O & M Cost: $300/month

A representative **lower-emission** model
- Capital Cost: $50K
- O & M Cost: $200/month

Incremental Cost Per Unit = (50K-20K) + (200-300) × lifetime of equipment in months

Monetize Public Health Benefits

- Value of statistical life (VSL), based on willingness-to-pay (WTP) for a small health risk reduction



Source: U.S. EPA, modified by Industrial Economics, Inc. and SCAQMD staff

- Cost of illness (COI)
  - Healthcare related costs
  - Time cost, e.g., missing work

Public Health Benefits

Public health benefits estimated to be $173 billion cumulatively (2017-2031)

Public Health Benefits -- Sensitivity Tests

Monetized Public Health Benefits (Billions of 2015 dollars)						
	2023			2031		
	Lower Bound	Mid-point	Upper Bound	Lower Bound	Mid-point	Upper Bound
Base VSL*	$4.2	$9	$13.7	$4.2	$9	$13.7
Income Elasticity	0	1.1	1.4	0	1.1	1.4
Mortality-related benefits	**$5.6**	**$14.2**	**$22.7**	**$10.9**	**$30.5**	**$49.9**

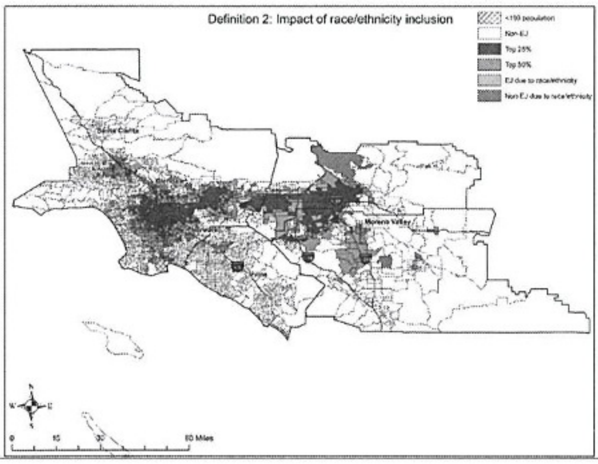
* The base VSL is expressed in millions of 2013 dollars and based on 2013 income levels.

EJ Definitions

ALTERNATIVE DEFINITION	DEMOGRAPHIC INDICATORS		ENVIRONMENTAL INDICATORS	
	Income	Other Sociodemographic	Air Quality	Other Environmental Burdens
1	Poverty status		$PM_{2.5}$, toxic cancer risk, ozone	
2	Poverty status	Age, asthma, education, linguistic isolation, low birth weight, unemployment	$PM_{2.5}$, toxic cancer risk, ozone	
2a	Definition 2, plus race and ethnicity			
3	Poverty status	Age, asthma, education, linguistic isolation, low birth weight, unemployment	$PM_{2.5}$, toxic cancer risk, ozone	Drinking water, pesticides, toxic releases, traffic, *cleanup sites, groundwater threats, hazardous waste, impaired water bodies, solid waste**
3a	Definition 3, plus race and ethnicity			

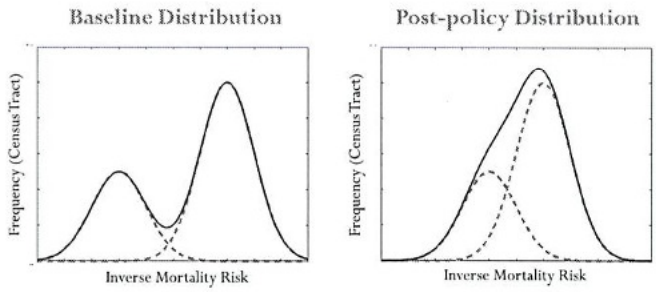
*Indicators in italics are given half-weight in the analysis

EJ Definitions (Cont'd)



Environmental Justice Analysis

Illustrative Example



- Overall inequality of health risks expected to decrease, with greater per-capita public health benefits accrued in EJ *versus* non-EJ communities.

Health Risk Inequality in the Basin

	PM2.5 and Ozone Exposure Related Mortality Risk (Among Residents 25 Years or Older)		Ozone Exposure Related Asthma ED Visits for Asthma (Among Residents Younger than 18)	
	Atkinson Index [Relative Inequality] Inequality Aversion = 0.5	Kolm-Pollak Index [Absolute Inequality] Inequality Aversion = 0.5	Atkinson Index [Relative Inequality] Inequality Aversion = 0.5	Kolm-Pollak Index [Absolute Inequality] Inequality Aversion = 0.5
	(Values in 10^{-8})	(Values in 10^{-8})	(Values in 10^{-6})	(Values in 10^{-8})
Baseline	6.3	6.3	15.7	15.5
Policy	4.4	4.4	13.9	13.8
Change	↓	↓	↓	↓

* Inequality aversion parameters are set at 0.5 for both Atkinson and Kolm-Pollak Indices. A higher value indicates that a society is more "inequality averse". However, it should be noted that the same parameter value does not imply the same degree of inequality aversion between Atkinson and Kolm-Pollak Indices.

Inequality Between EJ and Non-EJ

	PM2.5 and Ozone Exposure Related Mortality Risk (Among Residents 25 Years or Older)				Ozone Exposure Related Asthma ED Visits for Asthma (Among Residents Younger than 18)			
	Top 50%		*Top 25%*		*Top 50%*		*Top 25%*	
	Between	Within	Between	Within	Between	Within	Between	Within
	(All values are in 10^{-8})							
Def. 1								
Baseline	0.3	6.0	0.3	6.0	1.7	14.0	1.3	14.5
Policy	0.2	4.2	0.2	4.2	2.0	12.0	1.5	12.5
Change	↓	↓	↓	↓	↑	↓	↑	↓
Def. 2								
Baseline	0.4	5.9	4.5	6.5	2.5	13.2	1.5	14.2
Policy	0.3	4.1	2.9	4.6	2.7	11.2	1.7	12.3
Change	↓	↓	↓	↓	↑	↓	↑	↓
Def. 3								
Baseline	0.4	5.9	4.0	6.7	0.9	14.8	0.6	15.1
Policy	0.3	4.1	2.8	4.6	1.1	12.8	0.8	13.1
Change	↓	↓	↓	↓	↑	↓	↑	↓

* Based on Atkinson Index. Same directional changes based on Kolm-Pollak Index.

Air Quality Impact Assessment and Modeling - *Discussions of Tools, Applications, and Limitations*

for LAEF SCCAEPA
August 8, 2018

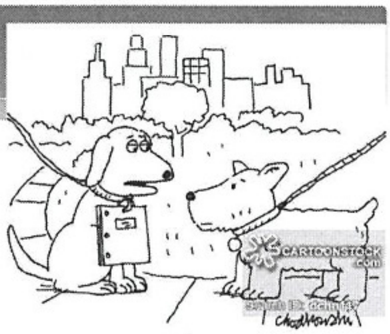
Sam Wang (王宣善)
SCAQMD
(909) 396-2649

Biography

- M.S. and B.S, Environmental Science and Engineering, focusing on AQ modeling
- 19-years of experience in AQ/GHG planning and engineering field in both private and public sectors.
- Currently, AQ Engineer II in Permit and Engineering, was an AQ specialist in CEQA group in Planning; was a project manager and senior air quality consultant in AECOM/URS; supervisor and engineer in other different firms and agencies
- Performed AQ assessment for more than 20 power plant and refinery projects and task lead for many local and international EIR/EIS projects, primarily in California and some in Taiwan, Hong Kong, China, and other countries.
- Technical specialties include CEQA and NEPA air quality and GHG impact assessment, industrial air quality permitting, air quality modeling and emission estimations, air toxic health risk assessment/AB2588, and research
- SCAQMD CPP, ISO14001 auditor, EPA modeling instructor

WHY we do AQIA ?


"Have you got an Environmental Impact Statement for that castle, son?"


"It's my Environmental Impact Report. And where, may I ask, is yours?"

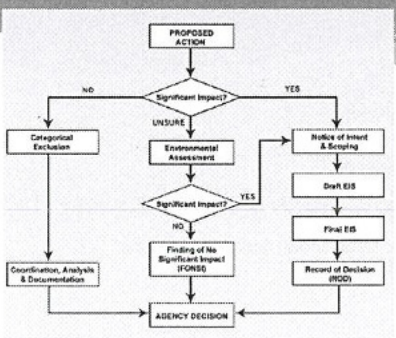
Introduction of Environmental Review

- The purpose of the assessment is to ensure that decision makers consider the environmental impacts when deciding whether or not to proceed with a project/action/policy.
- Terminologies
  - EIA, EIS, EIR, EA, ER, IS, IR, and etc.
- National Environmental Policy Act (NEPA) applies specifically to Federal proposed actions while California Environmental Quality Act (CEQA) applies to state and local government proposed actions
- "Action" (NEPA) versus "project" (CEQA)
- Categorical Exclusion versus Exemption
- Environmental Assessment and Finding of No Significant Impact versus Initial Study and Negative Declaration
- EIS versus EIR

NEPA

- Purpose: To declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation; and to establish a Council on Environmental Quality.
- National Environmental Policy Act (NEPA) signed into law on January 1, 1970 by President Nixon
- codified under Title 42 of the United States Code, in section 4331 et seq. (42 U.S.C. §§ 4331 et seq.)
- Congress established the White House Council on Environmental Quality (CEQ) to ensure that Federal agencies meet their obligations of the Act
- CEQ Regulations are in Title 40 of Code of Federal Regulations sections 1500 et seq. (40 C.F.R. §§ 1500 et seq.)

NEPA Decision Making



"Let's just approve it and see what happens."

CEQA

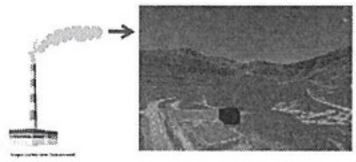
- California State Law adopted on September 18, 1970
- The Legislature declared it is the policy of the state to "[e]nsure that the long-term protection of the environment, consistent with the provision of a decent home and suitable living environment for every Californian, shall be the guiding criterion in public decisions." (Pub. Res. Code Section 21001(d).)
- Purpose *[CEQA Guidelines § 15002(a)]*
  - Inform governmental decision-makers and public about potential significant effects of projects
  - Identify ways to avoid or reduce adverse impacts
  - Require feasible alternatives and mitigation measures to prevent significant environmental damage
  - Disclose to the public why a project was approved
- CEQA Applies to: *[CEQA Guidelines § 15002(b)]*
  - Projects undertaken by a Public Agency
  - Funded by a Public Agency
  - Issuance of a Permit by a Public Agency

AQIA MODELING 101

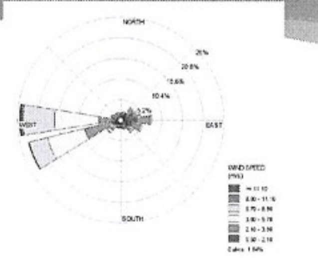
What is air dispersion modeling?

- From the U.S. Environmental Protection Agency's (EPA's) Support Center for Regulatory Atmospheric Modeling (SCRAM):
  - "Dispersion modeling uses mathematical formulations to characterize the atmospheric processes that disperse a pollutant emitted by a source. Based on emissions and meteorological inputs, a dispersion model can be used to predict concentrations at selected downwind receptor locations."
- In English!
  - Dispersion modeling uses a (computer) model to predict air concentrations from mostly industrial facilities at specific locations.
  - Moves pollutants from a modeled source through a modeled world

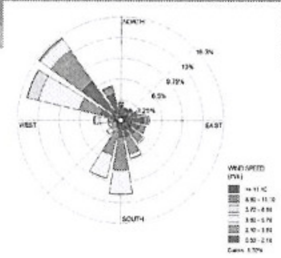
Move pollution from a modeled source to a modeled world



Wind Roses

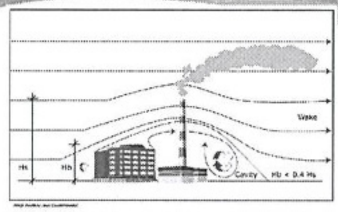


KLAX (Los Angeles Int'l Arpt), 2012 - 2016

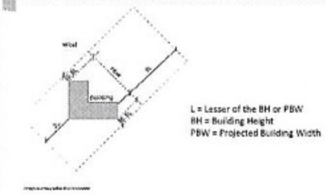


KLGB (Long Beach Arpt), 2012 - 2016

Building Downwash



If stack is at least 2.5 times building height, downwash will not come into play.



If building is 5L away from stack then downwash also not in play.

Why do we conduct air dispersion modeling?

- To substantiate with modeling that new emissions from a new or modified source will not cause or contribute to a violation of the Ambient Air Quality Standards (National and California) or the Prevention of Significant Deterioration (PSD) increments
- To conduct risk assessments to determine compliance with toxic regulations based on the downwind concentration values that result from emissions dispersion from modeled source releases
- Impacts from new and modified sources can only be determined through modeling

What are the benefits of modeling? The cons?

- Benefits
  - Monitoring networks are limited in spatial and temporal coverage
  - Monitors are mostly insufficient to determine individual source impacts
  - Pre-construction monitoring usually needs at least a year's worth of data
- Cons
  - Requires detailed source inputs
  - Modeling can over- and under-estimate impacts by a factor of 2
    - Your model is only as good as your input data!
  - Should not be used to do conduct hourly pairing with monitoring data or to calibrate the model with monitored data

What modeling can and cannot tell us?

- It can tell us…
  - What the predicted concentrations will be from an emission source on a receptor
  - Whether the predicted concentrations will comply with state and local ambient air quality standards and human health risk thresholds
  - Estimated source contributions
- It can't tell us…
  - The exact time and location of a modeled concentration

What inputs are needed to conduct air dispersion modeling?

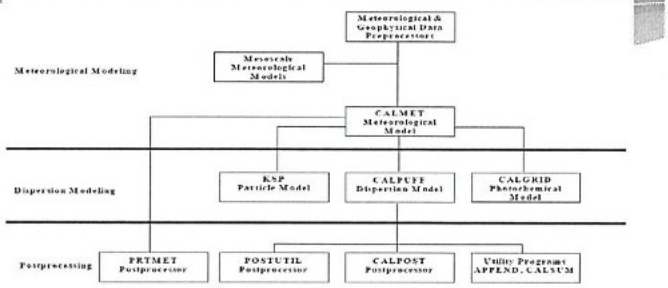
- Coordinates
- Source parameters
  - Emission rate
  - Release height
- Meteorological data
- Terrain data
- Background concentrations (criteria pollutants)
- Building dimensions

- Remember, your model is only as good as your inputs!!

CALPUFF MODELING SYSTEM

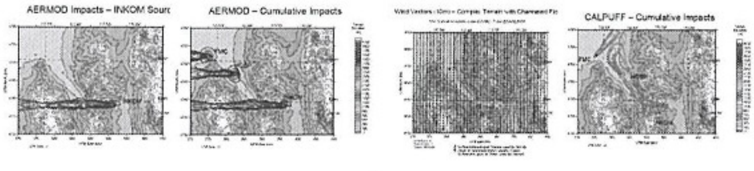
- CALPUFF is a non-steady-state Lagrangian puff dispersion model
  - Allows variable/curved trajectories
  - Meteorological conditions variable and not assumed steady-state
  - Spatial variability to winds and turbulence fields
    - Uses information downwind of each stack rather than upwind of a single stack or the meteorological station
  - Retains information of previous hours emissions
    - Stagnation
    - Fumigation
    - Recirculation
  - Allows calm and low wind speed conditions
  - Includes causality effects

CALPUFF MODELING SYSTEM



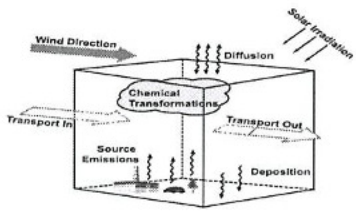
Model Applicability and Complex Terrain Application (Pocatello, Idaho)

- AERMOD is default near-field model (defined as < 50km) for typical regulatory use in USA, including in complex terrain
- CALPUFF is default far-field regulatory model (> 50km), accepted for near-field applications on a case-by-case basis

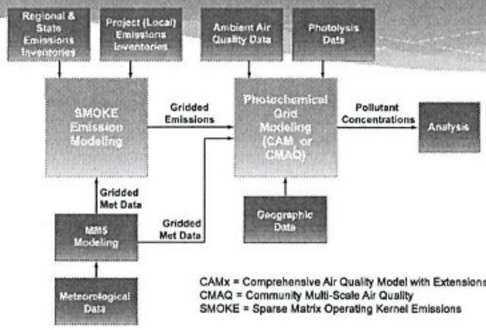


Types of Air Quality Models

- Photochemical grid model (PGM)
  - Three-dimensional Eulerian grid-based that treat chemical and physical processes in each grid cell and use diffusion and transport processes to move chemical species between grid cells. Eulerian models assume that emissions are spread evenly throughout each model grid cell.
    - CMAQ, CAMx



PGM Modeling Data and Process



CAMx = Comprehensive Air Quality Model with Extensions
CMAQ = Community Multi-Scale Air Quality
SMOKE = Sparse Matrix Operating Kernel Emissions

Advantages & Disadvantages of PGM

Advantages	Disadvantages (Diminishing *)
• Great method for predicting ozone and visibility – Uses comprehensive emission inventories • Accounts for dispersion, deposition, pollutant transport, and atmospheric reactions – Transport from far-distant locations – Includes more than 100 atmospheric chemical reactions	• Requires huge amounts of data – 14 terabytes (TB) for one ozone modeling project – 1 TB = 1,000 gigabytes (GB) • Requires fast, highly capable computers • Longer computation times than other conventional regulatory modeling systems

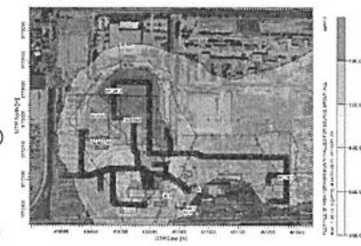
* Data storage and computing costs are decreasing rapidly while computation speeds are increasing.

Current Applications of PGM

- **Traditional uses**
  - State Implementation Plans (SIPs) for nonattainment areas
  - Regional visibility modeling for USEPA Regional Haze Rule
    - Goal: "natural visibility" by 2064 for Class I areas (National Parks)
- **Additional uses**
  - National Environmental Policy Act (NEPA) oil and gas projects
    - Federal Land Managers' Resource Management Plans (RMPs)
    - Initially, only ozone episodes. Now, transitioning to all pollutants and air quality related impacts (e.g. visibility)
  - Winter-time ozone events
  - Evaluate effectiveness of emission controls to reduce ozone
  - Secondary $PM_{2.5}$

How is air dispersion modeling used within SCAQMD?

- Permitting
  - Criteria pollutants
    - Rules 1303, 1703, and 2005
  - Health Risk Assessments (HRAs)
- Rules
  - Determine thresholds and emission limits
  - Screening tables (R1401)
- Air monitor placements (Rule 1420.2 lead monitor)
- AB2588
- CEQA
- Orders of Abatement (OA's)



Ambient Air Quality Standards for Criteria Pollutants [d]	
NO2 1-hour average annual arithmetic mean	SCAQMD is in attainment; project is significant if it causes or contributes to an exceedance of the following attainment standards: 0.18 ppm (state) 0.03 ppm (state) and 0.0534 ppm (federal)
PM10 24-hour average annual average	10.4 $\mu g/m^3$ (construction)[e] & 2.5 $\mu g/m^3$ (operation) 1.0 $\mu g/m^3$
PM2.5 24-hour average	10.4 $\mu g/m^3$ (construction)[e] & 2.5 $\mu g/m^3$ (operation)
SO2 1-hour average 24-hour average	0.25 ppm (state) & 0.075 ppm (federal – 99th percentile) 0.04 ppm (state)
Sulfate 24-hour average	25 $\mu g/m^3$ (state)
CO 1-hour average 8-hour average	SCAQMD is in attainment; project is significant if it causes or contributes to an exceedance of the following attainment standards: 20 ppm (state) and 35 ppm (federal) 9.0 ppm (state/federal)
Lead 30-day Average Rolling 3-month average	1.5 $\mu g/m^3$ (state) 0.15 $\mu g/m^3$ (federal)

SCAQMD Localized Significance Thresholds (LST)

- LST's established by SCAQMD Board as voluntary guidance
  - Limited to onsite sources
  - LST's based on daily emissions levels
  - Simplified method that avoids complex dispersion modeling for projects <5 acres in size and out to 500m for receptors
  - LST table updated regularly
  - LST's are based on Source-Receptor Area (SRA) map (Ref:4)
  - SCAQMD conducts a template dispersion modeling analysis for each SRA and produces max emissions allowed
  - LST table for NOx, CO, PM10 and PM2.5 (Ref: 5)

AAQS (Ref:6)

Pollutant	Averaging Time	California Standards [1]		National Standards [2]		
		Concentration [3]	Method [4]	Primary [3,5]	Secondary [3,6]	Method [7]
Ozone (O_3)[8]	1 Hour	0.09 ppm (180 $\mu g/m^3$)	Ultraviolet Photometry	—	Same as Primary Standard	Ultraviolet Photometry
	8 Hour	0.070 ppm (137 $\mu g/m^3$)		0.070 ppm (137 $\mu g/m^3$)		
Respirable Particulate Matter (PM10)[9]	24 Hour	50 $\mu g/m^3$	Gravimetric or Beta Attenuation	150 $\mu g/m^3$	Same as Primary Standard	Inertial Separation and Gravimetric Analysis
	Annual Arithmetic Mean	20 $\mu g/m^3$		—		
Fine Particulate Matter (PM2.5)[9]	24 Hour	—	—	35 $\mu g/m^3$	Same as Primary Standard	Inertial Separation and Gravimetric Analysis
	Annual Arithmetic Mean	12 $\mu g/m^3$	Gravimetric or Beta Attenuation	12.0 $\mu g/m^3$	15 $\mu g/m^3$	
Carbon Monoxide (CO)	1 Hour	20 ppm (23 mg/m^3)	Non-Dispersive Infrared Photometry (NDIR)	35 ppm (40 mg/m^3)	—	Non-Dispersive Infrared Photometry (NDIR)
	8 Hour	9.0 ppm (10 mg/m^3)		9 ppm (10 mg/m^3)	—	
	8 Hour (Lake Tahoe)	6 ppm (7 mg/m^3)		—	—	
Nitrogen Dioxide (NO_2)[10]	1 Hour	0.18 ppm (339 $\mu g/m^3$)	Gas Phase Chemiluminescence	100 ppb (188 $\mu g/m^3$)	—	Gas Phase Chemiluminescence
	Annual Arithmetic Mean	0.030 ppm (57 $\mu g/m^3$)		0.053 ppm (100 $\mu g/m^3$)	Same as Primary Standard	

AAQS

Sulfur Dioxide (SO_2)[11]	1 Hour	0.25 ppm (655 $\mu g/m^3$)	Ultraviolet Fluorescence	75 ppb (196 $\mu g/m^3$)	—	Ultraviolet Flourescence; Spectrophotometry (Pararosaniline Method)
	3 Hour	—		—	0.5 ppm (1300 $\mu g/m^3$)	
	24 Hour	0.04 ppm (105 $\mu g/m^3$)		0.14 ppm (for certain areas)[11]	—	
	Annual Arithmetic Mean	—		0.030 ppm (for certain areas)[11]	—	
Lead[12,13]	30 Day Average	1.5 $\mu g/m^3$	Atomic Absorption	—	—	High Volume Sampler and Atomic Absorption
	Calendar Quarter	—		1.5 $\mu g/m^3$ (for certain areas)[12]	Same as Primary Standard	
	Rolling 3-Month Average	—		0.15 $\mu g/m^3$		
Visibility Reducing Particles[14]	8 Hour	See footnote 14	Beta Attenuation and Transmittance through Filter Tape	No National Standards		
Sulfates	24 Hour	25 $\mu g/m^3$	Ion Chromatography			
Hydrogen Sulfide	1 Hour	0.03 ppm (42 $\mu g/m^3$)	Ultraviolet Fluorescence			
Vinyl Chloride[12]	24 Hour	0.01 ppm (26 $\mu g/m^3$)	Gas Chromatography			

AAQS Modeling - DV

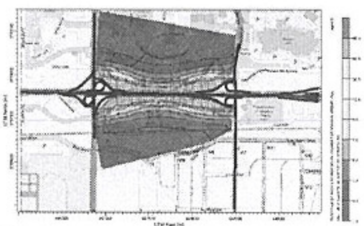
- Fed 1-hr NO2: 3-year average of the annual 98th percentile of the 1-hour daily maximum concentrations must not exceed 100 ppb (188 µg/m3) - 8th Highest High (98th percentile) value selection in AERMOD
- Fed 1-hr SO2: 3-year average of the annual 99th percentile of the 1-hour daily maximum concentrations must not exceed 75 ppb (196 µg/m3) - 4th Highest High (98th percentile) value selection in AERMOD
- Fed 24-hr PM2.5: 3-year average of the annual 98th percentile of the 24-hour concentrations must be equal to or less than 35 µg/m3 - 8th Highest High (98th percentile) value selection in AERMOD
- Others:
  - Fed 24-hr PM10, Fed 1-hr and 8-hr CO: not to be exceeded more than once a year: 2nd Highest High in AERMOD
  - Fed annual: Average of each year's highest annual value
  - CA AAQS: not to be exceeded in any year modeled

Sources and Emissions in AQIA Analyses

- Source types:
  - Point
  - Area (AREA, AREAPOLY, AREACIRC)
  - Volume
  - Open-pit
  - Line
- Short-term construction v.s. long-term operation
- Emissions and EFs:
  - Onroad: EMFAC, MOVES
  - Offroad: OFFROAD, NONROAD
  - CalEEMod
  - Other models: TANKS, CT-EMFAC, ACAM
  - Other resources: AP-42, CARB database, source test, API, EPA, and etc.

Other Considerations and Models in AQIA

- Conformity
  - regional and project level
  - CO, PM10 and PM2.5
- Other dispersion models in CEQA analyses (Ref:7):
  - ISC (ISCST/ISCSTPRIME)
  - CALINE3, CAL3QHC/CAL3QHCR, CL4
  - SCREEN3, AERSCREEN
  - VISCREEN
  - PLUVUEII, SACTI
  - CALPUFF, CMAQ



Example 1: Warehouse Project

- West Valley Logistics Center in Fontana in SB County (Ref: 8)
- EIR, 7 industrial buildings are proposed, ranging in size from approx. 100,000 sq. ft to over 1 million sq. ft , encompassing a total of approx. 3.6 million sq. ft of building area
- will generate and receive truck traffic to/from I-10 to the north and to/from SR-60 to the south
- Operational HRA
- What's wrong you can see here?

Air Toxics Program –
Health Risk Assessment and Emission Inventory

吳震球

Robert Wu

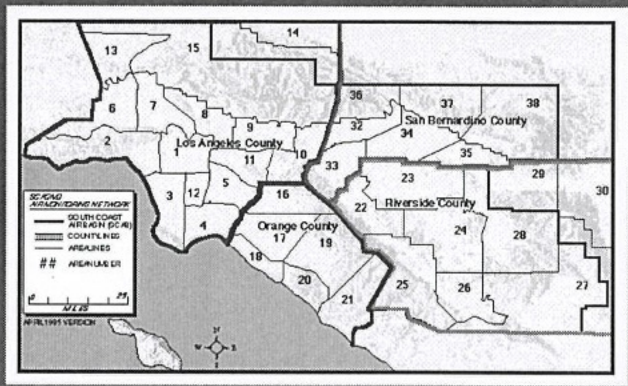
South Coast
Air Quality Management District

South Coast Air Quality Management District

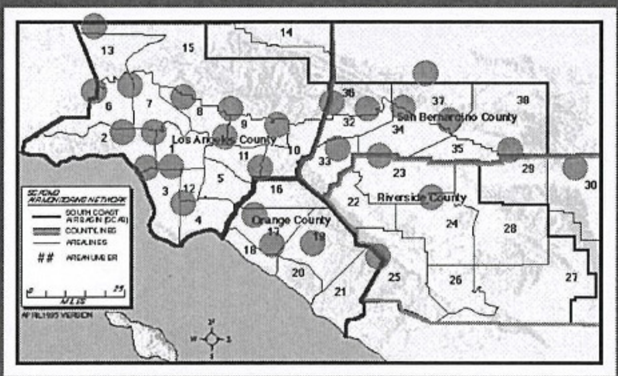
- ~ 16 Millions population
- ~ 10,000 square miles
- ~ 10 Million Vehicles
- ~ 27,000 Permitted Facilities (60,000+ Permits)
- Stagnant Weather Patterns
- Nation's Most Severe Air Pollution

South Coast Air Quality Management District

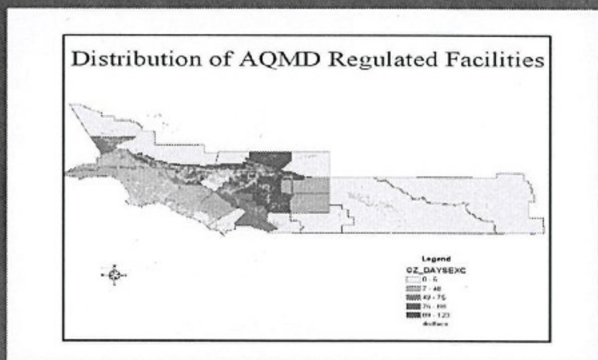
South Coast Air Quality Management District
Source/Receptor Areas



South Coast Air Quality Management District
Air Monitoring Stations



South Coast Air Quality Management District



REGULATORY AGENCY

- FEDERAL
  - US EPA
- STATE
  - California Air Resources Board
- LOCAL
  - Air Pollution Control District

Rule 1401
New Source Review for Air Toxics

- **Adopted in June 1, 1990**
- **Initially specified limits for maximum individual cancer risk (MICR) and excess cancer cases for new, related, or modified sources which emit carcinogenic air contaminants**
- **Amended several times to include non- carcinogenic compounds and to update the list of toxic compounds and the corresponding risk values**

Computer Modeling on Air Toxics

- Pollutant Type
  Carcinogenic vs. non-Carcinogenic
- Source Type
  Point, Area, Line, Volume
- Temporal
  Long-term vs. Short-term
- Scale
  Regional vs. Local

SUMMARY

- Command and Control
  - Regulation, Rule Development
- Environmental Justice
  - Community Awareness
- Coordination and Communication
  - Partnership with other agencies, the regulated Industries, the Environmental Groups, and the Public

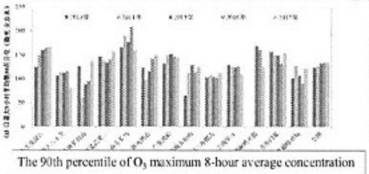
华南理工大學
South China University of Technology

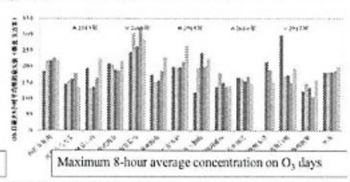
VOCs emission characteristics and change trend in China during the "13th Five-Year Plan"

Ye Dai Qi
South China Universuty of Technology

Severe Ozone Pollution

From 2013 to 2017, the concentration of O_3 at 13 national ambient air background points showed an increasing trend year by year.

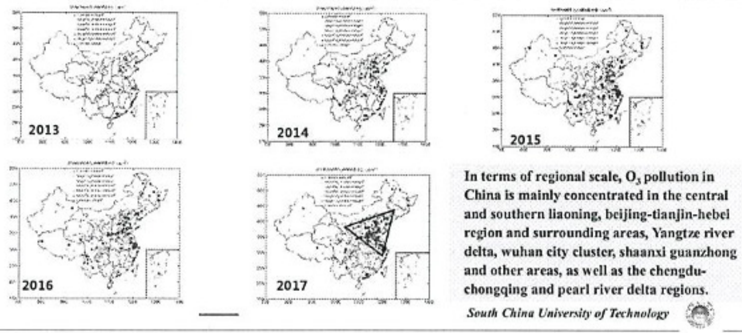

The 90th percentile of O_3 maximum 8-hour average concentration


Maximum 8-hour average concentration on O_3 days

- From 2013 to 2017, the mean values of the 90th percentile of the maximum 8-hour average concentration of the 13 national air quality background points on O_3 are 123μg/m³、126μg/m³、132μg/m³、133μg/m³、134μg/m³ respectively, showing an increasing trend year by year, but the variation trend of different stations is quite different.
- The mean values of maximum 8-hour average concentration on O_3 day of each site are 182μg/m³、184μg/m³、183μg/m³、186μg/m³、198μg/m³ respectively, showing a gradual upward trend.

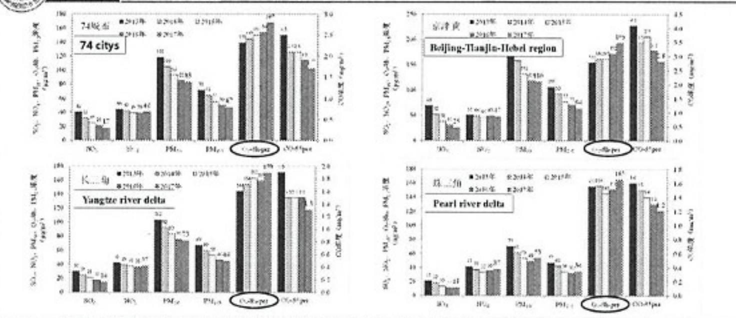
Severe Ozone Pollution

From 2013 to 2017, the 90th percentile of maximum O_3-8H concentration in 338 cities in China (μg/m³)



In terms of regional scale, O_3 pollution in China is mainly concentrated in the central and southern liaoning, beijing-tianjin-hebei region and surrounding areas, Yangtze river delta, wuhan city cluster, shaanxi guanzhong and other areas, as well as the chengdu-chongqing and pearl river delta regions.

臭氧污染现状与变化规律zone Pollution



- From 2013 to 2017, the concentration of O_3 in 74 cities in China showed an increasing trend year by year, with the Pearl river delta decreasing from 2015 to 2016, but with a large increase in 2017.

臭氧污染现状与变化规律zone Pollution

- In recent years, the state and local governments attach great importance to the prevention and control of air pollution and have achieved certain results. PM2.5 and PM10 concentrations have decreased. However, ozone problem is still prominent, and China's air pollution control has entered a new stage of **coordinated control of ozone and particulate matter.**
- **VOCs** are important precursors of ozone and PM2.5, reducing VOCs pollution is the key to winning the blue sky defense.

Report Content

一、VOCs pollution situation

二、Problems and challenges

可行性分析

1 VOCs pollution situation

1.1 Anthropogenic source VOCs emission analysis
1.2 Remote sensing observation
1.3 Ground monitoring
1.4 Meteorological factors

scenario analyses of VOCs emission in "13th Five-Year Plan"

Reference year
- 2015

Target year
- 2020

Methodology
- emission factor method，scenario analysis method

Equation $\sum_m \sum_n A_{i,j} EF_{i,j} (1-\eta_{i,j})$

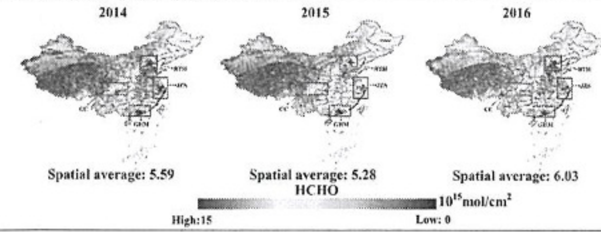
scenario analysis

scenario 1 : business-as-usual scenario , assuming that VOCs control level in "13th Five-Year Plan" is consistent with the level in 2015.

scenario 2 : control scenarios 1 (Medium control scenario) , considering industry status quo, assuming that some of VOCs control requirements are implemented nationwide in "13th Five-Year Plan".

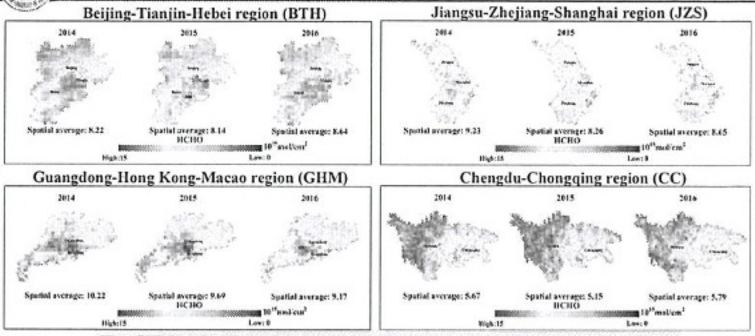
scenario 3 : control scenarios2 (Optimal control scenario) , assuming that all of VOCs control requirements are implemented nationwide in "13th Five-Year Plan".

Variations of national HCHO from 2014 to 2016 in ozone season



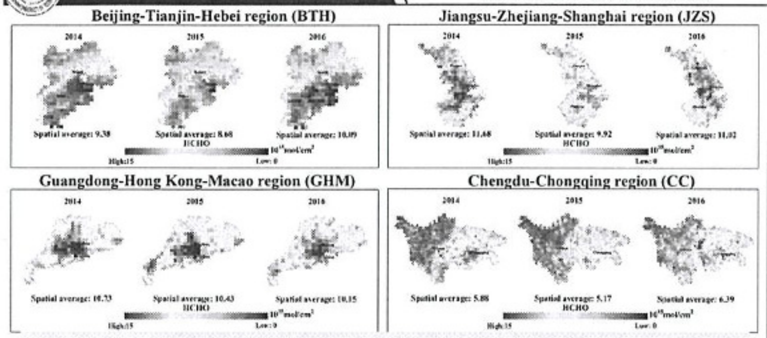
- Ozone season: from May to October.
- In the ozone season from 2014 to 2016, the concentration of formaldehyde also showed a trend of decreasing first and rising later in China.
- In the eastern region, pollution is more serious, especially during the ozone season.

Variations of regional HCHO from 2014 to 2016



The GHM region showed a decreasing trend year by year, while other regions fell first and then rose, and the pollution in CC region was relatively light.

Variations of regional HCHO from 2014 to 2016 in ozone season

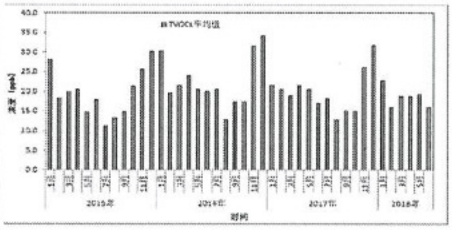


Regardless of the region, the pollution in ozone season is generally worse than that in the annual average. GHM region dropped slightly year by year, while other regions first fell and then rose.

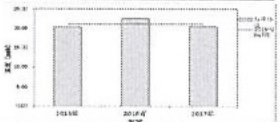
VOCs concentration change

(2015-2018 , Shanghai)

From 2015 to 2018 year , there was no significant change in TVOCs concentration in Shanghai.



Time(year)	Daily mean(ppb)
2015	20.38
2016	22.65
2017	20.50
2015~2017	21.18

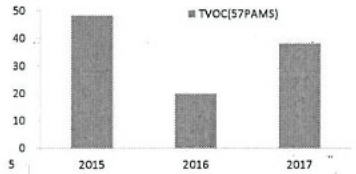


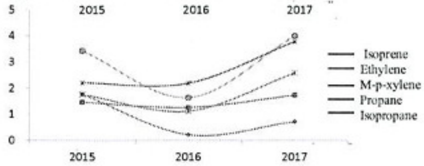
From the above data, it can be seen that the concentration of TVOCs increased in 2016 compared with 2015, and there was a slight decline trend in 2017. Compared with the same period in 2017, the concentration of TVOCs remained unchanged in 2018.Therefore, in general, the concentration of TVOCs has not changed significantly.

(Fu qingyan, Gao song, Shanghai environmental monitoring center)

VOCs concentration change

(2015-2017, autumn in Heshan, Guangdong)





- The annual ozone concentration in 2016 was significantly lower than that of 2015, and rebounded in 2017, but still lower than that of 2015.
- The concentration of ethylene mainly from petrochemical is stable.
- The use of organic solvents represents an inter-species/p-xylene concentration that rebounded to close to 2015.
- The concentration of isoprene from natural sources was significantly lower than that in 2015.

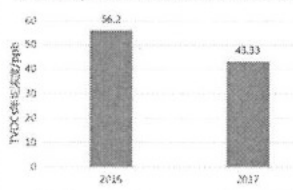
(Yue Dinli, Guangdong provincial environmental monitoring center)

VOCs concentration change

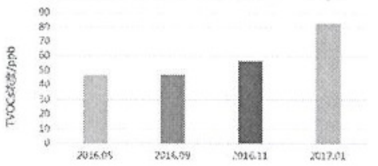
(2016-2017, Chengdu)

From 2016 to 2017 , The concentration of TVOCs decreased in Chengdu.

2016-2017, annual VOCs concentration in Chengdu



2016-2017, the VOCs concentration in Chengdu



In Chengdu, the concentration of TVOCs in 2017 was 43.33 ppb, down 14.4% from 2016.

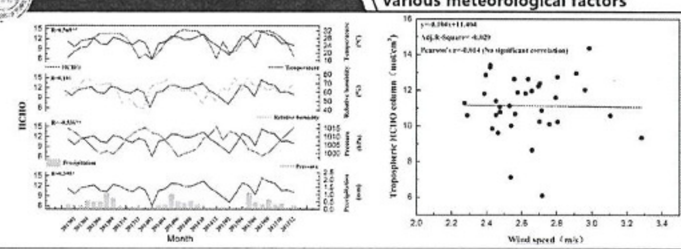
In 2017, new regulations were issued in Chengdu, and the central environmental protection inspection in August of the same year further strengthened the enforcement of the regulations.

(Liu Hefan, Chengdu institute of environmental protection science)

Summary

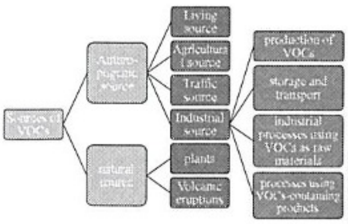
VOCs concentration in **Heshan of Guangdong increased** in 2017 compared with that in 2016, but it was still **lower** than that in 2015.There was no significant change in **Shanghai**. In **Chengdu-Chongqing area** the VOCs concentration **decreased** in 2017. It will continue to rise in other areas without greater control.

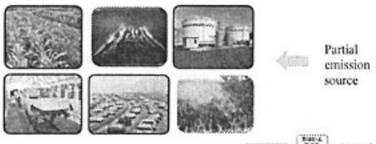
Correlation analysis between VOCs and various meteorological factors



The picture shows the correlation analysis between formaldehyde and temperature, relative humidity, air pressure, rainfall, wind speed and other meteorological factors from 2013 to 2015: formaldehyde concentration is **the strongest correlation with temperature**, negatively correlated with air pressure, and precipitation and relative humidity. The wind speed correlation is not significant.

②The status quo of VOCs remains to be clarified





Petrochemical industry VOCs production link

- The sources of VOCs are relatively complex: many emission industries, complex components, and different characteristics.
- The status of national VOCs needs to be clarified：The VOCs emission inventory of each research is quite different, and the uncertainty of it is also very large.
- Dynamic real-time updated emissions inventories at the regional and city levels are not yet widely available.

③Treatment technology is mixed and the effect of emission reduction is poor

□ **Insufficient source control**

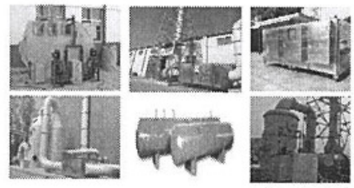
Low-volatility raw materials such as paints, inks, cleaning agents, and adhesives are used in a low proportion.

□ **Lack of process control**

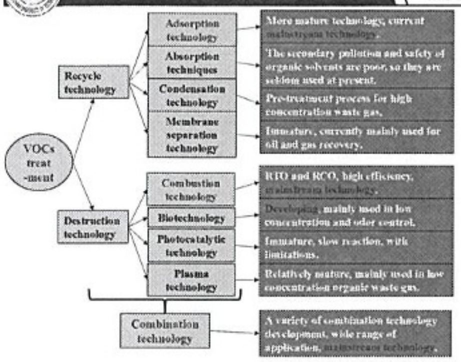
Low utilization rate of new technologies, serious unorganized emissions, and low collection efficiency

□ **Inefficient end treatment**

- When choosing technology, enterprises have blindness and fluke mind, which makes most of the management facilities become decoration.
- Inefficient technologies such as simple adsorption technology, direct combustion technology, photocatalysis technology, and non-thermal plasma technology are frequently used.

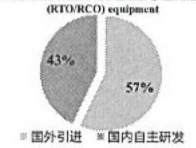


③Treatment technology is mixed and the effect of emission reduction is poor



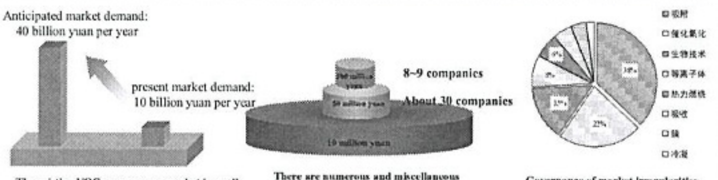
Distribution of Molecular sieve adsorption concentration Runner equipment in the World Market

Source Distribution of domestic Combustion (RTO/RCO) equipment



④Small enterprises are numerous, and the treatment market of VOCs is chaotic.

- There are many small and miscellaneous enterprises for VOCs harnessing.
- The treatment ability of the third party governance enterprises is uneven, and the ability gap is significant.
- The VOCs treatment market is not standardized, and lacks the corresponding constraint mechanism.

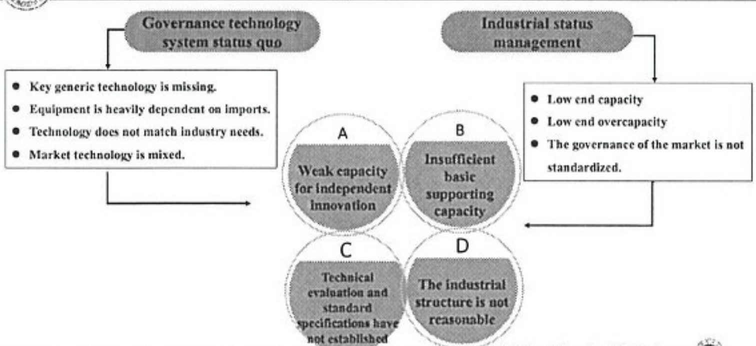


The existing VOCs governance market is small

There are numerous and miscellaneous small enterprises

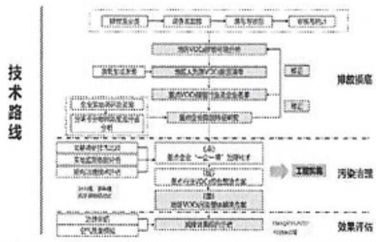
Governance of market irregularities Large proportion of application of single activated carbon method

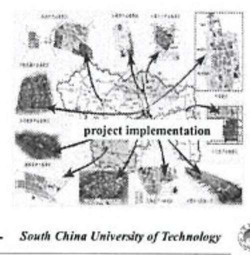
Management technology and market status



⑤ Governance experience is lacking

- VOCs comprehensive management and demonstration work is insufficient
- Local government departments do not pay enough attention to VOCs demonstration management
- Lack of replicable, scalable industry governance experience and management experience

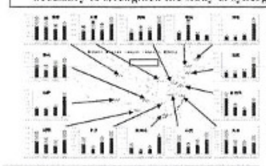




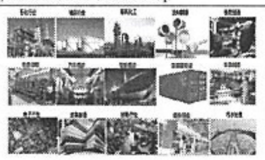
⑥Insufficient investment in science and technology

□ **The basic data such as VOCs pollution characteristics are unclear, and the collaborative control study of VOCs and NO_x needs to be strengthened.**

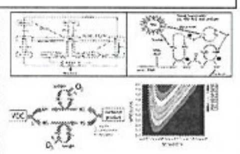
- The industrial structure and geographical climate are different in different regions, and the VOCs emission characteristics are significantly different. The study on localized VOCs emission characteristics needs to be strengthened.
- VOCs sources are complex, and there are many emission industries, covering a wide range of industries. VOCs emission links are numerous, and the composition of VOCs is complex. So the research on VOCs activity and other prevention strategies should be strengthened according to the industry characteristics.
- VOCs are important precursors of ozone generation, and VOCs and NO_x have typical non-linear relationship with ozone, so it is necessary to strengthen the study of synergistic control of VOCs and NO_x.



Spatial and temporal distribution characteristics of VOCs in different regions of China



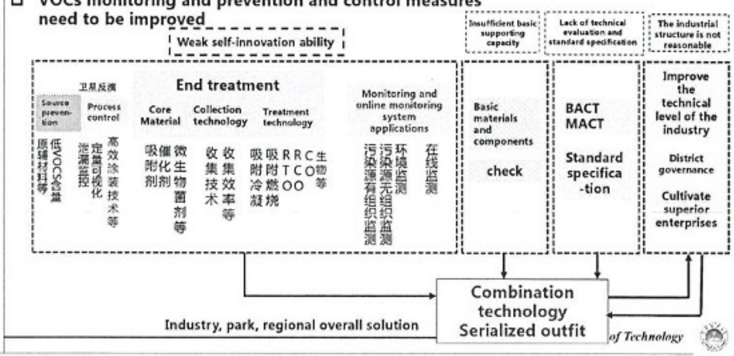
Part of the VOCs emission industry



Effects of VOCs on Ozone

⑥ Lack of technology investment

□ **VOCs monitoring and prevention and control measures need to be improved**



第十一屆洛杉磯環境論壇-主題：改善空氣品質，保護水質資源

參考美國加州經驗於台灣推動石化工業區VOCs改善歷程

簡報人：戴忠良

戴忠良[1]、蔡國聖[1]、盧彥廷[2]、郭子豪[2]、宋國安[2]、曠永銓[2]

[1]行政院環境保護署空氣品質保護及噪音管制處,台灣
[2]環興科技股份有限公司,台灣

2018年8月11日

大綱

- 背景資料
- 臭氧議題
- HAPs議題
- 結論和建議
- 參考文獻

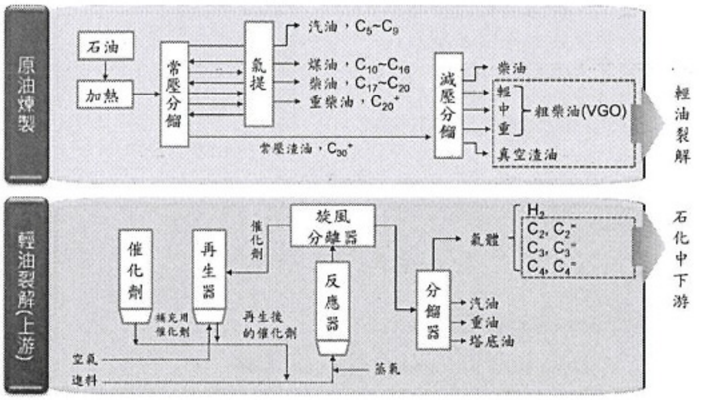
壹、背景資料

- 台灣石化業聚落
- 石化業生產流程
- VOCs物種特性
- 石化業管制架構

台灣石化業聚落

石化業生產流程

❖原油煉製⇨輕油裂解(石化上游) ⇨石化中、下游



VOCs物種特性

❖光化站監測54物種⇨臭氧、HAPs

- 臭氧生成潛勢(OFP)⇨參採最大增量反應性(MIR)

$$O_{3(total)} = \sum MIR_n \times C_n \times \text{單位轉換係數}$$

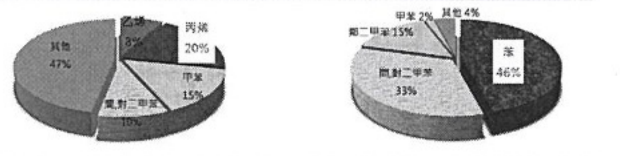
第n種物種貢獻比例 = $\frac{MIR_n \times C_n \times \text{單位轉換係數}}{O_{3(total)}}$

MIR_n：第n種污染物之MIR(g-O_3/g-VOC)
C_n：第n種污染物之濃度(ppbC)

- 吸入危害(HI)⇨參採風險推估於慢性非致癌的物質之參考濃度

$$HI = \sum \frac{C_n}{RfC_n \times \text{單位轉換係數}}$$

C_n：第n種有害物質之暴露濃度(ppbC)
RfC_n：第n種有害物質之參考濃度(mg/m³)
RfC_n參考美國環保署綜合風險資訊系統(IRIS)

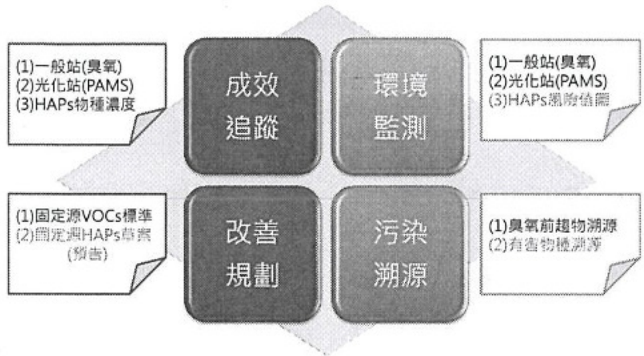


2007年台西(工業區)光化站VOCs物種OFP貢獻占比　　2007年萬華(都會區)光化站VOCs物種HI貢獻占比

註：OFP= Ozone Formation Potential；MIR= Maximum Increment Reactivity；HI= Hazard Index

石化業管制架構

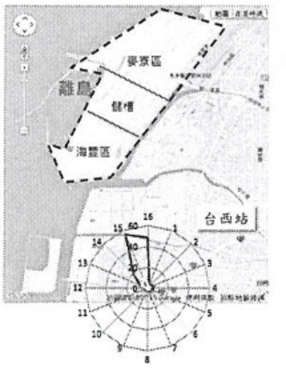
❖採滾動式檢討管制、降低空氣污染排放



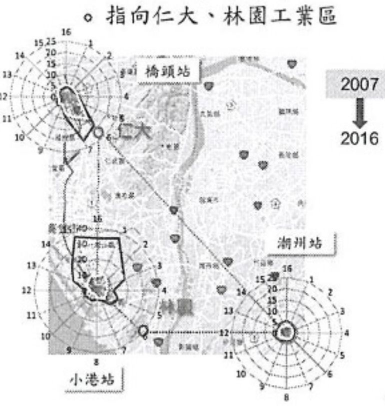
貳、臭氧議題

成效追蹤

❖ 雲林縣丙烯雷達圖
- 指向離島工業區

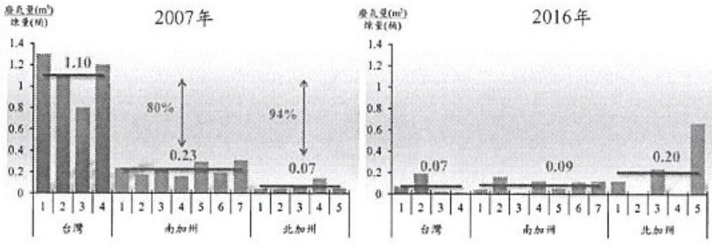


❖ 高雄市乙烯雷達圖
- 指向仁大、林園工業區



成效追蹤

❖ 單位煉油量之燃燒塔廢氣量(以美國加州為標竿)
- 2007年臺灣平均為1.10，為加州5~16倍
- 2016年臺灣降為0.07，改善94%，達加州水準

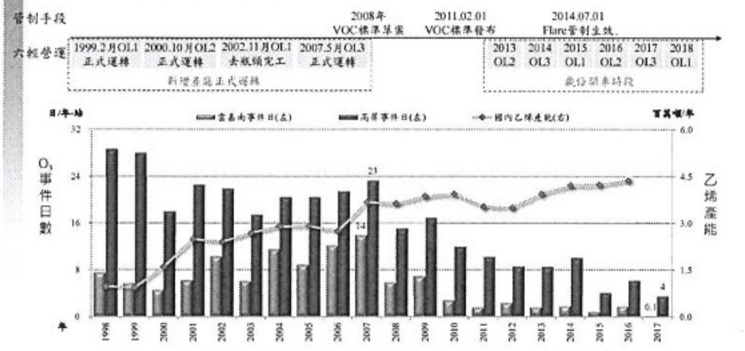


資料來源：南加州(SCAQMD)，北加州(BAAQMD)政府網站

臺灣與美國加州燃燒塔廢氣量基準分析(單位煉油量之燃燒塔廢氣量)

成效追蹤

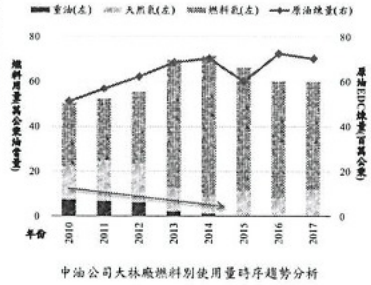
❖ 石化業產能與O_3事件日數時序趨勢
- 石化業產能與臭氧事件日脫勾



註：臭氧事件日包含雲嘉南9站及高屏11站；國內產能包含六輕、中油林園廠及高雄廠乙烯產能

其他成效指標

❖ 燃料氣取代重油，中油公司大林廠已完成全燃氣
- 單位燃料硫氧化物排放量約降52%
- 中油公司其他廠持續規劃全燃氣

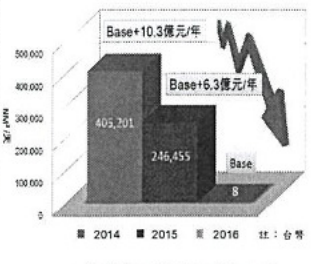


中油公司大林廠燃料別使用量時序趨勢分析

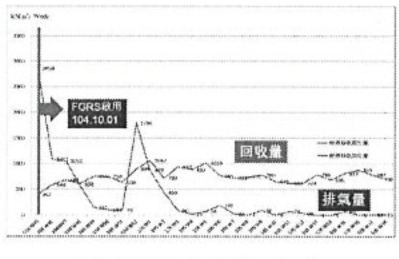
中油公司大林廠單位燃料SOx排放量變化

其他成效指標

❖ 燃燒塔廢氣回收之經濟效益分析
- 中油公司大林廠改善前後節省10億新台幣/年(約3,200萬美金)



改善前後燃燒塔排放成效圖

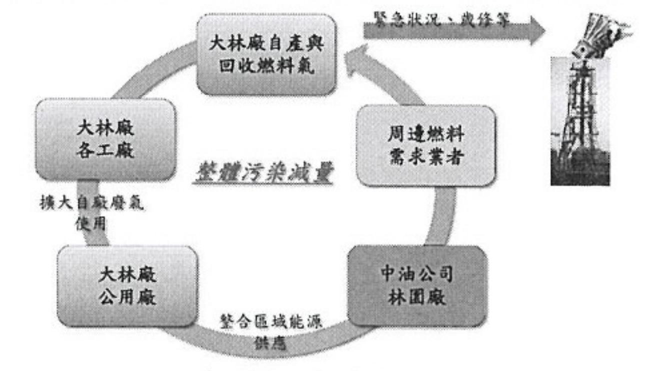


燃燒塔廢氣排放改善執行時間序列

資料來源：邱金山、卓顯勳，燃燒塔廢氣回收及促進循環經濟推動之成效檢討，環保署石化業燃燒塔管制成效檢討會議，2016年11月23日

其他成效指標

❖ 精進廢氣回收技術⇨擴大自廠廢氣使用、整合區域能源



中油公司大林廠燃料整合應用

持續精進項目

❖ 106年以後優化歲修開車⇨臭氧事件日減少73~76%

六輕所有燃燒塔廢氣量(開車時段+前後2日) vs 臭氧事件日站日數(日最大小時>120ppb,全國77站)

參、HAPs議題

What's on the Horizon – A California Perspective

South Coast AQMD

Bay Area Air Quality Management District

2018 National Ambient Air Monitoring Conference

Jason Low and Eric Stevenson

Review of Goals/Outcomes of Current Network

- Regional and limited source-oriented NAAQS compliance and trends determination with a focus on population
- Aids in "truth testing" of regional and single source-oriented models
- Disassociated with emissions inventory and non-regional source attribution

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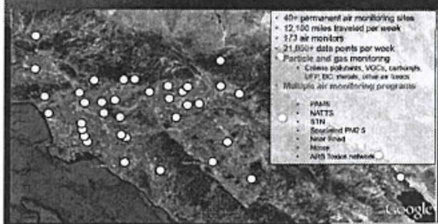
AIR MONITORING NETWORKS

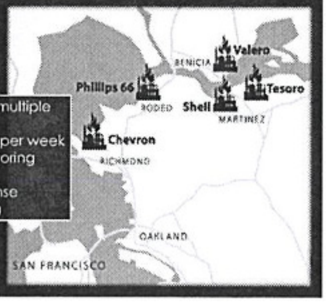


- 40+ permanent air monitoring sites
- 12,100 miles traveled per week
- 173 air monitors
- 21,000+ data points per week
- Particle and gas monitoring
  - Criteria pollutants, VOCs, carbonyls, UFP, BC, metals, other air toxics
- Multiple air monitoring programs
  - PAMS
  - NATTS
  - STN
  - Speciated PM2.5
  - Near Road
  - Noise
  - ARB Toxics network

- 35+ permanent air monitoring sites
- 150+ air monitors
- Particulate and gas monitoring
  - Criteria pollutants, speciated VOCs, carbonyls, UFP, BC, metals, air toxics, speciated $PM_{2.5}$ and PM_{10}
- Multiple air monitoring programs
  - PAMS
  - NATTS (discontinued this year)
  - CSN
  - Near road
  - NCore
  - Toxics network
  - Extensive meteorological network

SPECIAL MONITORING PROJECTS

- Mobile platforms and multiple fixed sites
- 10,000s of data points per week
- Particle and gas monitoring
- Other activities
  - Emergency response
  - Wildfire monitoring



AB 617 background

- Originated in negotiations regarding the extension of Cap & Trade program (AB 398)
- Responds to advocates' concerns with continued high levels of air pollution in local communities
- Directly addresses toxics and criteria pollutants in the most impacted communities

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AB 617 program components – designed so elements link at iteratively improve

- Community selection
- Monitoring
- Emission reduction action plans
- Emissions inventory
- Incentives
- BARCT Update/Clearinghouse

Change of focus to hyper-local air quality impacts

- Determine impacts of local contributions and focusing monitoring to identifying localized disproportional impacts
- Identify localized "hotspots", contributions from individual sources and contributions from background and regional sources
- Develop source attributions based on monitoring
- Truth test highly resolved modeling and improve emissions inventories

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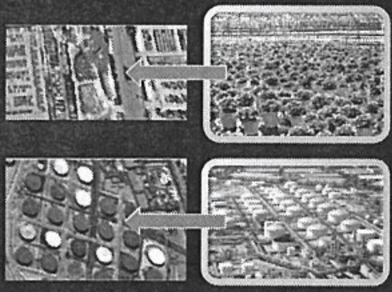
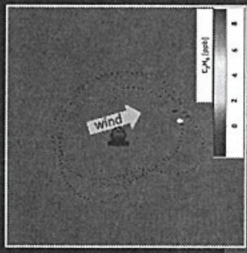
AB 617 Goals

FLIGHT-BASED AIR TOXICS MEASUREMENT



- Survey large areas, including refinery areas
- Detect plumes & emissions
- Guide ground-based efforts

Airborne Surveillance of Potential Sources



- Elevated CH_4 and C_2H_6 measured downwind of an oil tanker ship
- FLIR gas imaging camera detected fugitive emission plume

MOBILE AIR TOXICS LABORATORY

- Survey major refineries and other petroleum facilities

- Fenceline and community mobile monitoring
- Identify sources and community levels

Metals/Toxics Mobile Platform

- 5-week monitoring in March-April, 2018
- Variety of fast time response instruments for the measurement of air pollutants:
  - ✓ VOCs
  - ✓ BC
  - ✓ Toxic metals including Cr6+
- Monitored >50 facilities in ~10 different communities
- Future could involve PTR-MS measurements for speciated and time-of-flight measurements

Areas visited by Aerodyne/DRI between 03/03 and 03/09

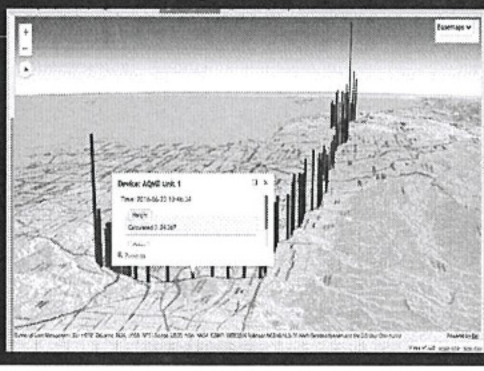
MOBILE METHANE MONITORING SETUP

- Methane analyzer and GPS mounted on top of hybrid SUV
- Instruments powered from a vehicle's cigarette lighter
- Methane concentrations and GPS coordinates are continuously recorded @ 1Hz
- Instruments controlled by a laptop PC
- Data-streams are combined by a custom software

LI-COR Biosciences LI-7700 Open Path CH_4 Analyzer

Hemisphere Atlaslink GNSS Smart Antenna

Refinery Emissions - FluxSense



alkane column (path integrated concentration)

Can Sensor be used to assist in the effort

- Need to develop standard for data export and ingestion
- Need to include ways for QA/QC to be evenly applied so that data are comparable
- Need to provide a way for appropriate visualization and context, so that people can determine appropriate ways to limit exposure

Communities can assist with sensor studies if:

- They are provided technical expertise on how to develop a network so data are actionable
- Provided or develop analytical skills necessary
- A means of data storage is provided to allow transparent access and further evaluation

AQ-SPEC

Air Quality Sensor Performance Evaluation Center

- Most comprehensive sensor evaluation progra in the Nation
- Recognition for:
  - Community educatio
  - Validation of satellite air quality data
- Pilot sensor network projects
- Next steps:
  - Statewide sensor network developmen
  - Sensor verification program

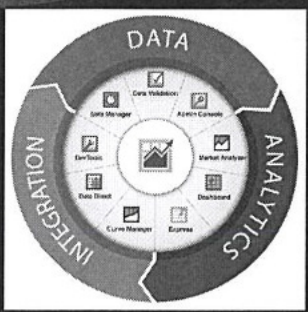
Frequency Map of Dust Emission Areas of Plant

Data generated July 21st, 2010 between 11:54 AM and 1:44 PM

DATA QUALITY

- Not all measurements are equal
- Remember to match quality requirements to monitoring goal
- Education and provide technical assistance

DATA COLLECTION AND MANAGEMENT



- Large amounts of data with geolocation
- Methods to make all data "apples to apples"
- Provide ways to give graphics and information context

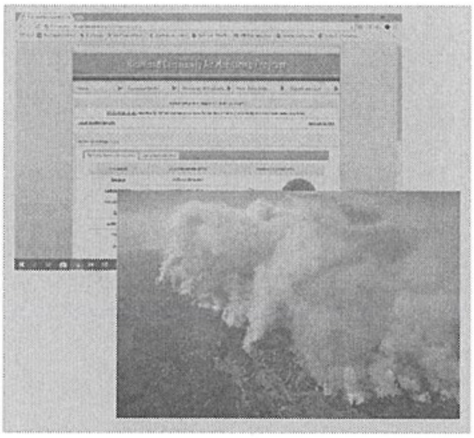
Further Integration

Communities expect incidents to be better characterized and measured

- Need to be able to evaluate "steady state", episodic and unintended releases
- Providing information about limitations

Regions expect better capabilities during regional events (wildfires)

- Provide forecasts of impacts
- Explain how concentrations, forecasts and impacts affect health outcomes



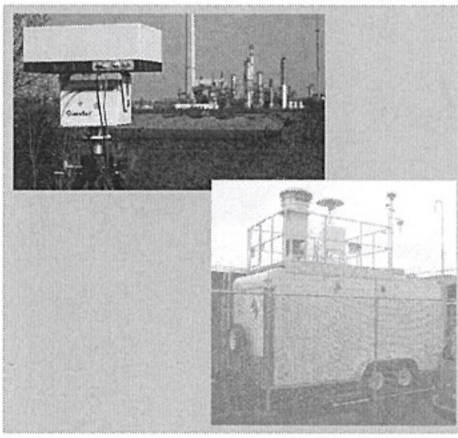
Path Forward

Develop methods to gain better spatial coverage, while balancing temporal coverage

- This will help identify sources that impact communities
- Need to be able to evaluate "steady state", episodic and unintended releases

Achieving more spatial and temporal measurements to achieve the goals improving better health outcomes

- Decrease air quality disparities with the goal of eliminating them entirely
- Enhance enforcement and compliance



Potential for Compliance and Enforcement

Identifies emissions as they develop

- Allow industry to take corrective action early
- Allows regulators to better focus resources

Aids in better defining where impacts occur

- Potential for determining where, and under what conditions, "lofted" emissions impact population
- Better identification of impacts leads to more focused regulatory actions

Emissions Inventory

- Annual stationary source emissions reporting for facilities:
  - already subject to mandatory GHG reporting
  - emits 250 tons/year or more of any nonattainment pollutant/precursor
  - has an "elevated prioritization score" based on cancer or noncancer impacts
- Uniform statewide annual reporting for criteria and toxic emissions
- Direct reporting to state of stationary sources emissions
- Third party verifier?

Incentives

$50 Million:

- Reduce diesel from mobile sources
- Prioritize impacted communities
- Dirty fleet replacement
- Voluntary participation
- Under contract by June 30, 2019
- Funds spent by June 30, 2021

Integrated Method of Combining Fixed and Mobile Stations for Air Pollution Tracking and Reduction Assessment

Speaker: Chung-Liang Tai

Hung-Teh Tsai[1], Chung-Liang Tai[1], Tzu-Hao Kuo[2], Yung-Chuan Kuang[2], Wen-Tzu Liu[3], Chung-Hsien Yu[3], Tsung-Kuan A. Chou[3,4]

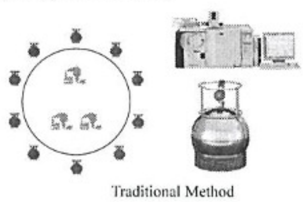
[1] Department of air quality and noise control, Environmental Protection Administration, Executive Yuan, Taiwan
[2] Sinotech Engineering Services, Ltd., Taipei, Taiwan
[3] TricornTech Corporation, Taipei, Taiwan
[4] TricornTech Corporation, San Jose, California, USA

2018.08.15

行政院環境保護署 Environmental Protection Administration Executive Yuan, R.O.C. (Taiwan)

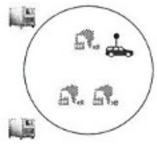
Introduction

- Traditional Method(Canister sampling & GC-MS)
  - Long-term exposures
  - Disadvantage
    - Limited sampling
    - Expensive
    - Poor mobility



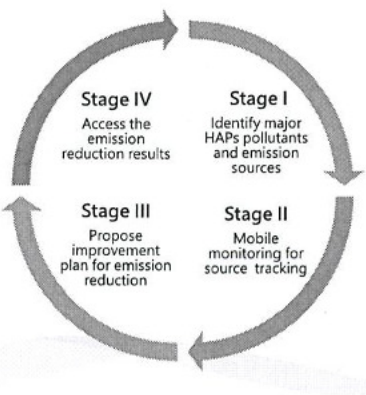
Traditional Method

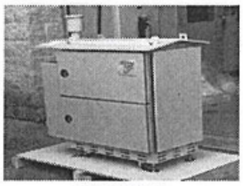
- This study
  - Fixed & mobility
  - Real-time auto micro-GC
  - Track source



This study

Procedure of This Field Study with Four Stages





Fixed Station

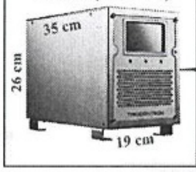
Mobile Stations

Monitoring station setup

- 15 HAPs specific to petrochemical industry
- HAPs hourly threshold for Stationary Sources*
  - Vinyl Chloride (20ppbv)
  - Benzene (20ppbv)
  - 1,3-Butadiene (100ppbv)

*Stationary Sources Fenceline HAPs Standard (draft), Taiwan, 2017

MiTAP (Auto-GC)



Alkanes & Alkenes	Aromatics	Oxygenated VOCs	Chlorinated VOCs
n-Hexane	Benzene	Acetone	Vinyl chloride
Propene	Toluene	Butanone	Trichloroethylene
1, 3-Butadiene	Ethylbenzene	Ethyl acetate	Perchloroethylene
	Xylenes		1, 2-Dichlorobenzene
	Styrene		1, 4-Dichlorobenzene

Figure1. MiTAP P310(Tricorntech Corp., Taiwan) auto-GC and representative VOCs detected in this study.

Stage I：Identify major pollutants and emission sources

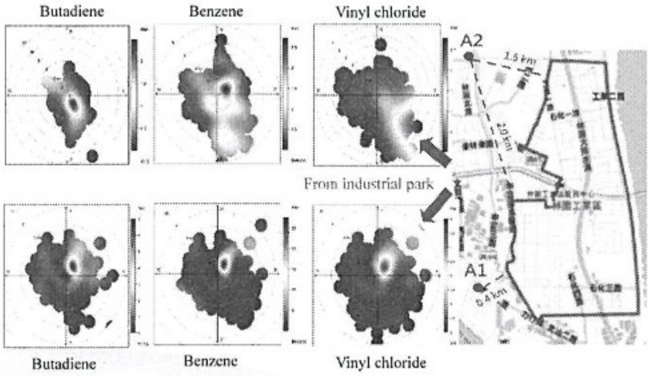


Figure2. Geographic locations of schools A1 and A2, and pollution roses observed by fixed stations.

Stage I：Identify major pollutants and emission sources

- From May to October, 2017

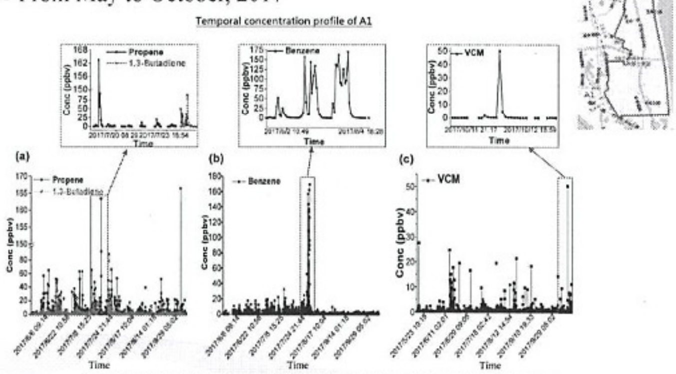


Figure3. Temporal concentration results of major toxic VOCs observed at school A1.

Stage I：Identify major pollutants and emission sources

- From May to October, 2017

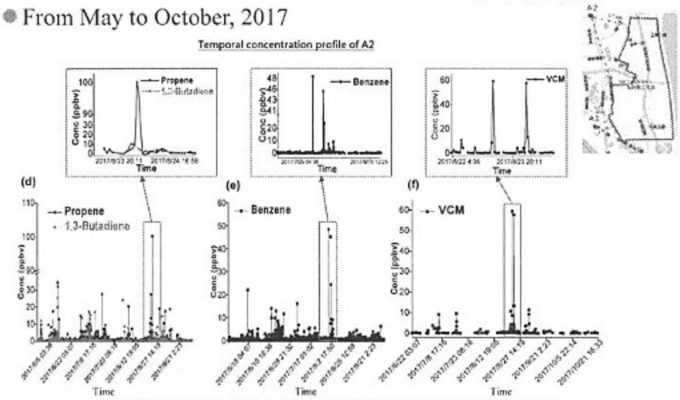


Figure4. Temporal concentration results of major toxic VOCs observed at school A2.

Stage II：Mobile monitoring for source tracking

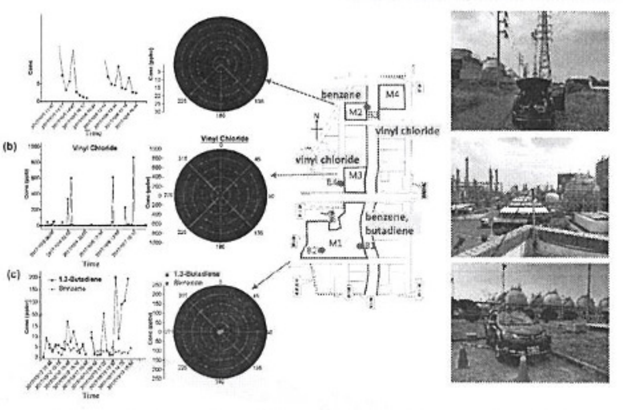


Figure5. Mobile monitoring verification results at selected locations relative to targeted plants for emission source tracking.