Air Quality Impacts of LNG in the South Coast Air Basin of California

California Energy and Air Quality Virtual Conference Series

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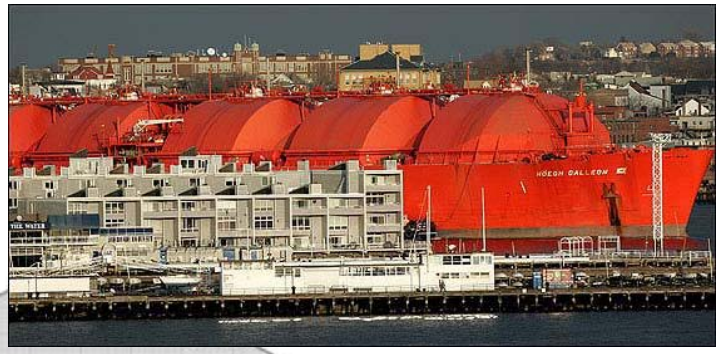
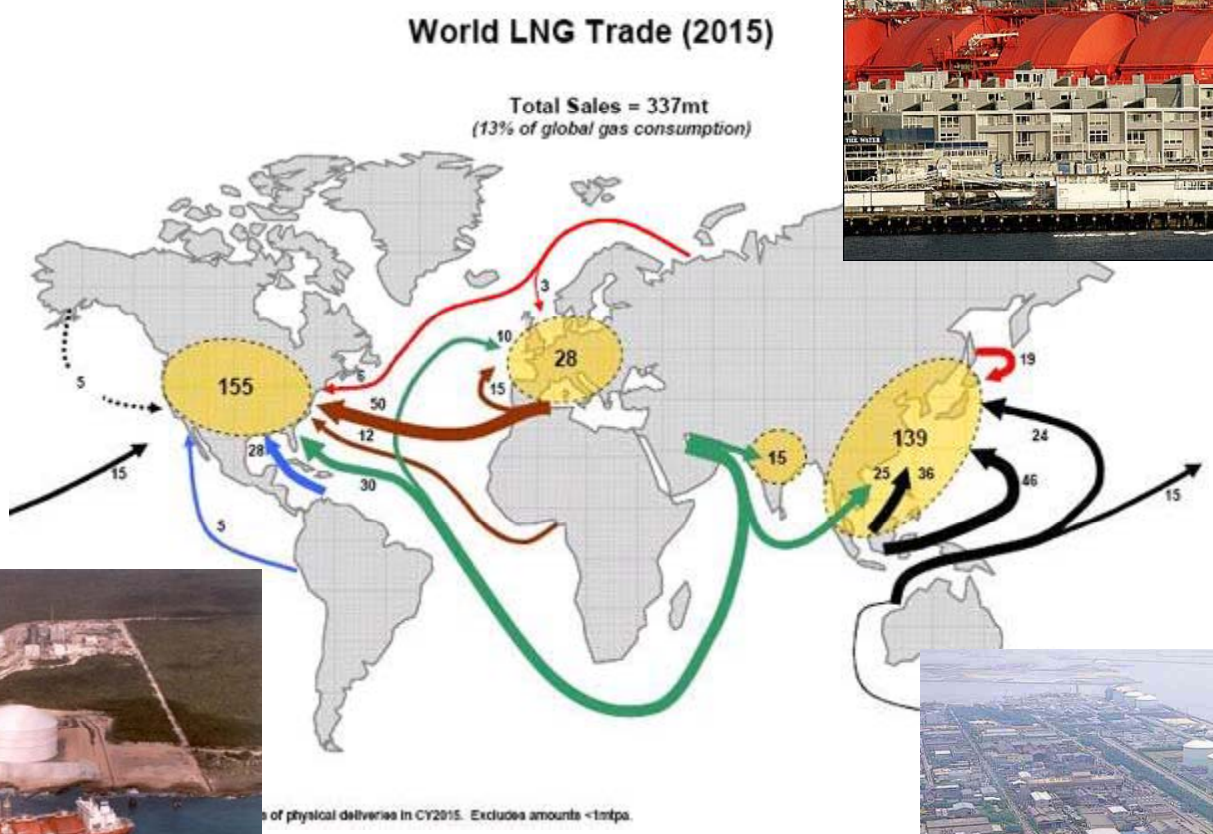
What is LNG?

- **LNG: Liquefied Natural Gas**





Why we care about LNG in SoCal?

LNG Terminal
Energia Costa Azul

NG Glossary

- **Interchangeability: ability to substitute one gaseous fuel for another without impacting combustion performance, emissions and safety**

- **Wobbe Index (WI): indicator of the interchangeability of fuel gases**

$$WI = \frac{HHV}{\sqrt{G_S}}$$

where:

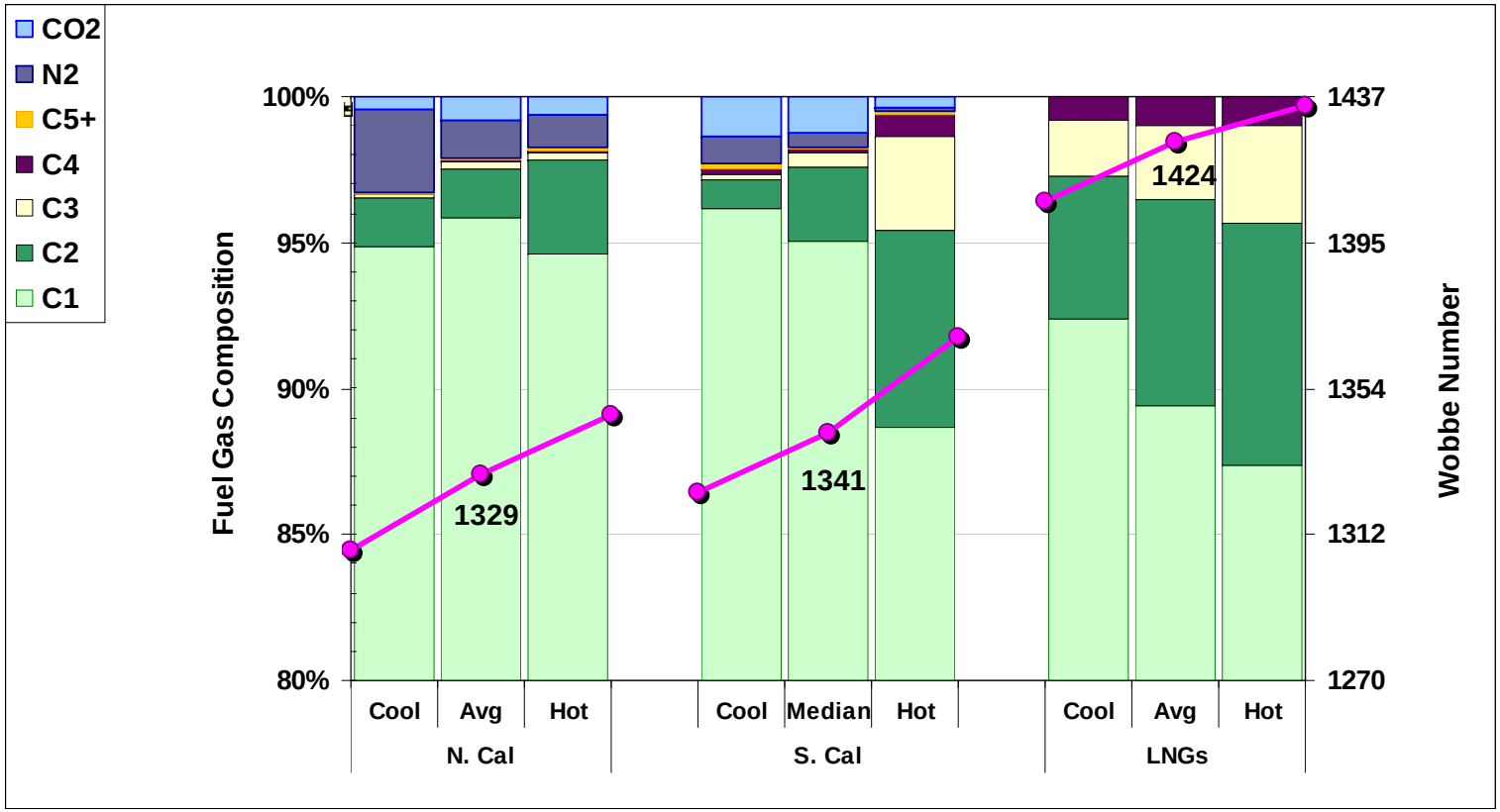
- **HHV: Higher heating value of the gas**
- **G_S: Specific gravity**

Average WI in SoCal is 1335 BTU/scf

Maximum allowed WI in California is 1385 BTU/scf

Imported LNG vs. Domestic NG

Composition of imported LNG compared to domestic NG



Source: Gas Technology Institute

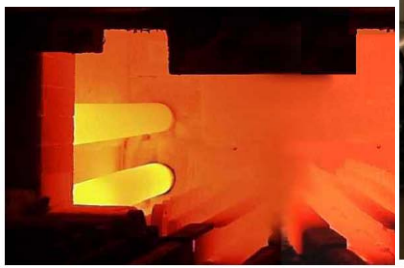
- **Changes in Wobbe Index and gas composition in NG lead to changes in pollutant emissions**

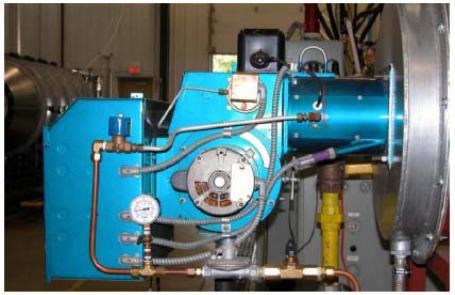
Overview of Study

Emission Testing

Residential Appliances by Berkeley Lab (LBNL)

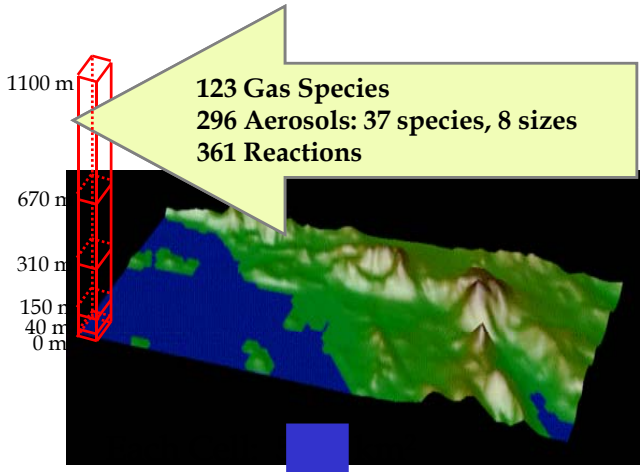
Industrial/Commercial Appliances by SoCalGas





Estimate emissions

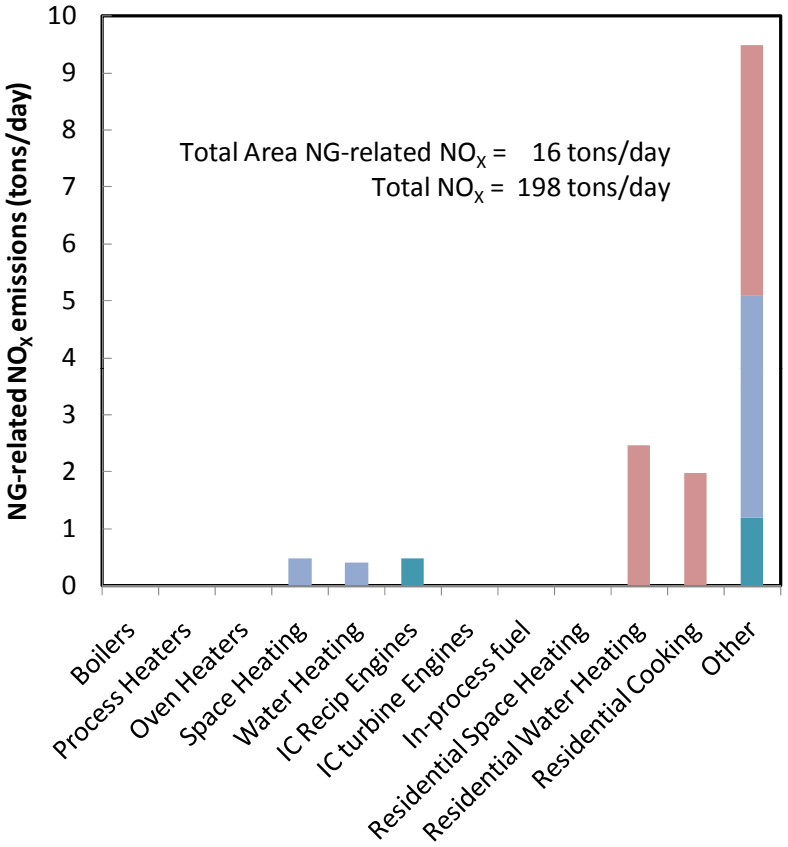
Air Quality Modeling



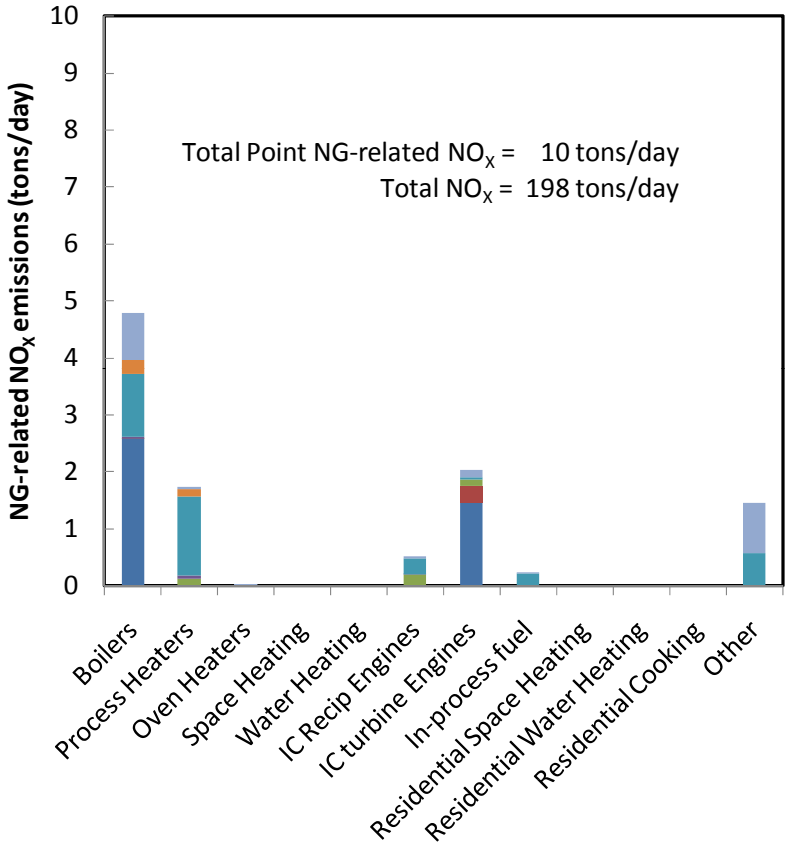
Determine spatial/temporal AQ impacts

NG-related Emissions from AQMD for Summer 2023

Area sources



Point sources

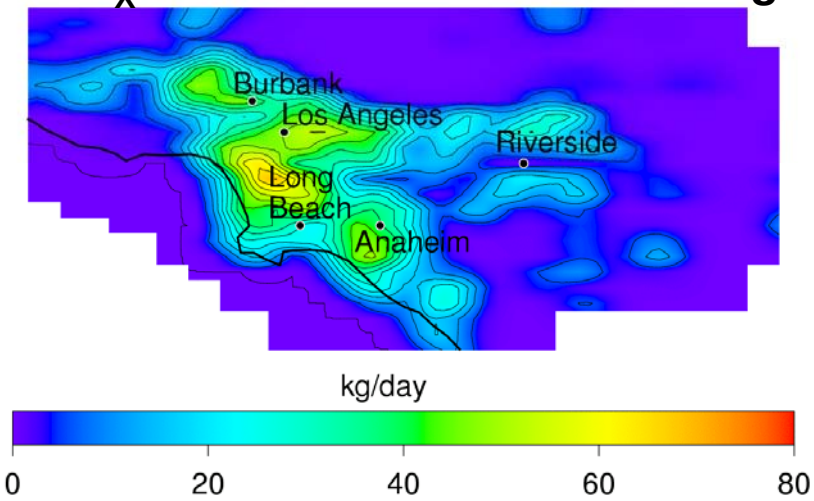


- Electric Utilities
- Cogeneration
- Oil and Gas Production
- Petroleum refining
- Manufacturing and Industrial
- Food and Agricultural
- Service and Commercial
- Residential Fuel Combustion

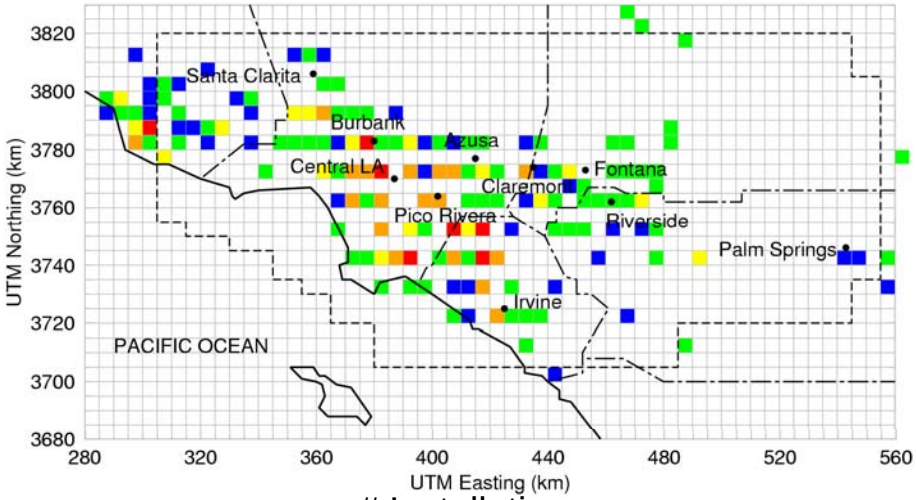
Distribution of Emission Sources

- **Spatial and temporal resolution provided by AQMD**
  - **Emissions from area sources based on generic emission factors**
  - **Emissions from point sources based on direct records from AQMD monitoring**

NO_X – Residential Water Heating



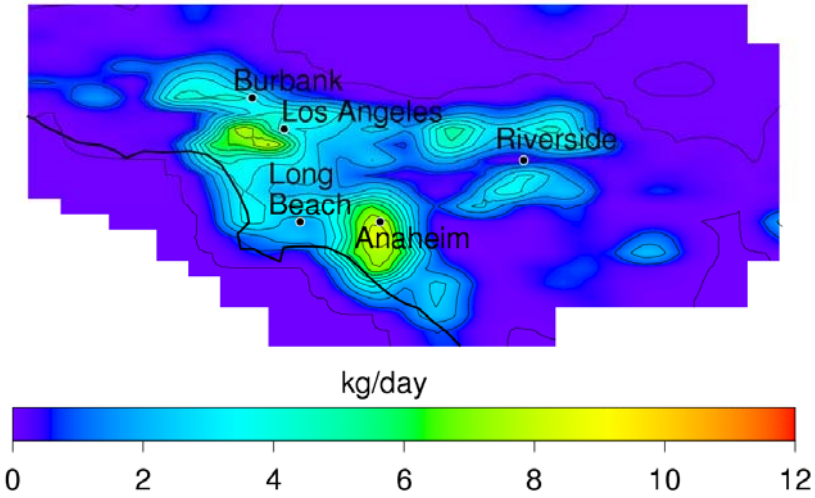
NG Boilers – All Sectors



Installations

1 2 – 5 6 – 10 11 – 15 16 – 20

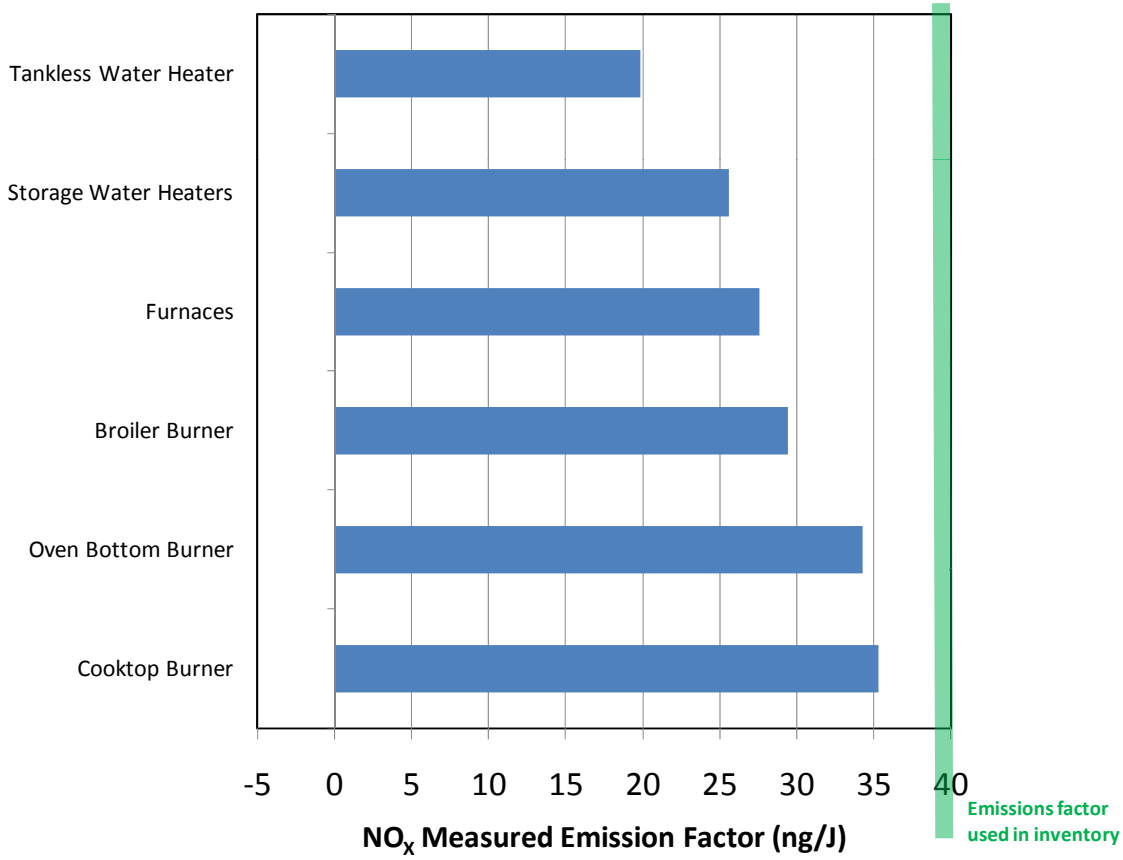
NO_X – Commercial Water Heating



Updated Emission Factors for Area Sources

Residential:

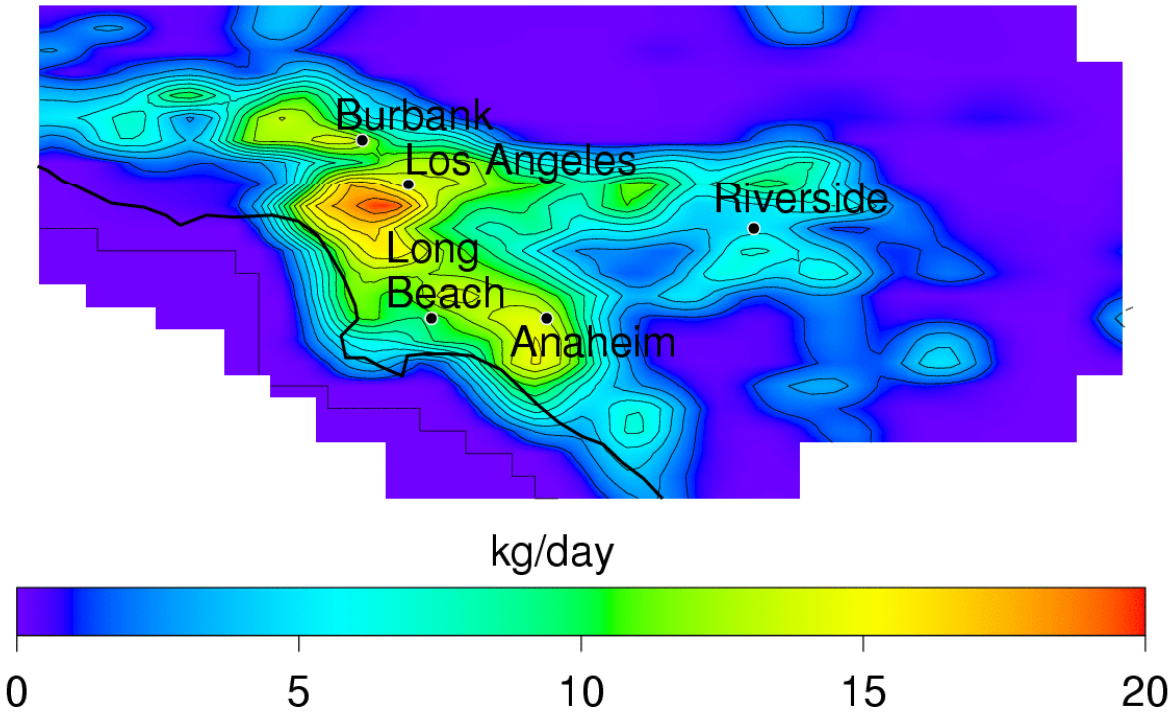
- **Average emission factors obtained by LBNL:**
  - **NO_X: lower than AP-42 for all appliances**



Update of Emissions Based on Measurements

- **Measurements by LBNL are used to update baseline emissions inventories**

Difference in NO_X emissions: Baseline – LBNL Case

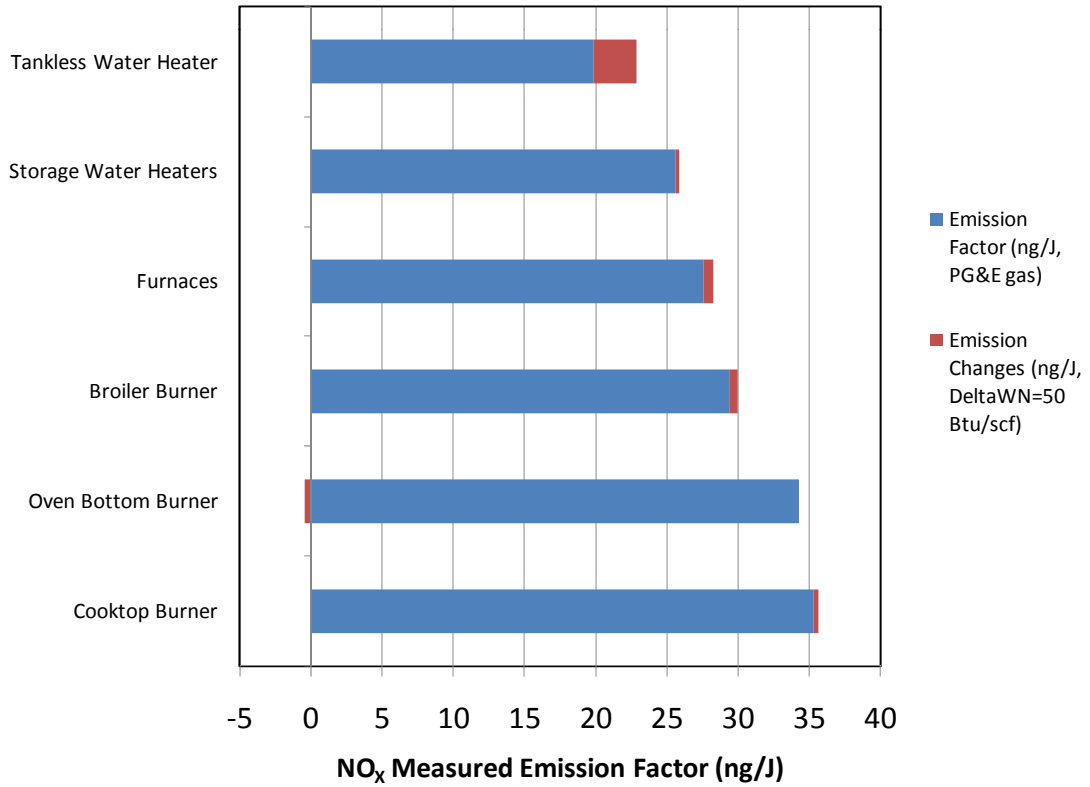


- **Difference in Total NO_X due to updating emissions based on LBNL measurements: 2.4 Tons/day (~1.2%)**

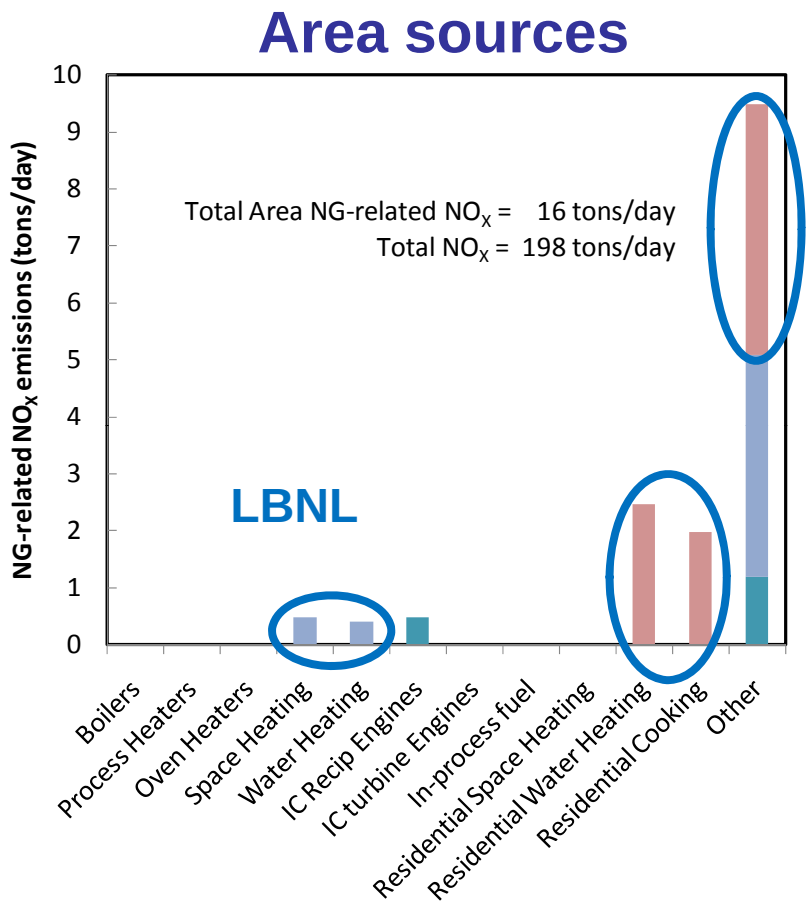
Impacts of LNG on NO_X Emissions Factors

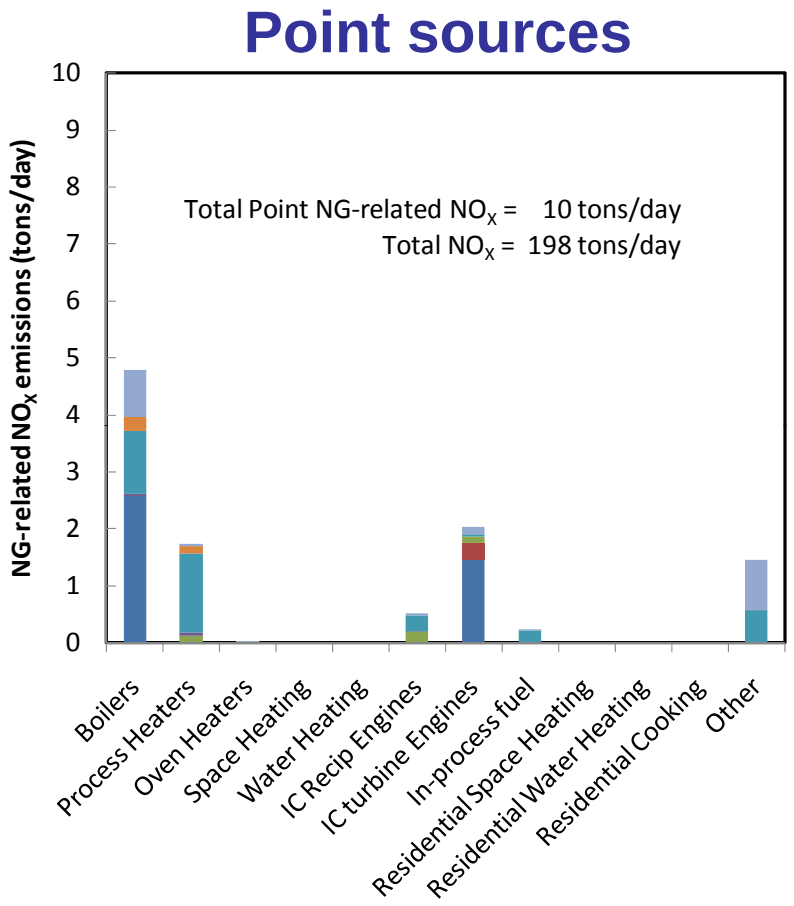
Residential:

- **Average LNG impacts obtained by LBNL:**
  - **Low NO_X sensitivity to changes in WN except for Tankless water heaters**
  - **Tankless water heaters are a small portion of all residential water heaters**



NG-related Emissions from AQMD for Summer 2023





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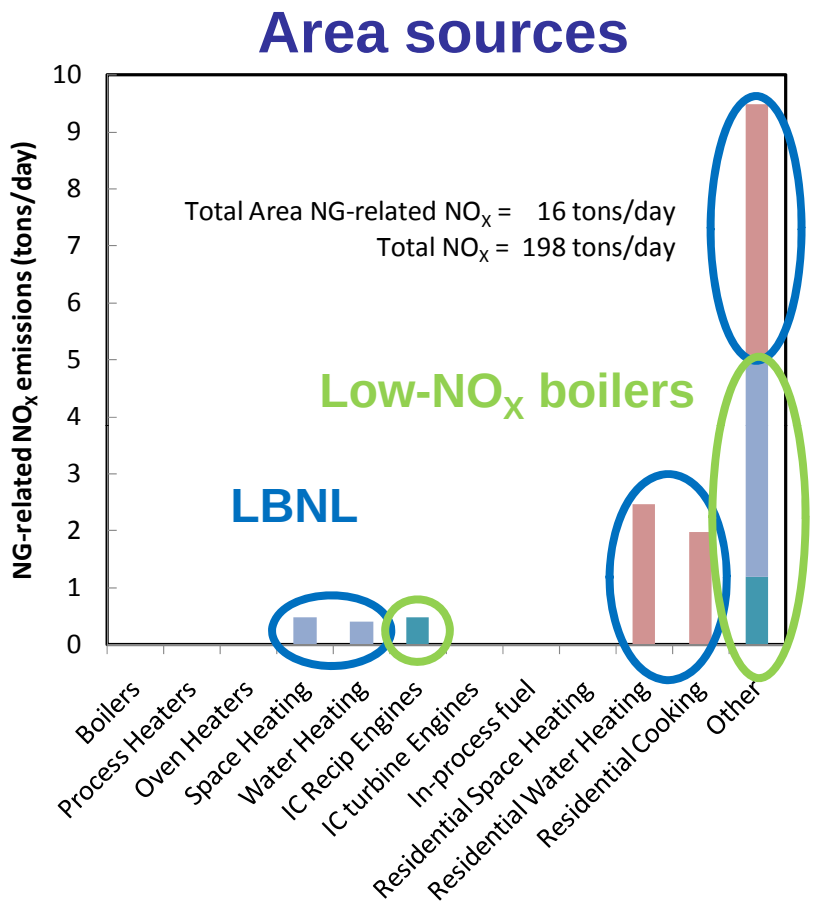
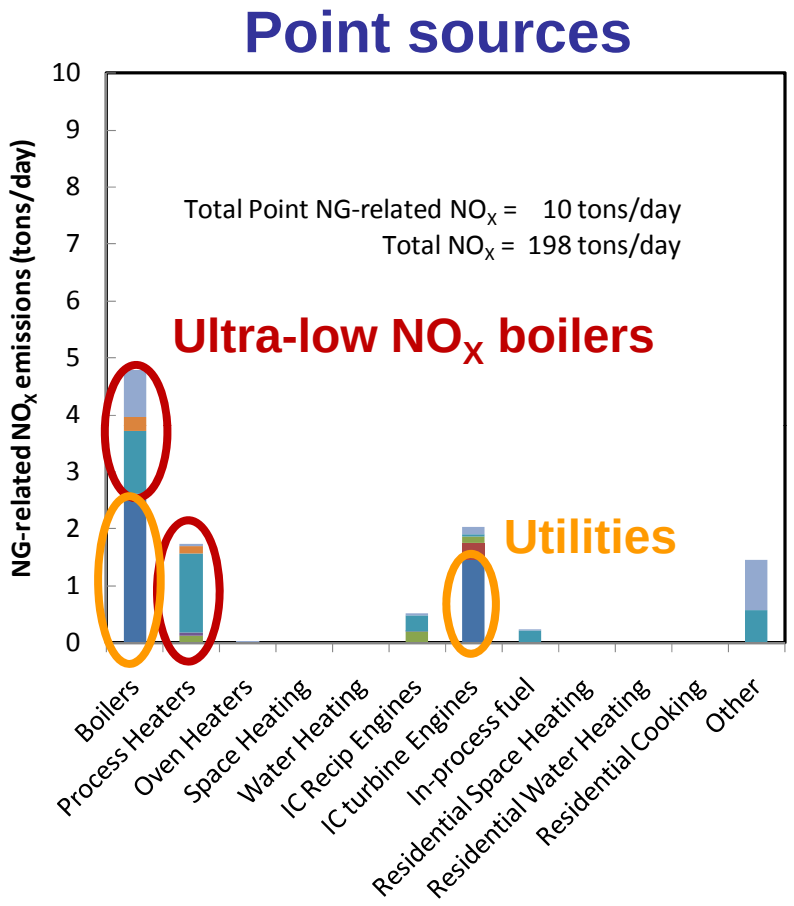
Impacts of LNG on Low-NO_X Boilers

- Most boilers in the SoCAB use low-NO_X burners
- Large boilers in the 'Electric Utilities' include active NO_X controls which minimize effects of LNG:
  - Electric Utilities not affected by LNG
- From SoCalGas "Equipment Studies", low-NO_X boilers showed sensitivity to changes in WN=1335-1385 range, without tuning:
  - Low-NO_X boilers: 40% increase in NO_X emissions
    - For 'Other' in the commercial and industrial area sources
  - Ultra-Low NO_X boilers: 15% increase in NO_X emissions
    - For boiler and process heaters in commercial and industrial point sources

NG-related Emissions from AQMD for Summer 2023





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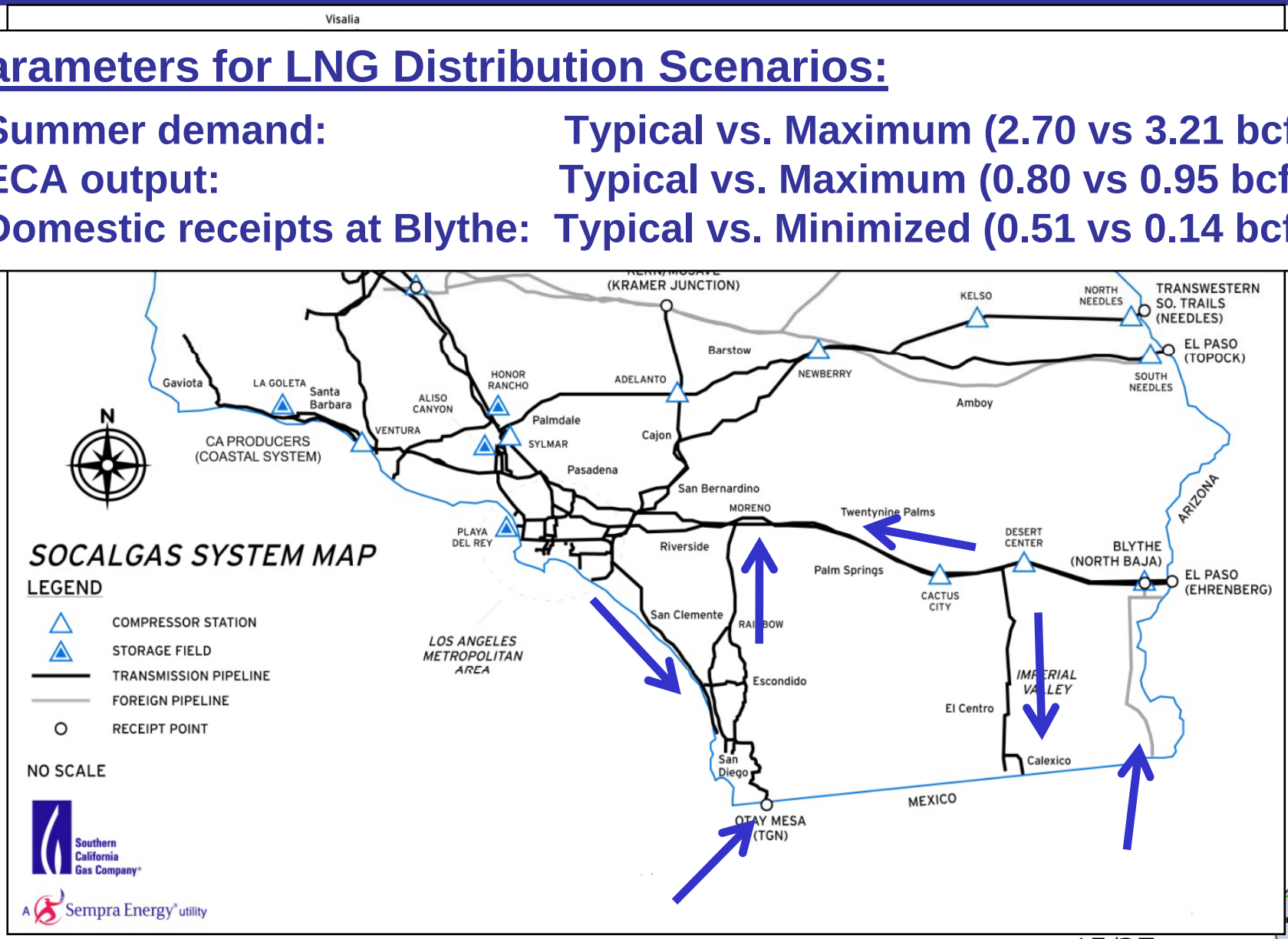
SoCalGas NG System

Parameters for LNG Distribution Scenarios:

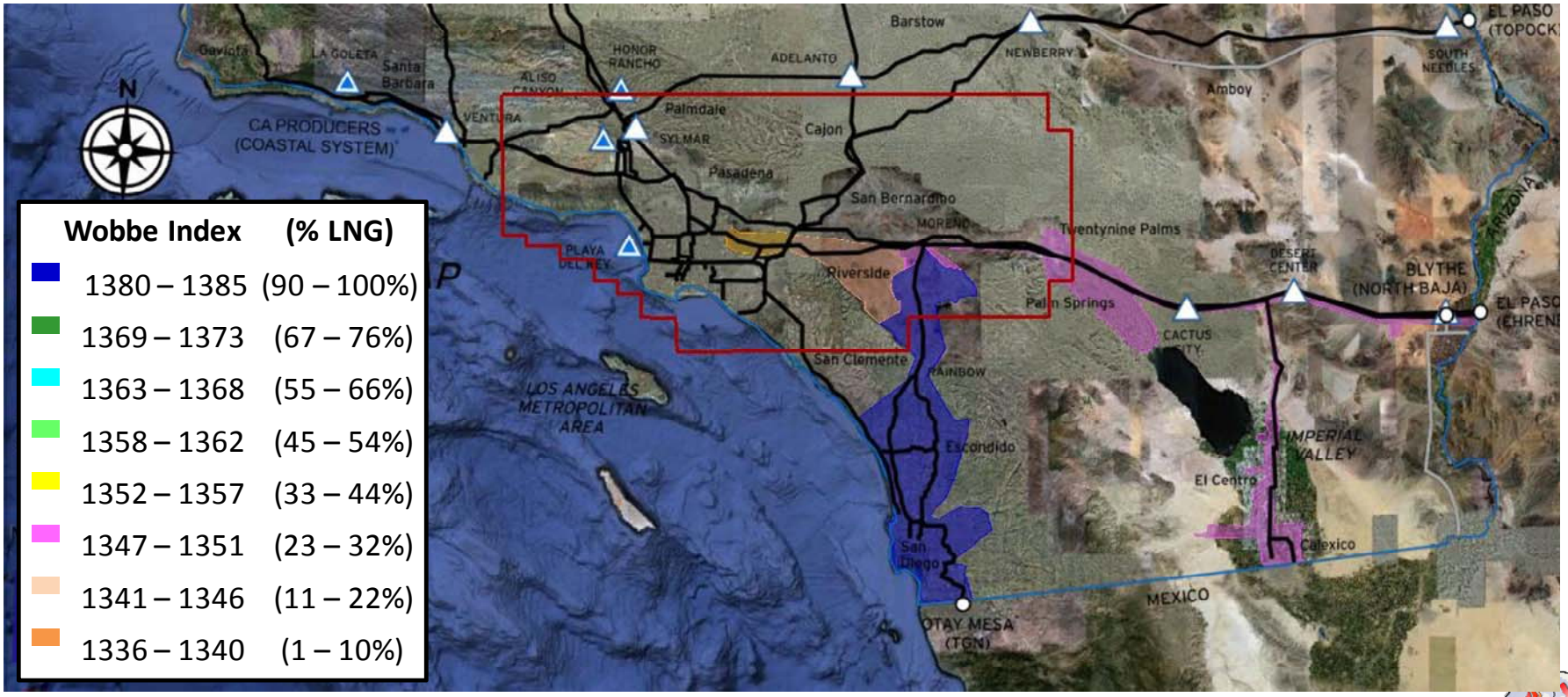
- **Summer demand:** Typical vs. Maximum (2.70 vs 3.21 bcfd)
- **ECA output:** Typical vs. Maximum (0.80 vs 0.95 bcfd)
- **Domestic receipts at Blythe:** Typical vs. Minimized (0.51 vs 0.14 bcfd)



Example: Future LNG Scenario

Parameters that maximize LNG fraction (Scenario 7):

- **Summer demand:** Typical (2.70 bcfd)
- **ECA output:** Maximum (0.95 bcfd)
- **Domestic receipts at Blythe:** Minimized (0.14 bcfd)

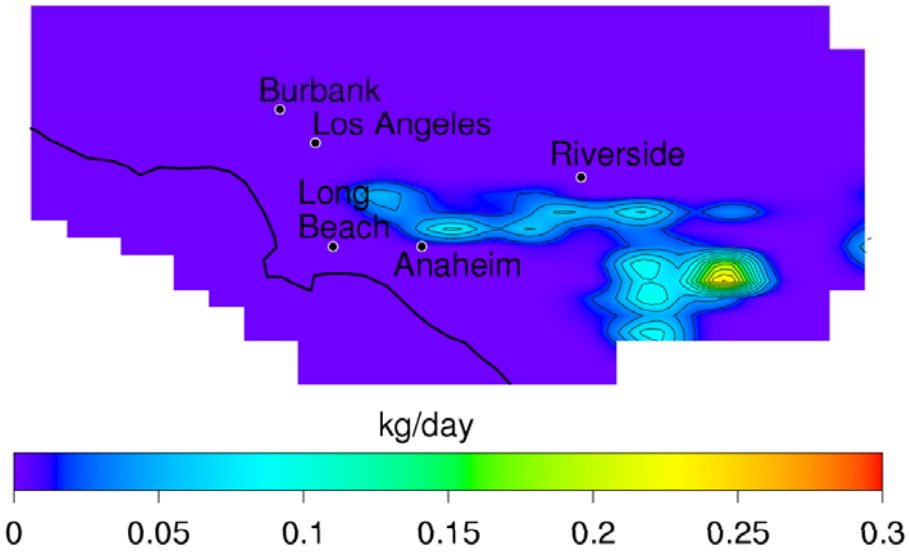


Impact of LNG on Total NO_X Emissions

- **Expected "high" penetration of LNG in the South Coast leads to small increase of NO_X emissions**
- **Complete shift from domestic NG to imported LNG could increase NO_X emissions more than 1.5%**

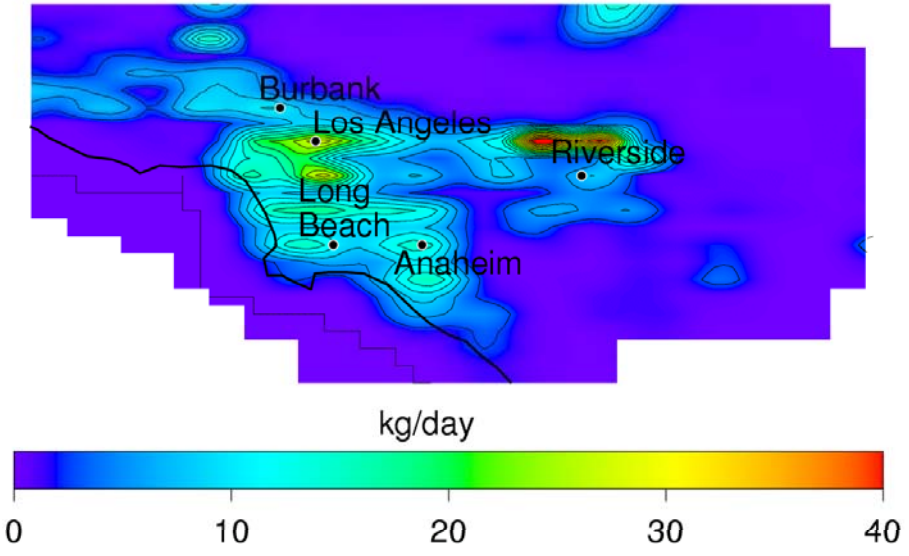
High LNG Penetration Case

Total Increase = 0.1 tons/day (<0.1%)

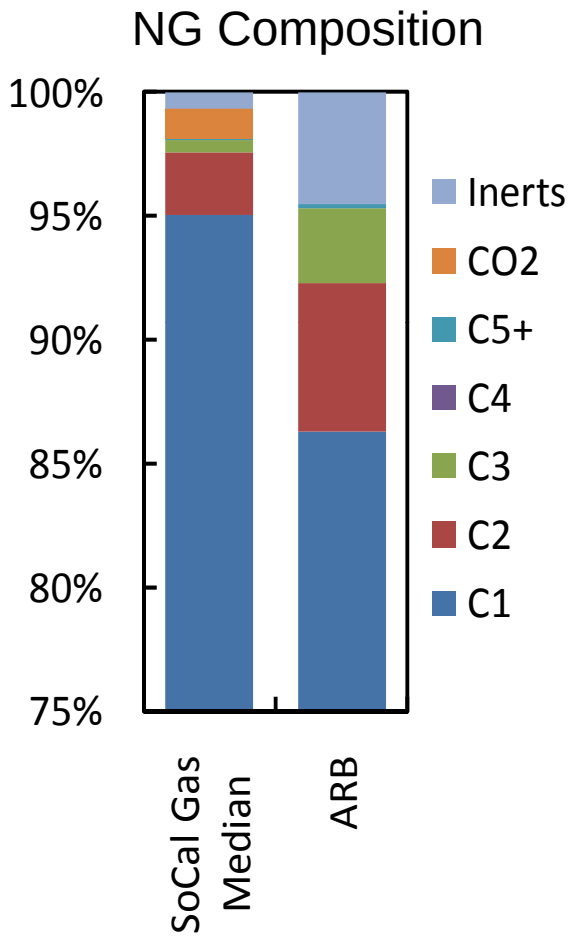


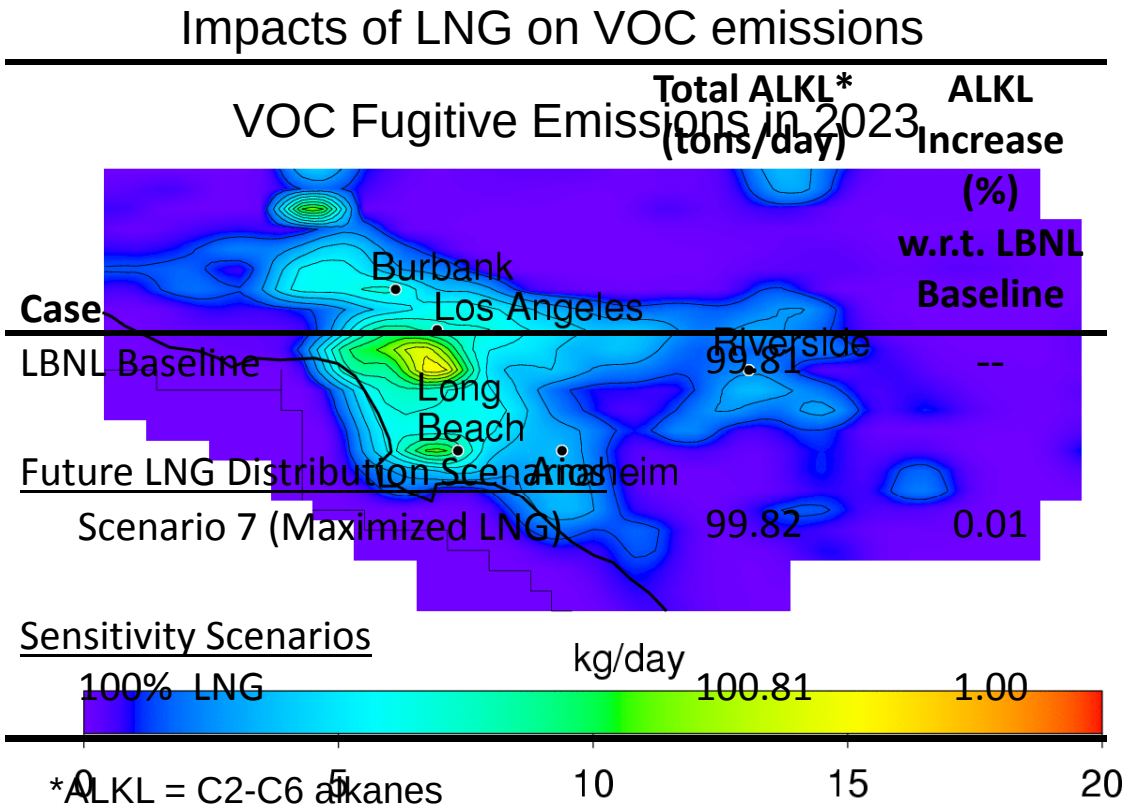
%100 LNG Case

Total Increase = 2.8 tons/day (~1.5%)



VOC Fugitive Emissions

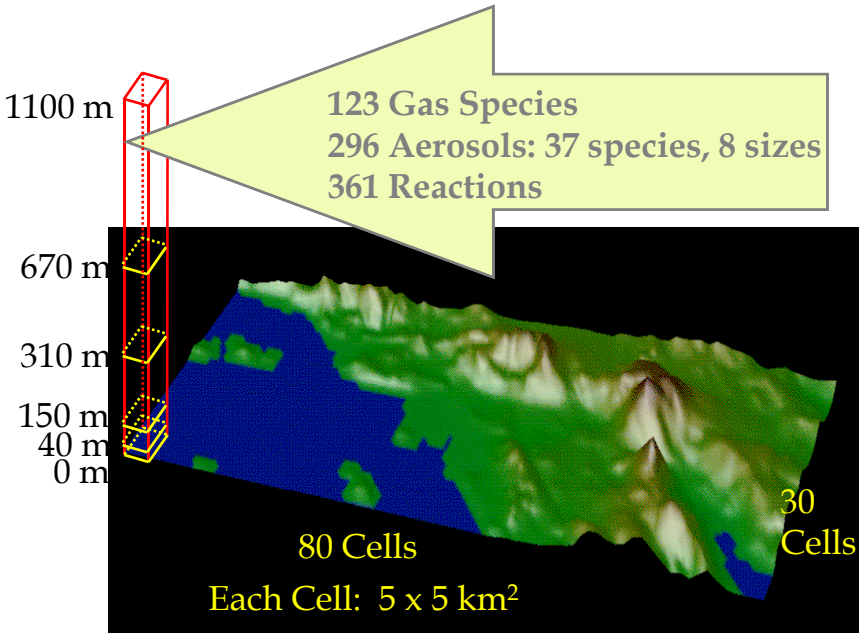




The Air Quality Model: UCI-CIT Airshed

Governing Dynamic Equation:

$$\frac{\partial Q_m^k}{\partial t} + \nabla \cdot \left(u Q_m^k \right) = \nabla \cdot \left(K \nabla Q_m^k \right) + \left(\frac{\partial Q_m^k}{\partial t} \right)_{\substack{sources / \\ sinks}} + \left(\frac{\partial Q_m^k}{\partial t} \right)_{aerosol} + \left(\frac{\partial Q_m^k}{\partial t} \right)_{chemistry}$$



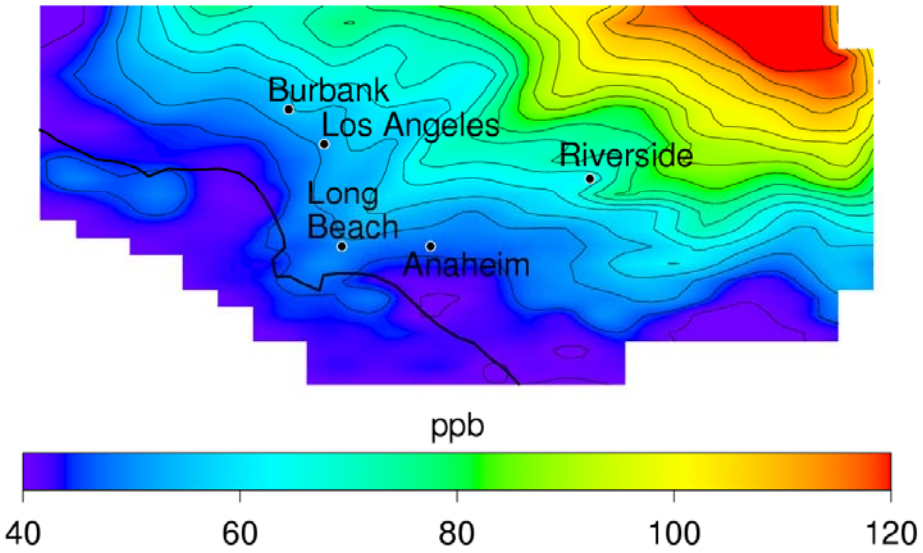
- Quintic-spline Taylor-series expansion (QSTSE) advection solver
- Caltech Atmospheric Chemistry Mechanism (CACM)
- Aerosol Modules:
  - Inorganic: Simulating Compositions of Atmospheric Particles at Equilibrium (SCAPE2)
  - Organic: Model to Predict the Multiphase Partitioning of Organics (MPMPO)

Baseline Air Quality

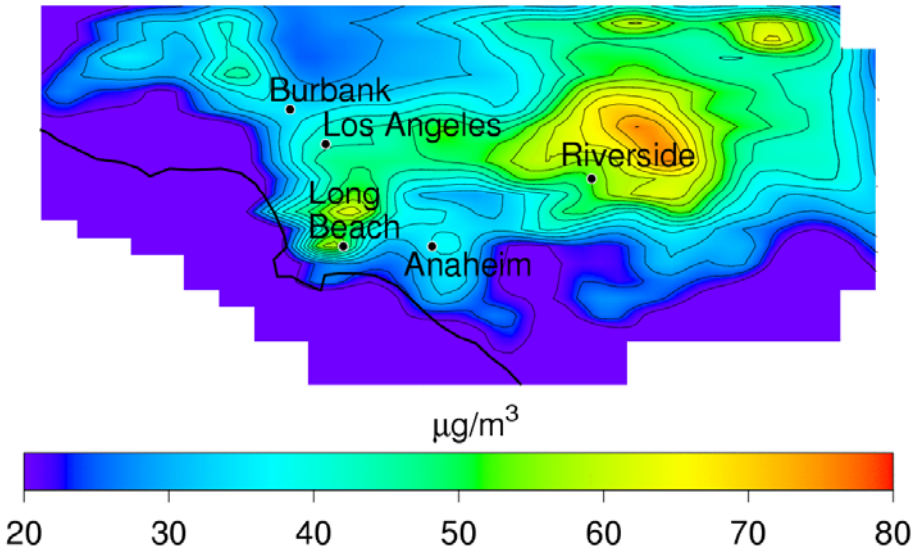
2023 AQMD Baseline Scenario:

- **Emissions from the 2007 Air Quality Management Plan (by AQMD)**
- **Meteorological parameters representative of summer high ozone conditions in the SoCAB**

8-hour average O_3



24-hour average $PM_{2.5}$



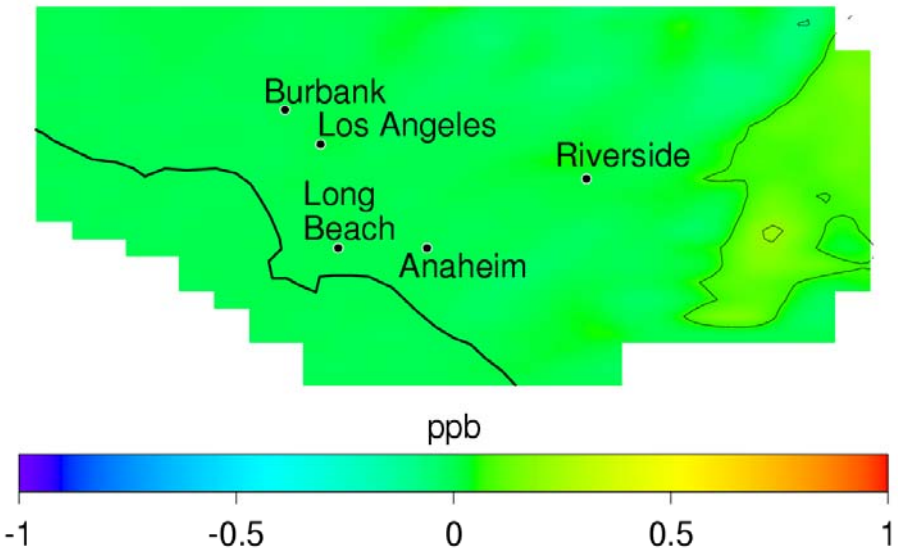
SoCalGas Scenario #7

Scenario #7:

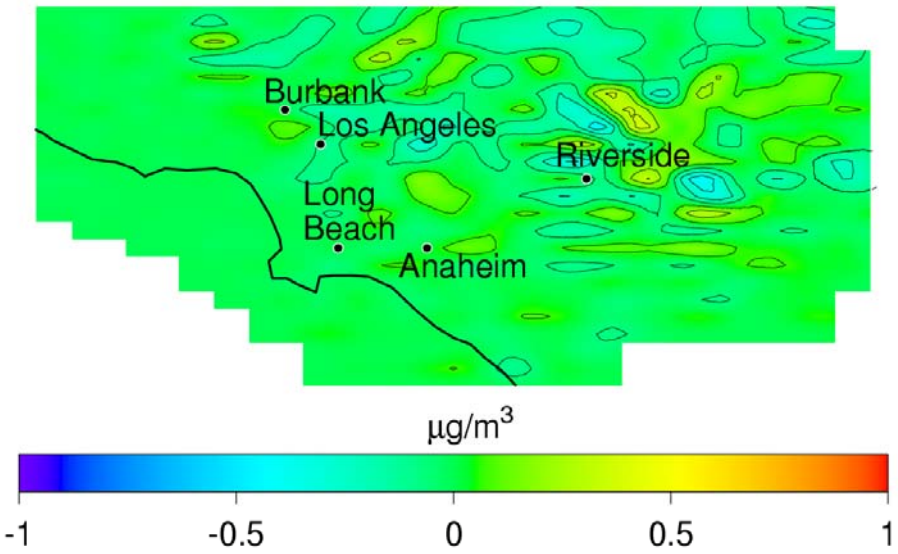
- **Maximum LNG penetration based on SoCalGas modeling**
- **Total NO_X emissions increase by of 0.04%**
- **Ozone increases by <0.5 ppb in a small area**

Scenario #7 – LBNL Baseline

8-hour average ΔO_3



24-hour average $\Delta PM_{2.5}$



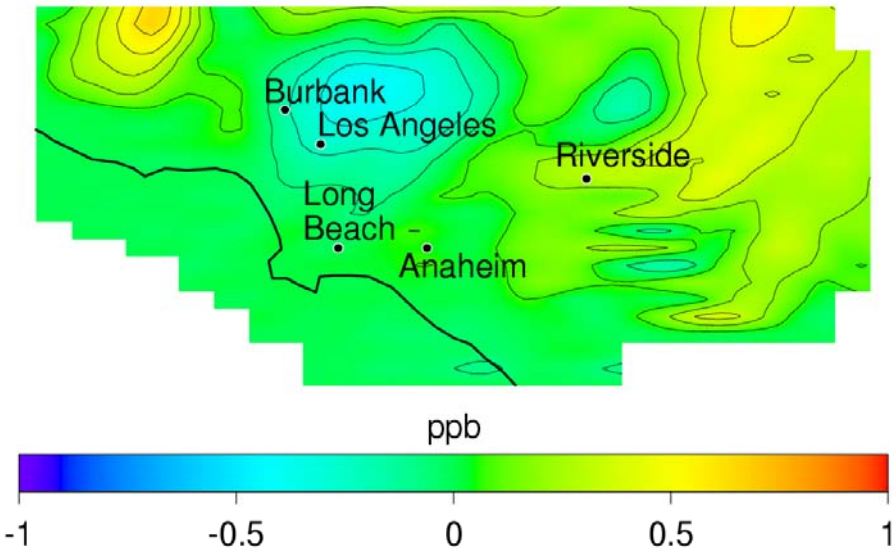
100% LNG

Scenario 100% LNG:

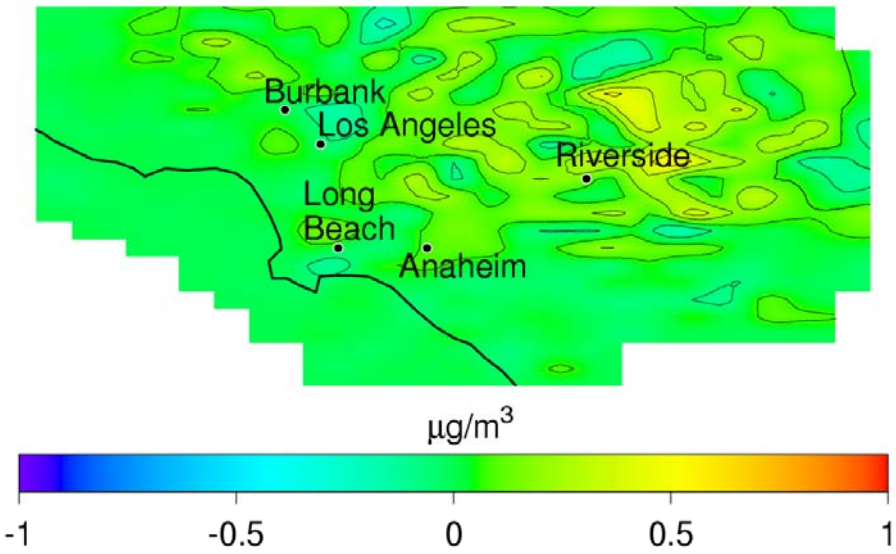
- **Uppermost bound for LNG penetration (not realistic)**
- **Total NO_X emissions increase by 1.3%**
- **Ozone increases by >0.5 ppb in sensitive areas**

Scenario 100% LNG – LBNL Baseline

8-hour average ΔO_3



24-hour average $\Delta PM_{2.5}$



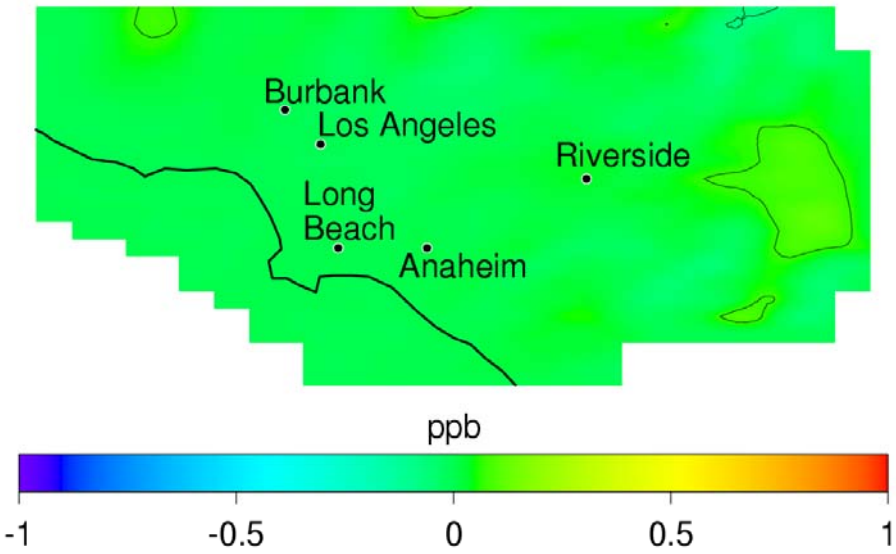
100% LNG with Equipment Tuning

Scenario 100% with Equipment Tuning:

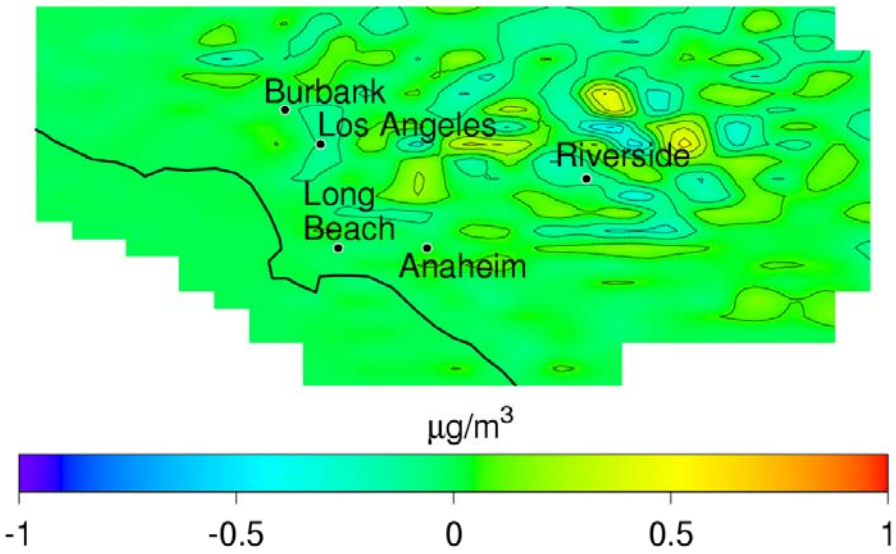
- NO_X emissions are comparable to Scenario 7
- ALKL emissions are the same as in Scenario 100% LNG
  - Effect of ALKL on ozone is negligible

Scenario 100% LNG w/ Tuning – LBNL Baseline

8-hour average ΔO_3



24-hour average $\Delta PM_{2.5}$



Conclusions – Impacts on Emissions

- Update of NG-related sources using measurements by LBNL reduces by ~1.2% basin-wide NO_X emissions
- Emission changes caused by LNG are small: <0.1% in NO_X emissions for projected LNG penetration by SoCalGas
- Maximum increases due to a complete shift to 100% LNG are 2.8 tpd (1.3%) for NO_X and 1 tpd (1.0%) for short-chain alkanes (ALKL)
- Re-tuning of commercial and industrial equipment would minimize the impacts of high penetration of LNG

Conclusions – Impacts on Air Quality

- In general, impacts of LNG on ozone and $PM_{2.5}$ are negligible to small
- Only in 100% LNG penetration cases impacts on ozone are noticeable
  - Air quality impacts of 100% LNG penetration are of the same order as the impacts due to updating emission factors for NG combustion
- The use of re-tuning strategies could minimize the impacts of LNG in high penetration cases
- The impact of fugitive VOC on ozone is limited due to the low reactivity of short-chain alkanes

Acknowledgments

- **Funding Agency: California Energy Commission**

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  - **Gas Technology Institute**

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  - **Air Resources Board**
  - **Environ**
  - **San Diego Air Pollution Control District**
  - **South Coast Air Quality Management District**
  - **Southern California Gas Company**

Thanks!