Warm-Mix Asphalt (WMA)
An Overview

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Introduction

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"Hot-mix asphalt (HMA) consists of a combination of aggregates uniformly mixed and coated with asphalt cement. To dry the aggregates and obtain sufficient fluidity of asphalt cement for proper mixing and workability, both the aggregate and asphalt must be heated before mixing – hence the term hot-mix."

Asphalt Institute, MS-4, The Asphalt Handbook

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Introduction

- Warm Mix Asphalt (WMA)
  - Fundamentally no different than HMA
  - Production Temperature 20-30°C (35-55°F) lower
    - Remain above 100°C (212°F) to stay above the boiling point of water

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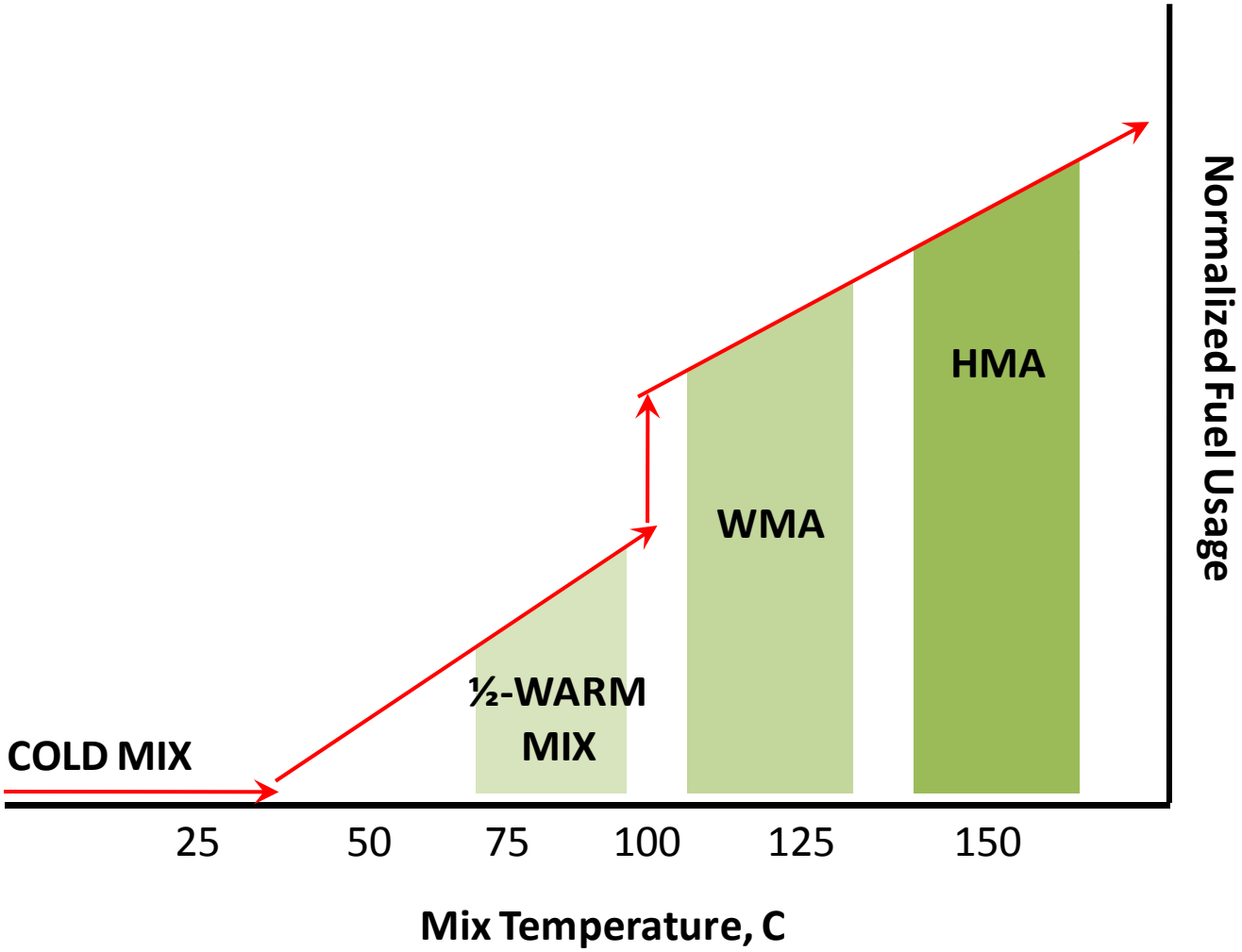

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Introduction

- WMA
  - "…a group of technologies which allow a reduction in the temperatures at which asphalt mixtures are produced and placed."

NAPA, QIP 125, Warm-Mix Asphalt: Best Practices

WMA Technologies

- Four General WMA Technology Categories
  - Organic additives
  - Chemical additives
  - Water-bearing additives
  - Water-based processes

WMA Technologies

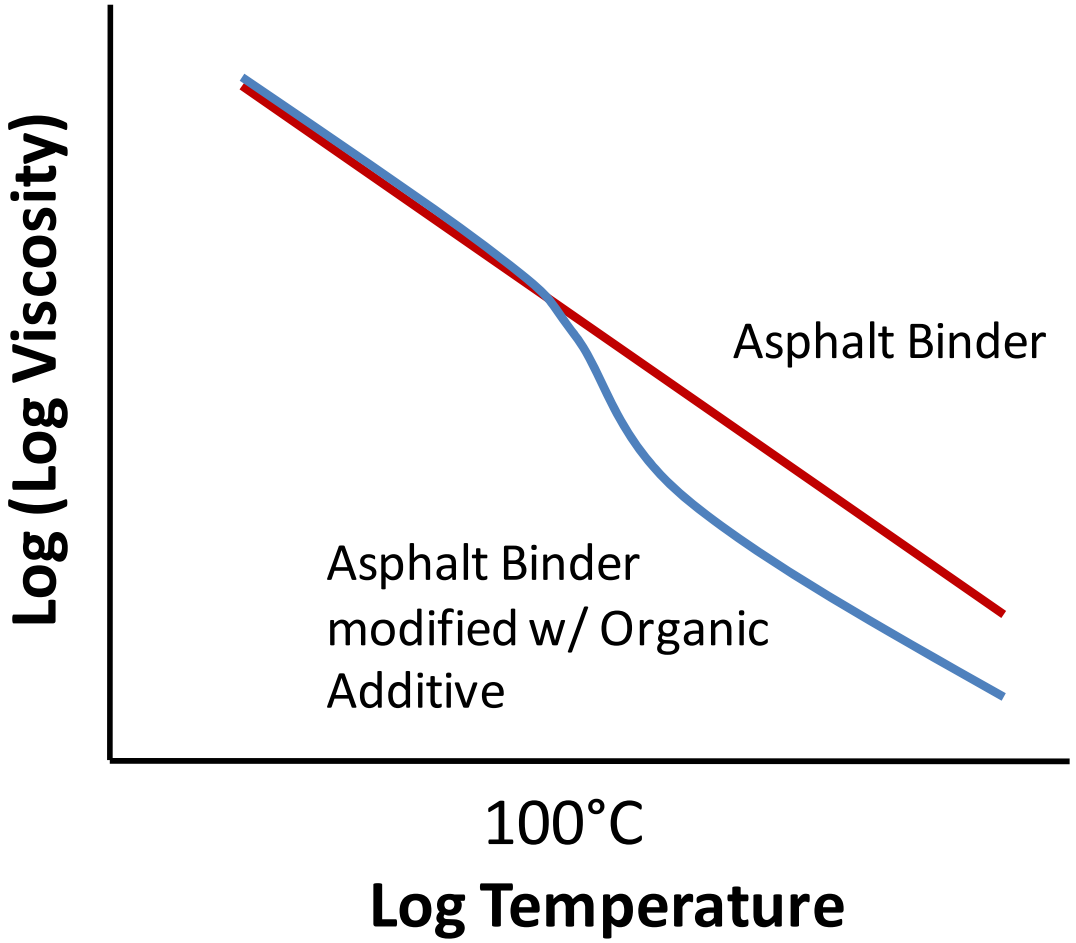
- Organic Additives
  - Sasobit (Fischer-Tropsch wax)
    - Longer carbon chain; finer crystalline structure than paraffin waxes
    - Melting point ~ 100°C
  - Asphaltan-B (Montan wax with fatty acid amide)
    - Melting point ~ 82-95°C
  - Licomont BS-100 (fatty acid amide)
    - Melting point ~ 140-145°C

WMA Technologies

Temperature-Viscosity relationship of asphalt binder modified with organic additives.

At temperatures above the melting point of the additive, the viscosity is reduced.

At temperatures below the melting point of the additive, the viscosity is unchanged



WMA Technologies

- Chemical Additives
  - Surfactants
    - Help the asphalt binder coat the aggregate at lower temperature
  - Evotherm
    - DAT (Dispersed Asphalt Technology)
    - 3G (REVIX)
  - Rediset WMX
    - Combination of organic and chemical additives
  - Cecabase RT

WMA Technologies

- Water-Bearing Additives
    - Synthetic Zeolites
        - Release crystalline water above 100°C to create foaming
    - Aspha-min
    - Advera WMA

WMA Technologies

- Water-Based Processes
  - Foaming Technology
    - Nozzles inject water into mixing chamber
  - Double Barrel Green (Astec)
  - Green Machine (Gencor)
  - LEA (McConnaughay)
    - Wet fine aggregate mixed with normally heated coarse aggregate to create foaming and reduction in temperature
  - WAM Foam
    - Two phase system
    - Soft binder with foamed hard binder

Why WMA?

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- Potential Benefits

Potential Benefit	Economic	Operational	Environmental
Reduced fuel use	X		X
Late season (cool weather) paving		X	
Better workability and compaction	X	X	
Reduced plant emissions of greenhouse gases			X
Increased usage of RAP	X		
Improved working conditions for plant and paving crew			X

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Why WMA?

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- Reduced Fuel Usage
  - Highly dependent on moisture and temperature
    - Rule of thumb is 2 to 3% decrease in fuel usage for every 6°C (10°F) decrease in temperature
    - Theoretically, WMA produced at 20 to 30°C (35 to 55°F) lower temperature should experience a 7% to 17% decrease in fuel usage
    - Moisture content affects fuel usage also
  - 10 to 35% decrease typically reported

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Why WMA?

- Late Season (Cool Weather) Paving
  - WMA remains compactable at lower temperatures than HMA
    - Case studies in Europe indicate WMA has been successfully placed at -3°C ambient air temperature
  - Slower cooling rate

Why WMA?

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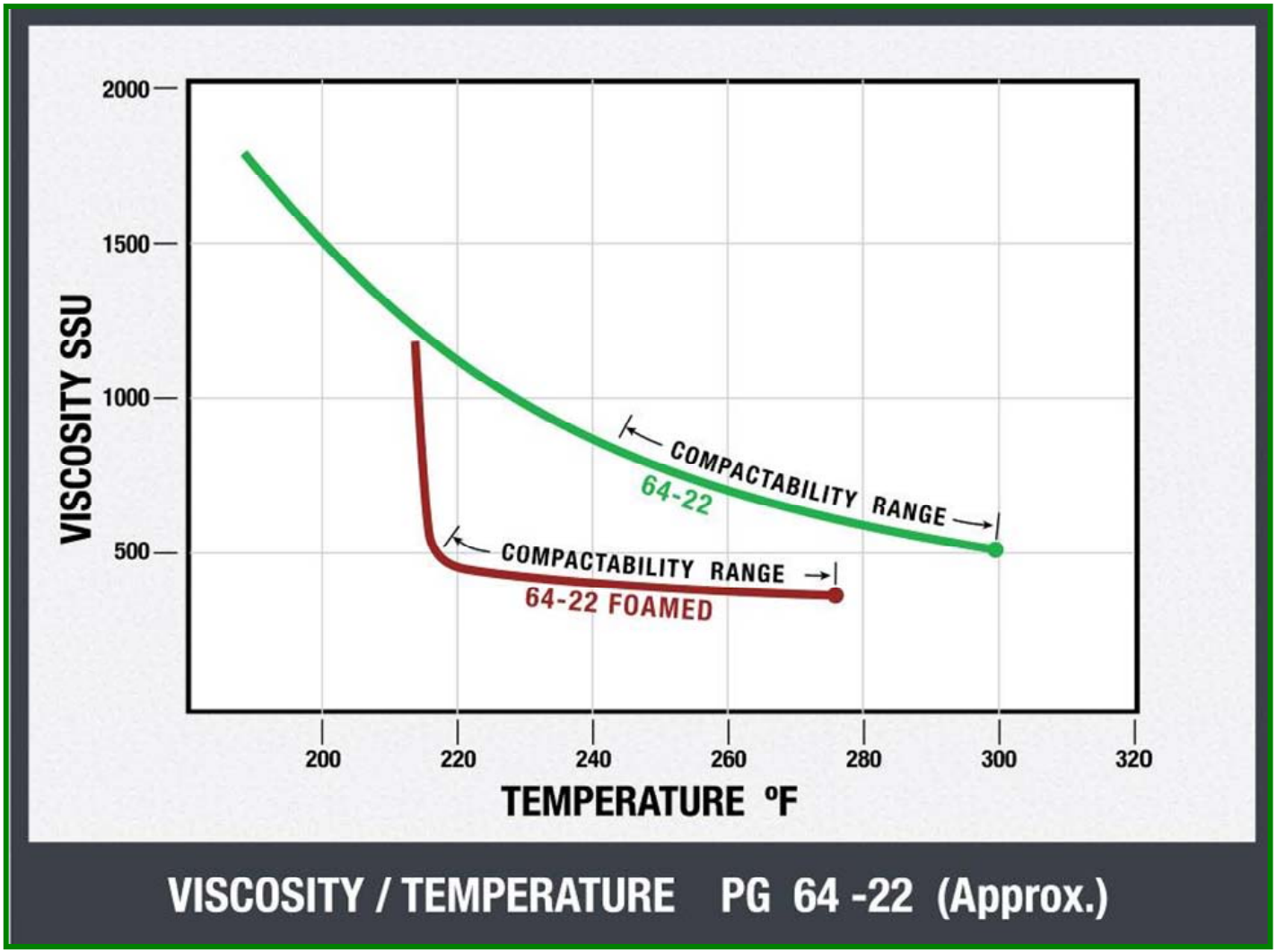

VISCOSITY / TEMPERATURE PG 64 -22 (Approx.)

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Why WMA?

- Better Workability and Compaction
  - Extended time for compaction
  - Densities comparable to HMA
    - Higher density possible?
  - More consistent density
    - Roller train tighter
    - Fewer passes
    - More uniform coverage

Why WMA?

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- Reduced Plant Emissions
  - CO_2, SO_2, NO_x
  - By-products of fossil fuel combustion
    - SO_2, NO_x lead to formation of O_3 (ozone) at ground level and particulate matter air pollution
    - Ozone and $PM_{2.5}$ have impact on human health
    - $PM_{2.5}$ has impact on haze, development of acid rain

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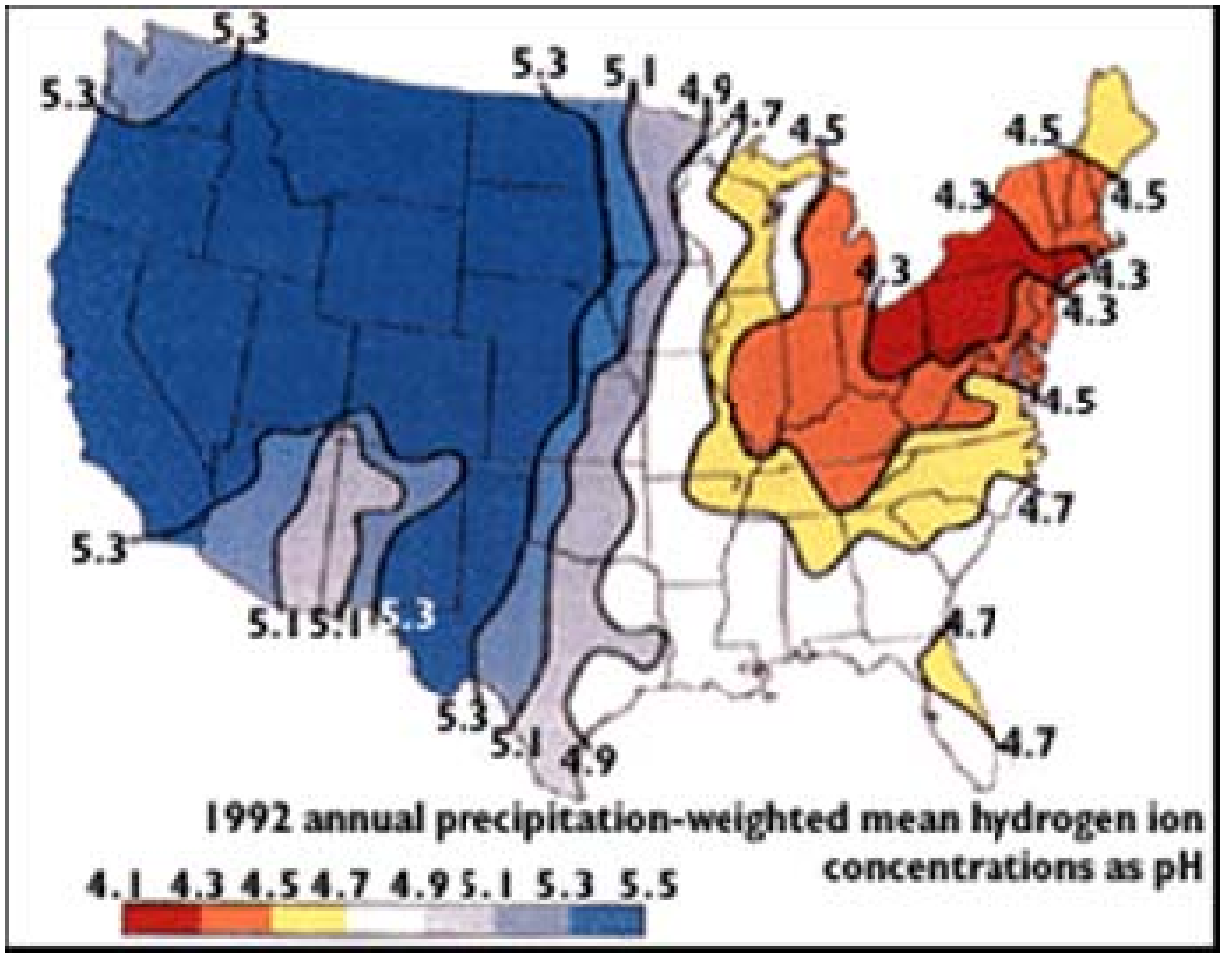
Why WMA?



Why WMA?

- Reduction of Greenhouse Gases
  - Kyoto Agreement
    - Implemented in 2005
    - Sets binding targets for 35 industrialized countries and European Union
      - Average of 5% reduction from 1990 levels from 2008-2012
      - EU pledged 15%
      - Germany pledged 25%
      - USA signed, but did not ratify

Why WMA?

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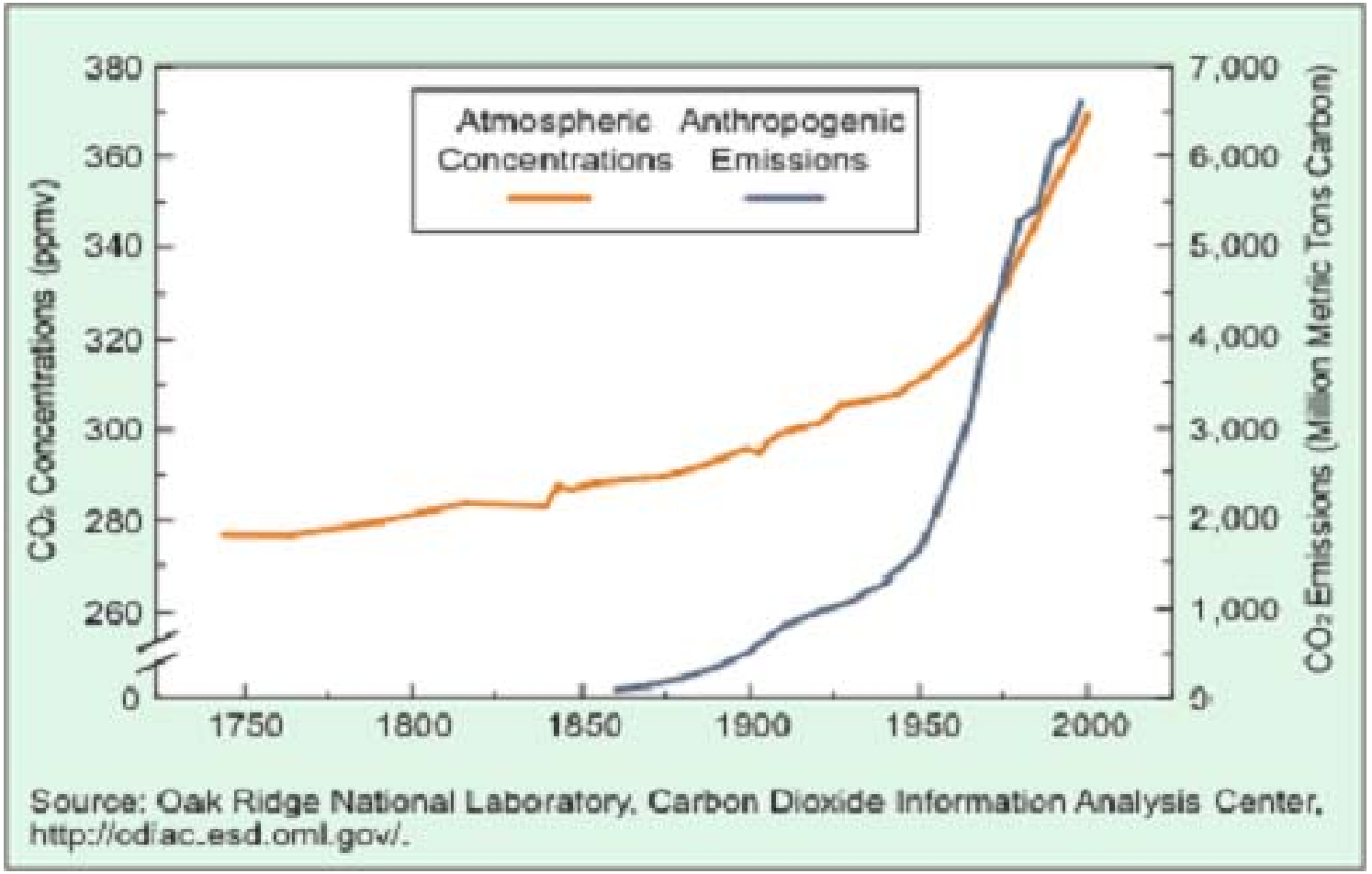

Source: Oak Ridge National Laboratory, Carbon Dioxide Information Analysis Center, http://cdiac.esd.ornl.gov/.

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Why WMA?

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- Increased Use of RAP
  - Economic benefit for user and producer
  - Traditionally limited to lower percentage (typically 10-20%) because of concerns about excessively stiff (aged) material
  - Lower temperature for WMA may reduce aging
  - Most projects in the US to date have used 20% RAP or less

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Why WMA?

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- Improved Worker Conditions
  - Less emissions at paver for WMA
    - Lower mix temperature = less visible smoke and odor
    - Measurable exposure data?
      - BSM (benzene soluble matter) and TPM (total particulate matter) often below detectable level
    - European data
      - German Bitumen Forum indicates 30-50% decrease in aerosols and PAHs (polycyclic aromatic hydrocarbons)
      - Different sampling and analytical protocols

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Better Working Conditions for Workers (Lower Fumes, Temperature)

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HMA Control Section

WMA Section

WMA Mix Design

- NCHRP 9-43
  - Advanced Asphalt Technologies
    - Ray Bonaquist, PI
- WMA Mix Design Process
  1. Materials Selection
  2. Design Aggregate Structure
  3. Design Asphalt Binder Content
  4. Evaluate Moisture Susceptibility
  5. Evaluate Rutting Resistance
  6. Evaluate Mix Performance (optional)

Comparison of WMA and HMA

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- Plant Emissions
  - European data from FHWA Scan Tour

Emission	Reduction in Measured Emission – WMA (compared to HMA)
CO_2	15-40%
SO_2	18-35%
NO_x	18-70%
VOC	19-50%
CO	10-30%
Dust	25-55%

  - Reported from France, Norway

Comparison of WMA and HMA

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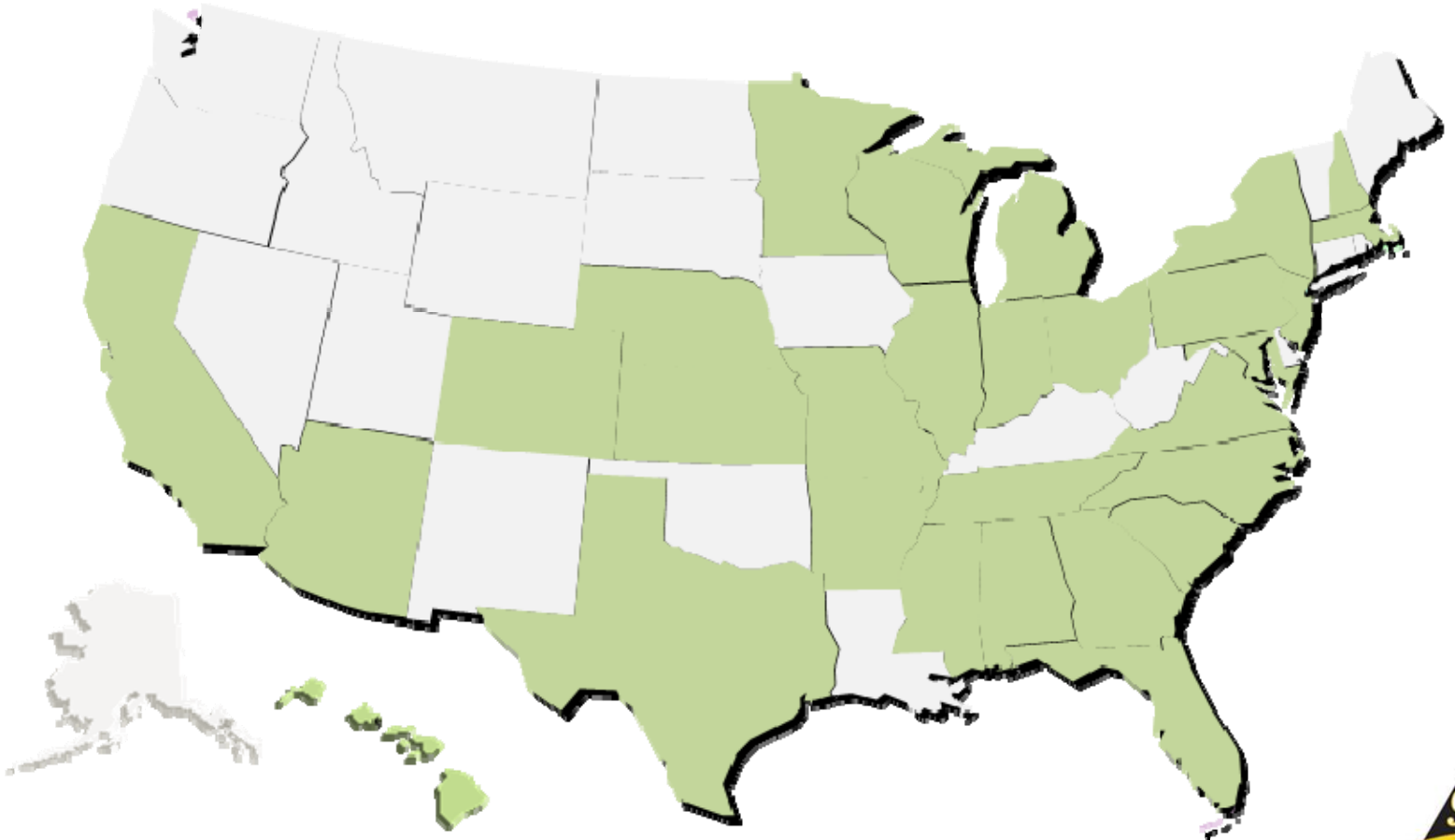
- WMA Use in United States



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Frankfurt Airport

2004 Replacement of Concrete Pavement on Main Runway with Warm Mix Asphalt While Maintaining Daily Flight Operations

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Frankfurt Airport - July 2004

Project Details

- Started in April 2003
- 4000-meter-long runway 61 m wide
- 300 incremental construction steps
- All night work to avoid interruptions in service
- Each night they replace 15 m length by full runway width
- Completed over 300 nights
- 60 cm asphalt layer on compacted gravel base and sand subgrade fill
- Low temperature asphalt with Sasobit (wax) in the beginning
- Later Shell bitumen with a different wax


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Schmitt
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Project Details

- 60 people on site each night – about 35 working on the site and about 25 are truck drivers
- 425,000 tonnes of asphalt in the contract
- Placed ~150 tonnes of WMA a night
- Because of conduits (runway lighting, etc.) and access issues, no paver used for the first lift of 240 mm of WMA
  - conduit diameter ~ 220 mm

Warm Asphalt

Project Details

- Contract requirement – temperature of the pavement surface was not to be higher than 85°C at 06:30 – contractor chose warm mix
- When 150 to 200 m on centre-line were constructed, halted WMA placement for the night and milled surface to a depth of 4 cm
- Repaved full width with SMA surface (European Spec – 0/11 [gradation] withPmB 45 [SBS modified binder]) for smoothness and friction

- Total project ~€38 million (~$62 million Can – 2004)
- Each night ~€ 120,000 (~$200,000 Can – 2004)

Thanks!