

Electro-Motive Diesel, Inc. Locomotive Experiences

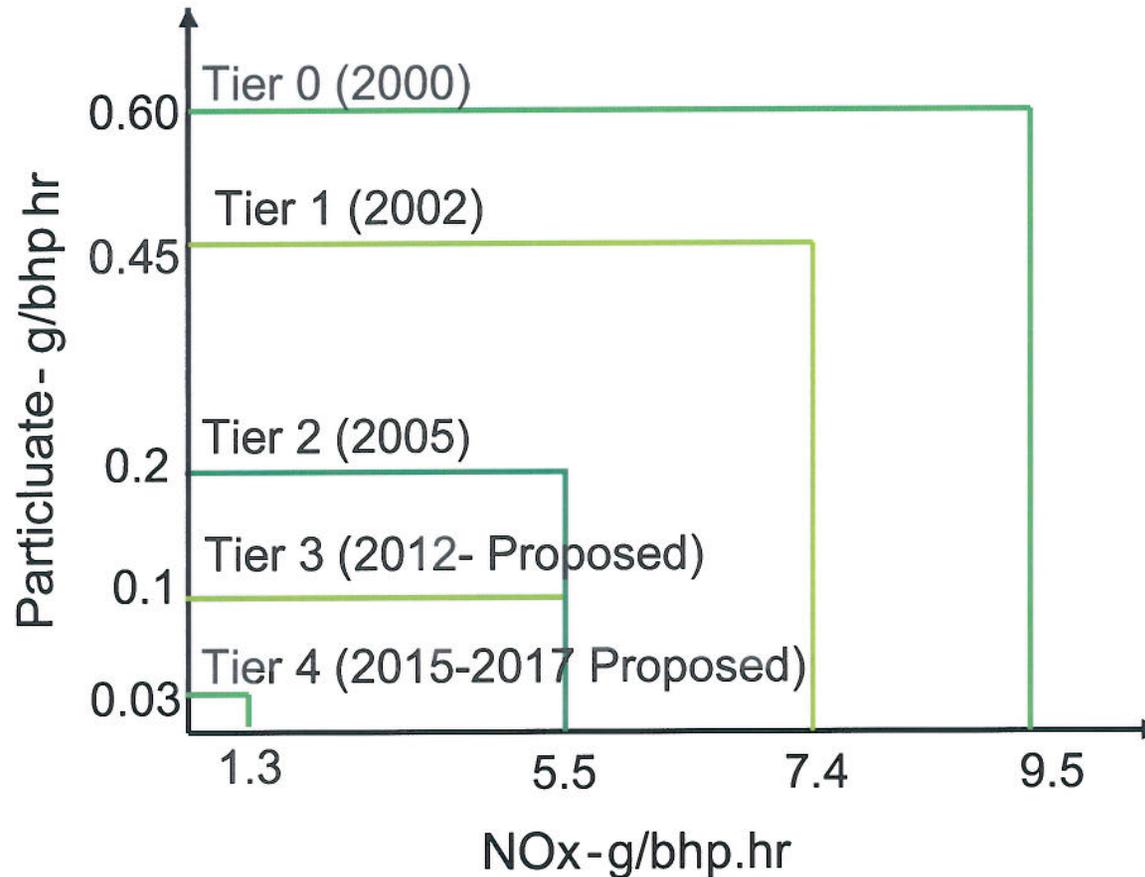
**Presented To
California Air Resources Board
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Presentation Topics

- Review of proposed Locomotive Emission Standards
- Meeting Customer Requirements
- Technology roadmap EPA Tier 3 / Tier 4
 - Technology Requirements
 - Technology Development plans
 - Technology Transfer Issues
- Summary

EPA Locomotive Emission Standards from 1998

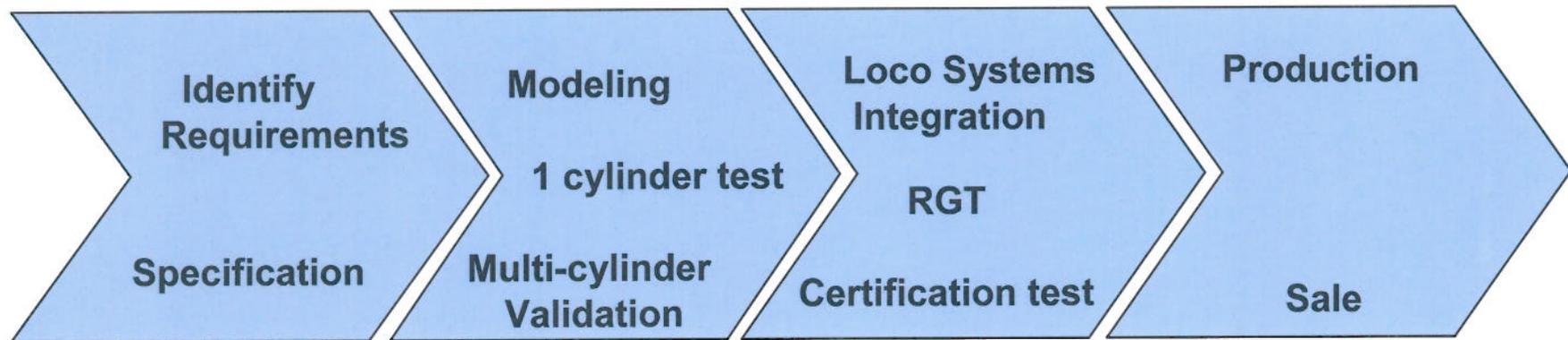


95% PM & 85 % NOx reduction

Meeting Customer Needs

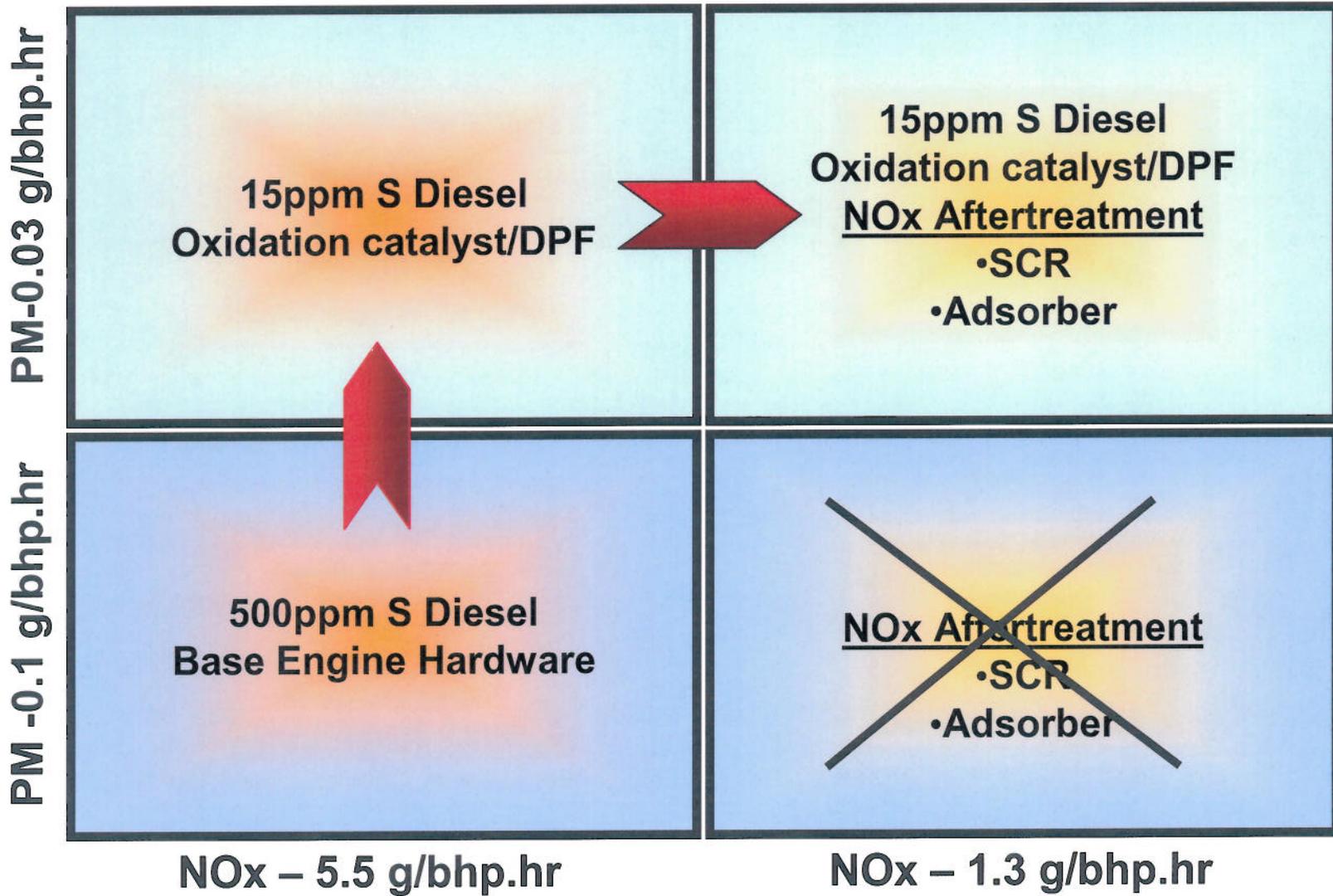
- Technology must meet the current maintenance practices –180 day maintenance interval
- Technology must maintain the long useful life of the engine
- Technology must be fuel efficient and reliable
- Technology must be adaptable to railroad infrastructure

EMD Product Development Plan

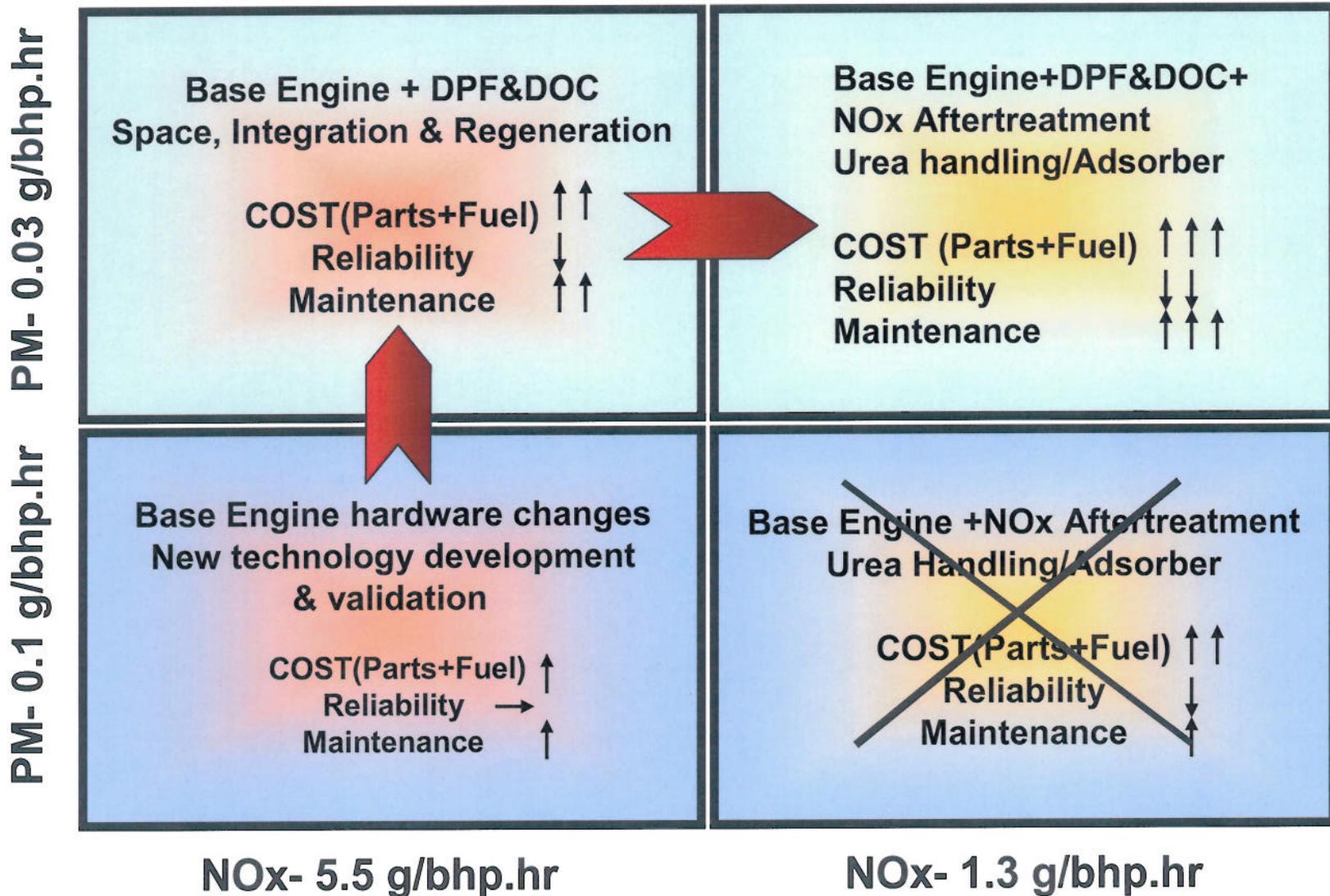


Deliver Cost Effective Reliable Products

EPA Tier 4 Emissions Roadmap



Impact of New Emissions Technology



Locomotive Economics based on 95% Availability

ELECTRO-MOTIVE

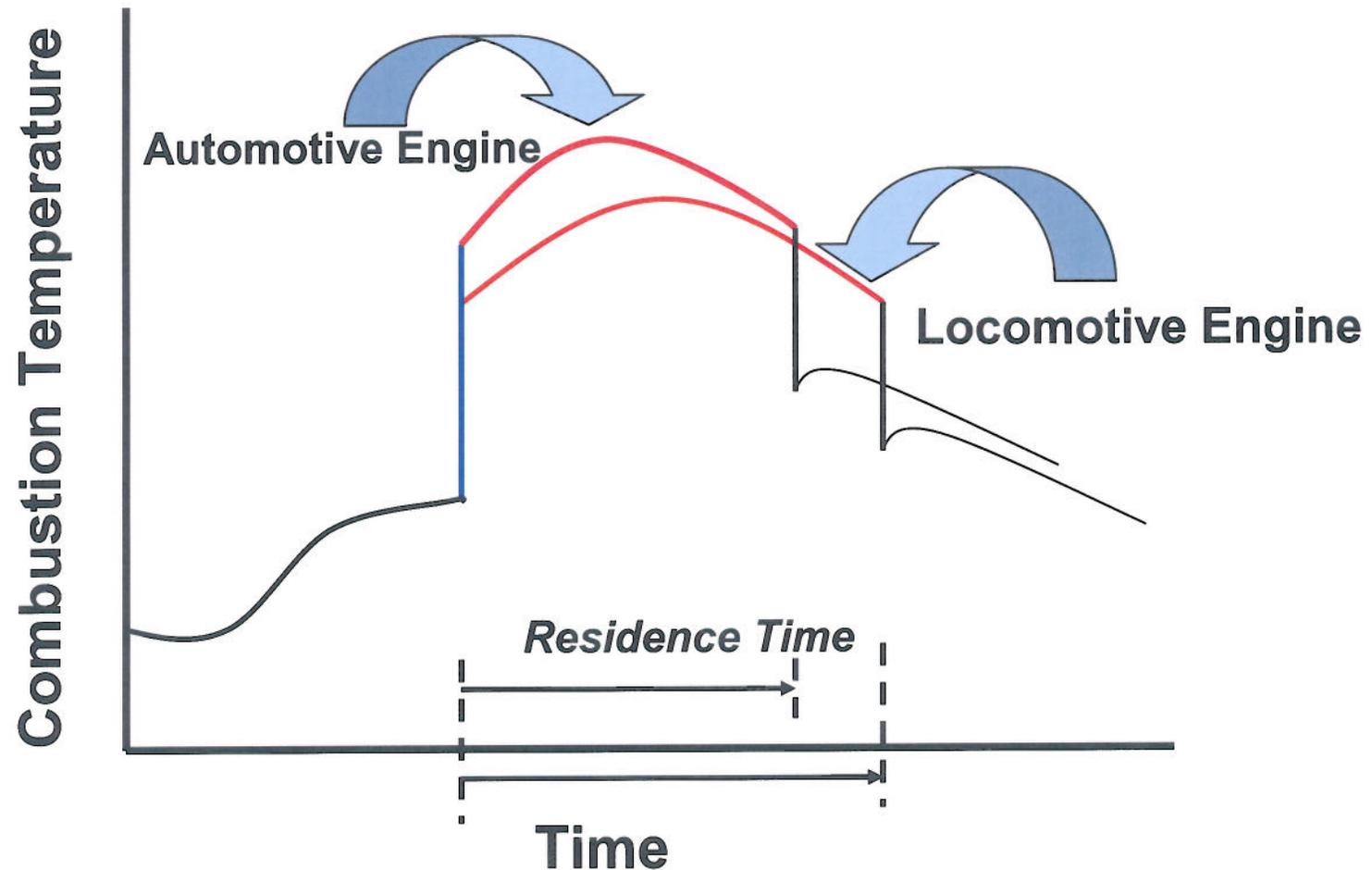
Technology Transfer!!!

- Standards and technology cascade from on-highway to off-highway to locomotives and marine vessels.

But . . .

- Major locomotive builders do not build on- or off-highway engines.
- Technology successful in truck engines often does not transfer well to locomotives.

Technology Transfer Issues



Emission is a f (Temperature & Time)

Technology Transfer Issues

- Combustion duration & temperature influences formation of emission.
- Longer Residence time increases NOx lowers PM.
- Residence time influences exhaust temperatures.
- Locomotive engine PM has high SOF (+70%), low insolubles.
- DPF technology and regeneration will be unique.
- NOx reduction technology will need to address low temperature issues and durability.

Technology successful in truck engines does not transfer well to locomotives.

Differing operating modes

Example: Air-to-Air Aftercooling

- On-highway vehicles – Utilize Ram Air (depends upon vehicle speed, High vehicle speed at High Power).
- Locomotives – Independent Cooling Fans
 - High power frequently used to haul heavy cargo slowly.
 - Bi-directional operation.
 - Subjected to very high ambient temperatures in tunnel operation.
- Air-to-Air application on locomotive is complex.

Summary

- New technology will need adaptation.
- New technology will need infrastructure development.
- New technology will need training and retraining.
- Other questions & comments.