

A Vision for Clean, Sustainable, Cost-Effective Heavy-Duty Engines & Fuels

Research Team: Charles J. Mueller (PI, cjmuell@sandia.gov), Christopher W. Nilsen, Drummond E. Biles, Boni F. Yraguen, & Nathan Harry

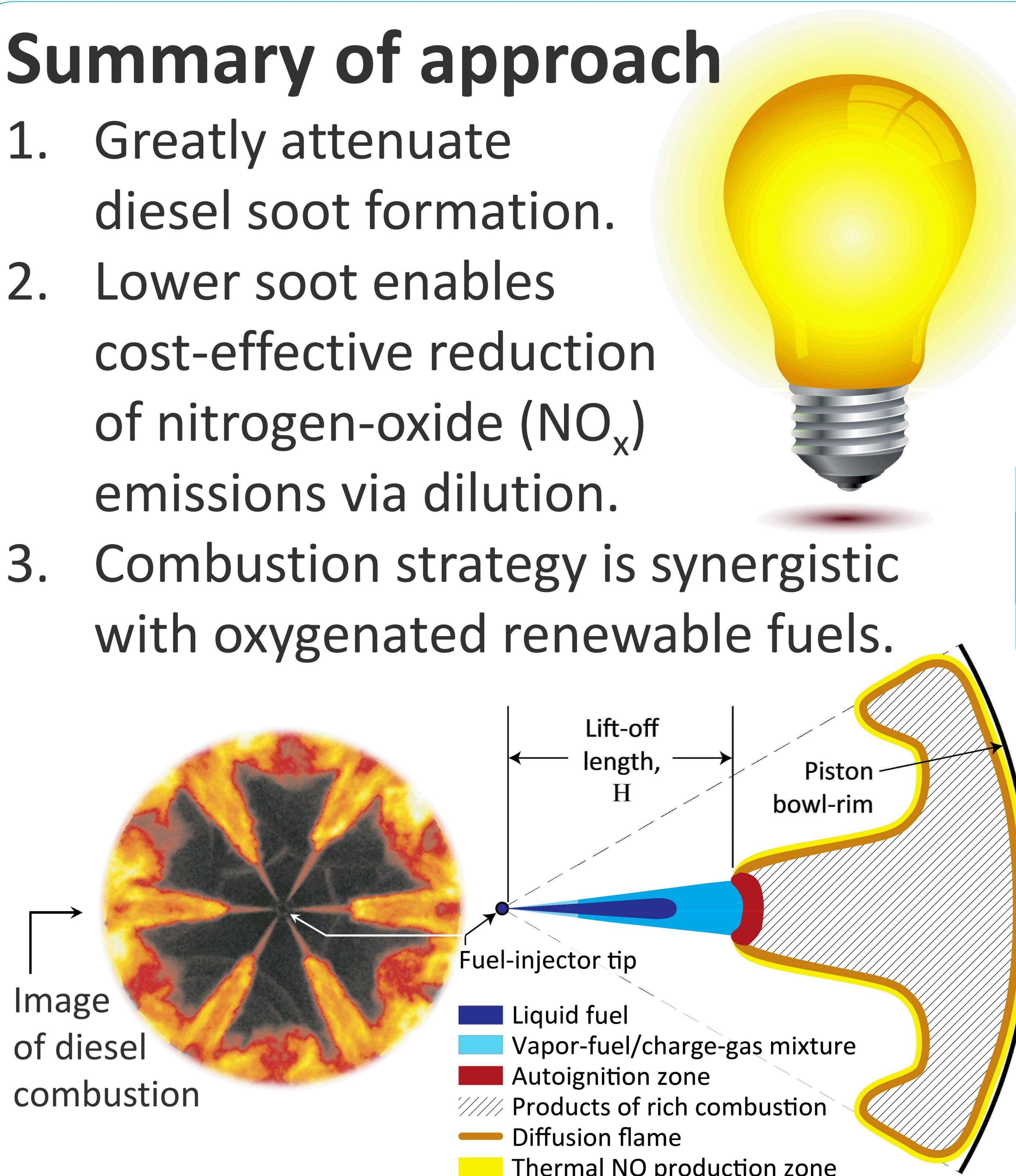
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Program Managers: Kevin Stork, Gurpreet Singh, & Michael Weismiller

Summary of approach

1. Greatly attenuate diesel soot formation.
2. Lower soot enables cost-effective reduction of nitrogen-oxide (NO_x) emissions via dilution.
3. Combustion strategy is synergistic with oxygenated renewable fuels.

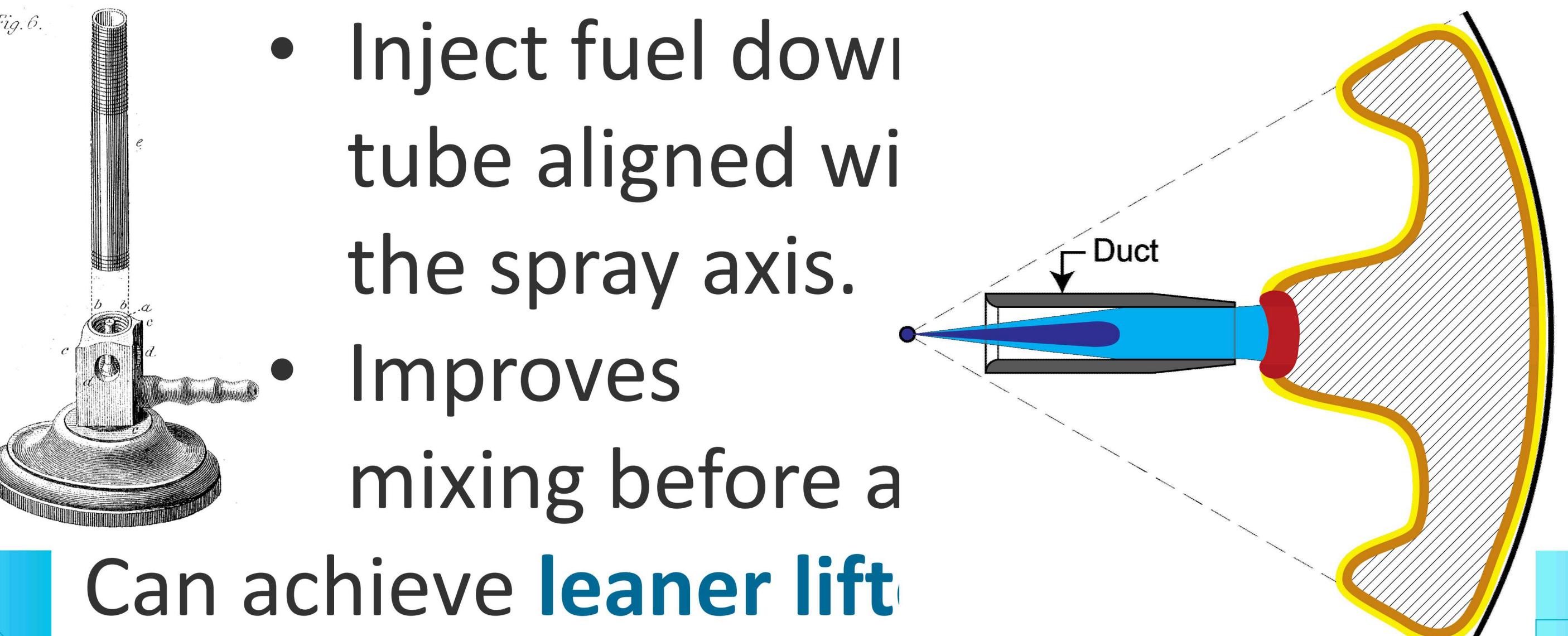


Advantages

- Inherently high thermal efficiency
- Low HC & CO emissions ($\text{HC} = \text{hydrocarbon}$, $\text{CO} = \text{carbon monoxide}$)
- Easy to control (vs. globally premixed)
- Compatible with current diesel fuels
- Synergistic with oxygenated bio/solar fuels
- Conceptually simple (low cost)
- Retrofittable to existing engines
- Scientifically distinct (from globally premixed)

Ducted fuel injection (DFI)

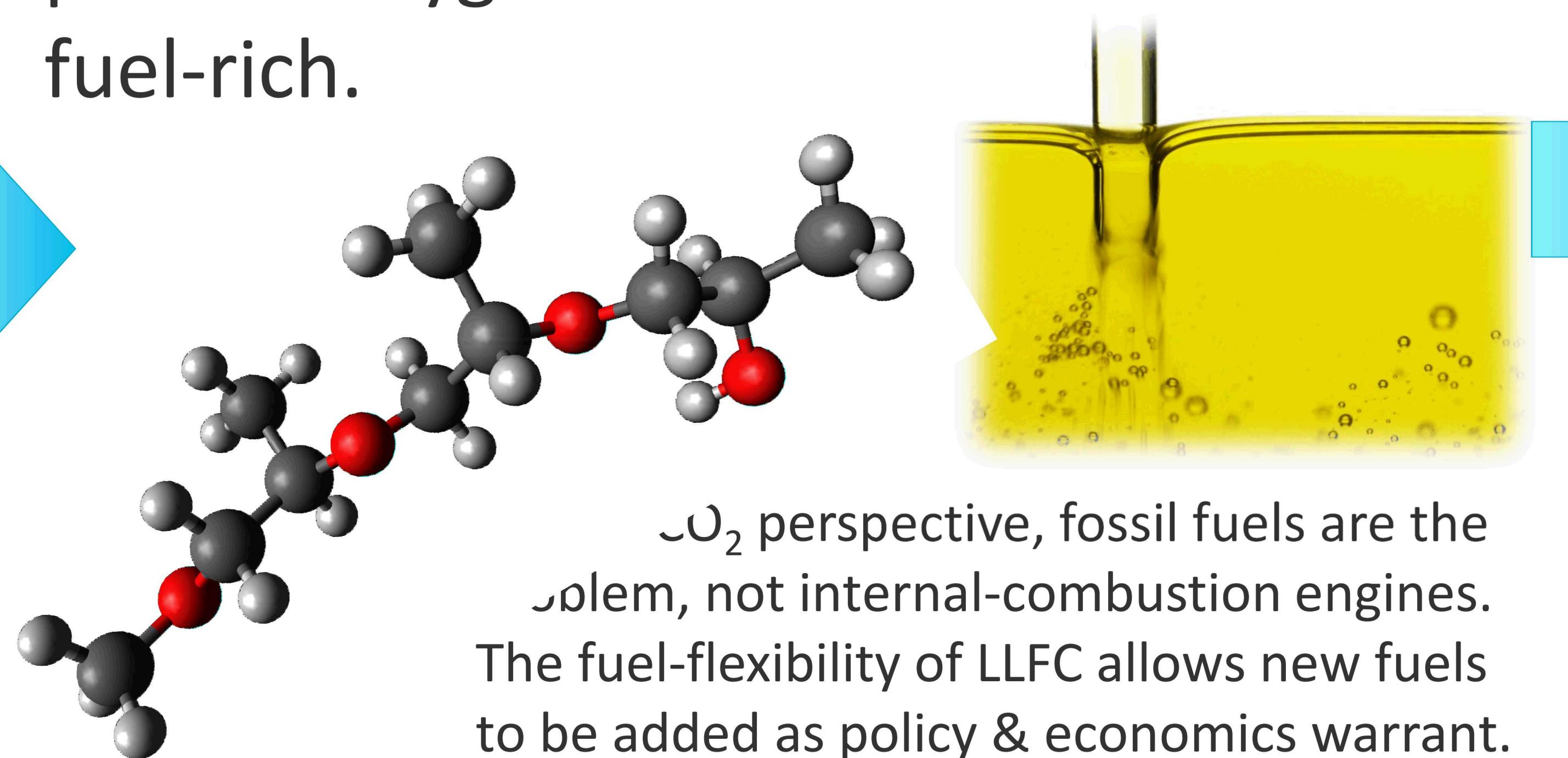
- Inject fuel down tube aligned with the spray axis.
- Improves mixing before a Can achieve **leaner lift combustion (LLFC)** = diesel combustion that does not produce soot because it occurs in mixtures that are “lean enough” (i.e., $\phi < 2$).



DFI implementation → with a two-hole injector tip & two ducts.

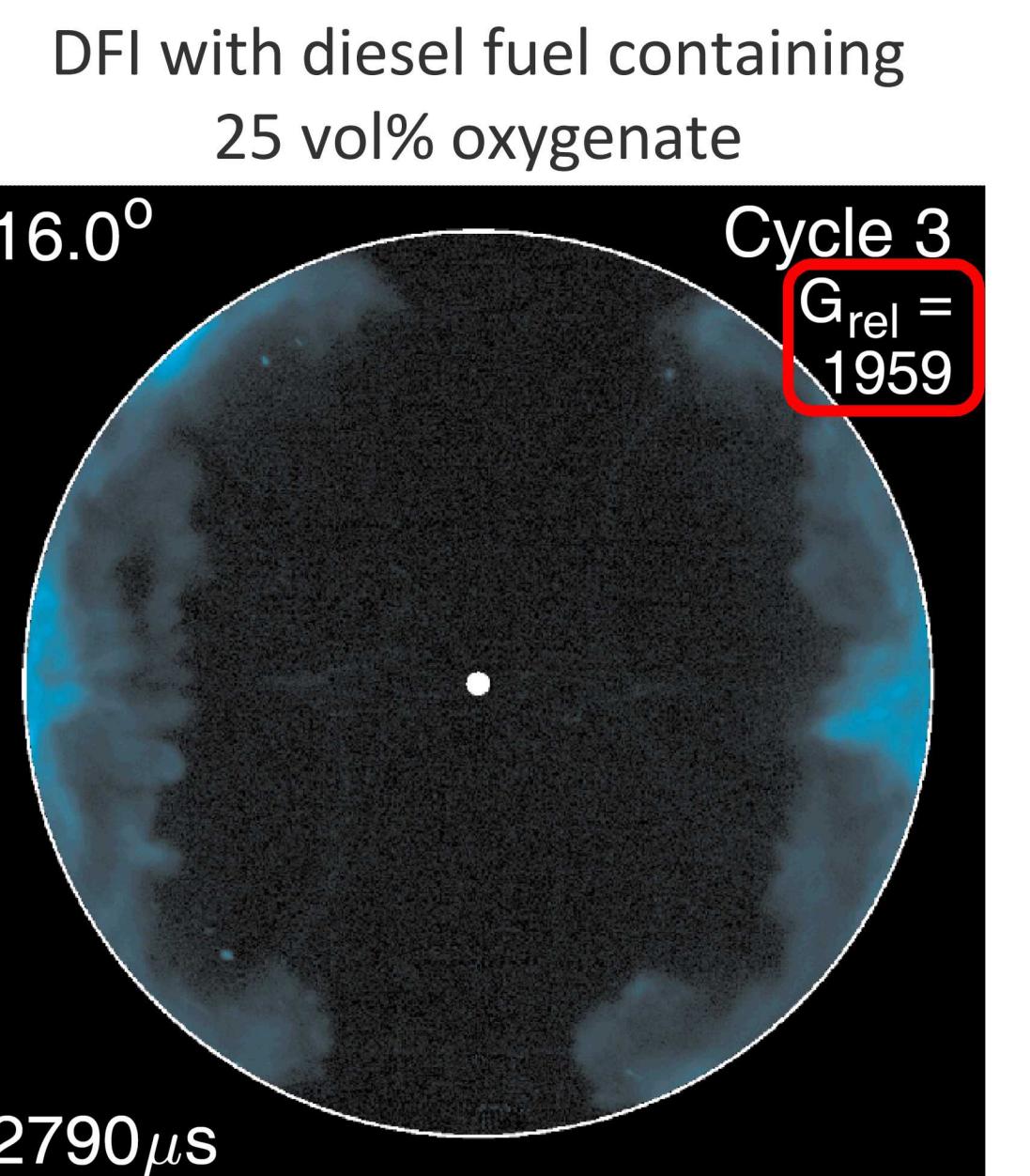
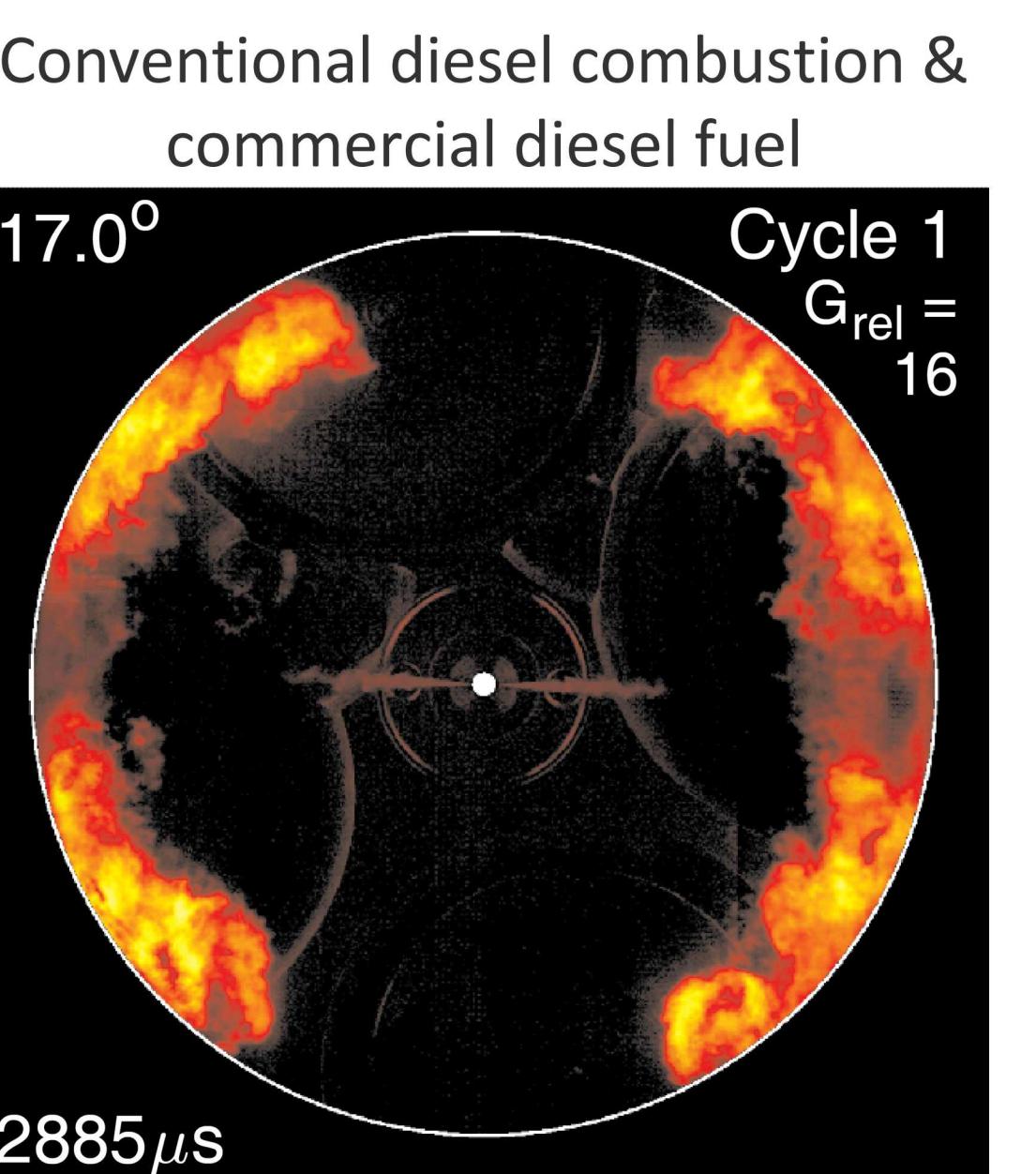
Oxygenated renewable fuels

are synergistic with **LLFC** because they provide oxygen where the mixture is most fuel-rich.

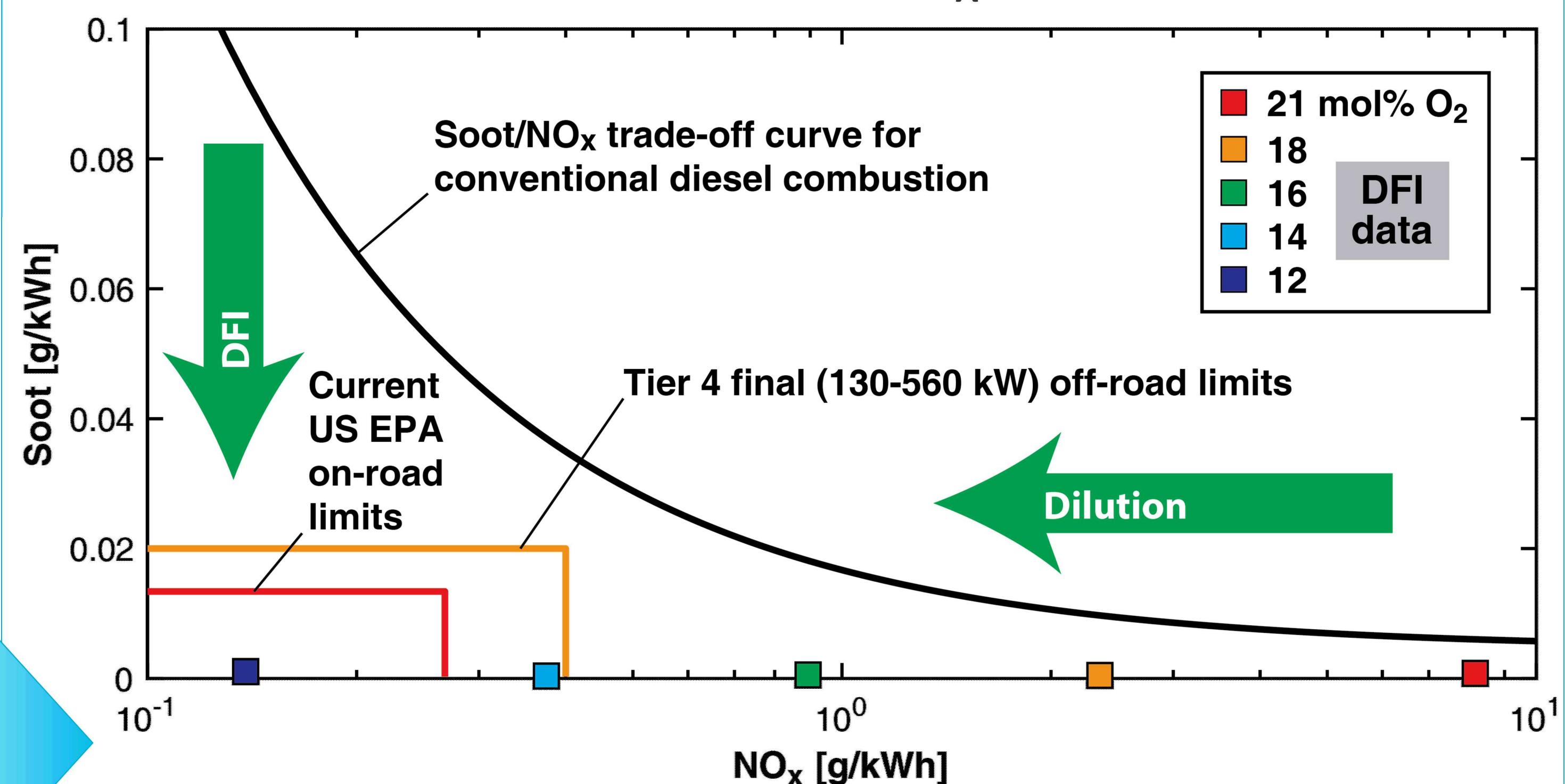


Results

- Soot incandescence images show DFI with diesel fuel containing 25 vol% oxygenate can achieve **LLFC** (16% O₂):



- DFI with dilution can break the long-standing diesel soot/NO_x trade-off:



- Other emissions & efficiencies are not significantly affected by DFI.
- DFI has been successfully demonstrated to ~50% engine load with a four-hole injector tip & four ducts.