Technologies For MD/HD GHG & Fuel Efficiency

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Agenda

1. Project Outline
2. Preliminary Results
   a) Heavy Duty Long Haul
3. Preliminary Observations
4. Considerations for Mexico

Project Sponsor, Purpose and Scope

- **Sponsor: NHTSA**
- **Purpose: support development of Phase 2 fuel consumption and GHG regulations for medium and heavy trucks**
- **Scope: evaluate technologies that could be used to comply with Phase 2 requirements**

NHTSA Project Outline

- **Engine and vehicle technology simulations**
- **Engines:**
  - **15 liter long haul diesel (with 12.5 liter 5-cylinder variant)**
  - **6.7 liter medium duty diesel**
  - **6.7 liter pickup truck diesel (with 4.5 liter 4-cylinder variant)**
  - **6.2 liter V-8 gasoline**
  - **3.5 liter V-6 turbocharged DI gasoline**

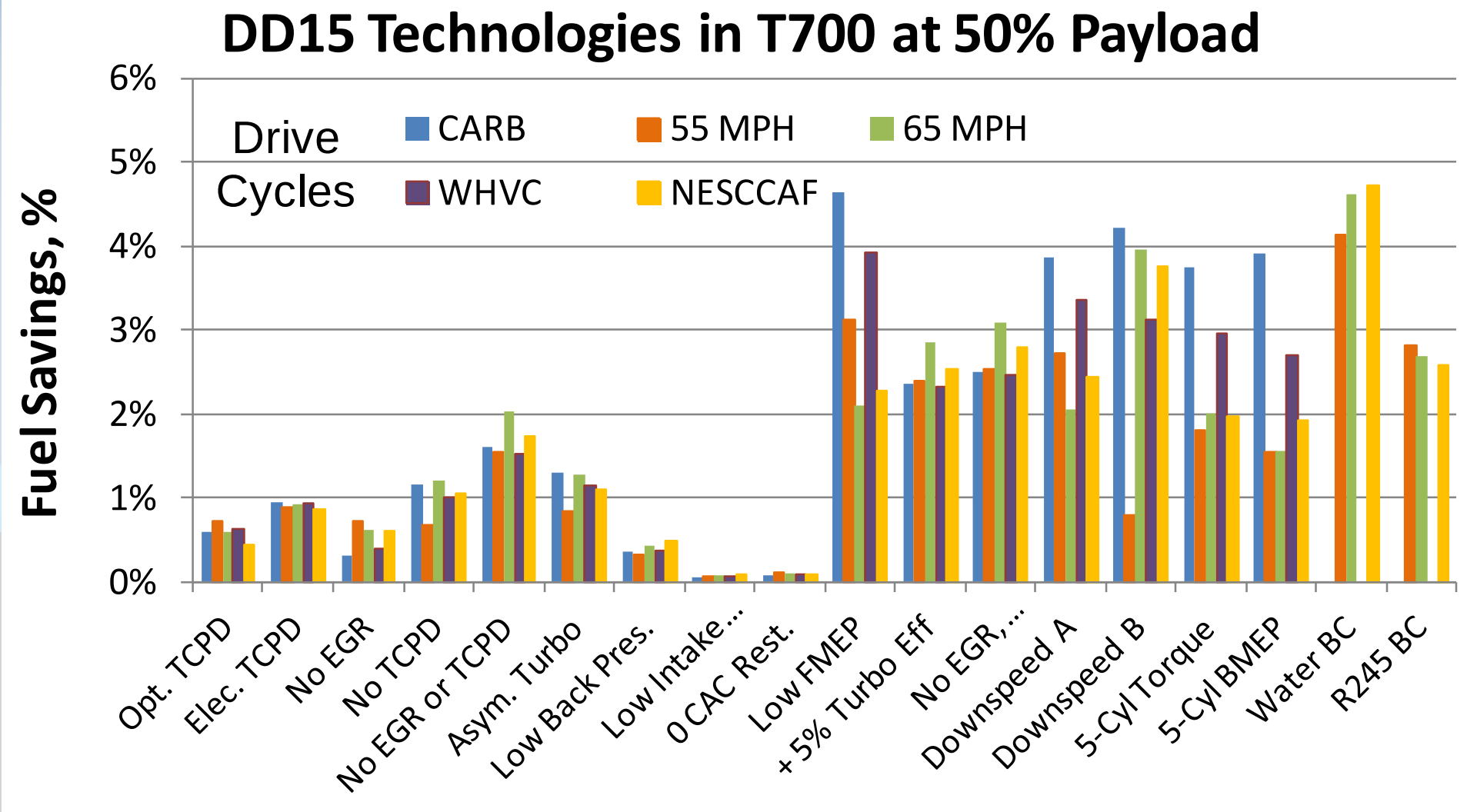
Project Outline

- **Vehicles:**
  - **Class 8 tractor-trailer**
  - **Class 6 delivery truck (box truck)**
  - **Class 5 roll-on tow truck**
  - **Class 2b / 3 pickup**

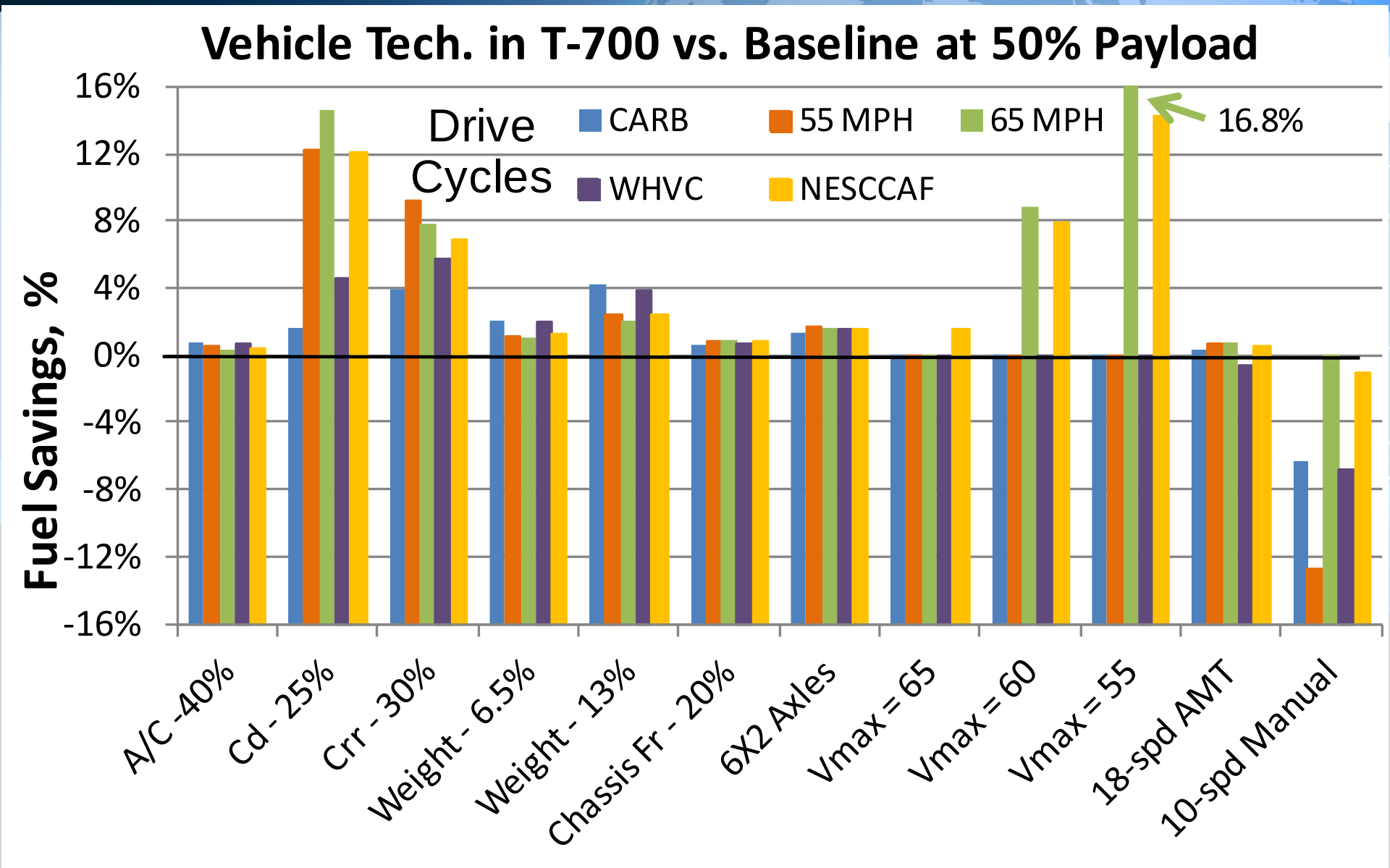
Heavy Duty Long-Haul

- **This category uses one base engine, the DD15**
- **This category uses one base vehicle, the Kenworth T-700 aerodynamic tractor with a standard (non-aero) 53 foot box van trailer**

Long Haul Engine Technologies



Tractor-Trailer Technologies



Some Preliminary HD Observations

- Engine friction reduction provides significant benefits, particularly on lightly loaded cycles
- Both downspeeding and downsizing show 1.5% to 4% benefit
  - Hard to combine both, because of BMEP limits
- R245 BC provides about 3% (for reference, water based BC provides about 5%)
  - Note transient performance issues – long haul only technology
- Large Cd and Crr reductions provide large benefits
- Turbocompound didn't work out well here. Other, smaller engines have shown better results

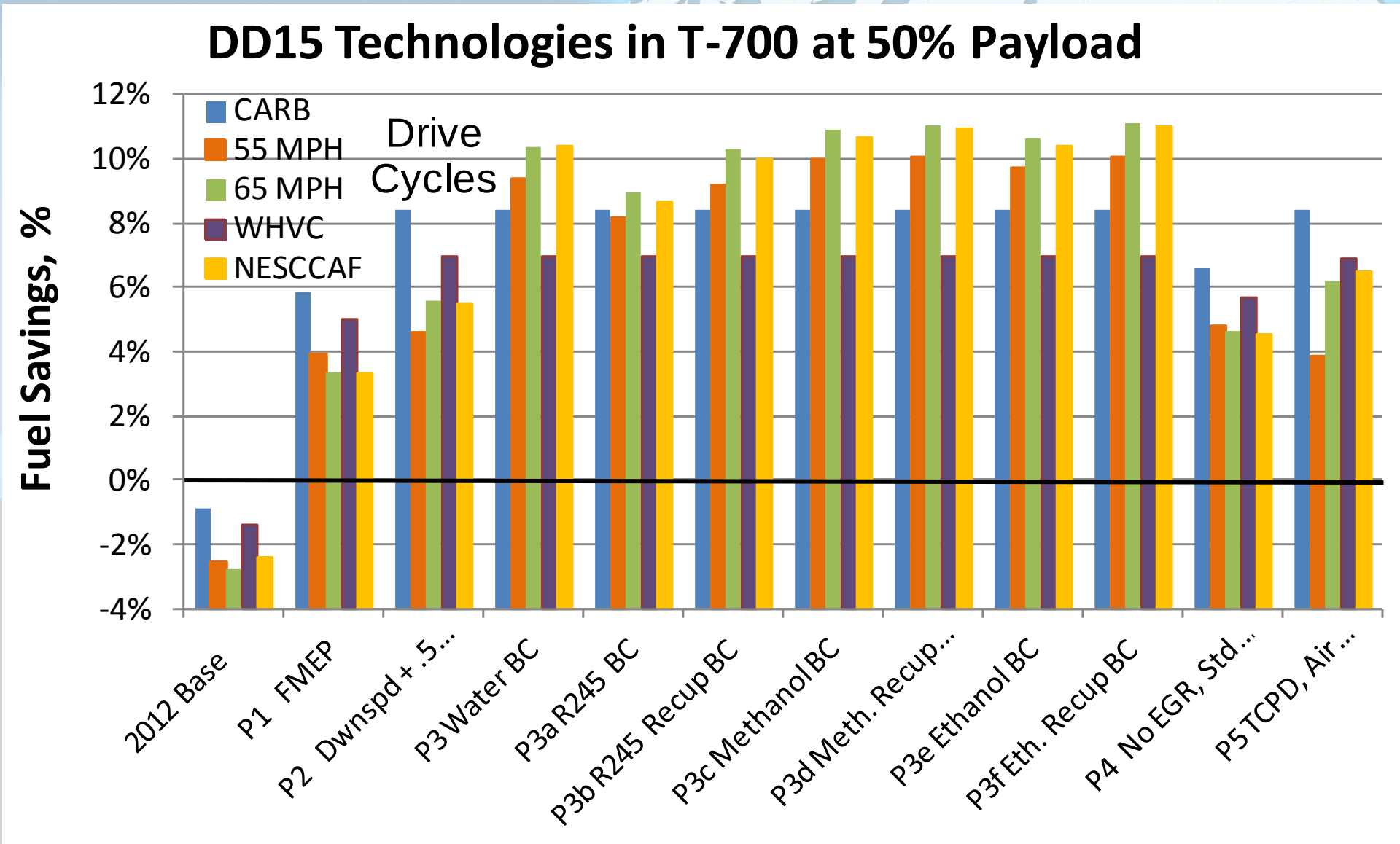
Some Preliminary HD Observations

- **Increasing the number of gear ratios doesn't help much**
  - **Engine has good BSFC over a wide enough range to work well with the 10-speed**
- **It takes big weight reductions to provide a significant fuel savings / GHG benefit (See notes)**
- **Road speed governors provide a big benefit, if the drive cycle has a large portion of high speed operation**
  - **Note productivity issue**
- **Simulating a manual transmissions is tricky, and needs to be supported by field tests**
  - **Fuel penalty for manual indicated by 55 MPH cycle and WHVC involve running a gear down, which causes a large penalty**

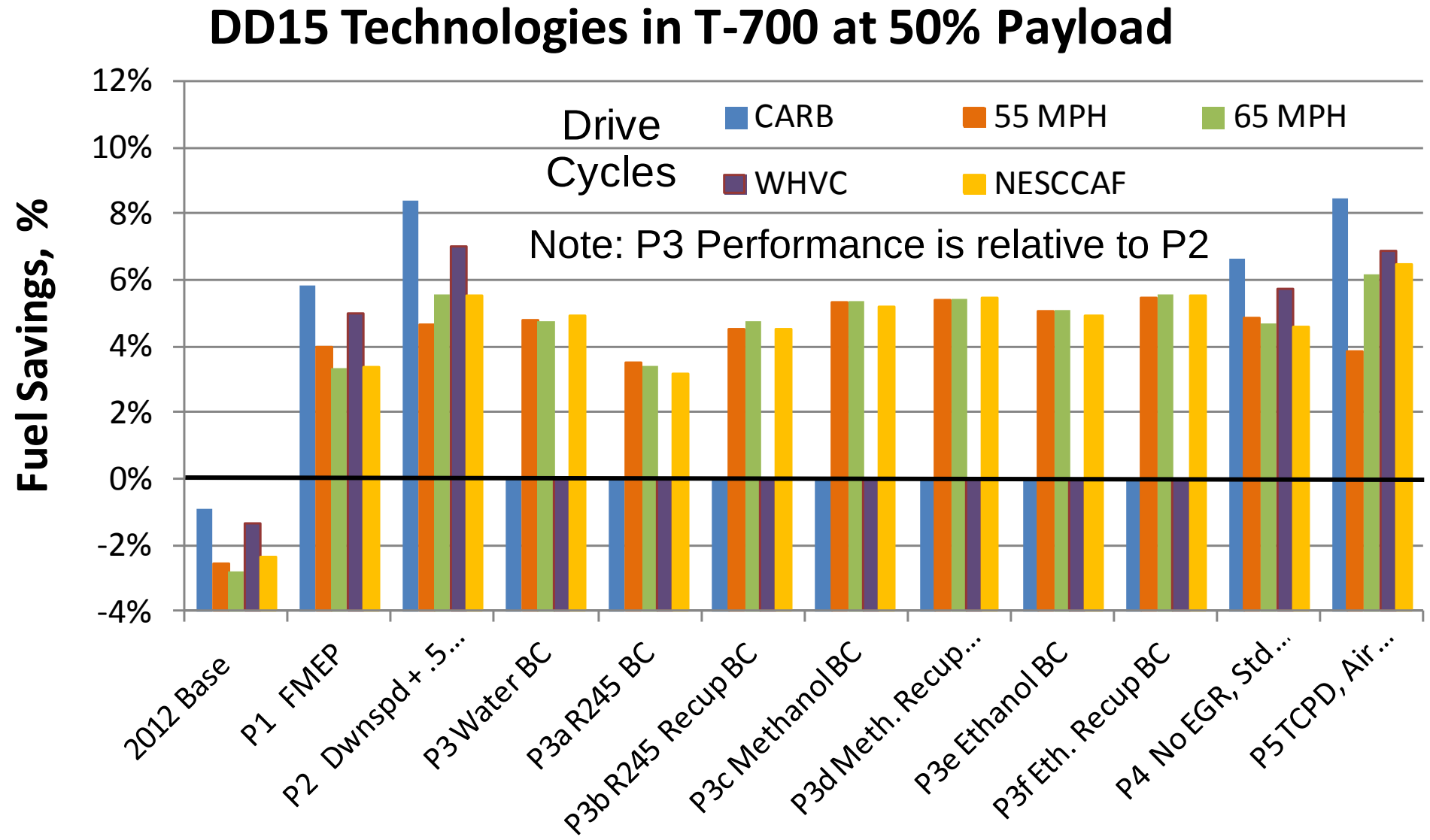
2019 Baseline DD15

- Uses asymmetric turbo – similar to 2014 production
- Assume a 1% improvement from shorter combustion duration
  - This can represent any incremental improvement
- Complies with 2017 GHG requirement
  - With zero margin

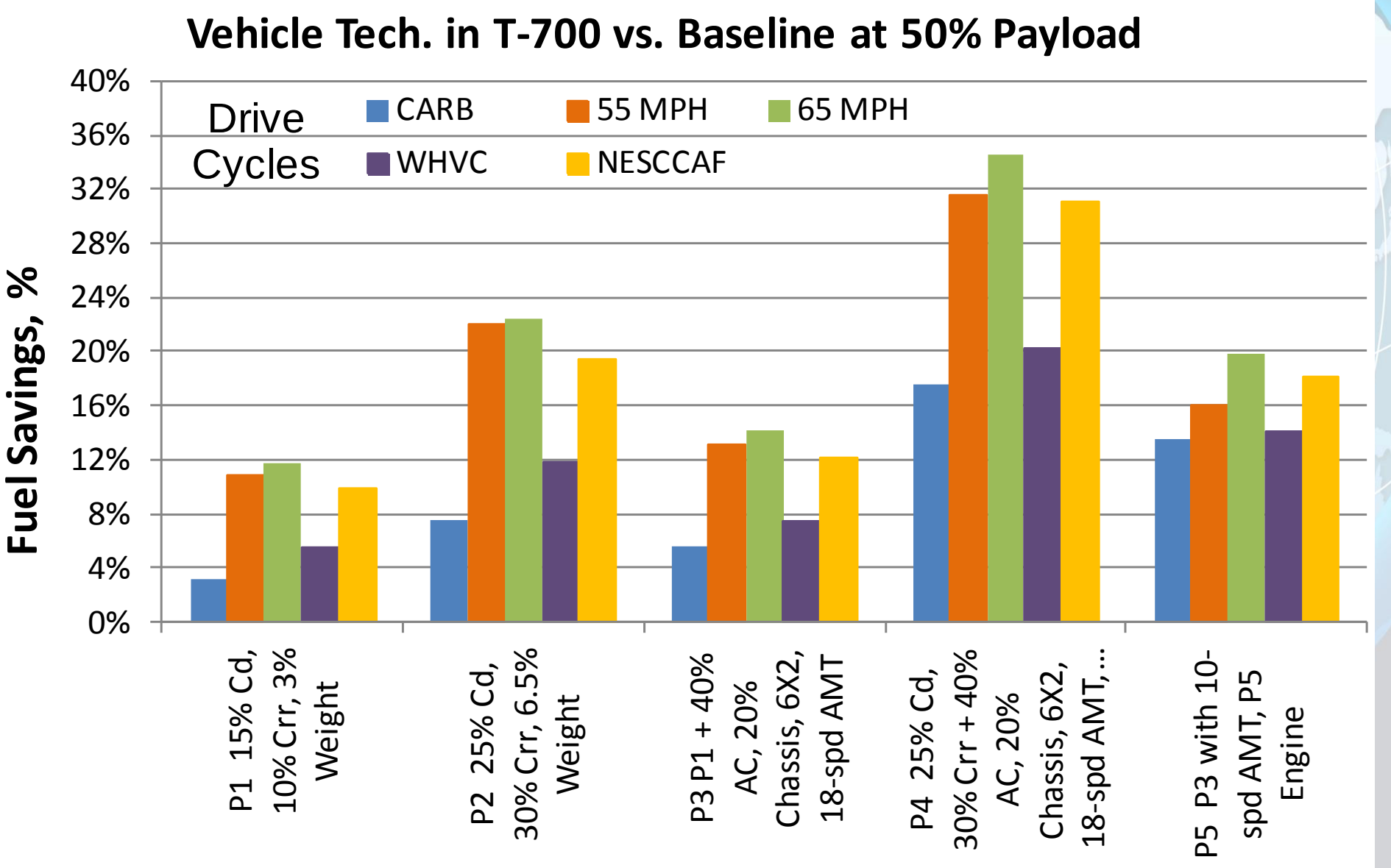
HD Engine Technology Combos



HD Engine Technology Combos



HD Vehicle Technology Combos



Some Preliminary HD Combo Observations

- Friction reduction and downspeeding perform on the 2019 baseline similar to the original baseline
- The refrigerant-based WHR system benefits significantly from a recuperator, but the other working fluids show a smaller benefit
- Methanol, ethanol, and water working fluids give similar WHR performance
- Throwing the kitchen sink at the turbocompound engine still does not result in performance better than asymmetric turbo packages on this particular engine
  - Note that turbocompound has shown a benefit on other engines

Some Preliminary HD Combo Observations

- **Vehicle Combo Package 4 pushes into SuperTruck territory**
  - **Combines vehicle and engine technology packages, similar to SuperTruck**
  - **~33% fuel savings on long haul cycles = ~50% MPG improvement**
  - **Note that SuperTrucks have ~50% Cd reduction, vs. 25% in this study, so SuperTrucks perform even better**
- **Larger fuel savings are available from vehicle power demand reductions than from engine efficiency improvements**
  - **Maximum engine potential fuel savings in this study is ~10%**

Overall Observations

- **Long haul trucks have the largest potential % fuel savings**
  - **Given their high VMT, they can also support more investment in fuel saving technology**
    - **Still, not all technologies will prove cost effective**
  - **Savings of up to 33% appear feasible, although not necessarily all cost-effective**
- **Medium trucks and pickups have a potential for up to 20% fuel savings**
  - **It will be a struggle to make some of these savings cost-effective**

The Full Reports

- **Are available at:**
  - **http://www.nhtsa.gov/Laws+&+Regulations/CAFE+-+Fuel+Economy/supporting-phase-2-proposal**
- **Report 1 covers all individual technologies**
- **Report 2 (still in draft form) covers technology combinations**
- **Cost study covers costs of the technologies evaluated in Reports 1 & 2, plus a few more**

The Proposed Phase 2 Regulations

- **Came out Friday, June 19**
- **Can be found at:**
  - **http://www.nhtsa.gov/fuel-economy**
  - **Just 1,329 pages…**

Considerations for Mexico

- **Remember the local truck market**
  - **Trucks are not like cars – they are tools used to earn money**
  - **Truck operators have a strong incentive to reduce fuel consumption**
    - **Profit margins are thin, and fuel is a large portion of total expenses**
  - **OEMs have a strong incentive to reduce fuel consumption**
  - **These conditions limit the possible benefits from regulation**
  - **However,**

Considerations for Mexico

- **Sometimes, the market can fail**
  - **Example: tractors and trailers may be owned by different companies**
    - **The trailer owner has no incentive to help the tractor owner save fuel**
  - **Example: companies may have incomplete information**
    - **How best to specify a truck**
    - **Which fuel saving features will work with the company's duty cycle?**
    - **How to operate the truck to get the highest efficiency**

Considerations for Mexico

- **Pay attention to market differences**
  - **What portion of the market is high speed, long haul?**
  - **What portion of the market is heavy haul or specialty haul? On/off highway?**
  - **How do length and weight regulations in Mexico affect regulatory targets?**
    - **Bigger, heavier trucks are more efficient, so efficiency goals should be an input to length & weight regulations**
    - **Higher axle load damages roads ~ axle load^4**
  - **Adapting US regulatory language without adapting it to Mexican conditions would cause problems**