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How Do Idling Reduction Technologies Compare?

SAE Commercial Vehicle Engineering Congress and Exhibition

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How Do Idling Reduction (IR) Technologies Compare?

- Background
- Cost to Truck Owner
- Emissions
- Conclusion

Background

Why do trucks idle?

- To keep fuel and engine warm
- For resting driver's comfort
- To mask out noises and smells
- For safety

- Overnight (Class 8)
  - At truck stops and rest areas
  - In parking lots and toll plazas
  - On roadsides and ramps
  - Near first appointment
  - Home
- Waiting for hours (all classes)
  - At job sites
  - Creeping in queues
    - *At ports, terminals, delivery sites*
    - *At border crossings*

What are the impacts on fuel expenditures and air quality?

- Over 500,000 long-haul trucks compete for about 300,000 parking spaces
  - Federal rules require 10-hour rest after 11 hours of driving
  - Drivers must park wherever they can
- Idling costs the trucking industry over $9 billion annually!
  - Fuel used approximately 3 billion gallons
    - *1 billion gallons for overnight idling, 2 billion gallons for workday idling*
  - Added maintenance cost about 15¢ per hour
- Emissions from overnight idling total ~180,000 tons of NO_x, 5,000 tons of PM, and 7.6 million tons of CO_2 (EPA estimates)
  - States use idling restrictions and electrified parking spaces to help meet air quality goals

What technologies can reduce idling?

- On-board equipment
  - Insulation and heat recovery
  - Automatic engine stop-start controls
  - Auxiliary power units (APU), possibly with filter (DPF)
  - Diesel-fired heaters (DFH)
  - Battery electric (BEC) or thermal storage air conditioners (AC)
- Electrified parking spaces (EPS)
  - Single system electrification requires no on-board equipment
  - Shore power allows driver to plug in on-board equipment (dual system)
  - Also called truck stop electrification
- None of these addresses creep idling
  - Hybridization solves the creep problem

What are the perspectives of different stakeholders?

- Trucking fleet owners and owner-operators want to
  - Minimize costs
  - Maintain cab comfort
  - Comply with regulations
- Air quality officials want to
  - Reduce local emissions
  - Get best bang-for-the-buck on funding *(not addressed here)*
- Are their decisions always
  - Compatible?
  - Equitable?
  - Efficient?
  - The same in all locations?

We compared cost and emissions for five options

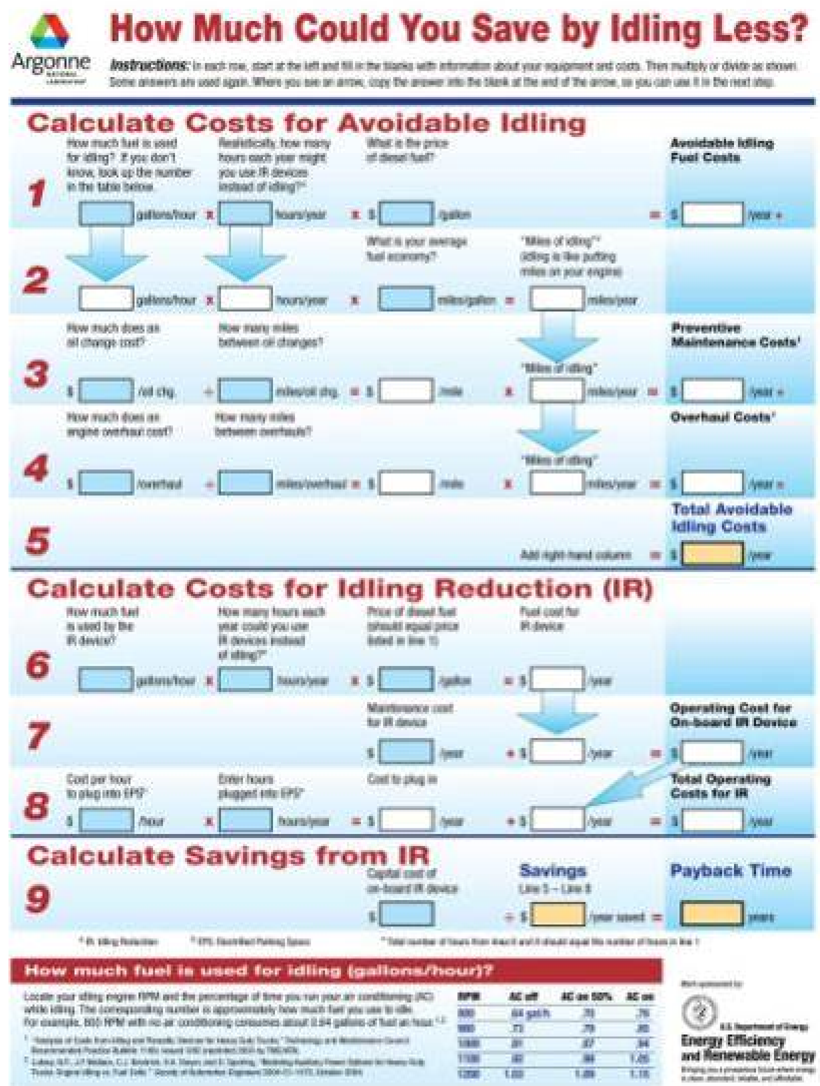
	Cost for low-idlers	Cost for high-idlers	Reduces global emissions	Reduces local emissions
APU	fair	good	good	good
Heater	good	excellent	excellent	excellent
BEC	good	excellent	good	excellent
EPS (single)	excellent	fair	good	excellent
EPS (dual)	good	good	good	excellent

Key: excellent good fair

Costs to Truck Owner

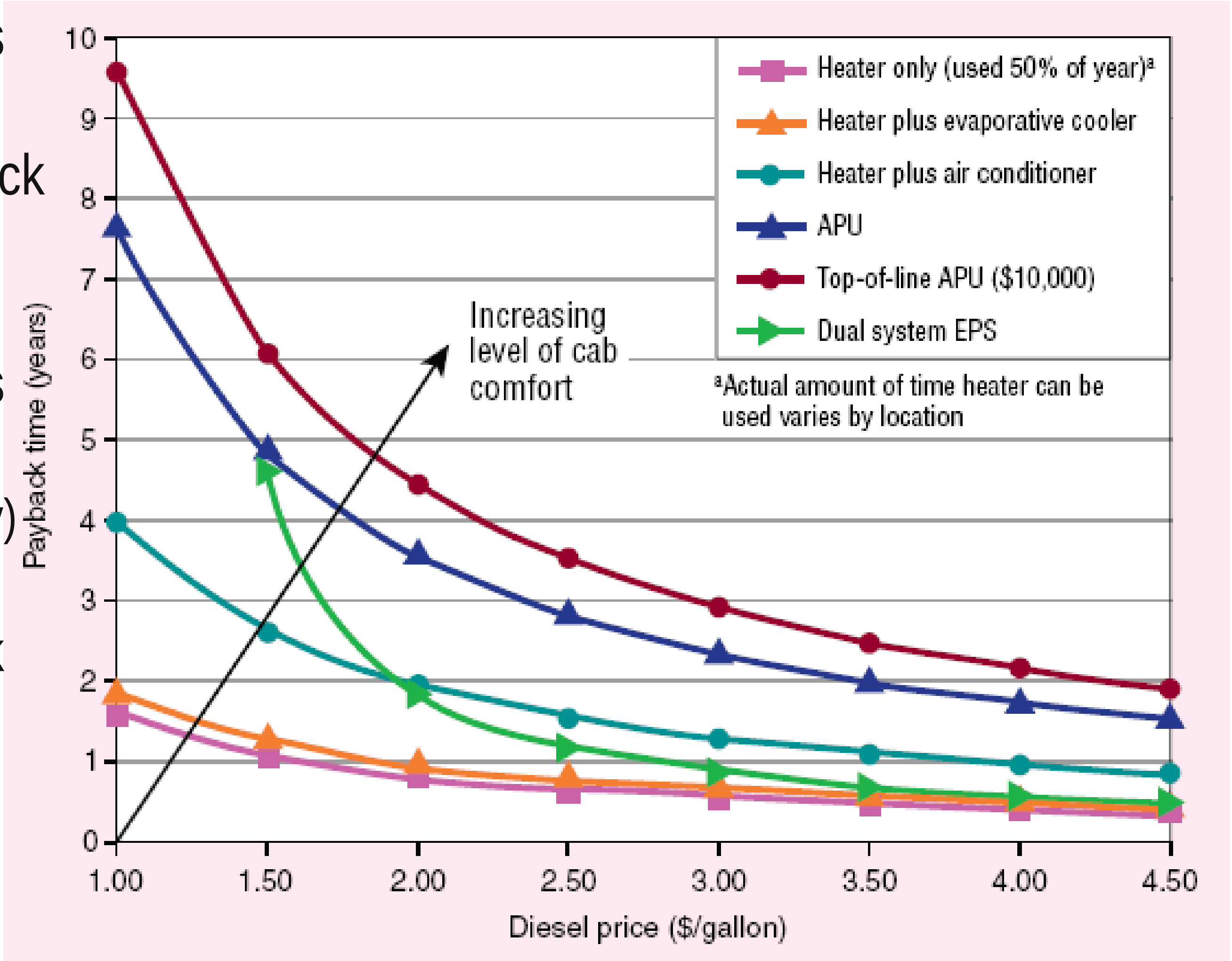
Worksheets enable technology cost estimation

- Advocates often claim unrealistic savings from idling reduction
- Worksheet allows truck owners to estimate payback themselves
  - Was described in Fleet Owner and LandLine
  - Available on the web at http://www.transportation.anl.gov/pdfs/EE/361.pdf
  - List of calculators available in National Idling Reduction Network News
- Excel version was used to compare technologies
- Complete economic study would include:
  - Infrastructure costs
  - Costs of exposure to emissions



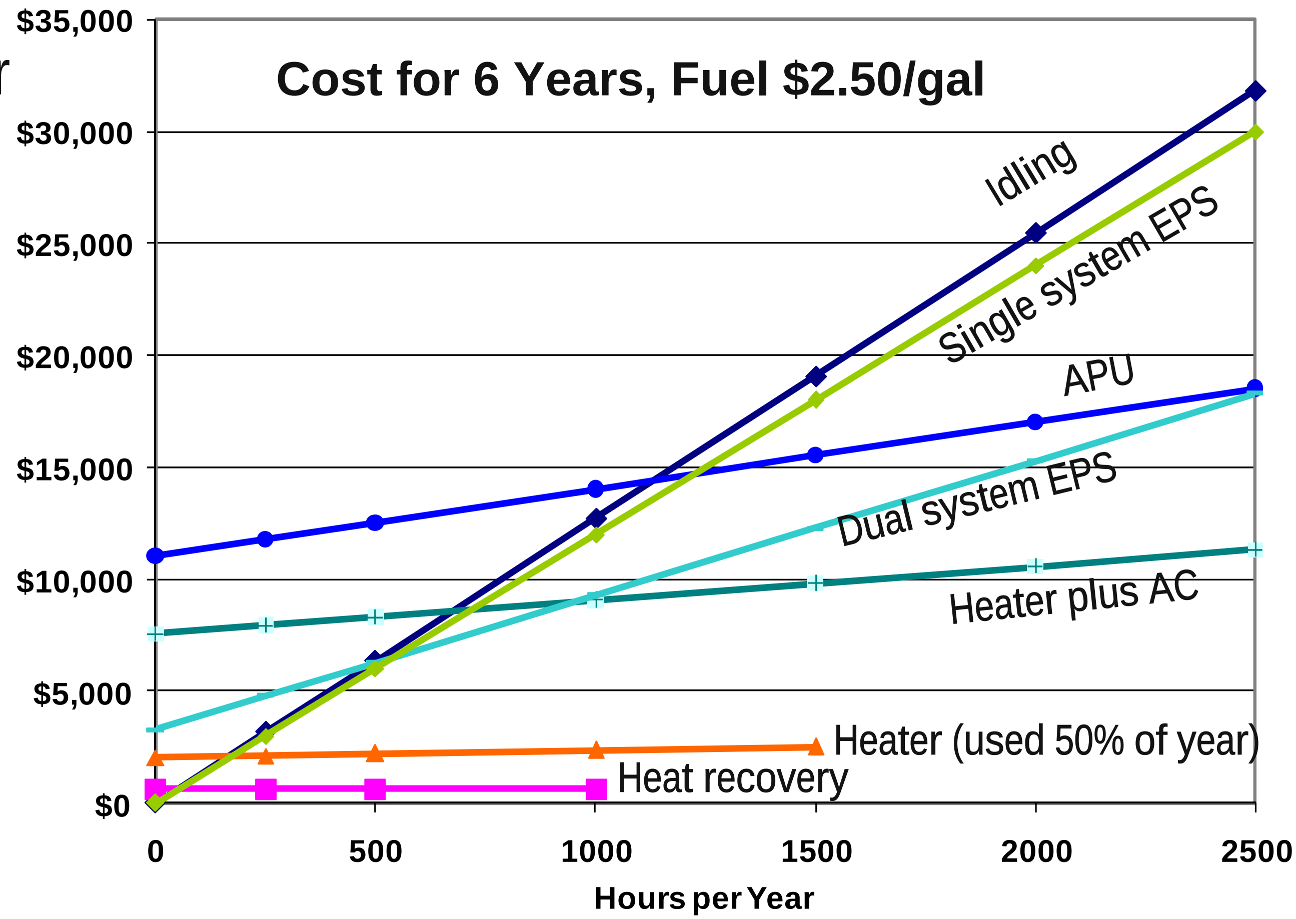
Payback is fastest for lowest cost devices

- Payback time declines as fuel price rises
- All alternatives pay back in 2-3 years at current diesel price ($3/gal)
- Payback time declines as idling hours rise (graph is for 2100 hours/y)
- Single system EPS pays truck owner back immediately for fuel price above $2



Truck owners want to minimize total cost

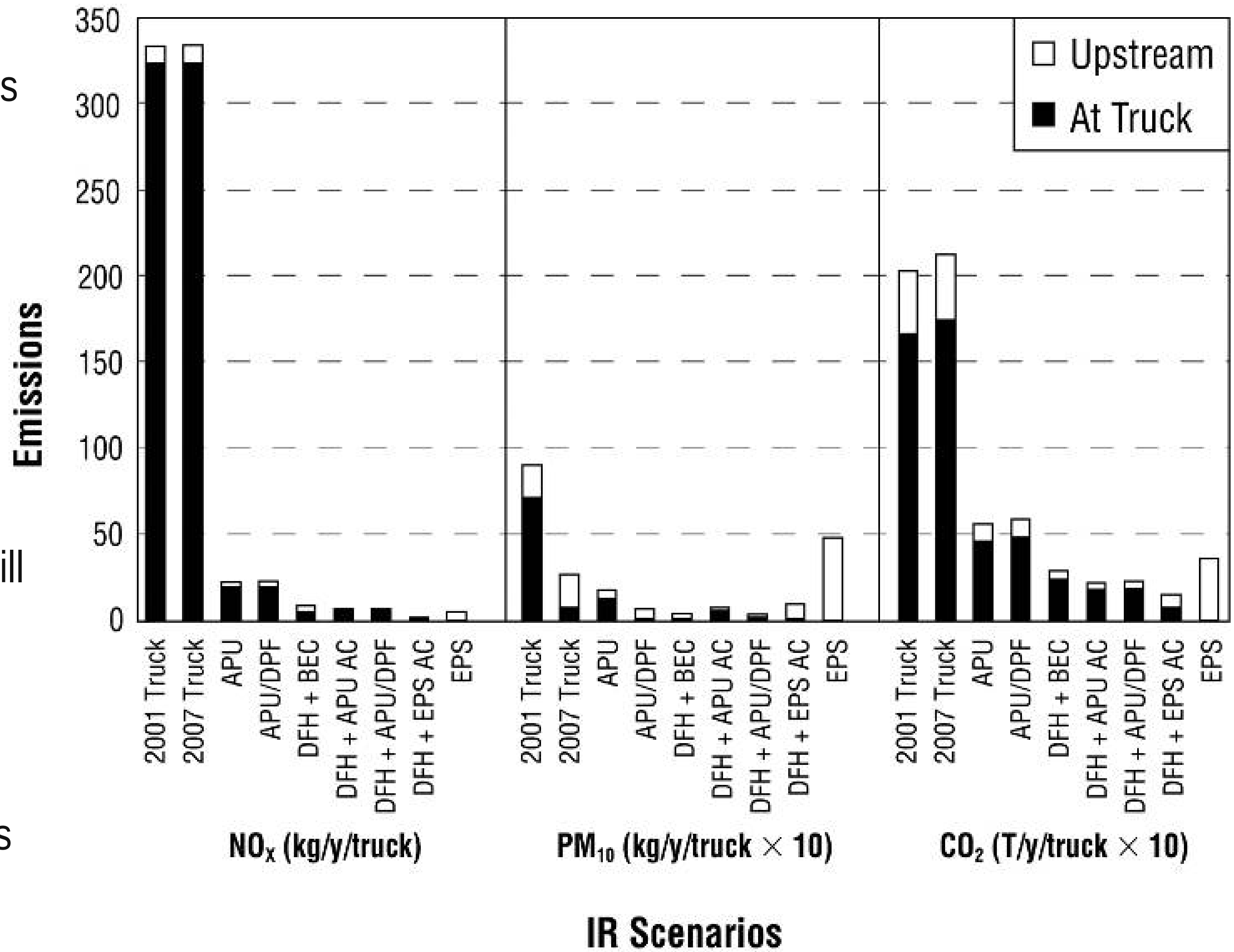
- All IR options eventually save owner money if fuel over \$2/gal
- Options with low initial cost to truck owner cheapest for low-idlers
- Options with low hourly cost cheapest for high-idlers
- Heat only is low cost
- Idling cost goes to \$38 K for \$3/gal fuel



Emissions

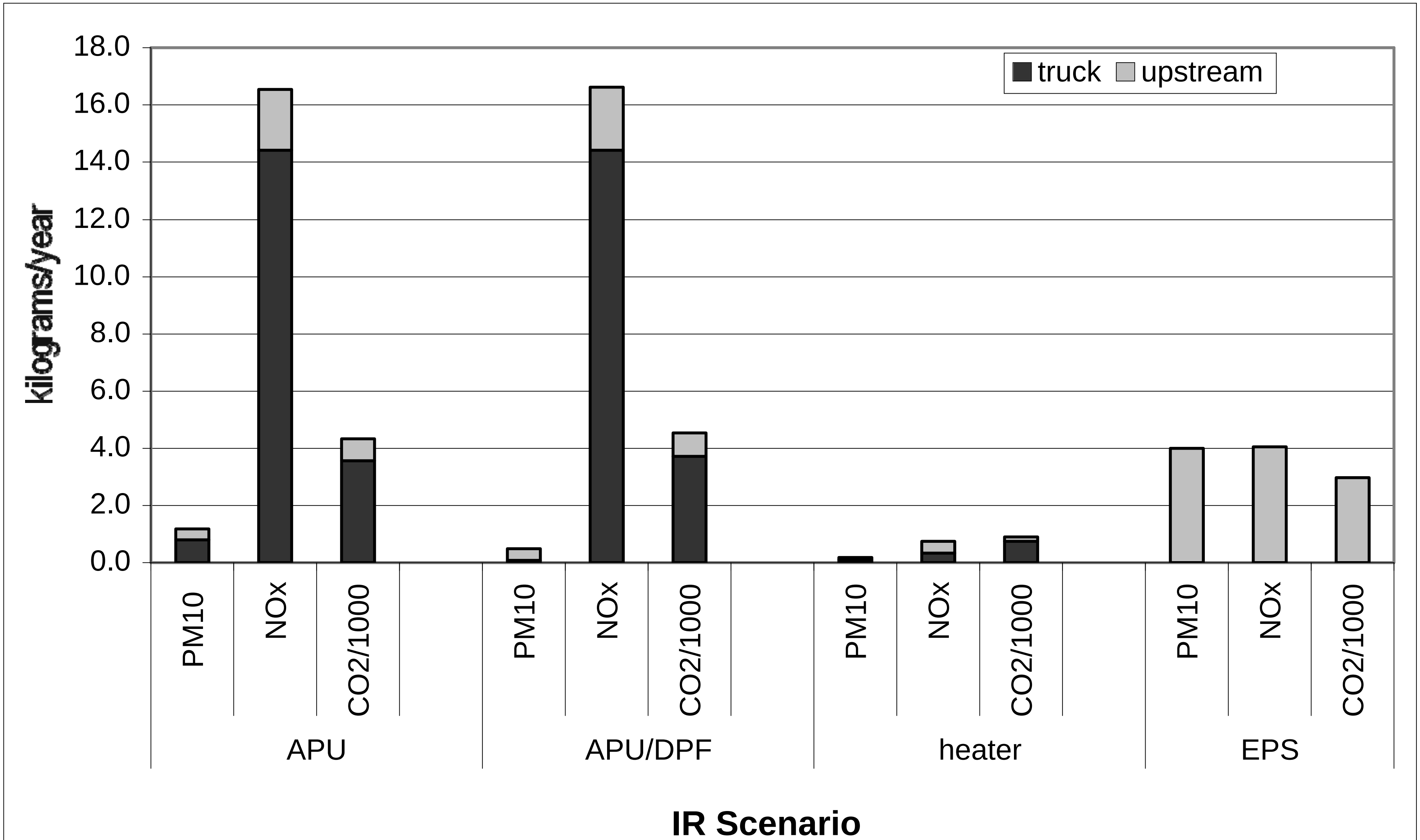
Air quality agencies seek to reduce local emissions

- All idling-reduction options reduce total emissions vs. idling
- Emissions at upstream locations are significant, too
- NO_x emissions for 2010 truck will be reduced
- Energy use comparison resembles CO_2
  - EPS options use no petroleum



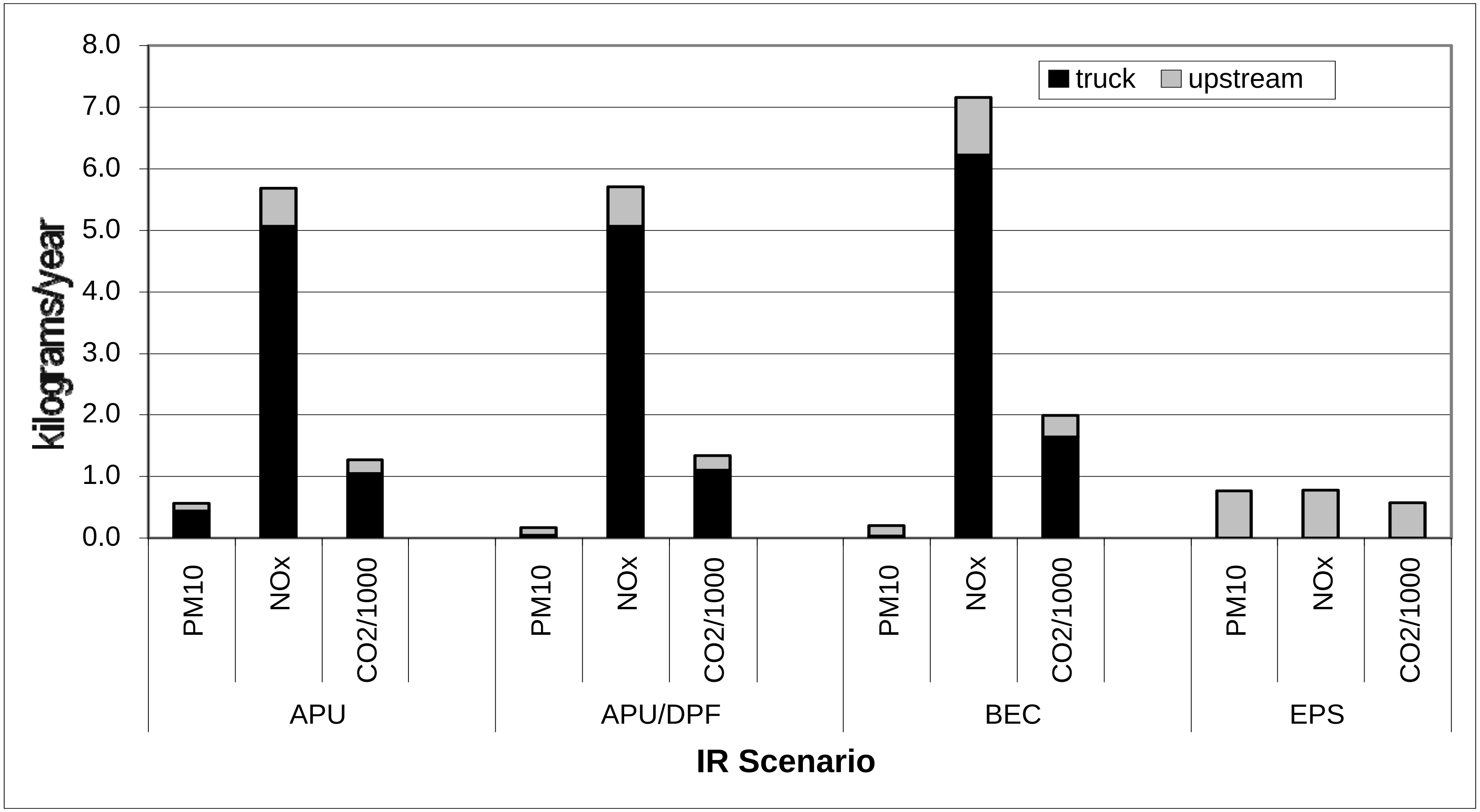
Diesel heater has lowest emissions of heating options

- APU has highest NO_x but still lower than idling



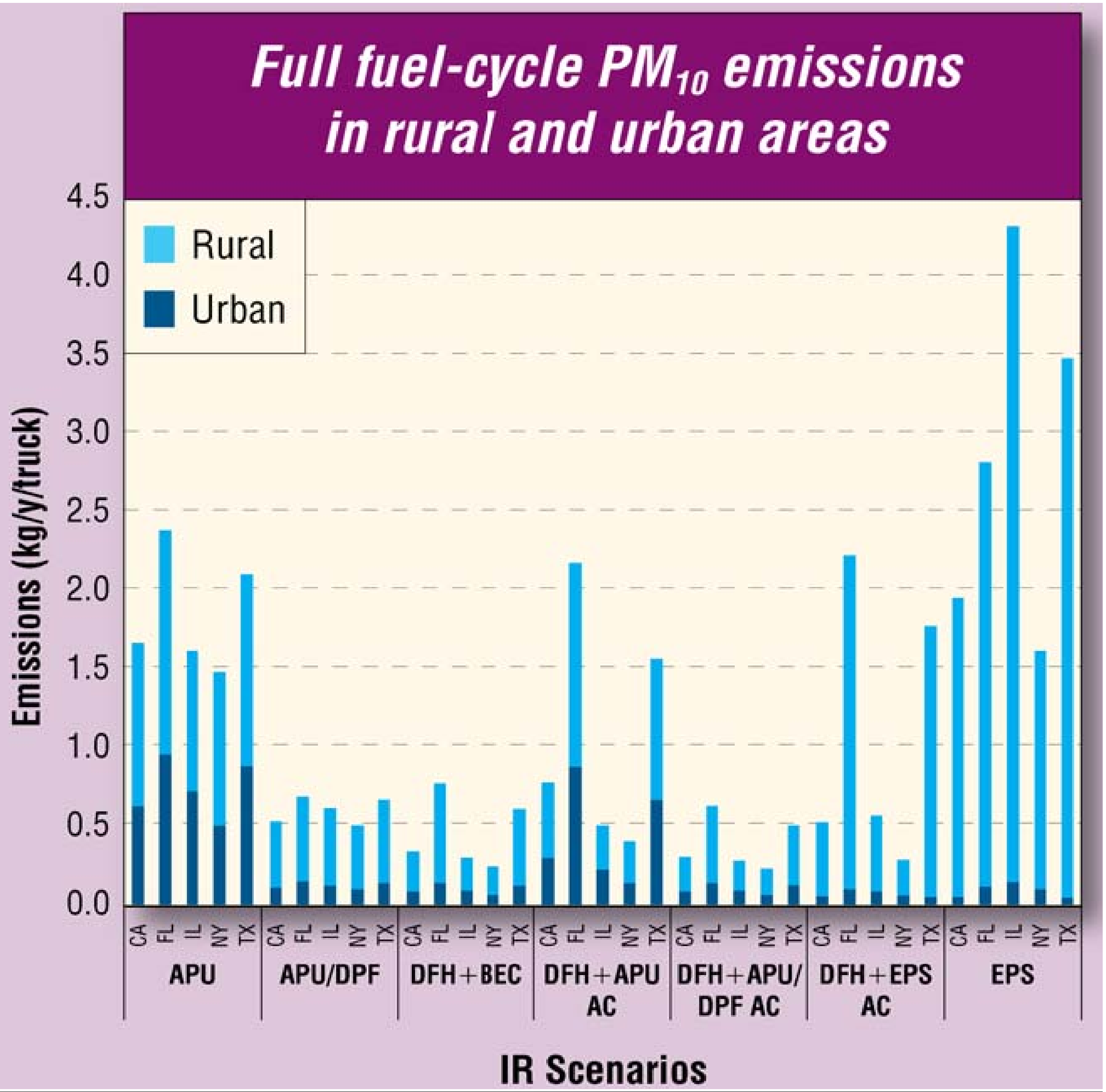
No cooling option minimizes all emissions

- BEC is charged by engine, so NO_x will decrease by 2010
- Marginal fuel use estimate may be high so BEC may then be lowest overall
- Heater plus battery (or thermal storage) AC would then minimize all emissions
- For now, heater plus EPS AC looks like lowest-emission combination



Emissions vary by location and technology

- High emissions in states with high cooling loads
- Urban emissions imply high population exposures
- Electrified parking space PM_{10} high where grid relies on coal
  - Urban component low
- APU options have high urban component



Conclusion

Is everybody happy, and why not?

- All IR alternatives reduce emissions at parking location
- Cost reductions depend on fuel cost and idling hours
- Lowest cost to truck driver may not minimize emissions everywhere
- Minimized local emissions might not minimize cost to jurisdiction
- Minimized local emissions might increase emissions elsewhere
- On-board technologies can be driven outside funding agency's area
- Lowest cost technology might not meet all jurisdictional requirements
- There aren't any simple answers

Institutional barriers need to be addressed

- Patchwork of state and local anti-idling regulations remains
- States have not all adopted the allowed 400-pound APU weight waiver
- Funding for IR equipment is often oversubscribed
- There are more long-haul trucks than parking spaces for them
- Equipment performance is not yet verified by independent third-party
- There is no system for getting emission reduction credits for on-board equipment

Thank you!

- SAE and organizers
- DOE Office of Vehicle Technologies
- Manufacturers who supplied data
- Co-authors Dan Santini (economics) and C.J. Brodrick (emissions) and students

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Background Information

System	Services	Advantages	Disadvantages	Fuel Use/h	Installed Cost ($)	Maintenance ($/y)	Charge ($/h)
Idling (baseline)	All	No investment	High emissions, noise, fuel use	0.8 gal	0	*see note	0
Heat recovery	Heating	Very low cost, weight, emissions	Insufficient for overnight heating	small	600	0	0
Automatic start/stop	All, intermittently	Low cost and weight	Noisy, minimal benefit in extreme weather	0.8 gal when on	1200	**see note	0
Cab/bunk heater	Heating (cab)	Low cost, weight, emissions	Only supplies heat	0.04 gal	1300	50	0
Coolant heater	Heat for engine	Low cost, weight, emissions	Only heats engine	0.1 gal	1400	50	0
Evaporative cooler	Cooling	Low cost, weight, emissions	Effective cooling in dry climate only	0.015 gal	1800		0
Air conditioner	Cooling	Relatively low cost	Only provides cooling; battery may be heavy	0.15 gal	4000	50	0
APU or generator set	All	Anywhere, anytime; doubles as survival system	High cost and weight	0.2 gal	8000	100	0
Electrified parking space (single system)	All	Quiet, no local emissions, amenities; no diesel use	Requires equipped location, high capital cost	1.26 kW avg	10	0	2***
Electrified parking space (dual system)	All	Quiet, no local emissions; no diesel use	Requires equipped location and on-board equipment	varies	2500		1

Default Direct Emissions and Energy-Use and Factors

Technology	**Setting**	**PM_{10} (g/hr)**	**NO_x (g/hr)**	**Diesel Fuel consumption [e] (gal/hr)**
2001 truck idling [a, b, c]	heating	3.74	156	0.77
	cooling	2.08	146	0.98
2007 truck idling [a, b, d, f]	heating	0.37	156	0.79
	cooling	0.21	146	1.02
2008 APU [d]	heating	0.48	8.7	0.22
	cooling	1.0	11.4	0.24
2008 APU with diesel particulate filter [d, f]	heating	0.05	8.7	0.23
	cooling	0.10	11.4	0.25
direct-fired heater [a]	heating	0.06	0.20	0.044
battery electric cooling [g]	cooling	0.07	14	0.36
electrified parking space [h]	heating	2.42	2.45	NA
electrified parking space [h]	cooling	1.72	1.73	NA

Footnotes for table

a Storey et al. (2001) data were used, because they reported on the widest range of pollutants. Results were reported for engine operation at 600 RPM and 1200 RPM.
b Fuel consumption is strongly dependent on accessory load and engine speed. Energy use was adjusted to 750RPM for heating and 900 RPM for cooling to better represent real-world operation. Linear interpolation was based on an estimate developed in TMC RP1108 of fuel consumption as a function of idling speed and load (TMC 1995a).
c Assumes 100% conventional diesel fuel (CD) containing 500-ppm sulfur.
d Assumes 100% ultra-low sulfur diesel (ULSD) containing 15-ppm sulfur.
e Fuel use in grams per hour was converted to gallons per hour using GREET default values: density 3167 g/gal and 3206 g/gal, and energy content 128,450 Btu/gal and 129,488 Btu/gal for CD and ULSD, respectively.
f No data were available for 2007 trucks, so we assumed that the use of a filter would increase energy use by 5% and reduce PM by 90%; we assumed that all other emission factors would not change from 2001 due to lack of data on other changes.
g For the BEC case, in which the battery pack is recharged during normal vehicle operation, we assumed efficiencies of 40% for the diesel engine, 50% for the alternator, and 65% for the battery. Total engine shaft power used for charging was calculated as well as power consumed by the engine (the energy contained in the fuel times the rate of consumption) for battery charging. For a 1.7-kW BEC load, effective shaft power required for battery recharging was found to be 7.0 hp. Using the GREET default lower heating value of 129,488 BTUs per gallon of ULSD, we found effective fuel consumption to be 0.36 gallons per hour of air conditioner operation. Since these emissions are generated during normal truck operation instead of at idle, they were assumed to be consistent with the current EPA HDDE emission standards (EPA, 2006b). The NO_x emissions will be required to drop by a factor of 10 by 2010.
•h Electric loads may vary widely depending on equipment type and operating conditions. Estimates range from 1 to 6 kW (DOE, 2000; TMC, 1995b; Brodrick, et al., 2001; Venturi and Martin, 2001). For this analysis, an average load of 2.4 kW for electric heating and 1.7kW for electric cooling are used. To obtain full fuel cycle emissions from electrification strategies, power consumption by IR technologies must be multiplied by the per-kW power plant emissions output by GREET. The emissions and fuel consumption values presented are for the US average fuel mix output from GREET.