Argonne NATIONAL LABORATORY

Analyzing Technologies to Reduce the Fuel Use of Heavy Vehicles

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Heavy Vehicle Systems Program Review

April 18-20, 2006

THE UNIVERSITY OF CHICAGO

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Energy Efficiency and Renewable Energy

Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

Systems analysis is a key part of DOE's programs

- Evaluate technologies' potential to enable cars and trucks to become
  - Highly efficient, and
  - Cost and performance competitive
  - That is the mission of the Office of FreedomCAR and Vehicle Technologies
- Estimate technology impacts
  - Enable minimization of petroleum demand and emissions (21CT goal)
- Identify technical, economic, and institutional bottlenecks
- Allow prioritization of research and development
- Enable evaluation of program benefits

Systems analysis produces results that are not always expected

Study area	Conclusion	Dates*
Trucks vs. trains for freight transport	Train and inter-modal reduce per ton-mile impacts	1997, 1998
Overnight truck idling	Upstream emissions may be greater than those at the truck; national coordination needed	2000, 2005
Research needs for 21CT, off-highway, rail	Work on systems besides engine would be fruitful	2001, 2002
Workday idling	Impacts may exceed overnight idling impacts; creep mode technology needed	2006
Aluminum vs. steel auto bodies	Use of aluminum saves energy over life cycle if it is recycled	1995, 2002, 2003
HEV and EV vehicle cycle	Battery manufacture has significant impacts	1996, 1997
Comparison of advanced auto efficiency	Diesel hybrid and fuel cell have similar lifecycle efficiency	1999, 2000**
Nickel-metal-hydride battery impacts	SO_2 from Ni production dominates impacts; Ni recycling necessary	2000, 2002
Lithium-ion battery costs	Materials dominate battery costs, especially at high volume	2000, 2001

* Gaines, Stodolsky, et al. publications **Colwell Award

Idling reduction (IR) has became a national priority

- Argonne published analysis of technology options in 2000
- National Energy Policy (2001) singled out IR for attention
  - Energy Policy Act of 2005 authorizes money for IR implementation
- 21CT Partnership includes idling reduction in its goals
- Inconsistent legislation in many states/localities restricts idling
  - Model law drafted to avoid confusion
  - Varied incentive programs offered
- Manufacturers market varied equipment and make unrealistic claims
- Many stakeholders needed to be coordinated
  - Argonne invited them to Albany, NY
  - We organized and chaired a national conference

NATIONAL IDLING REDUCTION PLANNING CONFERENCE

Developing comprehensive, nationwide solutions for heavy-vehicle idling reduction

MAY 17-19, 2004

ALBANY, NEW YORK

- **214 people attended from**
  - Broad range of government agencies at all levels
  - **Industry: users, truck stop operators, truck and IR manufacturers**
  - Research institutions
- **All relevant topic areas were covered**
  - Technology and research for all modes
  - Legislation and regulation
  - Energy, environmental impacts, and economics
- **Objective was coordinated action**
  - **Exemplified by multi-agency sponsorship (DOE, EPA, DOT, DOD, NYSERDA)**
- **Working groups formed to plan education, financing, consistency in regulations, and improved technology**

Our conference was a milestone

- Buy-in from multiple stakeholders was key
- Argonne recognized as technical experts

Objective technology comparison revealed pros and cons

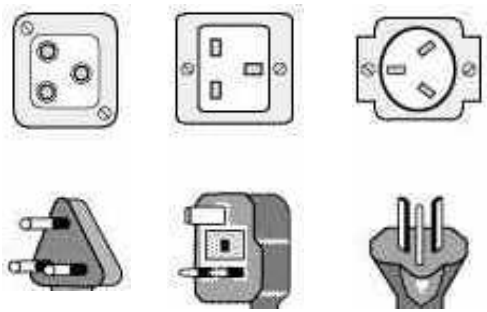
System	Services	Advantages	Disadvantages
Idling (baseline)	All	No investment	High emissions, noise, fuel use
Automatic start-stop	All, intermittently	Low cost	Noisy, minimal benefit in winter
Heater	Heating	Low cost and weight	Not full service
Air conditioner	Cooling	Low cost	Not full service, battery may be heavy
APU* or similar device	All	Anywhere, anytime	High initial cost and weight
Electrified parking space	All	Local emission reductions, quiet	Requires equipped location, high costs for some systems

NO ENDORSEMENTS IMPLIED!

*APU= auxiliary power unit

Working group identified technology needs

- Trucks have greater potential for improvement than other transport modes
  - Positive ferry docking and cold-ironing have potential for marine transport
- Reduction of load would streamline all technologies
- Better idling and device data would help direct R&D efforts
- Smaller, lighter, cheaper, quieter, cleaner APUs desired [21CT goal]
- OEM installation and integration would reduce cost, weight
- Small engine emissions could be reduced
- Standardization needed for electrical devices [21CT goal]
- Radio notification of electrified parking spot availability needed
- Plug-in modules could be installed at company depots



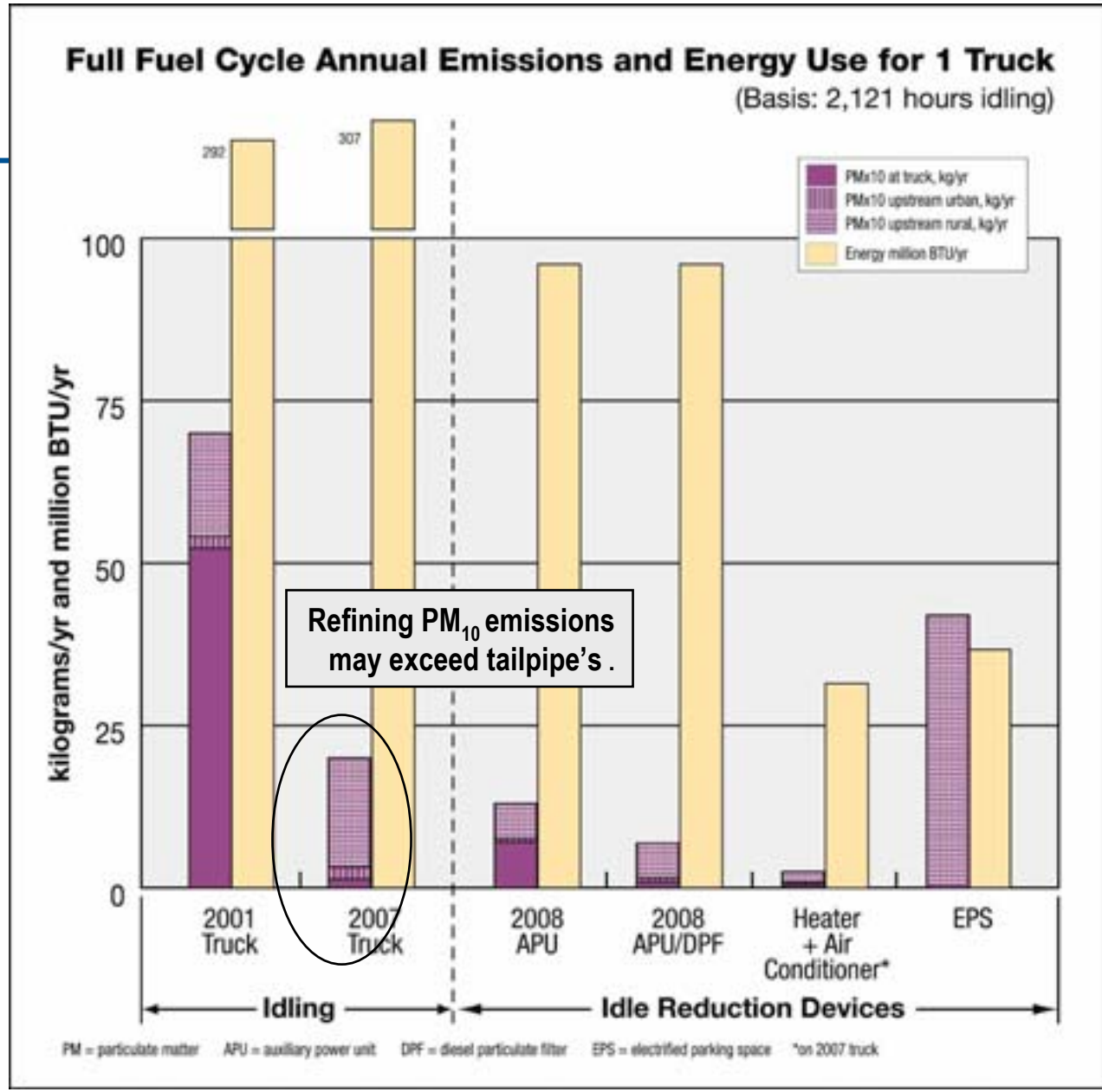
Experiment would inform about APU impacts

- CARB requires automatic 5-minute shutoff but allows APU
  - 2007+ truck APU must have filter or use main engine exhaust treatment
  - Rationale: direct APU PM emissions might exceed 2007 engine's
  - Full fuel cycle emissions not considered
- Data needed on
  - Long-duration idling emissions for 2007 engines
  - Emissions for 2008-compliant APUs, with and without controls
  - Effect of ultra-low sulfur diesel use on these emissions
- Argonne and CAT proposed measurements at WVU or CARB
  - CAT offered to supply truck and APUs
  - Particulate morphology would also be examined
- Plan put on hold because similar project was planned elsewhere

Emissions at the truck represent only part of the impacts

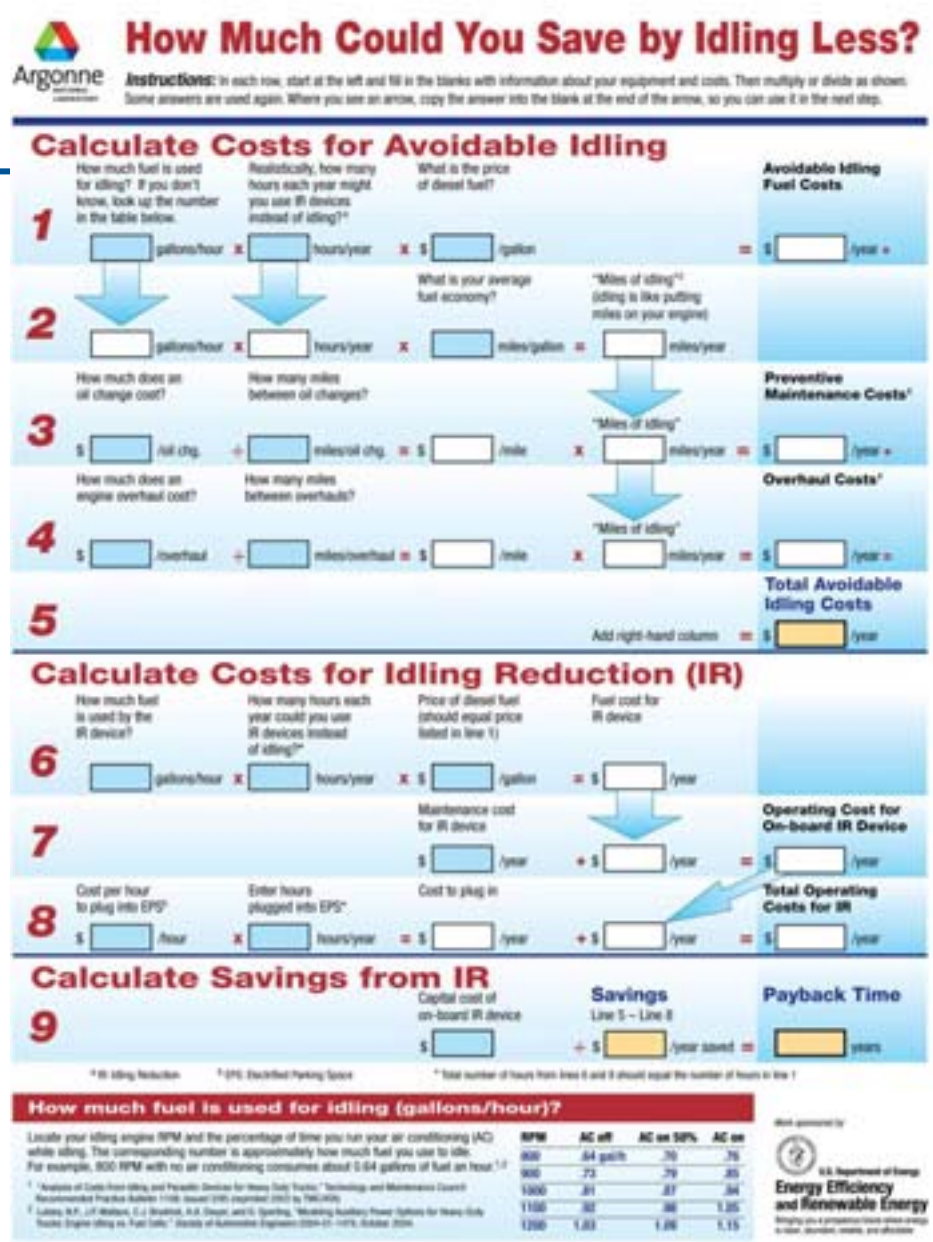
We need to identify where high population exposures result.

Results apply to other technologies as well, e.g., plug-in hybrids.

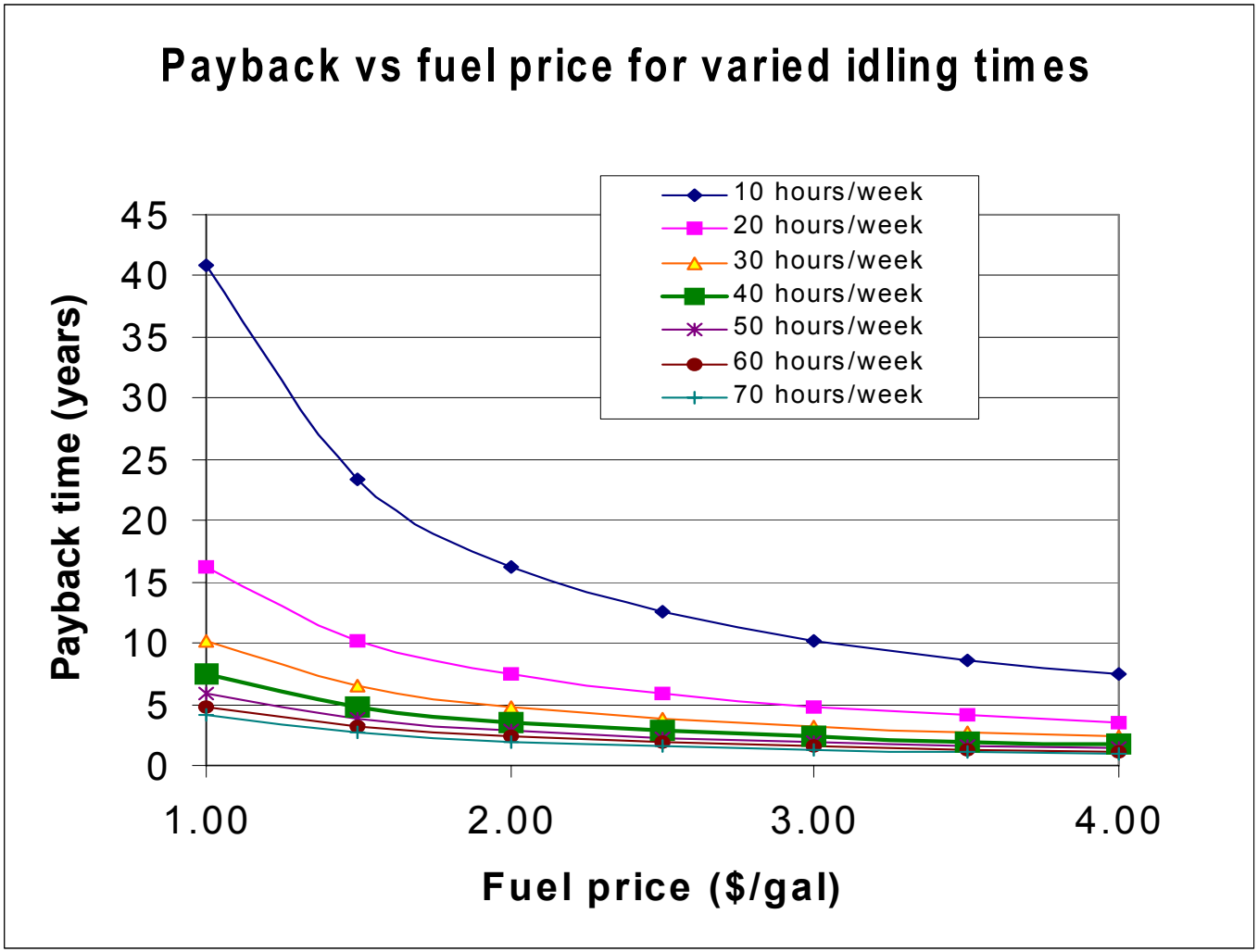


Argonne study will enable cost comparison of technologies

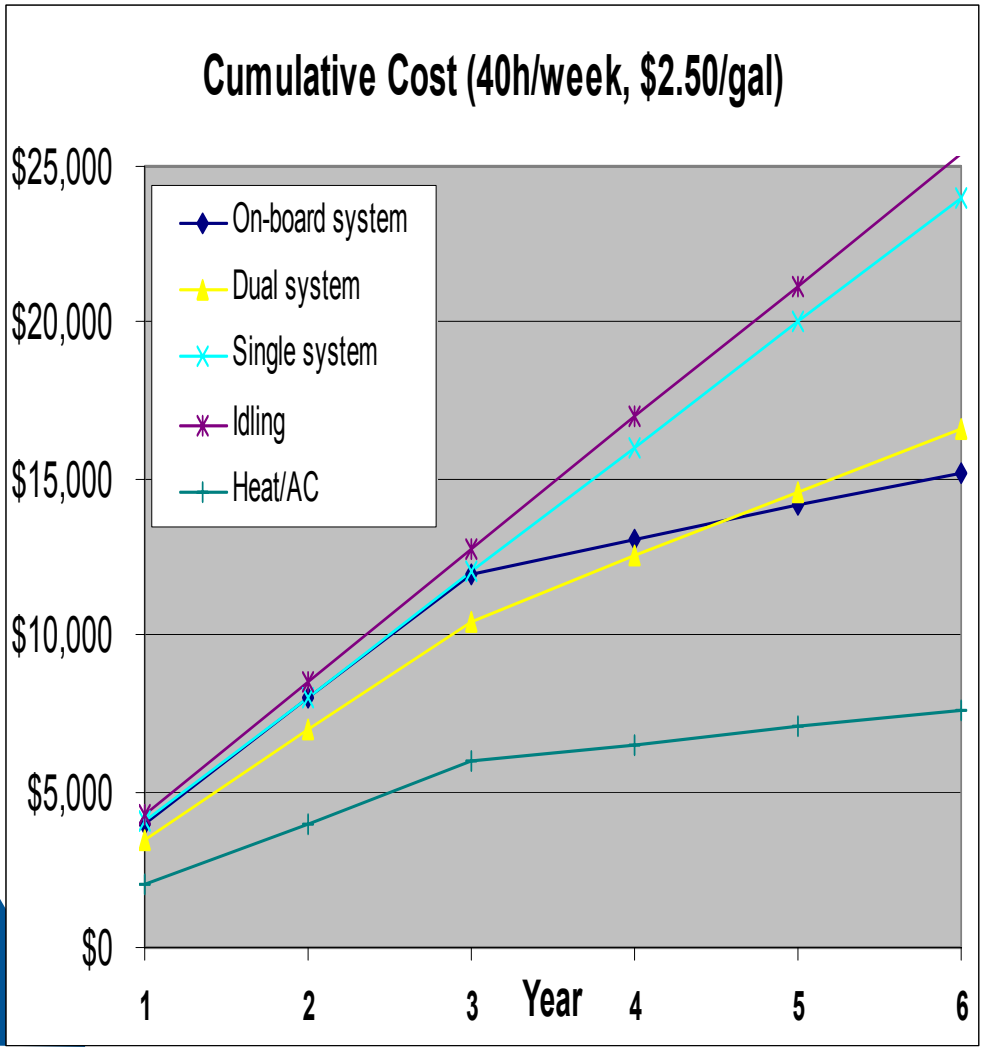
- Advocates claim unrealistic savings from idling reduction
- Worksheet allows truck owners to estimate payback
  - Will be tested in Fleet Owner and LandLine
    - *On Argonne website as well*
    - http://www.transportation.anl.gov/pdfs/EE/361.pdf
- Sensitivity analysis to be published
- More complete economic study is needed
  - Includes all stakeholders
  - Considers location and transport of emissions
  - Estimates exposure and health effects



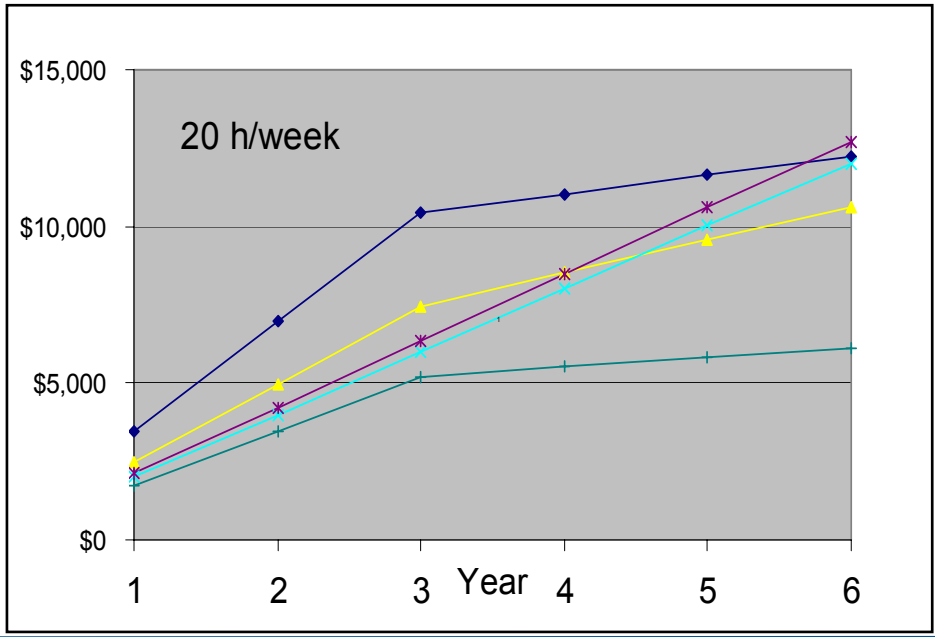
Spreadsheet model shows sensitivity of owner cost to key factors



Idling duration changes technologies' relative positions



System	Cost	Fuel use (gal/h)	Charge/h
Idling	$0	0.8	
On-board (APU)	$8000	0.2	
Heater/battery AC	$4000	0.1	
Dual system EPS	$2500		$1
Single system EPS	$10		$2



New Census data illuminate idling impacts

- 2002 Vehicle Inventory and Use Survey (VIUS) is available
  - Provides detailed data on numbers of trucks by class
  - Also has statistics on routes
- Previous overnight idling estimate based on sleepers >500 miles/day
  - 1997 VIUS
  - Not well documented
  - Was widely quoted
- New estimate includes work day
  - Shorter routes
  - Idling at ports, depots
  - Smaller trucks

- TRB paper including numbers, idling hours, fuel use, emissions has been accepted by TRR
- Workday idling impacts estimated to be more than double sleepers'
  - Preliminary data are available from ATRI

Workday idling is important

- Long-duration idling occurs
  - At ports and terminals
  - In line at busy delivery sites
  - At border crossings
  - At restaurants
- All truck types may idle during the work day
  - We focus on long-duration idling (>30 minutes)
    - *Power take-off excluded*
  - Idling reduction devices do not enable slow movement in queue ("creep mode")
    - *Creep propulsion device needed*
  - Scheduling can reduce workday idling
  - Workday idling is beginning to be studied

Idling was estimated to use over 8% of commercial truck fuel

	Fuel use (million gallons/year)			
	Gasoline	Diesel	Other	Total
Overnight idling	0	666	0	666
Workday idling	1,416	1,002	73	2,491
Total long-duration idling fuel use	1,416	1,668	73	**3,157**
Total fuel use for commercial trucks	13,922	22,681	378	36,982
Idling % of total use by fuel type	10.2%	7.4%	19%	8.5%

Oil quality will indicate wear from idling

- ANL monitored New West*/INL project
- Buses idled for long periods
- Oil contaminants were analyzed
  - Normal operation (very variable)
  - Long-duration idling (1000 hours total)
  - Will be compared
- This has been controversial topic
  - Some analysts have used old TMC RP to overestimate costs from wear
  - Start-stop advocates claim extra wear when restart with cold oil
- Results will be indicative for trucks, too
  - Similar engine type

Formerly Antares

There is still work to be done

- Continue analysis of workday idling
  - Obtain data
  - Evaluate need for “creep mode” device
  - Formulate operational idling reduction strategies
- Complete impact analysis to determine most cost-effective IR technologies
  - Determine engine and IR device emissions with ULSD
  - Determine direct costs to truck owners and other stakeholders
  - Estimate impacts and geographical distribution of full fuel cycle emissions
  - Support development and deployment as appropriate
- Complete the items recommended by the Technology Working Group
  - Reduce cab energy load
  - Develop smaller, lighter, cheaper, quieter APUs
    - *Encourage OEM installation and integration*
    - *Reduce small engine emissions*
  - Standardize electrical devices
  - Test plug-in module effectiveness at depots

Thank you!

- Sid Diamond, FreedomCAR
- Frank Stodolsky, Argonne
- Lee Slezak, FreedomCAR

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