Technologies for Reducing MAC Indirect Emissions:
From AB 1493 Credits to a LEV III Standard

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Presentation Outline

- Description of AB 1493 (Pavley) AC indirect emissions credits
- How the credits were determined for the Pavley rule
- Approach being taken for LEV III – GHG with respect to AC indirect emissions
- Open questions

AB 1493 (Pavley) Credits

Regulation provides credits to vehicles that:

- Have managed outside and recirculated air balance;
- Are optimized for energy efficiency by utilizing state-of-the-art high efficiency evaporators, condensers, and other components; and
- Have an externally controlled compressor (such as an externally controlled variable displacement or variable speed compressor or an externally controlled fully cycling fixed displacement compressor) to minimize reheat

 http://www.arb.ca.gov/cc/ccms/ccms.htm

AB 1493 (Pavley) Credits

- For an AC system that meets all of the criteria of a "system with reduced indirect emissions" credits of up to 9.0 CO_2eq g/mi are allowed if the system has one evaporator, and up to 11.0 CO_2eq g/mi if the system has 2 evaporators
- For an AC system with a refrigerant having a GWP of $\leq$ 150, up to 0.5 CO_2eq g/mi are allowed
- Credits calculated based on compressor displacement with caps in place to prevent incentivizing increasing compressor size

AB 1493 (Pavley) Credits

- Credits based on modeled results presented in NESCCAF (2004)
- Vehicle simulation modeling using the CRUISE model was performed to estimate the CO_2 benefit from the use of improved AC systems for 5 vehicle classes
- Modeling done for average U.S. enthalpy
- Baseline AC system = pneumatic freeze point controlled fixed displacement compressor (FDC)
- Improved AC system = externally controlled variable displacement compressor (VDC) with recirculation and HFC-152a refrigerant

Northeast States for a Clean Air Future (2004) Reducing Greenhouse Gas Emissions from Light-Duty Motor Vehicles. Available at *www.**nesccaf**.org/documents/rpt040923ghg**lightduty**.pdf*

Modeled AC Emissions

Table 3-1: Air Conditioning Emissions

Emissions Source	Vehicle Class	Baseline A/C System	Alternative A/C System	Emissions Change
Indirect Efficiency-Based Emissions (Not Adjusted for A/C "On" Time)	Small Car	49.5	22.7	-54%
	Large Car	56.1	25.7	
	Small Truck	69.2	31.8	
	Large Truck	69.2	31.8	
	Minivan	69.2	31.8	
Indirect Efficiency-Based Emissions (Adjusted for A/C "On" Time)	Small Car	16.8	7.7	
	Large Car	19.1	8.7	
	Small Truck	23.5	10.8	
	Large Truck	23.5	10.8	
	Minivan	23.5	10.8	
Indirect Mass-Based Emissions	All	1.7	1.5	-9%
Direct Leakage Emissions	All	8.5	0.4	-95%

Note: Indirect mass-based emissions are not included in Tables 3-4 through 3-8 since vehicle test weights, as simulated by CRUISE, include the weight of the A/C system.

Adjusted AC "on" time based on average U.S. usage of 34%

Determination of Credits

Table 5.2-12: Indirect CO_2 Emissions from Baseline and Improved Mobile Air Conditioning Systems

		Vehicle class				
		Small Car	Large Car	Minivan	Small Truck	Large Truck
Emissions (g/mi)	With no A/C system operation	277.9	329.2	376.4	425.7	492.6
	With baseline A/C system [1]	291.4	344.6	395.4	444.7	511.6
	Due to baseline air conditioning	13.5	15.4	19.0	19.0	19.0
	With improved A/C system [2]	284.4	336.6	385.6	434.9	501.8
Reductions Due To Improved A/C System	(g/mi)	7.1	8.1	10.0	10.0	10.0
	In A/C emissions	52%	52%	52%	52%	52%
	From baseline A/C system	2.4%	2.3%	2.5%	2.2%	1.9%

[1] *Utilizes fixed displacement compressor*
[2] *Equipped with a variable displacement compressor, air recirculation, and HFC-152a as the refrigerant*

- Modeling results adjusted to reflect 29% AC usage in CA
- For each OEM, credits are adjusted by a factor developed in the NESCCAF study to prorate the total benefit according to the size of the A/C compressor used in their vehicles
  - In grams per mile CO_2 per 100cc of compressor displacement, the factor is equal to 5 for the combined UDDS cycle and highway cycle.

LEV III – GHG: Background

- Will go into effect in 2017 and have separate CO_2 standards for the vehicle and AC indirect emissions
- Demonstration of compliance using a whole-vehicle performance test
- Credits not appropriate for 2017 and beyond
  - Expect that most vehicles will have VDCs due to credits available prior to 2017 and engine downsizing to meet fleet fuel economy and CO_2 requirements
  - Standard prevents backsliding and promotes uniform adoption of efficient technologies
  - Performance test increases enforceability
  - Performance test evaluates current and new technology without needing to be updated

LEV III – GHG: MAC Technologies

- Goal is to develop a test that will accurately evaluate all cooling technologies within the vehicle envelope
  - Core cooling technologies: mechanical AC components and control systems
    - Examples include externally controlled compressors with reduced reheat, high efficiency evaporators and condensers, automatic recirculation, and solar/humidity sensors
  - Additional cooling technologies: soak temperature reduction and comfort perception systems
    - Examples include solar control glazing, parked-car ventilation, ventilated seats, instrument panel heat pipes, reflective upholstery, and reflective paint

LEV III – GHG: Open Questions

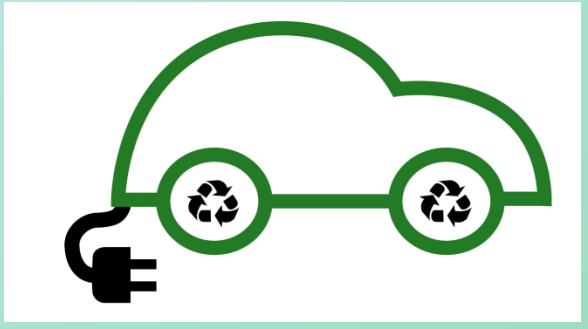
- How to define 2017 baseline AC system?
  - Initial thought is to have some mix of more and less efficient AC systems (e.g., 80% VDC:20% FDC)
- What will the inherent variability of the test be, and how do we design the test to maximize our ability to observe the effect of all components that impact indirect AC emissions?
  - Need to try and get the largest delta between AC off and AC on, which suggests testing “worst case” vehicles in terms of body architecture, plan view glass area, and interior/exterior color

LEV III – GHG: Open Questions

- How to account for technologies not captured in the performance test?
  - Components likely not captured (e.g., ventilated seats) may need to be incentivized through a credit scheme
  - Uncertainty regarding the ability to observe the benefit of some technologies in a performance test (e.g., solar control) means that significant vehicle testing will be required to set the standard and determine the need for additional technology credits

LEV III – GHG: Open Questions

- Consideration of increased penetration of advanced vehicle technologies (BEVs, PHEVs)
  - Will require separate tests to account for reduction in battery-only range due to AC use
  - Need to ensure that innovative solutions to cooling battery vehicles, such as active cooling or ventilation while parked and plugged in, are not disincentivized



Thank You

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