INNOVATIVE TECHNOLOGY REGULATION: ARB STAFF DISCUSSION DOCUMENT
May 27, 2015 New Engine or Vehicle Certification Work Group Meeting

Background

California has made substantial progress in reducing emissions from all mobile sources, with many vehicles sold today being over 90 percent cleaner than those sold just a decade ago. However, despite this progress, these vehicles and equipment remain major contributors to statewide emissions of oxides of nitrogen (NOx) and greenhouse gases (GHG). Compared to today's levels, a 90 percent reduction in NOx emissions by 2031 will be necessary to achieve compliance with the current federal ozone standards, and an 80 percent reduction in GHG emissions below 1990 levels by 2050 is necessary to meet California's climate targets. Significant improvements in efficiency are also needed to meet the Governor's 50 percent petroleum reduction and 40 percent greenhouse gas emission reduction target by 2030. Achieving each of these goals will require a transition to zero and near-zero emission technologies in all mobile source sectors.

The contemplated Innovative Technology Regulation (ITR) proposal is intended to provide defined, near-term California Air Resources Board (ARB) certification and aftermarket conversion approval flexibility to help facilitate market launch of the next generation of truck and bus technologies that California needs to meet these long-term air quality and climate goals. ARB's existing certification and on-board diagnostics (OBD) requirements provide a critical and effective mechanism for ensuring a vehicle's expected emission benefits are achieved and maintained. However, ARB's engine and vehicle approval paradigm, geared towards traditional technologies, may discourage some manufacturers from developing promising new technologies if they are uncertain to achieve market acceptance. This draft discussion document updates staff concepts regarding potential innovative new truck or bus technology certification flexibility identified in the March 9, 2015, ITR Public Workshop Discussion Document, and is intended to encourage additional stakeholder feedback.[1]

Possible Regulation Applicability for New Engine or Vehicle Certification

An innovative truck or bus technology for the purposes of new engine or vehicle certification may include those transformational zero- and near-zero emission technologies which California needs to meet its long-term air quality and climate goals, and which have yet to be deployed in significant numbers. This definition would include strategies that enable or provide a technology pathway to zero-emission technologies, such as hybrids, and is dependent upon vehicle class and vocation.

The regulation may also include certification flexibility for heavy-duty engine or vehicle technologies that may not be transformative but which provide incremental progress towards greater engine or driveline efficiency. These technology diversity provisions would apply to promising technologies such as waste heat recovery.

The Innovative Technology Regulation is intended to provide flexibility to technologies that affect the engine or driveline in a meaningful way, and have an impact on the engine or vehicle

1 For more information, see ARB staff's Innovative Technology Regulation March 9, 2015 Public Workshop Concept Paper; http://www.arb.ca.gov/msprog/itr/itr.htm .

OBD system. Technologies taking advantage of this regulatory flexibility would have to be surplus to what is required by California air quality standards, including all applicable engine or fleet average emission standards. Finally, by encouraging development and early deployment of these advanced truck and bus technologies, this potential regulation could help lay the foundation for future potential California regulations needed to effect widespread fleet transformation.

Eligible Technologies Under Consideration

Table 1, below, provides a list of technologies that may be considered innovative for the purposes of obtaining new engine or vehicle certification flexibility under a proposed ITR. Each vehicle vocation and technology combination (i.e., each cell) would represent a discrete 'innovative technology.' Each manufacturer would be eligible to receive certification flexibility for a defined California sales volume for each 'innovative technology.[2]

Table 1: New Engine or Vehicle Certification: Possible Technology Applicability[1]

	Hybrid with No/Low Zero-Emission Operation	Hybrid with Significant All-Electric Range (AER)[1]	>20% CO_2 Benefit (Non-Hybrid)[2]	Optional NOx Standard ↓50%	Optional NOx Standard ↓75%	Optional NOx Standard ↓90%
Class 2b/3	√	√	NA	NA	NA	NA
Vocational Truck/Bus	√	√	√	√	√	√
Urban Bus	√	√	√	√	√	√
Class 8 Tractor	√	√	√	√	√	√

1 – Vehicle would have to be capable of a minimum of 40 miles zero-emission range. Class 8 tractors capable of a minimum 20 mile zero-emission range, which also offer hybrid propulsion may also be eligible.

2 – Non-hybrid technologies that achieve at least a 20 percent CO_2 benefit may apply to be defined as innovative if they can demonstrate a discrete technology bridge or pathway to achievement of heavy-duty vehicle zero-emission range. *(Note: Staff is not aware of any technologies that would meet this criteria at this time.)*

Urban Buses. Staff has included a discrete vehicle vocation for urban buses in this discussion document. Urban transit fleets were the first to adopt new technologies like compressed natural gas (CNG) engines and exhaust retrofits, and have been the first adopters of zero emission technologies in heavy duty applications, with multiple fleets already operating zero-emission buses in regular revenue service. Urban buses are also unique in that ARB's engine certification regulations require an engine used in an urban bus to be certified specifically to the urban bus service class. ARB staff also anticipates bringing an update to California's Advanced Clean Transit Regulation to the Board for consideration in Spring 2016, to help accelerate development and deployment of advanced technology urban and transit buses.[3] The ITR may help accelerate deployment of key urban bus technologies that may be encouraged or required as part of a potential Advanced Clean Transit Regulation.

2 See the Innovative Technology Regulation March 9, 2015, Public Workshop Concept Paper for more information regarding criteria for determination of potentially eligible technologies; http://www.arb.ca.gov/msprog/itr/itr.htm .

3 ARB, Advanced Clean Transit Regulation Public Workshop Discussion Document, (Workshop Dates: May 11, 14, and 20, 2015), http://www.arb.ca.gov/msprog/bus/actdiscussiondocument.pdf .

Work Group Discussion Topic #1: Urban Buses.

- *Should urban buses be included as a discrete vocation due to their advanced level of commercialization (and discrete engine Executive Order (EO) category)?*
- *Some hybrid engine and driveline manufacturers have already worked collaboratively to receive a dual-party ARB executive order for hybrid engine and driveline combinations in the urban bus vocation. If hybrid urban buses receive significant ARB certification flexibility as part of a proposed ITR, how can ARB staff minimize certification "backsliding" by these manufacturers, which are already complying with OBD and other certification requirements in an equitable way, and still encourage new hybrid urban bus technology manufacturers to enter the market?*

Hybrids with Significant All-Electric Range (AER). Hybrid vehicles with significant zero-emission range represent the most advanced specific technology potentially addressed by the ITR. Increasing the application of zero-emission propulsion technology can provide significant emissions benefits, support battery innovation in higher power demand zero-emission applications, and help build supply chains for zero-emission components like controllers, motors, and electricity converters. Because the vehicles utilize a robust electric drive, they can also help foster fleet acceptance of zero-emission technologies and drivetrains. In order to be eligible as a hybrid with significant AER for the purposes of the ITR under consideration, a manufacturer would be required to provide an engineering analysis or other credible data/information to ARB demonstrating that the vehicle achieves a minimum 40 mile zero-emission range.

Staff is also considering Class 8 tractors with a minimum 20 mile zero-emission range as potentially eligible for this category if the vehicle is designed to subsequently operate as a traditional hybrid (post-zero-emission operation). This type of Class 8 tractor has the potential to provide zero-emission operation while hauling goods to or from a sea port or rail yard, or within disadvantaged communities, and operate as a hybrid outside of these or other disproportionately impacted areas. For purposes of context regarding a minimum 20 mile zero-emission range requirement for Class 8 vehicles, the I-710 corridor between the Ports of Los Angeles and Long Beach and the Pomona Freeway (SR-60) is 18 miles.[4]

Work Group Discussion Topic #2: Hybrids with Significant AER.
Staff has identified a 40 mile zero-emission range as a potential threshold for differentiating a hybrid with significant AER from a hybrid vehicle with more modest or no zero-emission capability, as a 40 mile zero-emission range is believed to be practical and technically feasible, and reflects an approximate typical daily mileage for Class 2b/3 vehicles. Do stakeholders have comments or concerns regarding this approach? Do stakeholders have comments regarding a potential 20 mile zero-emission range threshold and requirement for traditional hybrid capability for heavy-duty tractors?

The remainder of this document discusses possible ARB approval pathways and sunset provisions for innovative new engine or vehicle certification and more targeted certification flexibility to encourage technology diversity.

4 Los Angeles County Metropolitan Transportation Authority; http://www.metro.net/projects/i-710-corridor-project/

Potential Innovative New Engine or Vehicle Certification Pathways.
Staff is considering the following for the potential ITR: a tiered ARB engine or vehicle certification pathway for each eligible vocation-technology combination (i.e., each cell identified in Table 1), providing each manufacturer with targeted new engine and vehicle certification flexibility at market launch (Tier 1: Demonstration Volumes) and early deployment (Tier 2: Pilot Volumes), and reverting back to full ARB certification requirements once each vocation-technology combination achieves a market foothold.

Each manufacturer would be eligible to utilize the new engine and vehicle certification pathway identified in Table 2. Table 2 identifies only those elements of ARB certification that would deviate from existing requirements. ARB certification requirements not identified in Table 2, such as engine dynamometer testing, would continue to apply. Attachment A provides an example of how a manufacturer might progress from Tier 1 to Tier 2 to full ARB certification utilizing flexibility under the potential ITR.

Table 2: Possible New Engine or Vehicle Certification Flexibility Provisions

Tier	Number that could be sold[1]	**All Existing Certification Requirements Would Apply Plus the Following DRAFT Provisions**	Potential Action items to proceed to next tier
1	Demo Volumes (per manuf.)	1. Approved application 2. Vehicles utilizing hybrid drivelines must provide engineering analysis and/or data providing credible evidence that vehicle achieves at least a 20 percent CO_2 benefit 3. ARB approves applicant's plan and process for independent portable emissions measurement system (PEMS) or chassis dynamometer emission testing (if technology impacts not quantified by engine dynamometer testing) 4. Report California sales to ARB 5. Labeling requirements 6. Meet diagnostic requirements rather than OBD 7. One new innovative technology per model year is exempt from counting as an additional engine family for the purposes of triggering an additional OBD demonstration data set 8. Assigned or carryover deterioration factors may be used	1. Application to advance to Tier 2 approved. 2. Emissions testing completed, confirms emission benefit.[2] ARB may request manufacturers provide vehicles for independent confirmatory testing.
2	Pilot Volumes (per manuf.)	1. Continue Tier 1 flexibility provisions, except as noted in this box. 2. Basic OBD (i.e., circuit and functional checks) required, may light separate malfunction indicator light (MIL) and use proprietary scan tools. 3. Demonstrate that OBD readiness can be achieved to ensure compatibility with Smog Check or other in-use inspection programs 4. Monitoring frequency evaluation required after vehicles are on the road for one year, but no enforcement action will be taken based on the results 5. Report California sales to ARB. 6. Labeling requirements. ➔ Additional vehicles beyond Tier 2 volumes must meet full certification/OBD requirements	1. Additional vehicles beyond Tier 2 meet full certification/ OBD requirements

1 – Represents maximum allowable California sales per manufacturer for each combination of vocations and technology types identified in Table 1 (i.e. each cell in Table 1). Potential Tier 1 and 2 sales volumes identified in Table 3.

2 – Required only for technologies for which emissions impacts not quantified by dynamometer testing.

Potential Tier 1 and 2 Sales Volumes

An effective certification flexibility pathway would maximize manufacturers' willingness to develop and commercialize eligible technologies and fleets' ability to conduct robust technology evaluations, while minimizing near-term performance uncertainties potentially associated with ITR certification flexibility. Table 3, below, provides staff's initial assessment of the potential Tier 1 and Tier 2 sales thresholds which would encourage meaningful manufacturer participation while providing a feasible and effective pathway towards full engine or vehicle certification.

Table 3: DRAFT Potential Cumulative Allowable California Sales Threshold per Eligible Technology

Vocation	Maximum Volume per Manufacturer		Industry Cap[2]
	Tier 1 (Demo)	Tier 2 (Pilot)[1]	
Class 2b/3	~100	~1,000	~2,500
Class 4-8 Vocational	~100	~1,000	~2,500
Class 8 Tractor	~50	~500	~1,200
Urban Bus	TBD	TBD	TBD

1 – Tier 2 volumes would be subject to the following multipliers: 2x for hybrids with significant AER, 2x for heavy-duty hybrid full vehicle certification (using ARB's December 12, 2013, optional heavy-duty hybrid certification procedures).

2 – Hybrids with significant AER would be eligible for 2x industry cap multiplier.

Possible Regulatory Sunset Provisions for New Engine of Vehicle Certification Flexibility

The potential ITR certification flexibility is intended to provide a temporary policy incentive for these key technologies, with technologies reverting to existing ARB certification (including OBD) requirements once they begin to achieve consumer acceptance. Staff agrees with stakeholder comments that ITR sunset provisions should be well defined and predictable, with enough lead time for manufacturers to plan for technology development and market launch, plus a sales volume component that is reflective of initial market acceptance. One potential approach that incorporates both these elements would be ITR certification flexibility for each vocation-technology combination sunset once the following conditions have been met.

1. Once a vocation-technology combination has been certified at Tier 2 volumes by at least two manufacturers, ITR flexibility would be available to all manufacturers for that vocation-technology combination for at least four model years (MY).[5] For example, if two manufacturers are certified to sell Tier 2 volumes of a Class 8 engine meeting the optional NOx standard in the 2016 MY, ITR flexibility for engines meeting this standard would sunset no earlier than the 2020 MY (i.e. 2019 could be the final year of ITR flexibility).

2. Eligibility for each vocation-technology combination would not sunset until a cumulative (i.e. multi-year) industrywide California sales volume has been reached. This industrywide sales volume should represent early market acceptance – a point at which consumer acceptance becomes more likely, sales begin to accelerate, and manufacturer diversity has an opportunity to flourish.

5 CAA Section 202(a) requires at least four years lead time for new engine standards, suggesting four years are needed for new product planning and rollout.

Table 3, above, identifies possible industrywide sales thresholds at which potential ITR flexibility for each eligible vocation-technology combination would sunset. These possible sales thresholds are based upon staff's assessment of relevant independent studies, empirical data, and ARB experience regarding technology costs, vehicle technology adoption rates, consumer acceptance rates, and other information. ARB strategies and programs to encourage market launch and consumer acceptance of hybrid and zero-emission vehicles, such as the Air Quality Improvement Program, have also helped inform this evaluation.[6] California engine family annual and cumulative sales data have also helped provide context for the potential ITR sales volumes identified in Table 3.

Staff believes these possible ITR sales thresholds and sunset provisions would provide a reasonable pathway for key truck and bus technologies to successfully enter the California market, while meeting California certification and OBD requirements as expeditiously as possible. However, staff recognizes that other metrics or approaches could be used to define advanced technology truck and bus market acceptance, and welcomes stakeholder comments regarding the potential manufacturer sales thresholds and sunset provisions identified in this discussion document. Attachments B and C provide additional context and detail regarding how potential Tier 1 and Tier 2 manufacturer and industrywide sales thresholds were derived.

Manufacturer Diversity. Staff believes having a diversity of advanced truck and bus technology manufacturers helps enable a robust market with greater potential for innovation, consumer acceptance and market growth. A potential ITR cumulative industrywide sales volume more than double the manufacturer-specific sales volumes would ensure at least 3 manufacturers in the market before regulatory flexibility sunsets, providing a minimum level of manufacturer diversity and enhancing the opportunity for smaller manufacturers to access the market. For example, if the industrywide cap is 2,500 for a vocation-technology combination, and the manufacturer specific cap is 1,100 vehicles (Tiers 1 and 2 combined), then at least 3 manufacturers would have access to ITR flexibility before it sunsets.

> *Work Group Discussion Topic #3:* Possible *Tier 1 and Tier 2 Sales Volumes.*
> *Do stakeholders have questions or comments regarding the possible Tier 1 (Demonstration) and Tier 2 (Pilot) manufacturer sales volumes identified in Table 3?*
>
> *Table 3 also includes potential provisions for a 2x multiplier that would be applied to the allowable Tier 2 volumes for eligible hybrids with significant AER and for hybrid heavy-duty vehicles that voluntarily certify as a complete vehicle utilizing ARB's optional Hybrid Heavy-Duty Hybrid-Electric Vehicles Certification Procedures.*[7] *These potential multipliers are intended to further encourage deployment of more advanced zero-emission technology, and to encourage manufacturers to certify heavy-duty hybrid vehicles as a complete vehicle (with chassis dynamometer testing) rather than just certify the engine and driveline (with engine dynamometer testing) as currently required.*

6 Fiscal Year 2014-15 Funding Plan for the Air Quality Improvement Program and Low Carbon Transportation Greenhouse Gas Reduction Fund Investments, ARB; May 23, 2014; http://www.arb.ca.gov/msprog/aqip/fundplan/final_fy1415_aqip_ggrf_fundingplan.pdf ..

7 Heavy-Duty Hybrid-Electric Vehicles Certification Procedures; ARB; December 12, 2013; http://www.arb.ca.gov/regact/2013/hdghg2013/hdghg2013isor.pdf .

Work Group Discussion Topic #4: Potential ITR Sunset Provisions. Do stakeholders have any questions or comments regarding potential certification flexibility sunset provisions identified in this document?

Staff is also soliciting stakeholder feedback regarding what possible Tier 1 and 2 manufacturer sales volumes and industrywide sunset provision sales volume may be appropriate for the urban bus vocation. Allowable sales volumes based upon a percentage of typical annual urban bus sales may be insufficient to fully demonstrate and advance key urban bus technologies due to this vocation's relatively low annual sales volume. As mentioned earlier, potential ITR certification flexibility may help pave the way for early deployment of key transit bus technologies that may ultimately be required by ARB's potential Advanced Clean Transit Regulation.

Finally, it could be a challenge to implement possible ITR sunset provisions based on both a minimum time threshold and concurrent minimum sales volume threshold. It may be difficult for ARB to have knowledge of cumulative industrywide sales volumes in a timely manner, as needed to determine if the potential ITR should sunset for a particular vocation-technology combination after 4 model years. For example, under the current vision of a potential ITR, if 2 manufacturers receive an ITR EO for their hybrid vocational truck in 2016, ITR flexibility would sunset for hybrid vocational vehicles after the 2019 MY, if the 2,500 industrywide hybrid vocational vehicle sales threshold is met. However, a manufacturer may want to certify a 2020 MY vocational hybrid truck using ITR flexibility before manufacturers had reported their 2019 MY sales (and before ARB staff could know if the sales threshold has been met).

One option might be a more nuanced approach, whereas a determination of whether a technology is to sunset after 4 years is made at the halfway point (i.e. beginning 2 years after 2 manufacturers receive a Tier 2 EO). Perhaps if a certain sales threshold is met after 2 years, or if a third manufacturer receives a Tier 2 EO after 2 years, ARB would indicate that the ITR certification flexibility for that vocation-technology combination will sunset at the 4 year mark. Staff encourages stakeholder feedback regarding how a possible ITR sunset provision based upon minimum time and sales volume components could most effectively be implemented.

Work Group Discussion Topic #5: Possible New Engine or Vehicle Certification Flexibility Provisions (Table 2). ARB staff has not received any stakeholder comments regarding the possible ITR certification flexibility identified in Table 2 during the March 9, 2015, public workshop and March 24, 2015, work group meeting. Some stakeholders have commented that potential Tier 1 and 2 sales volumes are needed to inform their feedback regarding the associated potential flexibility provisions. Given the potential Tier 1 and Tier 2 sales volumes identified in this document, do stakeholders have questions, comments or suggestions regarding the potential ITR certification pathway identified in Table 2? Should ARB staff consider a more nuanced approach, in which hybrids and engines meeting the optional low NOx emission standard have different ITR sales thresholds and certification pathways tailored to address each technology's specific OBD and other certification challenges?

Work Group Discussion Topic #6: Defining an Eligible Hybrid Technology Manufacturer. Should any potential ITR require that a manufacturer for the purposes of determining Tier 1 and Tier 2 sales thresholds be defined as the engine manufacturer, the hybrid driveline manufacturer, the hybrid vehicle manufacturer, or some combination of these three? ARB staff believes a single EO is critical to ensure a minimum level of integration of, and accountability for, the engine and hybrid driveline. In the case of vertically-integrated manufacturers, a single entity assumes full responsibility and receives a single party EO. However, ARB has also provided a dual-party EO for non-vertically integrated hybrid manufacturers, with the engine and driveline manufacturers each being held responsible for their respective components.

It may make sense for the hybrid vehicle manufacturer, for the purposes of defining possible ITR sales volumes, to be limited to the party or combination of parties identified on the ARB EO. This approach would help ensure some engine and driveline manufacturer coordination and component integration, and enable a more seamless transition from Tier 2 to full certification and OBD requirements. ARB staff welcomes stakeholder comments regarding the pros and cons of this approach, and any potential alternate approaches for defining a hybrid vehicle manufacturer while enabling an eventual transition to full OBD. Tables B-4 and B-5 (in Attachment B) provide context for this issue by grouping the hybrid vehicle, engine, and driveline manufacturers receiving ARB Hybrid and Zero-Emission Truck and Bus Incentive Project (HVIP) funding since 2010.

Work Group Discussion Topic #7: PEMS Testing. Full chassis or vehicle emission testing of hybrid vehicles to determine criteria pollutant emission impacts of hybridization is one of the most critical elements of a potential ITR. Hybrid vehicles with excess emissions of NOx or other criteria pollutants would likely not be eligible for a Tier 2 EO. While chassis dynamometer emissions testing procedures have been developed and defined in multiple regulatory documents (including ARB's Hybrid-Electric Vehicle Certification Procedures), more work must be done to develop effective and robust regulatory PEMS testing procedures, particularly for vocational vehicles. Federal regulations provide some guidance regarding PEMS testing. However, these are geared towards demonstrating heavy-duty tractor trailer compliance with Not-To-Exceed (NTE) in-use engine emission limits, and are primarily geared towards identifying gross polluters.[8] Potential ITR PEMS protocols would have to define the key required elements to ensure robust and statistically valid PEMS testing while being applicable to the wide range of potential duty cycles. Staff welcomes stakeholder comment on the following questions:

- *Is A to B testing and emissions comparison (i.e., for a base and hybrid vehicle) testing needed?*
- *How should a proposed ITR define eligible PEMS equipment, equipment calibrations, and verification of emission testing results?*

8 40 Code of Federal regulation; Part 1065, Subpart J - Field Testing and Portable Emission Measurement Systems.

- *How many vehicles and/or hours of emissions testing are needed to ensure statistically-relevant results?*
- *What specifically should constitute an acceptable duty cycle for emissions testing? Is there a minimum or maximum number of cold starts, idle time, average speeds, etc?*
- *What is the pass-fail protocol for PEMS testing results? If five trucks are tested and four show NOx emission benefits and one shows a disbenefit, how would this be assessed?*
- *If a hybrid vehicle is deemed to fail its PEMS testing, under what circumstances could it retest? One possible approach would be to allow retesting only after the ARB Executive Officer determines that the manufacturer has identified and addressed the cause of the emission disbenefit.*

These and other PEMS-related questions will likely require significant additional discussion and stakeholder feedback. Staff recommends convening a discrete ITR Work Group dedicated to defining potential ITR PEMS testing protocols.

Work Group Discussion Topic #8: Possible Anti-Backsliding Provisions. The potential ITR is intended to encourage manufacturers to bring critical new advanced technology trucks and buses to the California market by providing a simplified, streamlined pathway to meet ARB certification and OBD requirements. However, some hybrid manufacturers, such as Hino Motor Company and some urban bus hybrid engine and driveline manufacturers already meet existing certification and OBD requirements. Is there an effective and equitable mechanism to encourage additional manufacturers to enter the market by providing potential ITR certification flexibility while locking in the benefits of existing manufacturers' certification and OBD compliance?

Work Group Discussion Topic #9: Defining "Surplus" Emission Reductions.
Staff envisions that manufacturers of technologies utilizing potential ITR certification flexibility would have to demonstrate that these technologies are not used to demonstrate regulatory compliance with any California fleet rule, emission standard or other applicable rule or regulation. While this should be relatively straightforward with regard to fleet rules and criteria pollutant engine emission standards, demonstrating a technology is surplus to California medium- and heavy-duty vehicle Phase 1 or eventual California Phase 2 greenhouse gas standards may be more complex.

ARB has adopted Phase 1 GHG standards which align with federal Phase 1 GHG emission standards. For Phase 1 standards, California has largely relied upon manufacturers' federal compliance demonstrations, typically deeming that vehicles and engines meeting federal Phase 1 standards also meet California's equivalent Phase 1 standards (providing a "Deemed-To-Comply" EO). Staff envisions that one way for manufacturers to demonstrate that a technology's benefits are surplus to California GHG standards could require a California-specific compliance demonstration which does not include the advance technology vehicles participating in a potential ITR. However, this would require manufacturers to perform dual compliance demonstrations – one for federal GHG standards and another to demonstrate the manufacturer's fleet

compliance with California standards without the benefit of the advanced technology. Staff welcomes stakeholder comment regarding other potential mechanisms by which manufacturers could demonstrate a technology utilizing potential ITR certification flexibility is surplus to California Phase 1 GHG standards (and eventual California Phase 2 GHG standards).

Work Group Discussion Topic #10: Engine Downsizing. Staff welcomes stakeholder comments regarding potential ITR flexibility that would enable engine downsizing, particularly in hybrid applications. Are there alternative approaches ARB staff should consider as part of this potential regulation for manufacturers to demonstrate durability of downsized engines?

Potential Role of Incentives. ARB has signaled the critical role financial incentive programs will have over the next decade in encouraging and accelerating demonstration and deployment of advanced truck and bus technologies California needs to meet its long-term air quality and climate goals. Staff envisions that a potential ITR would work in tandem with ARB incentive programs, such as HVIP, to accelerate market launch of these technologies, including hybrids and heavy-duty engines meeting the optional NOx standard.

Possible Technology Diversity Provisions

The potential ITR would include more modest, targeted flexibility provisions for certification of heavy-duty engine or vehicle technologies that may not be transformative but that provide incremental progress towards a more efficient engine or driveline. Eligible technologies would have to impact the engine or driveline in a meaningful way, or present a significant OBD compliance challenge. Eligible technologies might potentially include:

- Advanced transmissions that utilize various technologies in order to optimize the performance of the transmission and improve fuel efficiency.
- Engine down-speeding, where the engine runs at low speeds and with high torques, which results in higher efficiency and reduced fuel consumption.
- Innovative fuel injection techniques that allow for fast and clean combustion and increased fuel efficiency.
- Waste heat recovery, using technology such as thermoelectric generators that can directly convert energy from the hot engine exhaust into electricity that can power vehicle auxiliary loads and accessories.
- Cylinder deactivation allows the engine to shut down some of its cylinders during light load operations for greater fuel efficiency.
- Camless valve actuation, which reduces mechanical losses by opening and closing engine valves electronically rather than mechanically.
- Stop-start technologies which conserve energy by shutting off the engine when the vehicle is at rest or predictive cruise, which utilize GPS and other technologies to optimize engine efficiency (if these technologies can demonstrate an OBD compliance challenge).

Work Group Discussion Topic #11: Possible Minimum Technology Criteria. The potential technology diversity provisions are intended to provide targeted certification flexibility for incremental but meaningful engine or driveline technology advances. However, the possible technologies identified above could range from very modest to robust. For example, a minimal level of waste heat recovery could be relatively straightforward and merit less (or perhaps no) certification flexibility relative to more advanced waste heat recovery systems. Is there a simple mechanism for setting appropriate potential minimum thresholds for the above technologies? Staff welcomes stakeholder comment on requiring a minimum level of CO_2 emission reductions as identified by the Greenhouse Gas Emission (GEM) Model for Medium- and Heavy-Duty Vehicle Compliance (more than one percent?) to be eligible for the potential technology diversity provisions.

Table 4, below, identifies potential "technology diversity" flexibility provisions for incremental engine or driveline technology advances. These potential provisions are identical to those identified for consideration in the March 9, 2015 ITR Public Workshop Concept Paper.

Table 4:
Possible Flexibility Provisions for Incremental New Engine or Vehicle Technologies

Number that could be sold	Possible ARB Certification Flexibility to Encourage Technology Diversity
Pilot Deployment	1. *Basic diagnostics (i.e. circuit and functionality checks) required for the innovative technology(?)* 2. One new innovative technology per model year is exempt from counting as an additional engine family for the purposes of triggering an additional OBD demonstration data set 3. Greater flexibility to use assigned or carryover deterioration factors 4. Other flexibility?

Possible Sunset Provisions. Staff is considering an approach with no manufacturer or industrywide sales volume limit for engines that utilize the potential technology diversity certification flexibility. Potential certification flexibility for each technology could sunset four model years after two manufacturers receive an EO utilizing ITR flexibility for that technology. After this period, manufacturers would have to meet full certification requirements. For example, if two manufacturers first certify an engine which utilizes waste heat recovery with the help of the potential technology diversity provisions in the 2016 MY, this flexibility would sunset in the 2020 MY for all manufacturers. This approach provides maximum certainty to engine and driveline manufacturers regarding when a technology will sunset.

Staff is not envisioning concurrent industrywide sales thresholds for the potential technology diversity provisions, as discussed for hybrid vehicles and engines meeting the optional low NOx emission standard, since these more incremental engine and driveline technologies may not necessarily all be adopted on a large scale. A diverse suite of these incremental engine and driveline technologies may ultimately achieve market acceptance, while others may never reach a sales "tipping point". Hybrids and engines meeting the optional NOx standard, on the other hand, are both critical to meeting California's long-term air quality and climate goals, and a sales volume component to their potential ITR sunset provisions is important to ensure potential certification flexibility is not prematurely withdrawn.

> *Work Group Discussion Topic #12: Potential Certification Flexibility Provisions. ARB has not received any stakeholder comments regarding the possible ITR technology diversity flexibility provisions identified in Table 4 during the March 9, 2015, public workshop and March 24, 2015, work group meeting. Some stakeholders have commented that potential sunset provisions are needed to inform their feedback regarding the associated possible flexibility provisions. Given the potential approach*

identified above, do stakeholders have comments or questions regarding the possible ITR technology diversity certification flexibility provisions identified in Table 4?

Table 4 assumes full OBD on the base engine, driveline, and other components, and basic diagnostics for the newly introduced technology. Given the integrated nature of OBD systems, is this approach feasible? If not, is there a way to account for technologies with less impact on engine or driveline hardware and OBD compliance, such as automatic stop-start, versus more complex technology advances, such as camless engines? Staff's intent is for OBD updates to require a basic, comprehensive OBD system while recognizing the potential challenges of integrating a new technology.

Next Steps. Staff invites stakeholders to provide feedback regarding the concepts identified in this discussion document, both at individual meetings and during this and future work group meetings and workshops. Staff anticipates the following opportunities for additional public feedback:

- June 2015: ITR Aftermarket Conversion Work Group meeting
- Summer – Fall 2015: Additional Work Group meetings, as needed, including PEMS Work Group
- Fall 2015: Final ITR Public Workshop to solicit stakeholder feedback regarding potential draft regulatory language
- Late 2015/Early 2016: 45-Day Notice and Proposed Rulemaking Documents Released for comment
- Early 2016: ITR Board Consideration

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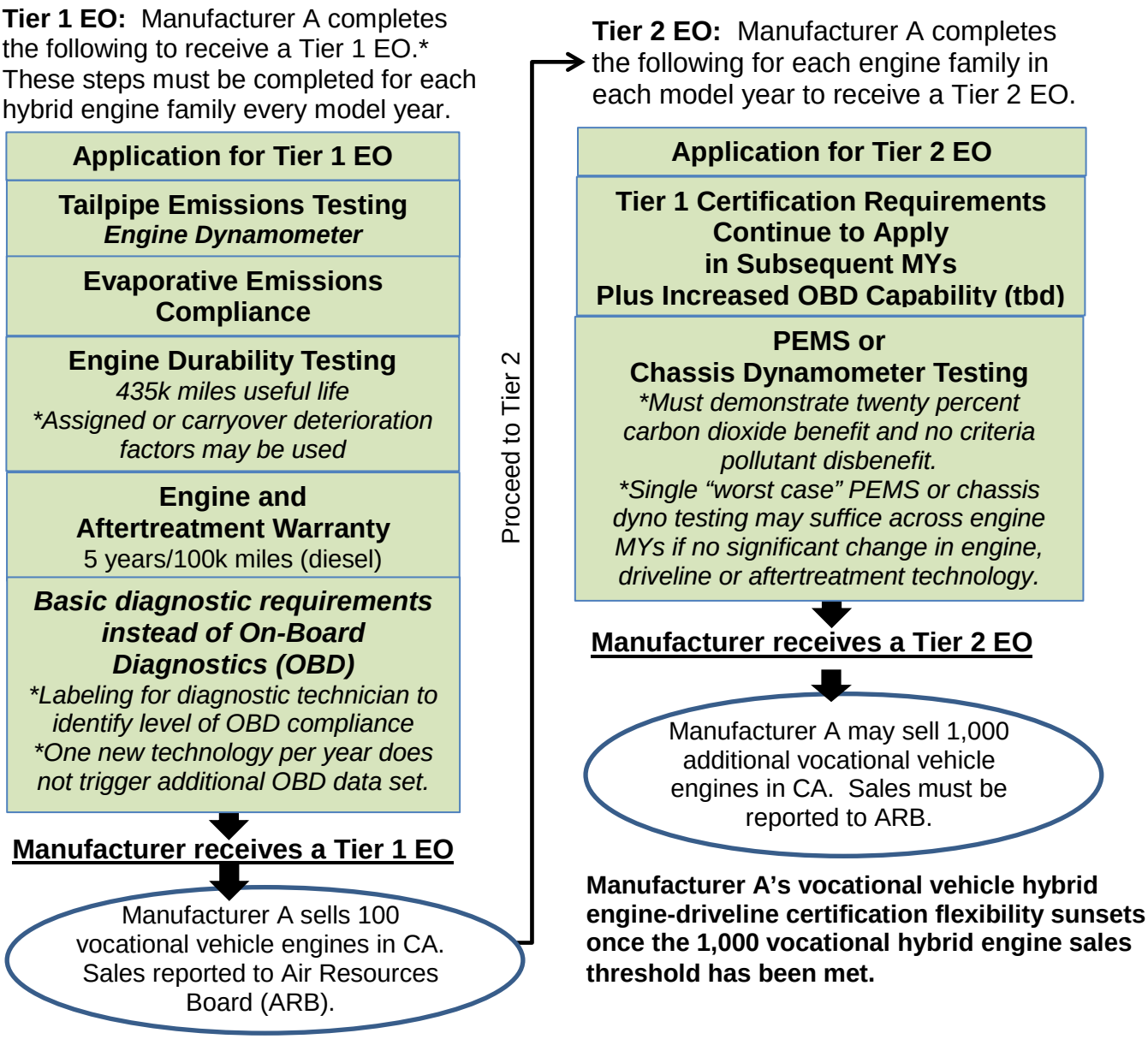
For more information regarding the potential Innovative Technology Regulation, including instructions on how to be appraised of upcoming ITR public work group meetings and workshops, visit: http://www.arb.ca.gov/msprog/itr/itr.htm .

Attachment A: Example of Potential Heavy-Duty Hybrid Engine-Driveline Certification/OBD Approval Pathway

Manufacturer A would like to certify a Class 8 hybrid engine for use in a refuse hauler application utilizing Innovative Technology Regulation (ITR) certification flexibility. The diagram below illustrates the steps the manufacturer might follow to receive a Tier 1 Executive Order (EO) to sell up to 100 of these hybrids, and a Tier 2 EO to sell an additional 1,000 of these hybrids engines in California.



* ARB staff encourages stakeholder feedback regarding whether the manufacturer of record for hybrids should be defined as the engine, driveline, vehicle manufacturer, or some combination of these. (See ITR Work Group Discussion Topic #6)

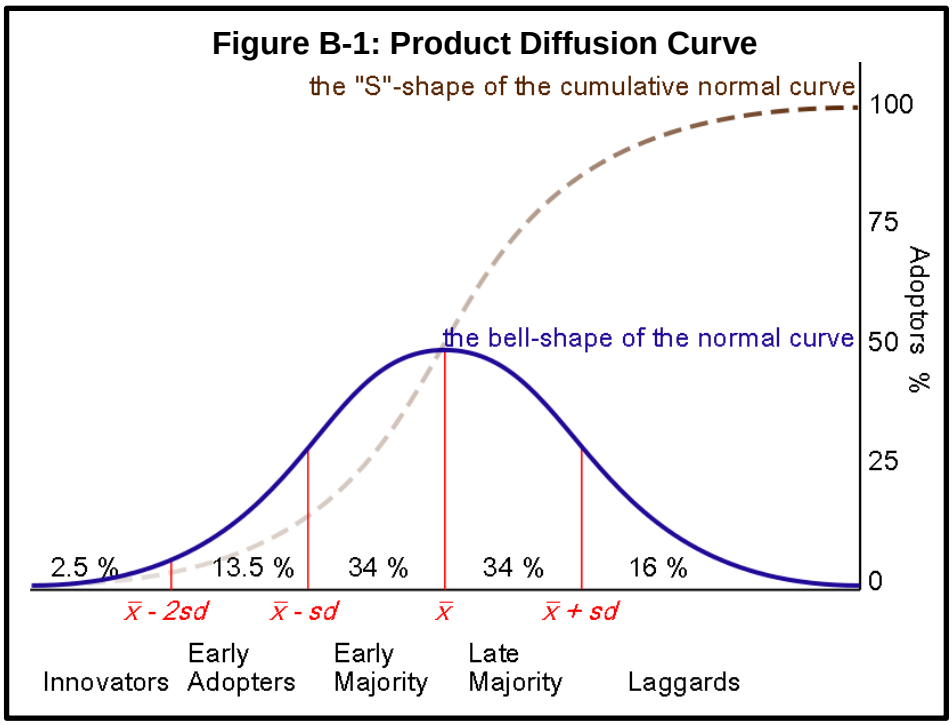
Attachment B:
Determining Potential Innovative Technology Regulation (ITR) Sales Volumes

California Air Resources Board (ARB) staff developed potential ITR sales volumes identified in this Draft Discussion Document based upon staff's evaluation of existing research regarding advanced technology adoption challenges and deployment rates, empirical data regarding similar program adoption rates and consumer acceptance thresholds, evaluation of available research regarding hybrid truck technology economies of scale, and other empirical data and information. Staff believes this research, data and supporting information, taken as a whole, indicate the potential sales volumes identified in this document can reasonably be defined as the minimum needed to encourage market launch and consumer acceptance of these technologies. Staff welcomes stakeholder feedback regarding its approach, and alternative mechanisms, to define potential ITR minimum manufacturer and industrywide sales volumes.

Empirical Research and Data Regarding Technology Adoption Curves

Diffusion of innovations has been the primary theoretical framework for the past several decades that seeks to explain how, why, and at what rate new ideas and technology are adopted.[9] This theory utilizes a cumulative normal S-curve to explain the initial rate of diffusion of technologies, including radio, television, refrigerator, air conditioning, dishwashers, cellular phone, per capita airline miles, personal computer and the Internet. Figure B-1 illustrates the five stages inherent in this Product Diffusion Curve.

Figure B-1: Product Diffusion Curve



9 (Rogers, E.M. (1995). Diffusion of Innovations (4th edition). The Free Press. New York)

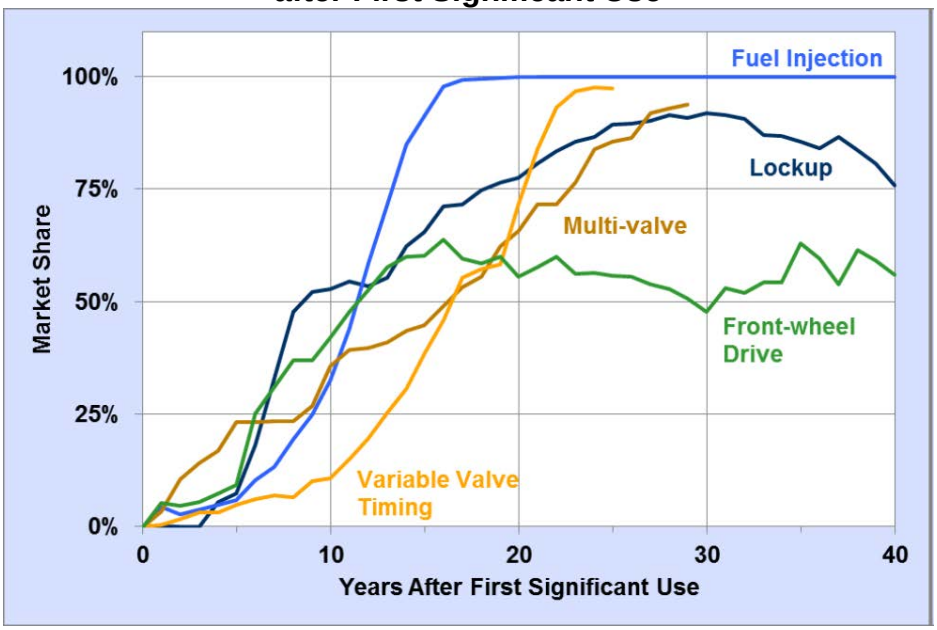
Diffusion of innovation theory defines innovators as the first 2.5 percent of risk-takers who are willing to try an unproven product. Based on the positive response of innovators, early adopters then begin to purchase the product. These are followed by the more cautious early majority, late majority, and finally, laggards. This theory has helped explain market trends for diffusion of new products that ultimately achieve widespread consumer acceptance.

Figure B-2 illustrates the time it has taken for various light-duty vehicle technologies to penetrate the United States market.[10] Adoption of these technologies does seem to follow cumulative normal S-curves, as predicted by diffusion of innovations theory. This theory further posits that specific technology adoption rates should vary, depending upon factors such as:

- compatibility with existing standards and values
- perceived benefits over alternative products
- communicability of the product benefits
- price and ongoing costs
- ease of use
- perceived risk
- divisibility (the extent to which a new product can be tested on a limited basis)

While the above factors that impact adoption rates are common across a wide variety of consumer goods, they clearly also retain relevance for the advanced vehicle technology market. For example, ease of use and perceived risk would likely be important factors in a fleet's decision to shift from a diesel to a hybrid refuse truck.

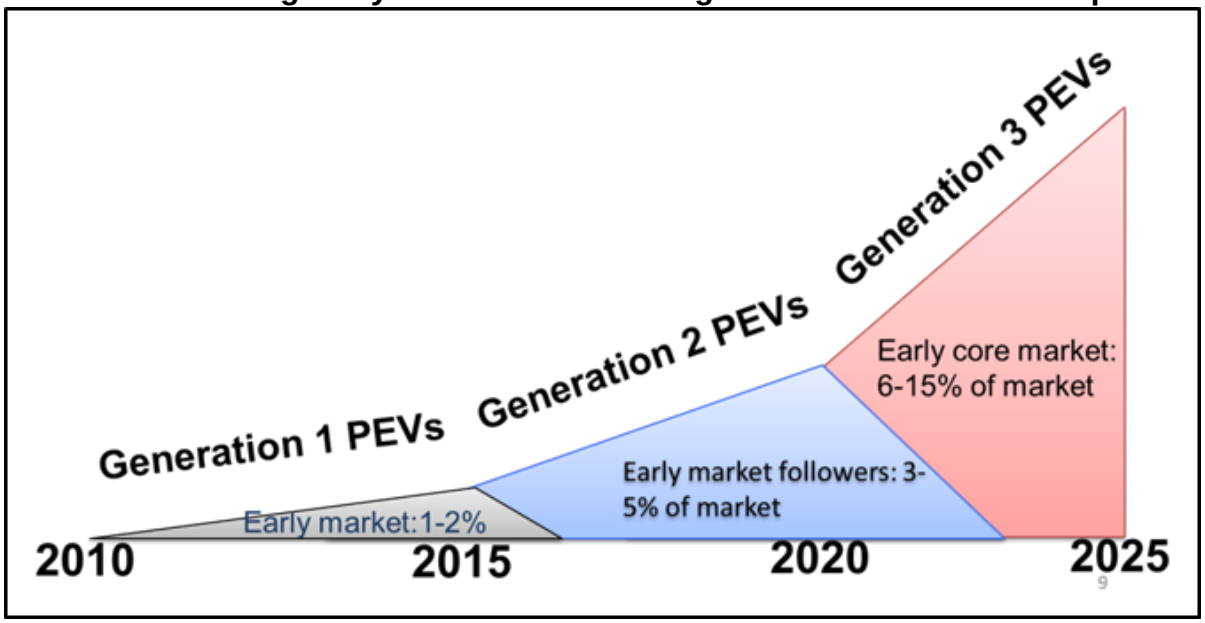
Figure B-2: Light-Duty Vehicle Technology Penetration after First Significant Use



10 U.S. Environmental Protection Agency, Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2014, EPA-420-R-14-023a, October 2014. http://www.epa.gov/otaq/fetrends.htm

Diffusion of innovations theory also informs the 3 stages of plug-in passenger vehicle market development identified in Figure B-3, below.[11] These 3 stages are: 1) early market (1-2 percent); 2) fast followers (3-5 percent); and 3) early core market (6-15 percent). The "fast follower" stage represents a key point at which a robust and viable market begins to become more certain.

Figure B-3:
Phases of US Plug-in Hybrid Electric Passenger Vehicle Market Development

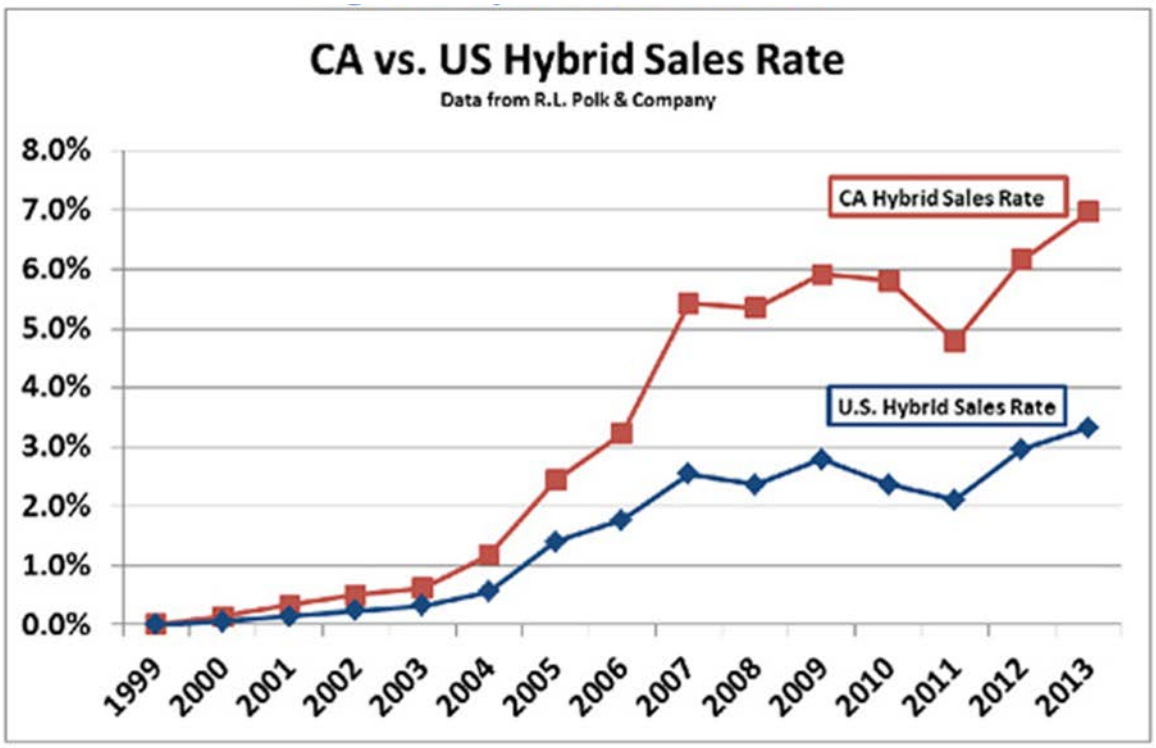


ARB's Clean Vehicle Rebate Project (CVRP) has indicated the fast follower five percent annual market sales threshold is a key metric for advanced clean cars that may indicate a readiness for project rebates to sunset.[12]

11 http://phev.ucdavis.edu/ieee-event-11-7-13-presentations/IEEE_Turrentine_UCDavis.pdf
12 Fiscal Year 2014-15 Funding Plan for the Air Quality Improvement Program and Low Carbon Transportation Greenhouse Gas Reduction Fund Investments, ARB; May 23, 2014; http://www.arb.ca.gov/msprog/aqip/fundplan/final_fy1415_aqip_ggrf_fundingplan.pdf ..

Figure B-4 (below) provides an empirical example of advanced technology market growth by illustrating hybrid passenger car sales in California and nationally from 1999 through 2013. The data support the early stages of a cumulative normal S-curve, with the exception of a stagnation in sales seen between 2008 and 2011. This could be attributed to an unprecedented recession and sharp decline in fuel prices beginning in 2008 and 2009.

Figure B-4: California versus United States Hybrid Car Sales Rates



In 2013, zero-emission electric vehicles represented 1.3 percent of new vehicle sales, plug-in hybrid electric vehicles (PHEV) represented 1.2 percent of new vehicle sales, and non-PHEV hybrids represented 6.8 percent of new vehicle sales.

The North American Council for Freight Efficiency (NACFE), a non-profit organization with the goal of doubling the efficiency of North American goods movement, also utilizes the product diffusion curve to illustrate anticipated accelerated adoption of technologies that increase freight efficiency. The shift from 'Typical Industry Adoption Curve" to "Accelerated Adoption Curve" in Figure B-5, below, illustrates the intended impact of public policy.

Figure B-5:
Adoption of Innovative Freight Technologies and Practices[13]

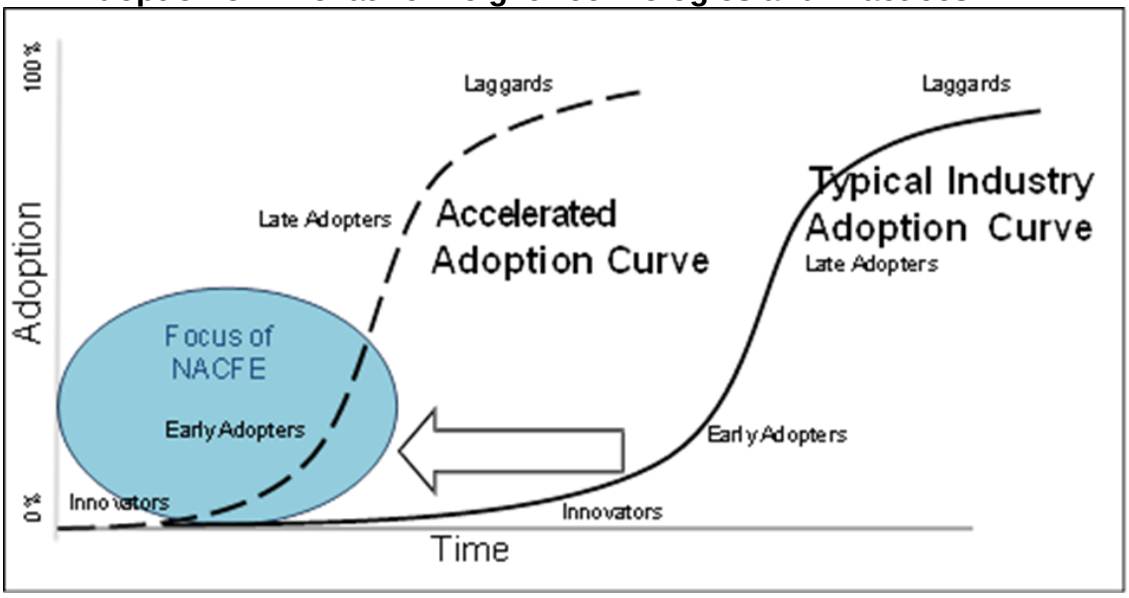


Figure B-6: Assumed Adoption Rates for Select Truck Technologies

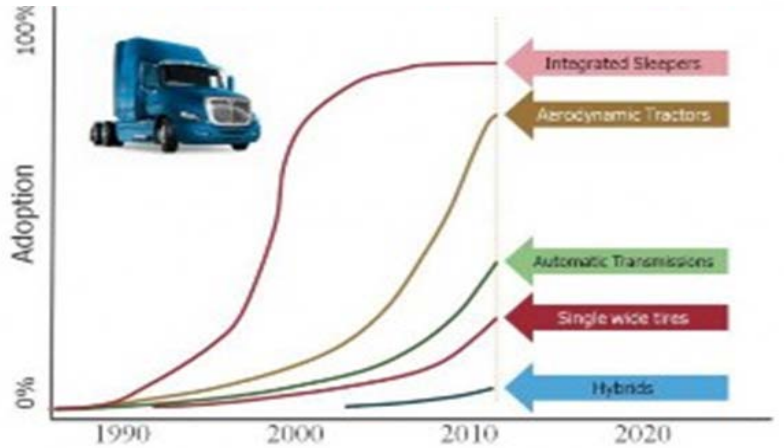


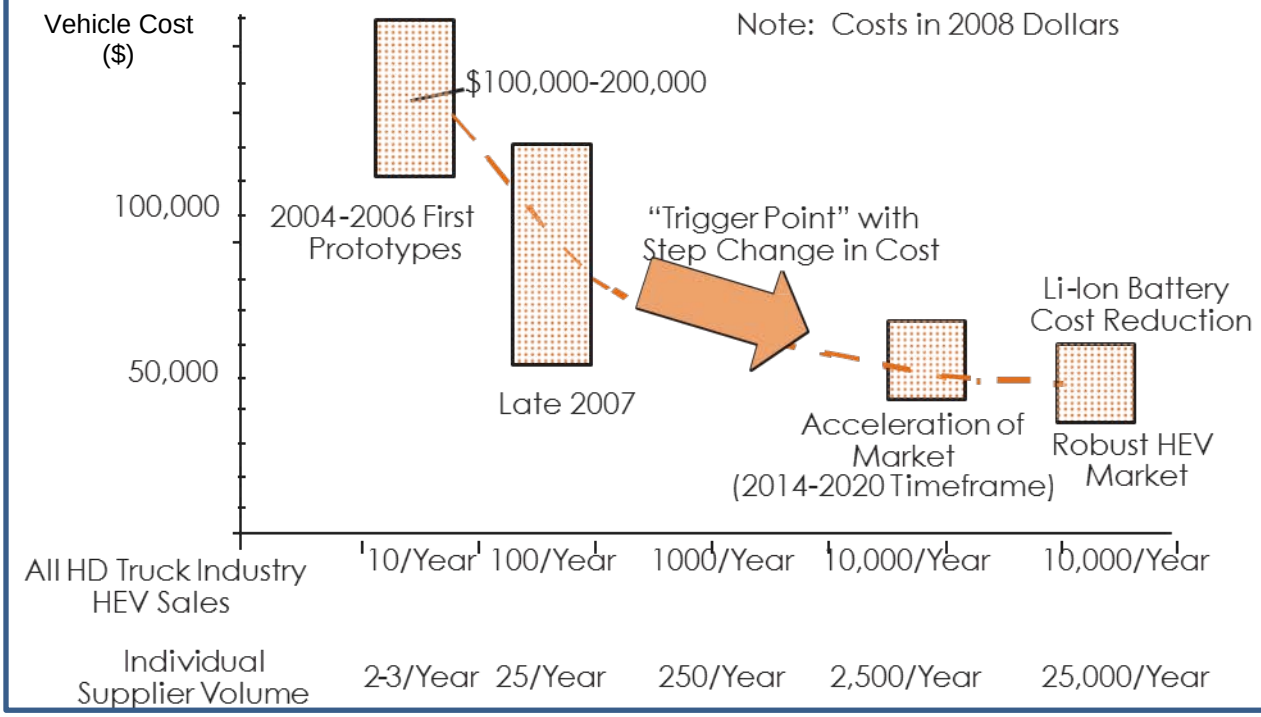
Figure B-6 illustrates NACFE's assumed adoption rate for selected heavy-duty vehicle technologies.[8] For example, integrated sleepers had a relatively fast adoption rate in the late 1990's, but some other technologies, such as automatic transmissions, seem to be on pace to take longer for full adoption.

13 NACFE, 2014 Fleet Fuel Efficiency Benchmark Study, August 31, 2014; http://nacfe.org/wp-content/uploads/2014/09/NACFE-2014-Study-Report-FINAL-083114.pdf .

Cost-Based Approach

The Northeast States Center for a Clean Air Future and others published a report in 2009 entitled *Reducing Heavy-Duty Long Haul Combination Truck Fuel Consumption and CO_2 Emissions* (NESCCAF Report), which illustrates how decreasing the production cost of heavy-duty vehicle hybrid drivelines is key to reaching a tipping point at which reduced costs drive market acceptance.[14] This threshold is reached at between 250 to 2,500 similar hybrid drivelines produced per driveline manufacturer, or 1,000 to 10,000 total hybrid heavy-duty vehicles sold annually industrywide (See Figure B-7, below). Specifically, the NESCCAF Report indicates that 1,000 hybrid truck sales per year "would not be enough to really drive down heavy-duty hybrid electric vehicle prices significantly, but the market would then be positioned to rapidly expand. (NESCCAF Report, Page 105.)"

Figure B-7: Heavy-Duty Hybrid Vehicle Costs as a Function of Annual Volume



Assuming manufacturers will produce these technologies for the California market first, this would correspond to a minimum of 1,000 annual heavy-duty hybrid vehicle sales in California as the threshold needed to launch the hybrid truck market. This represents about 4 percent of California's annual heavy-duty vehicle sales, which is within the 3 to 5 percent annual sales volume identified in Table B-3 as needed to accelerate the plug-in light-duty passenger vehicle market.

14 Northeast States Center for a Clean Air Future et al; Reducing Heavy-Duty Long Haul Combination Truck Fuel Consumption and CO2 Emissions; October 2009; www.nescaum.org/.../heavy-duty-truck-ghg_report_final-200910.pdf

The Product Diffusion Curve and Figure B-3 (Phases of US PHEV Market Development) suggest the first 2.5 percent to up to 5 percent of annual new product sales as transitions at which consumer acceptance and market growth may accelerate. ARB's CVRP has also identified 5 percent of annual sales volumes as the threshold at which the market for plug-in hybrid and battery-electric passenger vehicles may begin to thrive without public funding. The NESCCAF Report indicates a minimum of 1,000 hybrid truck sales are needed annually to reach a price point at which the market can begin maturing. These data points, on their own, provide an incomplete picture of what sales threshold might be considered reflective of the beginning of a healthy market. Taken collectively, however, staff believes these data provide a compelling argument for a potential 2.5 percent to 5 percent annual sales thresholds as a reasonable "tipping point" at which advanced heavy-duty vehicle technology cost reductions and consumer acceptance may begin to take hold. Table B-1 identifies the number of vehicles per vocation associated with a possible California annual 2.5 to 5 percent sales threshold. If we exclude Class 2b/3 medium-duty vehicles, the range of annual heavy-duty hybrid vehicle sales identified in Figure B-3 would be 650 to 1,300 per year, consistent with the 1,000 vehicle minimum "tipping point" identified in the NESCCAF report.

Table B-1: DRAFT Assumed Low and High Annual California Sales Threshold Tipping Points per Vehicle Vocation

	Approximate CA Annual Sales	
Vocation	**2.5 %**	**5 %**
Class 2b/3 (Medium-Duty)	~400	~800
Class 4-8 Vocational	~450	~900
Class 8 Tractor	~200	~400
Urban Bus	~10	~20
TOTAL Heavy Duty	**~650**	**~1,300**

Defining Cumulative (Multi-Year) Industrywide Sales Volumes

Staff believes these possible annual sales thresholds approximate the point at which advanced heavy-duty vehicle technology economies of scale may begin to take hold and consumer acceptance may accelerate. However, using an annual sales threshold may be ineffective as a metric for advanced technology truck and bus consumer acceptance given the volatile nature of the market. Over 600 hybrid delivery trucks were sold in California in 2010 when the market for this technology launched; however, this number had declined by 90 percent by 2012 and has not yet fully recovered (see Figure B-11). This may be due to factors such as fleets' perceived performance issues from first generation, non-vertically integrated hybrid trucks in 2010 and 2011, decreasing diesel fuel costs, and the high incremental cost of hybrid technology. This example suggests that basing consumer acceptance upon a peak year of vehicle sales rather than more comprehensive data could result in premature sunsetting of potential ITR certification flexibility.

A cumulative sales volume may provide a more robust and meaningful sales metric. Staff calculated approximate cumulative hybrid truck or bus sales volumes that are reflective of 2.5 to 5 percent annual sales per vocation, utilizing an S shape cumulative normal curve

and an assumed sales growth rate consistent with that for hybrid light-duty vehicles (as shown previously in Figure B-4). These potential cumulative sales volumes per vehicle vocation are identified in Table B-2 (below).

Table B-2:
Potential Approximate Low and High Cumulative California Sales Threshold Tipping Points per Vehicle Vocation

Vocation	2.5 %	5 %
Class 2b/3 (Medium-Duty)	~800	~2,400
Class 4-8 Vocational	~900	~2,700
Class 8 Tractor	~400	~1,200
Urban Bus	TBD	TBD

Cumulative industrywide sales thresholds towards the high end of the ranges in Table B-2 may be appropriate, given the critical need to transform California's truck and bus fleet to utilize zero- and near-zero-emission technologies, and the challenges inherent in effecting this transformation. Because of the low annual sales volume of urban buses, staff believes a potential industry cap of 75 (which would be reflective of 5 percent of average annual sales) may be too low to allow for multiple manufacturers to bring advanced transit bus technologies to market, and for multiple urban bus fleets to gain experience with a diversity of bus technologies. For this reason, staff suggests a higher potential urban bus manufacturer and industry cumulative sales thresholds may be appropriate. Possible cumulative Tier 1 and 2 sales thresholds and industry-wide caps for each potential vocation-technology combination are identified in Table B-3 (below). Table B-3 also illustrates staff's initial assessment of the initial timeframe by which these technologies may be ready for market launch.

Table B-3: Potential Cumulative Allowable California Sales Threshold per Eligible Vocation-Technology Combination and Anticipated Market Launch Timelines

Vocation		Maximum Volume per Manufacturer		Industry Cap (Reg Sunset)[1]
		Tier 1 (Demo)	Tier 2 (Pilot)	
Class 2b/3	Hybrid[2]	~100	~1,000	~2,500
	Hybrid with Significant AER[3]	~200	~2,000	~5,000
Class 4-8 Vocational	Hybrid[2]	~100	~1,000	~2,500
	Hybrid with Significant AER[2,3]	~200	~2,000	~5,000
	>20% CO2 Benefit (Non-Hybrid)[4]	~100	~1,000	~2,500
	Optional NOx Standard ↓50%	~100	~1,000	~2,500
	Optional NOx Standard ↓75%	~100	~1,000	~2,500
	Optional NOx Standard ↓90%	~100	~1,000	~2,500
Class 8 Tractor	Hybrid[2]	~50	~500	~1,200
	Hybrid with Significant AER[2,3]	~100	~1,000	~2,400
	>20% CO2 Benefit (Non-Hybrid)[4]	~50	~500	~1,200
	Optional NOx Standard ↓50%	~50	~500	~1,200
	Optional NOx Standard ↓75%	~50	~500	~1,200
	Optional NOx Standard ↓90%	~50	~500	~1,200
Urban Bus	Hybrid[2]	TBD	TBD	TBD
	Hybrid with Significant AER[2,3]	TBD	TBD	TBD
	>20% CO2 Benefit (Non-Hybrid)[4]	TBD	TBD	TBD
	Optional NOx Standard ↓50%	TBD	TBD	TBD
	Optional NOx Standard ↓75%	TBD	TBD	TBD
	Optional NOx Standard ↓90%	TBD	TBD	TBD

Anticipated Market Launch Timelines[5]

= 2015 - 2025 = 2026+

1 – Potential ITR flexibility would potentially not sunset for a minimum of four years after two manufacturers receive Tier 2 certification and the industry cap is reached for each technology-vocation combination.
2 – Hybrids would likely not be eligible for Tier 2 volumes unless chassis dynamometer or PEMS testing determine no criteria pollutant emissions increase relative to the appropriate base vehicle. Hybrid heavy-duty vehicles certified using hybrid full vehicle certification procedures (adopted by the Board on December 12, 2013) may be eligible for 2x Tier 2: Pilot Deployment manufacturer sales volumes.
3 – Would have to achieve a minimum forty mile zero-emission range. Tier 2 and Industry Cap volume thresholds reflect a potential 2x multiplier for this technology category.
4 – Non-hybrid technologies that achieve at least a 20 percent CO_2 benefit may apply to be defined as innovative if they can demonstrate a discrete technology bridge or pathway to achievement of heavy-duty vehicle zero-emission range.
5 – Based upon ARB Technology and Fuels Assessments Workshop Presentation, September 2, 2014, Truck Summary Presentation; http://www.arb.ca.gov/msprog/tech/presentation.htm, and Staff Report: Initial Statement of Reasons for Proposed Rulemaking –Optional Reduced Emission Standards for Heavy-Duty Engines; October 23, 2013; http://www.arb.ca.gov/regact/2013/hdghg2013/hdghg2013isor.pdf .

These potential Tier 1 and 2 manufacturer sales thresholds and industry caps identified in Table B-3 provide a reasonable pathway for key truck and bus technologies to successfully enter the California market and meet California certification and OBD requirements as expeditiously as possible. These potential volume thresholds are based upon staff's evaluation of existing studies and empirical data regarding market launch and consumer

acceptance of similar technologies. Other ARB strategies and programs to encourage market launch and consumer acceptance of hybrid and zero-emission vehicles, such as the Air Quality Improvement Program, have also helped inform this evaluation.[15] California engine family annual and cumulative sales data have also helped provide context for these potential ITR sales thresholds (See Figures B-8 through B-13). Figure B-11, for example, illustrates growth trends for California sales of alternative-fueled medium-duty, heavy-duty, and transit bus engines between 2003 and 2012. Cumulative transit bus alternative-fueled engine sales would have surpassed the industry cap for most transit bus technologies identified in Table B-3 in 2008, while heavy-duty alternative fuel engines would have a 1,200 California sales threshold in 2009 and a 2,500 California sales threshold in 2011.

Staff believes this combination of approaches and perspectives have resulted in a reasonable assessment of the minimum California sales volumes needed to help launch these key technologies. However, staff recognizes that other metrics or approaches could be used to define advanced technology truck and bus acceptance in an advanced technology market with many inherent uncertainties, and welcomes stakeholder comments regarding the potential ITR sales thresholds and sunset provisions identified in this discussion document.

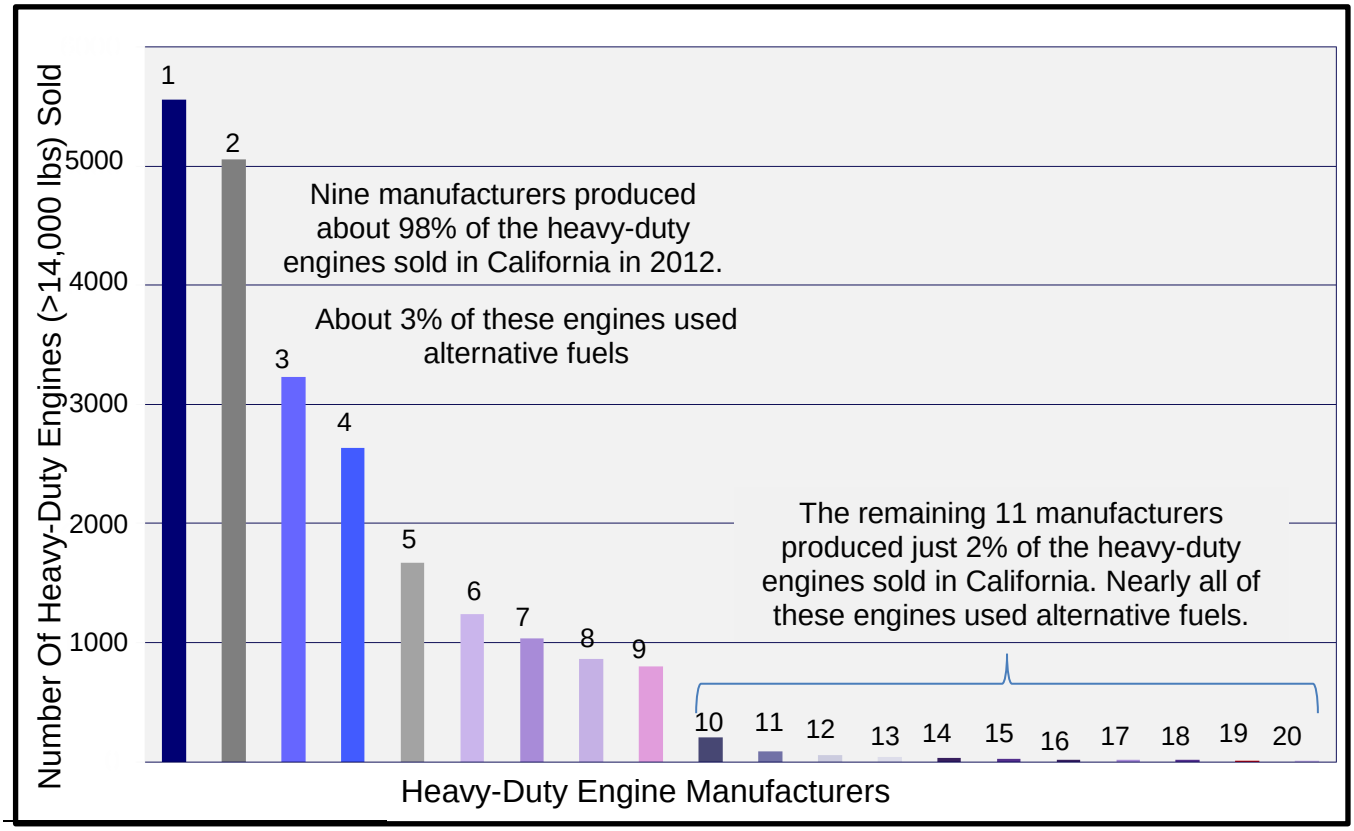
Finally, the sales volumes and approach identified in Table B-3 reflect staff's initial analysis regarding the minimal, potentially impactful manufacturer and industry sales volumes that may be reasonable to meet the goals of the ITR. This approach and these sales thresholds are intended for stakeholder discussion only, and may be adjusted during ITR rule development based on staff evaluation of updated information and/or stakeholder feedback, or to enable more effective ITR implementation (See ITR Discussion Topic #4 for more information).

15 Fiscal Year 2014-15 Funding Plan for the Air Quality Improvement Program and Low Carbon Transportation Greenhouse Gas Reduction Fund Investments, ARB; May 23, 2014.

Other Supporting Tables and Information ARB staff has also utilized extensive California population, trend, and other empirical data to help provide context for and identify possible reasonable sales thresholds and sunset provisions for the purposes of the potential ITR. These include engine sales and engine family population data, by manufacturer, vocation, engine family and fuel type, alternative fuel heavy-duty vehicle and engine cumulative sales volume over time, experience and lessons learned encouraging California launch of the hybrid truck and bus, and California transit bus fleet population data by technology type.

Existing Engine and Engine Family California Sales Data. Figure B-8 (below) illustrates the distribution of heavy-duty (>14,000 lbs Gross Vehicle Weight Rating (GVWR)) engine sales by the 20 manufacturers that sold 2012 MY heavy-duty engines in California. This figure provides context for the total volume of engines sold in California, the difference in sales volume between the largest and smallest manufacturers, and the role smaller manufacturers play in helping bring newer technologies (in this case, alternative fuel engines) to market. The 9 largest manufacturers averaged about 2,500 2012 MY engines sold annually, while the 11 smaller manufacturers averaged fewer than 50 engines sold. Only about 3 percent of the engines sold by the largest manufacturers used alternative fuels, while the vast majority of the 11 smaller manufacturer sales were for alternative fuel engines. This overall trend is similar for previous model years, suggesting that smaller manufacturers may play an important role in introducing newer heavy-duty engine technologies to market.

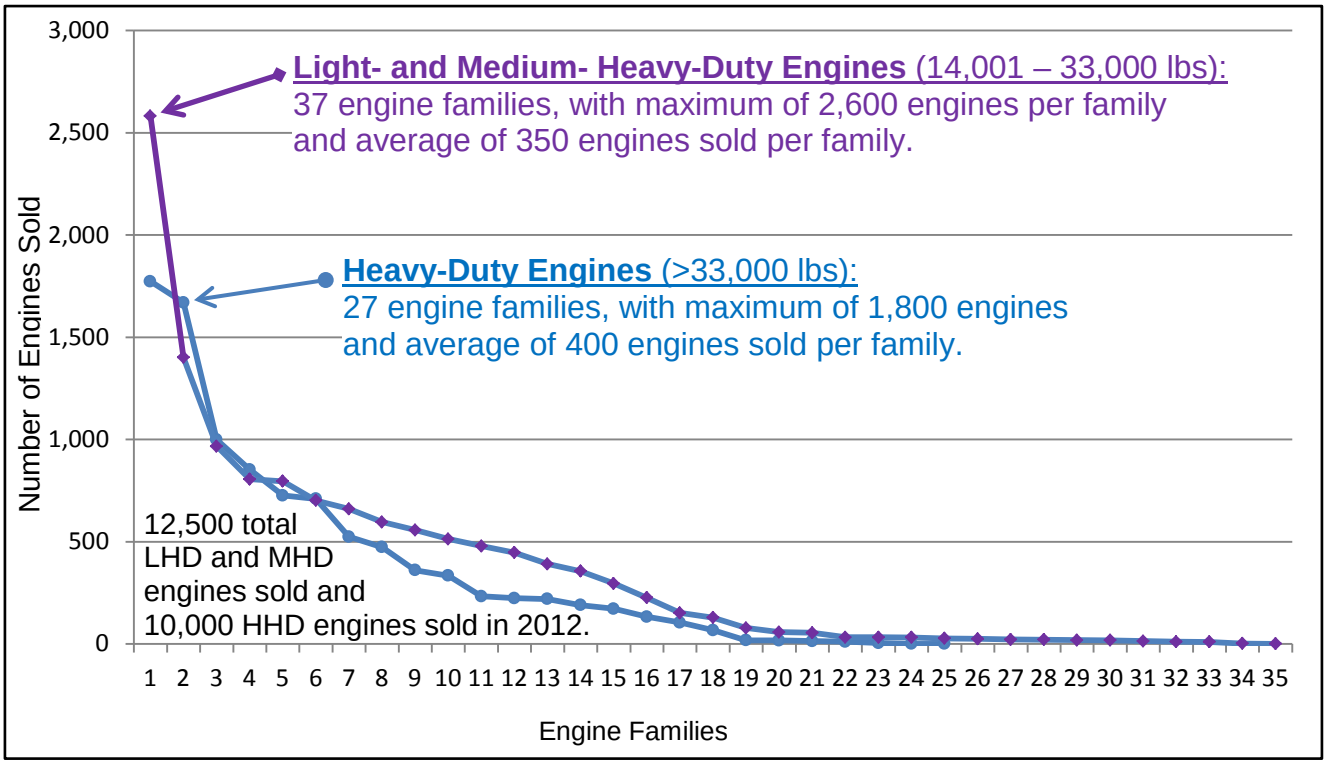
Figure B-8:
Approximate Number of 2012 MY Heavy-Duty Engines Sold in California by Manufacturer[16]



16 Based upon estimated engine sales data as reported by engine manufacturers to ARB.

Engine family data for these manufacturers provide additional useful information (see Figure B-9, below). An engine family is a group of engines that shares very similar characteristics, such as manufacturer, displacement, fuel type, emissions control strategy, and other key parameters. A manufacturer must complete ARB certification (including OBD) for each heavy-duty engine family. The 9 largest manufacturers in Figure F averaged almost 6 engine families each (meaning they certified 6 discrete engines), with an average of about 400 engines sold within each family. The 11 smaller manufacturers averaged just over 1 engine family each, with about 40 engines sold from each engine family. Ideally, the potential ITR would balance the needs of both large and small manufacturers, providing a mechanism that encourages both to bring hybrids and other innovative technologies to market while ramping up their diagnostics capabilities.

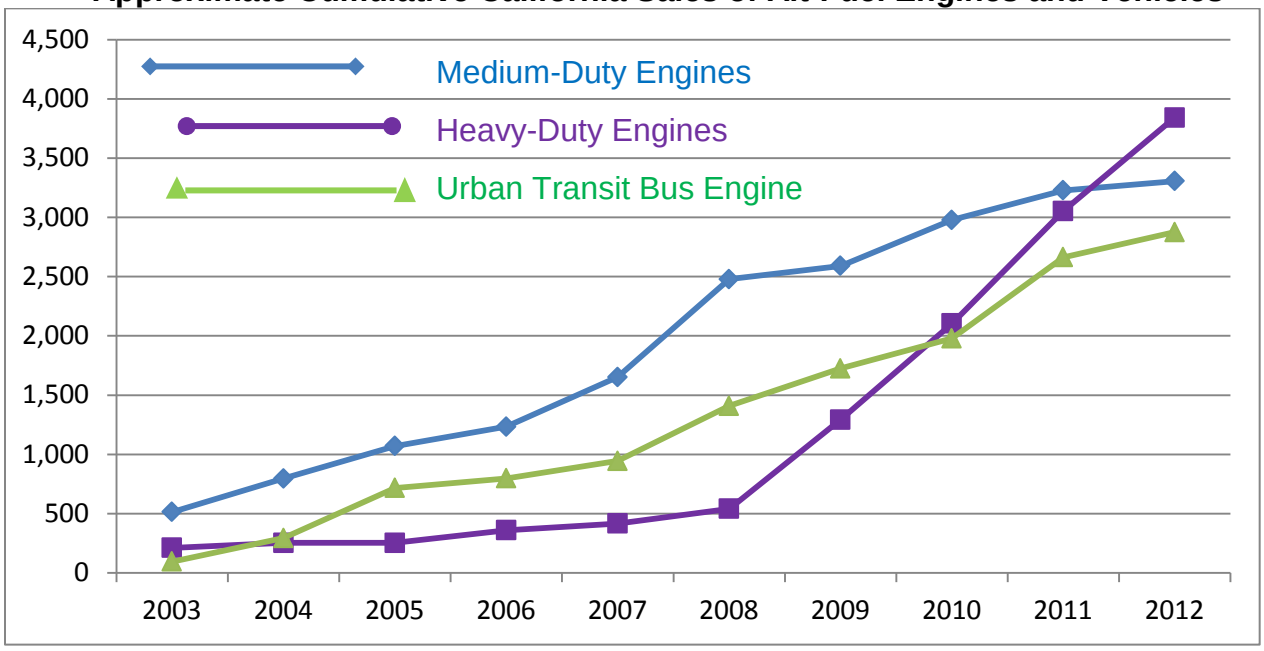
Figure B-9: Approximate Distribution of California Sales of 2012 MY Heavy-Duty Engines by Discrete Engine Family[17]



17 Based upon estimated engine sales data as reported by engine manufacturers to ARB.

California Sales of Alternative-Fueled Engine Sales. Finally, figure B-10 illustrates cumulative California sales of alternative medium-, heavy-duty, and transit bus engines. Cumulative transit bus alternative-fueled engine sales would have surpassed the industry cap for most transit bus technologies identified in Table B-3 in 2008, while heavy-duty alternative fuel engines would have a 1,200 California sales threshold in 2009 and a 2,500 California sales threshold in 2011.

Figure B-10:
Approximate Cumulative California Sales of Alt-Fuel Engines and Vehicles[18]

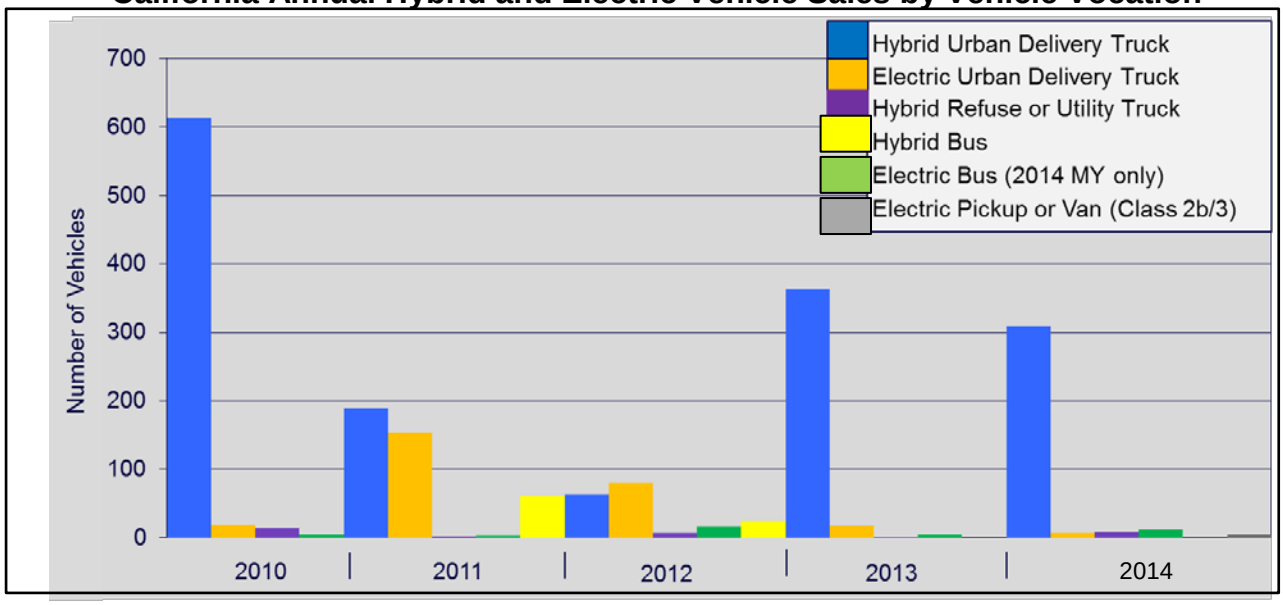


18 Based upon estimated engine sales data as reported by engine manufacturers to ARB.

California Hybrid Truck Market Challenges. The hybrid truck market in California has been extremely volatile since its major launch in 2010, when four major truck manufacturers (i.e. Freightliner, Kenworth, Navistar and Peterbilt) produced hundreds of hybrid urban delivery vehicles utilizing a Cummins engine and an Eaton driveline. While a handful of large fleets such as UPS and Coca-Cola drove initial demand for these vehicles, none of these early adopter fleets subsequently purchased additional vehicles and the market had stagnated by the end of 2011. In 2013, these non-vertically integrated hybrid trucks had challenges meeting California's new OBD requirements for heavy-duty vehicles, and these four manufacturers no longer produce hybrid trucks for the California market (see Figure B-11, below). Subsequent portable emissions measurement system (PEMS) emissions testing of these hybrid trucks conducted by the US Department of Energy, National Renewable Energy Laboratory (NREL) for ARB indicated that these non-vertically integrated hybrid trucks may also emit more oxides of nitrogen (NOx) that their non-hybrid counterparts (and underscores the need for full vehicle emissions testing of hybrids).[19]

Hino Motor Company entered the California market with a Class 5 vertically-integrated box truck in 2013, which has met ARB certification and OBD requirements. California's hybrid heavy-duty vehicle market in 2015 consists of Class 5 Hino hybrid trucks and non-vertically integrated hybrid urban bus manufacturers. Hino has received an ARB Executive Order (EO) for the hybrid engine-driveline combination, while Allison and BAE have each received dual party ARB EO's in conjunction with Eaton for their respective transit bus engine driveline combinations.

Figure B-11:
California Annual Hybrid and Electric Vehicle Sales by Vehicle Vocation[20]



19 Public release of the associated NREL Report is pending.
20 Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) data, Calstart, February 15, 2015. Reflects the vast majority of hybrid trucks and buses sold, with the exception of those in the urban bus sector.

Figures B-4 and B-5 identify the hybrid heavy-duty vehicles funded by HVIP between 2010 and 2014. Staff believes, with the exception of urban buses, this is reflective of the vast majority of heavy-duty hybrid vehicles sold in California during this period. Tables B-12 and B-13 are intended to provide context for the issue of how a hybrid technology manufacturer might most effectively be defined in a potential ITR.

Table B-4:
Hybrid Vocational Vehicles by Vehicle Manufacturer (Cumulative for 2010-2014 MYs)

Vehicle	Engine+Driveline	CA Sales	Notes
Hino	Hino	790	Mostly 2013+ MY
Freightliner/FCCC	Cummins+Eaton	402	Mostly pre-2013 MY
Kenworth		214	
Navistar		106	
Azure	Ford+Azure	138	
Peterbilt	Cummins+Parker	15	
Autocar		14	
Total		**1,679**	

Does not include hybrid transit bus applications.

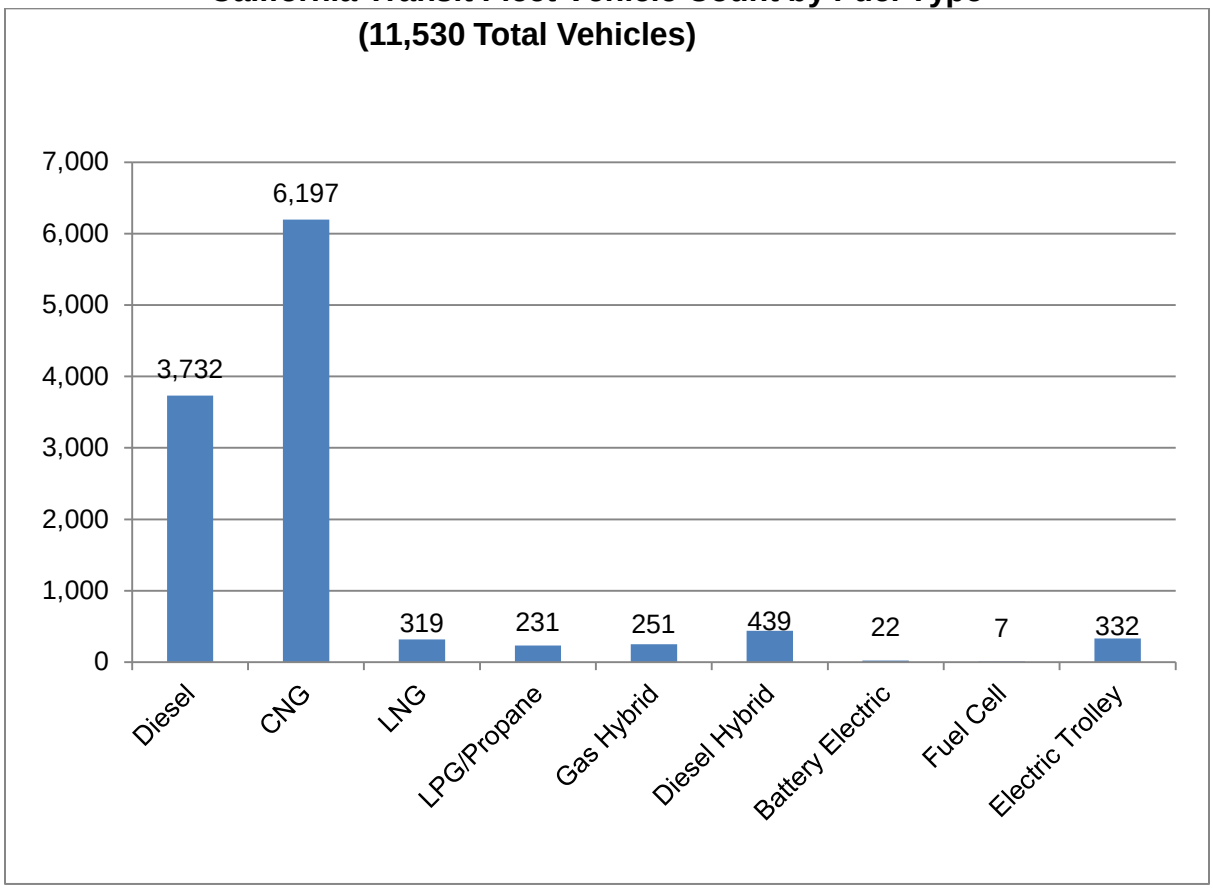
Table B-5:
Hybrid Vocational Vehicles by Engine-Driveline Combination (Cumulative for 2010 - 2014 MYs)

Hino	790	Mostly 2013+ MY
Cummins+Eaton	737	Mostly pre-2013 MY
Ford+Azure	138	
Cummins+Parker	14	
Total	**1,679**	

Does not include hybrid transit bus applications.

California Transit Bus Population. As shown in Figure B-12, below, approximately 32 percent of the heavy-duty transit vehicles operating in California are diesel-fueled. About 57 percent of transit vehicles are operating on natural gas, while 6 percent are hybrids. For agencies that are operating diesel buses, diesel hybrids represent about 50 percent of bus purchases.[21] Hybrids may provide an important technology bridge to meet potential Advanced Clean Transit Rulemaking zero-emission bus deployment requirements.

Figure B-12:
California Transit Fleet Vehicle Count by Fuel Type[22]
(11,530 Total Vehicles)



21 ARB, Advanced Clean Transit Regulation Public Workshop Discussion Document, May 11, 14, and 20, 2015, http://www.arb.ca.gov/msprog/bus/actdiscussiondocument.pdf .

22 Source: ARB Transit Fleet Reporting Database, March 2015.