

**ACT Workgroup Meeting Summary**  
 Thursday, April 7, 2016  
 Cal/EPA Headquarters, Sacramento, California

**Attendees**

Following is the list of workgroup members who participated in the meeting in person or identified themselves via telephone or email during the meeting.

<b>Name</b>	<b>Organization</b>
Abas Goodarzi	US Hybrid Corporation
Alan Price	Solano County Transit
Andrew Merenda	Sierra Club California
Andrew Papson	Foothill Transit
Arthur Douwes	Valley Transportation Authority
Bernie Kotler	Labor Management Cooperation Committee
Claire Van Zuiden	California Strategies, LLC
Cliff Thorne	Orange County Transportation Authority
David Renschler	City of Fairfield
Danielle Chambers	California Air Resources Board
Diana Vazquez	Sierra Club California
Don Curry	North County Transit District
Donna DeMartino	San Joaquin RTD
Doug Cameron	Clean Energy
Edward Lovelace	XL Hybrids
Eileen Wenger Tutt	California Electric Transportation Coalition
Fang Yan	California Air Resources Board
Fred Silver	CALSTART
Greg Fritz	ACTIA
Greg Mann	Allison Transmission
Hannah Goldsmith	CalETC
Jaimie Levin	Center For Transportation and the Environment
Jennifer Lee	California Air Resources Board
James Pachan	Alameda-Contra Costa Transit District
Jamie Hall	General Motors
Jim Wilson	Humboldt Transit Authority
Jimmy O'Dea	Union of Concerned Scientists
Jing Guo	California Air Resources Board
John Somers	Clean Energy
Jordan Ramalingam	California Air Resources Board
Joseph Policarpio	Gillig

Judy K Dennis	Nova Bus
Karen King	Golden Empire Transit District
Katherine Garrison	California Air Resources Board
Kent Leacock	Proterra
Laura Renger	Southern California Edison
Len Engel	Antelope Valley Transit Authority
Marty Mellera	San Francisco Municipal Transportation Agency
Matthew Williams	California Air Resources Board
Michael Abegg	Solano County Transit
Dr. Michael D. Geller	Manufacturers of Emission Controls Association
Michael Masquelier	WAVE
Mike Pimentel	California Transit Association
Mona Babauta	Solano County Transit
Nathan Bengtsson	PG&E
Nico Bouwkamp	California Fuel Cell Partnership
Paul Arneja	California Air Resources Board
Paul Hernandez	Center for Sustainable Energy
Paul Jablonski	Chair of Transit Agency Subcommittee/ San Diego Metro Transit System
Peter Ward	Alternative Fuels Advocates
Pippin Brehler	California Air Resources Board
Ray Pingle	Sierra Club California
Rick Ramacier	Vice Chair of Transit Agency Subcommittee / Central Contra Costa Transit Authority
Ron Zirges	Victor Valley Transit Authority
Ryan Kenny	Clean Energy
Ryne Shetterly	Complete Coach Work
Sarah Katherine Williams	California Energy Commission
Shirin Barfjani	California Air Resources Board
Shrayas Jatkar	Coalition for Clean Air
Stephen Ptucha	Cummins Westport
Steve Miller	Golden Gate Transit
Tim Carmichael	Southern California Gas Company
Todd Campbell	Clean Energy
Tommy Edwards	SunLine Transit Agency
Tony Brasil	California Air Resources Board
Yachun Chow	California Air Resources Board
Zach Kahn	BYD

This was the second meeting of the Advanced Clean Transit Workgroup. This meeting was webcast and recorded. The detailed agenda, meeting materials, and video recording for this meeting are available at <http://www.arb.ca.gov/msprog/bus/actmeetings.htm>. The following were the primary agenda items for the meeting:

- Update on previous action items
  - Transit Fleet Survey
  - Cost projection for batteries and zero emission buses
- Electricity rate and demand charges
- Transit Agency Subcommittee update
- Maintenance costs
- Potential off-ramp options
- Flexibility/ performance based options —Integration with Senate Bill (SB) 375
- Topics for next meeting

The agenda, an Off-Ramp Discussion Draft, and an Electricity Rates Discussion Document were provided for attendees as handouts.

### **Update on Previous Action Items**

Transit agency surveys were sent out to Transit Agency Subcommittee, CalACT and CTA members. The due date was April 12, 2016. By the date of this meeting, ARB had received about 10 surveys, and was expecting to receive more by the end of the month. ARB will provide updates about the survey in the next subcommittee meeting.

ARB has been conducting a literature review and gathering data from manufacturers and technology providers about battery cost projections that can be used as part of the total cost of ownership analysis for mid-life battery replacement costs and to guide battery electric bus cost projections. Most battery cost studies were done for light duty (LD); however, ARB is looking at available information that is applicable to the heavy duty (HD) sector. A write up on this topic will be shared.

Based on a comment from a representative of the ACTIA Corp., there are big differences in the battery chemistry, pack robustness, and design of batteries for HD and LD applications. Batteries are not a standard fit for each vehicle; therefore, we should be cautious using LD battery prices to project the cost reduction for HD vehicles. ARB will follow up with ACTIA Corp. to get the battery price information. In addition, Joe from Gillig is working with battery manufacturers and interested in providing some battery information. Paul Jablonski mentioned they have done a study on the (conventional) bus prices from 2000 to 2015. According to their study, the bus price has increased about 55% over the period of 15 years from an average \$270,000 to \$420,000 as the number of buses manufactured remained constant around 5200 per year. These numbers are inflation adjusted.

In the morning of April 7, ARB hosted another public meeting to help transit agencies, public fleets, and school districts understand how the Low Carbon Fuel Standard (LCFS) Program can benefit these fleets and generate additional revenue resources. Staff reviewed the

highlights of the LCFS meeting from the morning, including some arrangements between transit agencies and fuel providers to receive LCFS credit, role of a broker in trading credits, and correlation between fuel type (pathway) and vehicle fuel efficiency and number of credits. LCFS staff also set up a booth to help interested fleets with program registration after the LCFS meeting. The LCFS presentation is available on the ACT website at <http://www.arb.ca.gov/msprog/bus/04072016.pdf>.

## **Electricity Rates and Demand Charges**

ARB discussed the purpose and topics of tomorrow's transportation electrification meeting with several electric utilities and transit fleets on April 8, 2016. The meeting was a spin-off of the Advanced Clean Transit Technology Symposium held on February 8 as requested by several transit fleets and the utilities and was discussed by the Transit Subcommittee on February 9, 2016.

One of the planned agenda topics to discuss with the CPUC and utilities includes what transit fleets see as barriers to transportation electrification. ARB provided a brief overview on the topics to be discussed at the electric utility meeting such as the transportation electrification components in SB 350, how to reduce the cost of electricity, grid balancing, temporary rates without demand charges, and energy storage. ARB shared a write up about the fundamentals of electricity rates and demand charges, which is also posted online at <http://www.arb.ca.gov/msprog/bus/ratesanddemand.pdf> that may be helpful for those who plan to participate in the upcoming utility meeting. Electricity rate issues are not limited to charging BEBs but also producing hydrogen, such as through electrolysis. CPUC is attending the utility meeting to understand the implementation and regulatory barriers for transportation electrification as required in SB 350. CPUC scheduled a workshop on April 29 to further solicit public input on transportation electrification. ARB will be providing the utility meeting summary at that workshop. Transit agencies and various other stakeholders discussed the following topics as potential electrification issues and solutions:

- Paul Jablonski from San Diego MTS stated that MTS is concerned about transmission charges, not just demand charges. This stems from their experience with natural gas transportation costs, which are more expensive for MTS than are their gas commodity costs and have increased significantly over the past three or four years.
- Reliability of utility services and the role of backup on-site electricity storage for transits fleets and integration strategies for electricity storage.
- Hydrogen storage after production. Electrolysis itself can be used to balance the grid.
- Demand charge and peak shaving, use of excess solar and renewable electricity from the grid, and the integration of energy storage were discussed. Managing peak demand with the help of on-site energy storage is relatively new to transit agencies and education and experiments may be needed for providing information to all parties.

- Whether utilities could install and maintain charging infrastructure for transit agencies. The same concept was used in the LD sector and could be explored for the HD sector to allow risk sharing by multiple parties.

## **Transit Agency Subcommittee Update**

Paul Jablonski, chair of the Subcommittee, mentioned they would talk about flexibility options and off-ramps as part of the off-ramp topic on the agenda as they prepared a write up that they are going to share with the group. The Subcommittee is comprised solely of the California Transit Association members. The activities of the flexibility subgroup would be discussed under off-ramp and flexibility option topics.

Steve Miller, lead of the cost subgroup, described that he was making progress on the life cycle cost model and had sent a copy to bus OEMs and a few transit fleets for review several weeks ago. He indicated that, while they had not received much feedback that their finding/assumptions are off-base, they continue seeking data from transit agencies that operating zero emission buses to fine-tune the cost model. Steve Miller mentioned they are updating the life cycle cost model based on feedback from OEMs, and also gathered information from NREL, Altoona, and LA Metro reports before making it available to other transits and workgroup members.

## **Maintenance Costs**

ARB updated the group on its progress on conducting a literature review of bus maintenance costs. Seven studies were reviewed including five NREL studies on five transit agencies, one Stanford University study on its battery electric buses, and the LA Metro study on the comparison between electric trolley buses and conventional technologies. ARB indicated the results lead to the following preliminary conclusions:

1. The propulsion related maintenance cost normally consists of one fourth to one third of the total maintenance cost for the CNG and diesel engines. The maintenance costs increase as vehicle gets older.
2. In the NREL Study on Foothill Transit, the propulsion related maintenance cost of BEBs was \$0.02 per mile, which is 13 percent of the total maintenance costs. The propulsion-related maintenance cost of BEBs is about one fourth of that of the CNG.
3. Based on NREL study on New York County Transit, hybrid systems provided saving over 79% of the brake repair cost during the study at the average speed of 6.3 mph. The brake repair cost for hybrid was \$0.04/mile versus for \$0.18/mile for the CNG buses.
4. The 2004 LAMCT Trolley Bus Study also indicated that total maintenance cost for the trolley buses was 20 percent lower compared to conventional diesel buses, when the overhead wiring system maintenance costs were included. Electric trolleybuses and battery electric buses are powered by similar electric propulsion systems where electricity source is the primary difference. If the average CNG and

diesel bus maintenance cost is \$0.85/mile, a 20 percent savings would equate to \$0.17/mile.

5. All together, regenerative braking, electric drive train, and fewer components of BEBs could result in \$0.20-0.30/mile maintenance costs saving compared to conventional buses. Maintenance costs of the electric drive train for fuel cell buses are expected to be similar where the fuel cell system maintenance costs would need to be added.

Comments about the preliminary findings were the following:

- Paul Jablonski suggested using percentage when comparing the propulsion related savings, like these studies.
- Labor cost, which is directly impacted by hourly rate, is the major part of the maintenance cost. The labor cost used in NREL studies is \$50/hour for all NREL studies. Labor rate for Golden gate transit is now about \$122/hour. The labor cost differs from one transit to another. Also, some studies were done a decade ago and inflation needs to be considered.

ARB will adjust the labor and parts costs to put all costs in similar terms and will share the updated summary with the workgroup.

In March, ARB sent out a request for information about repair frequency and costs to OEMs and a few transit agencies that are currently operating multiple propulsion systems. Only a handful of them have responded to the survey so far. ARB is expecting to receive more responses. The Steve Miller indicated their preference is to use empirical data, and fuel cell electric bus (FCEB) data is as important as BEB. Many transit agencies are more interested in this technology due to its range.

- Steve commented that ARB's maintenance survey requires a lot of time to be filled out because it is activity-based. Preventive maintenance data is especially hard to get. Corrective maintenance can be obtained through asset management software. Steve Miller suggests using empirical data to calculate the maintenance costs. Both AC transit (baseline vehicles are diesel) and SunLine (baseline vehicles are CNG) expressed that they can help provide more data for maintenance cost. Golden Gate can also provide access to their asset management data as well.
- Ballard suggested looking at European empirical data for maintenance cost calculations as well. Steve Miller is going to talk to Ballard about those data.
- Several attendees mentioned the learning curve for new advanced technologies is steep. Mechanic training costs are higher and needs to be considered in maintenance costs. As the volume increases and technology matures for agencies, the maintenance costs will drop substantially.
- ACTIA Corp. recommended doing one level deeper calculation and figuring out the life cycle cost in relation to battery chemistry.

- Other variables such as charger installation cost and charger location affect the total cost of ownership. Maintenance of fueling station has to be considered for all types of fuels, based on discussion with OEM<sup>1</sup>. ARB mentioned the inflation and discount rate of 3 percent is reasonable to get the total ownership.
- Marty Mellera from SFMTA agreed with Steve Miller on maintenance cost calculation. SFMTA is using cost/energy instead of cost/mile. Their agency has 80 years of experience with trolley buses and he can look at different manufacturers and different generations of the trolley buses.
- Len Engle from AVTA is going to create a team of electric vehicle maintenance personnel to help with data gathering for ZEB. ARB is also collecting data from projects using solicitation grants. ARB will continue to collect the BEB data from Foothill Transit for another year, and will be collecting data from the Zero Emission Truck and Bus Pilot Commercial Deployment Project funded by the Greenhouse Gas Reduction Fund.

## Potential Off-Ramp Options

As a follow-up to prior meetings, ARB posted a draft discussion document about potential off-ramp concepts about one week prior to the meeting. The draft was intended to address transit fleet concerns about technological barriers in implementing zero emission bus technology and to provide assurance that transit fleets would be able to avoid situations that presented extra costs, like 2 for 1 replacement concerns or service concerns if technology did not meet their needs. The draft is available at <http://www.arb.ca.gov/msprog/bus/offrampdiscussiondraft.pdf>. The concept for discussion would allow a transit fleet to receive an extension from any zero emission bus purchase requirement if not technologically feasible for the fleet. At the meeting, the following feedback was provided by the Workgroup members:

- Jamie Levin emphasized the importance of addressing the issues of fueling capacity, charging and throughput. Large transit agencies need lots of coordination and labor to fuel large numbers of buses within a limited time. Not thinking this through can result in significant operational impacts.
- James Pachan noted that the draft document looks like transit agencies have to choose a path. For example, if one technology was not available, transit agencies are required to use another path. Todd Campbell echoed these comments.
- Paul Jablonski commented that this draft is not providing true alternatives to the ZEB purchase requirement, but just provides detours to postpone the requirements for few years. CTA was expecting to see a major shift in ACT direction that matches direction given by the Board on February 18, 2016. He also noted that many Board

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<sup>1</sup> ARB's Draft Discussion Topics on Costs, prepared for the first ACT Workgroup meeting, states that "The total cost of ownership includes the total costs of buying, operating, and maintaining a bus over its lifetime of 14 years, and building, operating and maintaining the charging/fueling infrastructure and maintenance bay." <http://www.arb.ca.gov/msprog/bus/wg201601cost.pdf>

members have supported a performance-based, rather than technology-specific, approach to this regulation. Another member requested ARB to identify the direction staff has taken after the Board update. There was discussion about what the ARB Chair directed the staff to do at the update.<sup>2</sup>

- Paul Jablonski also mentioned that the draft document doesn't give credit to agencies that utilize other technologies, like rail, to move people. He also argued that transit agencies should be provided flexibility to meet reduction from today's baseline.
- Todd Campbell argued that the draft document fails to acknowledge the direction of the Board and their concerns about the costs and its impacts on transit. Todd also noted that the Board voiced concerns about abandoning investments made under the current rule and ignoring advancements made in near-zero technologies, which he believes can lead to even greater reductions in GHG and NOx emissions. Todd Campbell noted that with low NOx engines, coupled with RNG, we can realize significant benefits today. He stated that with this rule, we're betting that certain truths will come to pass; and highlighted the original fleet rule as a missed opportunity.
- ARB believes it is appropriate to prioritize answering cost questions and some fundamental analysis first. Providing clarity on off-ramp provision is important to inform the cost analysis (e.g. that 2 for 1 replacement were not needed). We know several fleets are adopting zero emission buses and believe understanding costs is fundamental to any proposal even if an alternative implementation approach is used. ARB also believes that working with utilities and transit agencies on electricity rates and exploring opportunities to balance the electricity grid is consistent with the Chair's comments about finding alternative ways to meet goals. ARB needs to have a clear, overall picture about emission reduction and costs in order to make a sound proposal. ARB believes the criteria that was shared at the February Board meeting, also needs to be consideration when evaluating any proposed approach including a performance based approach. As a reminder those items include considering the impact of excess engine emissions as a result of deterioration over time, enhancing transit service especially in disadvantaged communities, improving vehicle energy efficiency, and reducing dependence on fossil fuels in all sectors. Finally, ARB reiterated that any proposal must provide GHG and NOx emission reductions under this control measure that are not already attributed to another program to avoid double counting.
- Rick Ramacier mentioned they are concerned about the zero emission technologies and believe a ZEB purchase mandate will force them to reduce service. He stated that ARB should support those agencies that are willing and can get there on alternative technologies first. According to transit agencies, they are required to increase ridership as they reduce emissions and it makes sense to look at these two

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<sup>2</sup> Transcript and webcast recording of the February 2016 board meeting is available at <http://www.arb.ca.gov/board/meetings.htm#future>.

parameters simultaneously. ARB staff agreed on the importance of the transit agencies mission and emphasized service cuts are not desired by anyone and should be avoided in any proposed approach.

- Some agencies mentioned that renewable natural gas (RNG) has lower carbon intensity than electricity and combined with low-NOx engines, RNG can achieve greater NOx reduction than ZEBs. With the new available technologies, transit agencies can contribute towards air quality and climate change goals, while meeting their duty cycle needs and having the freedom of choosing their preferred technology. ARB staff added that the low carbon fuel standard program will achieve about a 10 percent reduction in carbon intensity from transportation fuels and the State needs to implement a suite of complementary measures to achieve more GHG reductions. Transit fleets that use renewable diesel and renewable natural gas support the LCFS program. The cost of renewable fuels is essentially the same as conventional fuels because the value of the credits off-set the fuel producer's higher costs. These emission reductions are attributed to the LCFS program and cannot be double counted in another control measure. To achieve more than is expected from the LCFS program in the long-term, we also need to support transit system efficiency improvements and other cleaner modes of transportation.
- CTA shared a handout at the meeting outlining their suggested approach with a request for ARB to prepare a formal response. Paul Jablonski commented the aim is to expand the ZEB technology and reduce GHG emissions of transit fleets, and ARB should be innovative in finding alternatives in this regard. ARB suggested working together to better define what transit fleets would include in developing such an approach. For example, is transit system efficiency a concept that should be included? Several members agreed. If desired, ARB can take the lead in preparing a discussion draft but is more likely to be responsive to concerns if fleets can provide examples of actions or methods that they believe would meet similar goals. CTA will post its handout on its website.
- Michael Pimentel emphasized that the Association's position has always been about advancing a menu of options for reducing emissions from transit fleets. He pointed out that what he heard from the Board is that they want to consider different pathways and the costs and benefits associated with each. He commended ARB staff for devoting increased time and resources to building out an alternative in alignment with the Association's draft document. He argued that given recent solicitations, there is a clear desire from many transit agencies to transition into cleaner technologies, and that we can pursue this regulation with a greater emphasis on incentives.
- The discussion continued with debates about emissions associated with electricity production and benefits of using renewable fuels because of the potential for negative carbon intensity fuels. ARB believes renewable fuels are essential for many sectors, and clearly supports the use of low carbon fuels to ensure the success of the LCFS program goals, and that is why the purchase of renewable

fuels was proposed in the initial staff proposal. However, in the long term renewable fuels will also be needed in other sectors that cannot reduce GHG emissions in other ways. Zero emission vehicles are also important way to meet State goals, and their higher energy efficiencies should also be considered in the long term.

- CalSTART suggested giving early adopters credits and establishing a system to trade credits amongst transit agencies. Learning from LD implementation, the same strategies would be beneficial in HD sector. He also mentioned one of the goals of this regulation is to force the ZEV technology into the market and added [with enough zero emission bus funding, the State can meet its ZEB purchases through 2020.](#)
- ARB explained a discussion document about alternative approaches that was planned for this meeting could not be completed prior to the meeting, but that questions from past meetings about complementing SB 375 actions could be discussed and is a key to developing a performance based approach and how to avoid double counting emissions.

### **Flexibility/ Performance Based Options —Integration with SB 375**

Flexibility options were briefly discussed within the previous topic. ARB is looking at possibilities to provide synergies with “Regional Transportation Plans” (RTP) and “Sustainable Communities Strategy” (SCS) under SB 375. Any possible actions under the flexibility options should be complementary to those taken to meet SB 375 goals and existing programs. SB 375 aims to reduce GHG through reduction of vehicle miles traveled from passenger cars and light trucks and one of the possible methods to achieve this is to increase transit fleet ridership. However, SB 375 does not differentiate the fuel type within the same type of public transportation systems and does not consider NOx reduction benefits. Therefore, actions that reduce emissions in all heavy duty modes including improving transit system efficiency would be complimentary action towards the SB 375. ARB continues to work on requirements of SB 375 and aims to provide a write-up to share with the public.

ARB plans to work with the subcommittee members in regards to the flexibility options, evaluate various options and discuss them with the Subcommittee before coming to the next Workgroup meeting.

### **Action Items**

- ARB will provide an update about the transit survey in the next Subcommittee meeting.
- ARB will post a discussion draft of the maintenance cost literature review for review and comment
- ARB will follow up with ACTIA Corp. to get battery price information.
- Gillig is going to share battery information with ARB. ARB is going to work with the Subcommittee to develop the flexibility options/performance based approaches.
- ARB will post a discussion draft about available studies on heavy duty battery costs for review and comment.