Fifth Innovative Clean Transit Workgroup Meeting Summary
Monday, June 26, 2017
Cal/EPA Headquarters, Sacramento, California

Attendees

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

#	Name	Affiliation
1	Andrew Papson	Foothill Transit
2	Bill Spraul	San Diego MTS
3	Bruce Abernathie	Santa Clara Valley Transportation Authority
4	Bud Beebe	California Hydrogen Business Council
5	Cal Silcox	Pacific Gas & Electric
6	Charles E. Love	Love's Travel Stops
7	Charles Watson	California Strategies/Proterra
8	Chris Young	Cummins Pacific
9	Cliff Thorne	Orange County Transportation Authority
10	Dan Nevin	Cummins
11	David Renschler	City of Fairfield
12	David Warren	New Flyer of America
13	Derek Turbide	Clean Energy
14	F. Kent Leacock	Proterra
15	Fang Yan	California Air Resources Board (CARB)
16	Fred Silver	CALSTART
17	Gustavo Collantes	ICF International
18	Hannah Goldsmith	California Electric Transportation Coalition
19	Ian Stewart	Rail Propulsion Systems
20	Jaimie Levin	Center for Transportation and the Environment
21	Jeff Grant	Zen Clean Energy Solutions
22	Jennifer De Tapia	Trillium CNG
23	Jennifer Lee	CARB
24	Jimmy O'Dea	Union of Concerned Scientists
25	Jing Guo	CARB
26	Jose Paul Plackal	Phoenix Motorcars
27	Joseph Policarpio	Gillig
28	Keely King	Allison Transmission
29	Kevin Maggay	Southern California Gas Company
30	Len Engel	Antelope Valley Transit Authority
31	Linus J. Farias	Pacific Gas & Electric

32	Marc Perry	California Energy Commission
33	Marcus Jackson	BAE Systems
34	Mark Perry	Antelope Valley Transit Authority
35	Matt Psota	Cummins
36	Matthew Williams	CARB
37	Michael Coates	Mightycomm/Nova/Volvo
38	Michael Masquelier	Wireless Advanced Vehicle Electrification (WAVE)
39	Mike Pimentel	California Transit Association
40	Nathaniel Atherstone	City of Fairfield
41	Nico Bouwkamp	California Fuel Cell Partnership
42	Patrick Decatrel	Allison Transmission
43	Paul Hernandez	Center for Sustainable Energy
44	Ray Pingle	Sierra Club California
45	Rick Ramacier	Central Contra Costa Transit Authority
46	Ron Zirges	Victor Valley Transit Authority
47	Ryan Kenny	Clean Energy
48	Shirin Barfjani	CARB
49	Shrayas Jatkar	Coalition for Clean Air
50	Steve Miller	Golden Gate Transit
51	Tim Carmichael	Southern California Gas Company
52	Todd R. Campbell	Clean Energy
53	Tony Brasil	CARB
54	Vincent Wiraatmadja	Weideman Group
55	Wente Yin	CARB
56	Yachun Chow	CARB
57	Zach Kahn	BYD Bus & Coach

This was the fifth meeting of the Innovative Clean Transit (ICT) Workgroup. The group was formerly called Advanced Clean Transit Workgroup. This meeting was webcast and recorded. The objective of this meeting was to provide an update on the Innovative Clean Transit program and transportation electrification for transit agencies, and to discuss the latest cost information. The agenda, meeting materials, and video recording for this meeting are available at: https://arb.ca.gov/msprog/ict/meeting.htm.

The following were the primary agenda items for the meeting:

- Innovative Clean Transit (ICT) status update
- Overview of prior meetings
    - Performance-based approach
    - Transit cost subgroup

- Opportunities for enhanced connectivity and mobility
- Cost inputs and assumptions update
- Cost of meeting zero-emission bus (ZEB) goal by 2040
- Action items and topics for next meeting

A presentation was used as a guide for the discussion of a range of topics. This summary is organized by topic area in the order discussed in the presentation. Some errors in the presentation that were identified at the meeting have been corrected and a list of errata is now provided on the final slide. The updated presentation with errata is posted at https://arb.ca.gov/msprog/ict/meeting/mt170626/170626_wg_pres.pdf.

Innovative Clean Transit Status Update

CARB informed stakeholders of its transition from Advanced Clean Transit to Innovative Clean Transit (ICT) and introduced the updated website. The name change is intended to reflect the vision for the program in the Mobile Source Strategy. The goals are to provide necessary flexibility for transit agencies improve service and reduce emissions. The ICT program expands upon the scope of the ACT program by including a long-term transition to zero-emission technologies in all modes, continuing to provide innovative transportation options as part of Sustainable Communities Strategies, and ensuring service to people with limited transportation options. The new ICT website is at: https://arb.ca.gov/msprog/ict/ict.htm. All meeting materials and information will be available on this new page.

Overview of Prior Meetings

Staff provided a brief overview of key discussions and action items that occurred in prior sub-group or subcommittee meetings.

Transit Agency Subcommittee Meeting (Oct 26th, 2016)

- Discussed the performance-based concept for lower emissions in transit with transit agencies and the Performance-Based Approach Subgroup that was coordinated by the California Transit Association (CTA). The purpose of the meeting was for ARB to support developing the details needed to define the CTA performance based concept. Agreement was made to devise practical and quantifiable implementation mechanism to result in new and real emission reductions. It was also agreed by the Subcommittee that emission reductions from proposed new measures must go beyond existing measures and be real, quantifiable, verifiable, and enforceable.

- The group generally agreed that data for implementing a performance based metric should be based on information already reported by transit agencies to the National Transit Database for all modes operated by transit agencies.
- The group discussed metrics for NOx emissions and for greenhouse gas (GHG) emissions. Multiple metrics that could be used as surrogates were also discussed such as fuel consumption, efficiency, certification emissions factors, and how they may be compared such as in emissions per mile or in emissions per seat-mile. Each have pro's and con's. Emissions per seat-mile were identified as the initial metric to evaluate for all modes. Emissions per passenger mile and other metrics were also discussed and may need to be evaluated if the initial approach presents unintended consequences. CTA solicited CARB's assistance to develop measurement metrics and identify data needs.

Performance-Based Approach Subgroup (Jan and Feb, 2017)

- CARB presented data sources and framework discussed at the prior TAS subgroup meeting to confirm that the methodology was consistent with what the Subgroup intended. CARB identified potential implications when comparing the results for individual agencies and identified questions/issues for the CTA/Subgroup to discuss and address. CARB also presented details of preliminary framework that included metrics for NOx (engine emission factors) and GHG emissions (fuel energy use). The meeting ended with questions to be addressed by the CTA and Subgroup on how to establish baseline emissions and how to move forward.

Cost Subgroup Meetings (Oct 14th, 2016 and April 28th, 2017)

- CARB staff and the Transit Agency Cost Subgroup (TACS) met to discuss cost data and assumptions to be used in a total cost of ownership analysis. Primary topics included major cost inputs for the cost models including, updates to the charging cost calculator, bus price updates, EIA prices for fuel costs, transit agency data on CNG contracts, and other cost assumptions. The Transit Agency Cost Subgroup provided a brief overview of their Life Cycle Cost Model (LCCM). The model includes a variable to model costs for more than a one-for one bus replacement when adding zero emission buses.
- The CARB cost model does not include a variable to reflect a more than one for one replacement because buses are already available to meet nearly all range needs and staff is committed to proposing a rule framework that would avoid more than a one for one replacement. Higher range buses have higher costs and those cost should be reflected when higher range buses are needed rather than assuming the fleet expands in size.
- The TACS requested CARB to generate statewide weighted average electricity costs for their model and to add spare parts to the CARB cost to model.

Funding, Other Incentive Opportunities, and Technology Status Update

CARB provided updates on current state policies and transit-related funding programs such as the focus of SB 350 on transportation electrification investments and access to clean transportation in disadvantaged communities, potential transportation infrastructure and transit upgrades of SB1, and continuing purchase incentives through Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP).

- CTA has been very involved in SB 350 and urged every transit agency to be active and vocal in project review processes.
- Concern was also raised on HVIP oversubscription and future of the program, as well as undersubscription of low NOx incentives indicative of over allocation of funding to low NOx and underfunding of zero emission buses.
- CARB is developing a new funding plan that will be discussed in a public process and staff will have a better understanding of how much HVIP funding will be available in September.
- Updates were given on current status of the battery electric bus (BEB) market and charging standardization progress, and key milestones met by fuel cell electric buses whose performance have exceeded previously established DOE targets.

Opportunity for Enhanced Connectivity and Mobility

CARB provided an overview of some existing programs which connect riders to public transit to improve transit connectivity.

- Concern was raised on the difficulty acquiring data from private entities and importance of acquiring data to quantify benefits.
- Some transits believe that increasing scope will cause increased complication, and recommend support for allowing transit agencies to diversify by increasing passenger trips into zero-emission modes without regulation. Transit agencies also believe that expanding the scope cannot be easily done due to equity issues as it is unclear whether transits and/or their partners would be regulated.
- Some environmental groups also voiced that the goals need to be clear about zero emission bus deployment to avoid distraction. They further emphasizes that there must have real data to support any shared mobility benefits. They also wondered how mobility would be factored in for a performance-based proposal.
- Commenters believe the multi-modal and mobility concept is extremely complex and could delay the process and result in further delays in zero emission bus deployment and delay their associated benefits.
- CARB is looking to reduce emissions by addressing a wide range of transportation options and to have transit and rider connectivity work together for a win-win scenario without delaying existing zero-emission goals.

- Some suggested that CARB reach out to SF MTA to acquire research on effect of Uber and Lyft on traffic congestion as Uber and Lyft may be moving commuters away from public transportation and increasing total miles travelled.
- Some suggested avoiding a regulatory approach and to diversity trips so fleets can work with private industry and provide service as they see fit.
- Concerns were raised regarding delays of the proposed zero emission bus (ZEB) mandate, some concerned that expanded role of ICT may not be productive due to uncertain state of future of ride-sharing technology.
- Transit agencies noted that the very face of transit service and how it's delivered is changing. New agencies and services outside of the scope of this rule may emerge.
- CTA also cautioned a few things for the entire ICT concept. As Senate Bill 1 could provide potential benefits to transit operation, ICT should avoid relying on SB 1 to deploy ZEB and need to provide transit flexibility. Further, for the "innovations" part, be cautious about data availability, American Disability Act and Title 6 requirements, congestion impact vs. emission reductions benefit, labor impacts, and exploration of what types of innovations can exist with legal limitations with real considerations.
- Transit agencies also encourage more engagement of metropolitan planning organizations (MPOs) in the process.

Cost Assumptions Update and Results

CARB updated stakeholders on cost analysis considerations and described the reasons for updating cost assumptions. Detailed costs, assumptions, and calculations are posted at: https://arb.ca.gov/msprog/ict/meeting/mt170626/170626costdatasources.xlsx.

Bus Prices

Based on prior comments, staff updated conventional bus prices based on the suggestions to analyze the bus specifications from a consortium 2013 bus purchase bid from the Central Contra Costa Transit Authority (CCCTA) and a bus purchase bid for different propulsion technologies from the Washington State Department of Enterprise Services in 2015. The price of a base diesel bus and CNG bus before tax and without options were reduced to $435,000 and $485,000 respectively in 2016 dollars. The battery electric and fuel cell electric bus prices remained unchanged. The analysis description and results are available for comment in a summary paper at https://arb.ca.gov/msprog/ict/meeting/mt170626/170626buspricesanalysis.pdf. Comments about bus prices at the meeting included the following:

- The estimated bus price differences among different propulsion systems by CARB were confirmed by the Gillig representative; however, options that are

commonly included cost around $75,000 and should be factored into cost of ownership for all technology types and acquisition to better reflect total expenditures.

- Others suggested that CARB review different bus purchase contracts to better understand and reflect bus pricing in the cost model.
- CARB total cost of ownership model has an input field for the value of options and will use the $75,000 as a default value for future cost estimates. The cost of bus options will be added to all buses regardless of technology and the incremental costs will remain the same.
- Stakeholders raised concerns that fuel-cell electric buses (FCEBs) prices were not represented on slides when bus price reductions have been significant.
- CARB staff stated that FCEB price projections are in the detailed cost assumptions sheet and in the cost model. They have not changed from prior estimates. Staff are observing the situation in Europe to see how the costs may change current fuel cell bus price projections.
- Stakeholders are also concerned that CARB is not including FCEBs in the discussion and will unintentionally divert potential fleets from considering this option.
- Clearwater has awarded a contract in which the BEB price was $840,000, and Gillig can provide the contract to CARB.
- CARB will also evaluate LA Metro's recent bus purchase contract when it becomes available and will make the appropriate adjustments of bus price estimates reflecting 2017 purchases.
- The Transit Agency Cost subgroup continues to caution that there is a big variation among different bus bids and Request for Proposals and any comparison needs to be with caution and caveats.

Fuel Related Costs

CARB staff updated fuel efficiency assumptions by using information provided by individual fleets and updated the cost model to include 2017 average fuel prices for diesel and CNG from EIA. CARB staff also provided a summary of the updates made to the electricity cost calculator to accommodate comments made in past meeting. The changes included an improved user interface, a new option that allows the user to select the time for charging, updated utility schedules, and rates from additional utilities. The Charging Cost calculator is available for comment at: https://arb.ca.gov/msprog/ict/meeting/mt170626/170626chargecostcalcv3.xlsm. The calculator will be posted for use if there are no significant changes needed.

Low-carbon fuel standard (LCFS) credit value by fuel type was presented and handed out at the meeting to show how the credit value reduces the net cost of low carbon

fuels. Number of LCFS credits for a given technology compared to diesel are dependent on the vehicle energy efficiency ratio (EER). CARB is in the process of updating the LCFS program and will consider increasing the heavy-duty battery-electric vehicle EER in the program based on new data for battery electric trucks and buses. If changes are approved the number of credits for operating BEBs would increase; thereby, lowering the total cost of ownership. CARB is seeking similar data for fuel cell trucks and buses and will reflect changes in its analysis if any are adopted. The following are comments relating to fuel use and LCFS program credits:

- Stakeholders suggest to only use newer engine fuel economy to calculate fuel efficiency because performance degrades over time. Limiting the analysis to newer engines would allow for a better comparison of fuel use for new electric and new conventional buses.
- CARB should use a 100 kW instead of a 60 kW charger to estimate electricity costs because more transit fleets are going to higher power chargers.
- Some fuel cell electric bus operators cannot claim LCFS credits as they are not fuel providers.1 CARB commented that for the LCFS program, transit agencies are second in line to receive LCFS credits when dispensing hydrogen and the fuel provider can forfeit their right to claim the credits. We know LCFS program staff have discussed this issue in workshops and may be proposing to modify the program to allow transit agencies to be first-in-line to claim LCFS credits when operating FCEBs. Interested parties should comment on this issue in the rulemaking.
- Some stakeholders were interested in seeing a table of the LCFS credits in the units of $/DGE or $/mile in order to simplify comparisons among fuel types. CARB can show examples but the credits are earned based on actual fuel use.
- Concern that LCFS credit values may fluctuate and suggestion that regulation should account for volatility in LCFS credit value. Credit value will vary with market conditions and the effect of higher or lower credit value in the total cost of ownership analysis is shown in the slides. In addition, AB 32 requires California to maintain the 2020 GHG emission cap and SB 32 sets new statewide emission cap in 2030. Both bills together provide a strong market signal for the LCFS program.
- Hydrogen stakeholders offered to share heavy duty fuel cell electric vehicle fuel efficiency data.
- RNG stakeholders raised concerns that CNG information is presented on slides showing fuel prices whereas RNG information is not presented. They stated that they are willing to share data regarding discounts for RNG over CNG. CARB

[1] The LCFS program held a workshop on September 22, 2017 for potential rule amendment. This issue can potentially be resolved by the proposed rule amendment. Workshop information can be accessed at https://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/lcfs_meetings.htm.

used CNG as the baseline gaseous fuel and RNG should be used as baseline instead of CNG. CARB staff noted that the baseline fuel should be consistent for costs and emissions analysis.

- The CARB baseline is with conventional fuel. The net pump cost of RNG after compression, transmission, distribution and after LCFS and RFS credits is similar to CNG for the transit agency. Any discounts CARB staff have seen, vary by contract. CARB staff are interested in other data about discounts over CNG.
- California Fuel Cell Partnership is willing to share efficiency curves on FCEBs from Ballard.

Bus Maintenance Costs

The TAS Cost Subgroup decided to reflect lower lifetime maintenance costs for diesel buses compared to CNG buses where they previously were assumed to be the same. CARB staff also updated maintenance costs to reflect the change.

- Concern raised regarding higher hourly maintenance cost for ZEB technicians because of higher cost of training for more skilled technicians. Technician will likely be paid at a higher hourly rate for new technology.
- CARB should consider comparison between hybrid bus and BEB for mid-life costs because hybrids are not as expensive when rebuilding battery modules or traction motors. King County may be willing to share data of mid-life cycle cost.

Training, Parts, and Other Costs

CARB provided an overview of an attempt to estimate the costs of training and parts associated with the purchase of a new technology as requested by the TAS Cost Subgroup. These initial estimates are preliminary placeholders intended to recognize effects of some expected higher initial costs for parts, training, and other non-capital costs. Some transition costs should be temporary but staff do not have solid estimates and are interested in feedback on how to estimate them.

- Some costs in the interim between transition from conventional to zero-emission buses may include higher cost (ex. due to more buses needed to compensate reduced range of BEBs compared to conventional) and are not presented.
- CARB should conduct a survey from transit agencies with zero emission buses to get better handle on soft costs.
- The BEB workforce development cost presented is low due to technology and training (high-voltage training and associated increased wage demands).
- Training is already in the bus price and is paid for by OEMs who work with community colleges and other programs. CARB estimates therefore are high because they double count costs.

- Associated soft costs of bus procurement in the short-run will be high for BEBs and lower over time as trained workforce and technology use increases.
- Transits with ZEB operating experience commented that CARB's estimates of BEB soft cost of $19,000 is too high, because there is no transmission and no need for the number of spare parts that are required for conventional buses.

Total Cost of Ownership

CARB presented total cost of ownership for a single BEB if purchased in 2016 and concluded that BEB's costs are comparable to conventional for almost all utility service areas with standard assumptions. The 2016 price does not reflect any estimated bus price reductions and is a conservative estimate. The results show that the total cost of ownership for a BEB (with a nominal range of about 150 miles) is still on par when compared to conventional technologies (without including grant funding) for most utility service areas. Fleets within the SDG&E service area would incur slightly higher total cost of ownership with a BEB because of higher electricity costs. The results are applicable where the buses would meet a fleet's existing needs. Staff also presented the total cost of ownership results with differing assumptions including the effects of vouchers, offsetting infrastructure costs, and higher and lower LCFS credit value.

Cost of Meeting Zero-Emission Bus Fleet Goal by 2040

CARB also presented the total cost of ownership for a full conversion to depot charging BEBs by 2040 without grants or rebates. The analysis uses longer range buses as more BEBs are deployed. This analysis is based on costs and assumptions consistent with extended range buses available today that have an off-board charger and a mid-life battery replacement. The analysis begins with purchases of buses equipped with 330 kWh batteries and changes to 440 kWh and 550 kWh in 2025 and 2030, respectively. The approach is consistent with transit fleet survey results that show most buses do not travel more than 150 miles/day. The total statewide costs were estimated based on a regional cost analysis grouped by utility area and bus fuel type. A description of the approach is available for comment at:
https://arb.ca.gov/msprog/ict/meeting/mt170626/170626statewidecostmethod.pdf

Statewide costs for a full transition to depot charging BEBs by 2040 were presented by utility service area showing a slight total cost of ownership savings for all regions during the analysis period. Further savings are possible depending on LCFS credit value, infrastructure, economies of scale, and if funding were used to offset some initial costs. Staff also showed the effect of variables (e.g. electricity cost, infrastructure funding, etc.)

The CARB Transit Fleet Cost Model with all detailed assumptions used in the analysis is available for review and comment at: https://arb.ca.gov/msprog/ict/meeting/mt170626/170626transitfleetcostmodel.xlsx. The model can also be used for estimating costs for other bus technologies or for individual fleets.

- Some stakeholders expressed that all transits need to place ZEBs in service and building a cost model alone will not get California there. We should not lose sight of the need of going zero tailpipe emissions.
- CARB should show the benefits of reducing social externalities from deploying ZEBs with the cost analysis.
- CARB should provide the numeric values of the data shown on the graphs.
- Some raised concern that bus purchase requirements are a technology mandate and not performance-based rule. CARB should consider NOx and SOx requirements and savings from mitigating NOx and SOx emissions.
- Concern that axle weight not considered in analysis, an issue for extended range buses.
- Some transits are still concerned about the potential inability of 1:1 replacement ratio and urged CARB to consider such cost.
- CARB's goal from the beginning has been to establish a framework that minimizes the potential for more than a 1:1 replacement for any fleet and is interested in comments on how to do that.

Action items

- Zen Clean Energy Solutions will share FCEV efficiency curves
- Love's Travel Stops will share information regarding price of RNG
- Gillig will provide the Clearwater BEB bus purchase contract
- Southern California Gas Company will provide CARB with LA Metro acquisition contract for bus price information
- California Fuel Cell Partnership will share the Ballard fuel cell efficiency data
- Gillig will provide fuel efficiency data for new (post-2010) conventional buses
- CARB will survey ZEB owners about their soft costs
- CARB will share data used to generate embedded graphs from presentation
- CARB will evaluate LA metro contract to make adjustments to bus prices as appropriate
- CARB will convert all applicable LCFS credit price comparisons to $/DGE or $/mile to aid comparison between different fuel types
- CARB will update conventional bus fuel efficiency of fleets based on data for new vehicles rather than reported fuel economy for the entire fleet

- CARB will reach out to King County for mid-life cost data for hybrid buses
- CARB will include a bus option costs of $75,000 as a default value for all bus technologies to reflect total purchase costs.