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Alternative Fuels – Technology Development Outlook

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ISE welcomes the interest of the legislature, as well as that of the CEC and ARB, in furthering the continued and renewed development of alternatives to conventional transportation fuels. ISE has made some specific contributions in this area (including heavy duty electric drive development and hydrogen hybrid buses using both fuel cell and HICE engines) and is fully engaged in several new approaches to zero and near zero emission vehicle development using hydrogen and electric energy storage.

We comment as follows:

Hydrogen Fueled Fuel Cell Buses:
With the federal fuel cell bus program as recently announced, and presuming the acceptance of the staff proposal for Z-bus incentives, the fuel cell bus programs will proceed at good pace, presuming the availability of the necessary co-funding and development of fueling infrastructure. California now has the opportunity of assuring these are truly zero emission vehicles through investing in renewable sources for the hydrogen.

This is important for several reasons:

1. The real advantages of hydrogen as a transport fuel are realized if energy can be "harvested" from local sustainable resources, such as wind, solar and biomass. ISE, with AQMD funding, did a 2002-2004 demonstration of wind to hydrogen, and years before the AQMD along with the USDOE funded a demonstration solar to wind system. As such fuel sources become commonly known and offer a real alternative source the arguments *against* hydrogen melt away.
2. Estimates from several sources indicate that sustainably sourced hydrogen, combined with distribution of the fuel become fully competitive *if* similar levels of investment capital are available for implementation.
3. Investing in renewable resources for fuel may be viewed as expensive, until one requests suppliers of fossil fuel resources to provide *firm fixed price quotes* for delivery over the next quarter century.

Hydrogen Hybrid ICE (HHICE) Bus Technology
Despite the preponderance of efforts on fuel cell development, and encouraging progress, there is as yet no assurance that the fuel cell engines will attain acceptable durability and cost.

From the days of before the Model T Ford to todays automotive and aircraft engine, it is apparent that the ICE (internal combustion engine) has evolved to a highly developed product. Is it not possible that hydrogen engines using pistons can also be developed into

a highly effective – efficient and durable – product? We hold that it is important to have a well funded and robust program to develop the HICE engine, and then to use the engine in buses to gain field application experience. Presently two automotive firms are leading the HICE development, but there is room for further programs that could involve commercial firms, universities and/or test laboratories.

- Engine durability testing will help to define the limits of engine application and the effects of long term operation.
- Direct injection, already the subject of early testing, is claimed to increase efficiency while providing more flexibility in NOx control.
- Exhaust gas treatment, such as with NOx absorbent technology, has (in early testing) resulted in order of magnitude reductions of emissions, sufficient that it appears the total emissions from a HHICE bus can be below that of a Prius automobile.

We expect that a modest investment in HICE engine and HHICE bus development can yield vehicles with large emissions reductions.

Battery Electric Buses – an Emerging Opportunity with Big Payoff

ISE vehicles are all electric vehicles, and they use a variety of engine drives to generate the power to charge the batteries. Batteries with high power and energy capability are central to the effective hybrid electric vehicles, and as a result we track carefully the recent rapid improvement in high technology batteries. We believe that an all electric bus with range capability in excess of 200 miles, suitable for many transit applications, will be possible in the near future. If such battery vehicles become available, they will make possible night time charging with emissions generation only at the power-plant.

Much attention has been provided to plug-in hybrid technology. The experience has been that the casual customer has been reluctant to invest in a vehicle with 60 mile range, and so the “plug-in hybrid” marketing has offered a gasoline vehicle which has batteries as well. We question whether the vehicle with both ICE and battery technologies is going to be warrantable for long battery life.

To the extent that the “plug-in hybrid” will have full battery life with deep discharge of the batteries, so will a battery only electric bus. The battery only bus offers simplicity and cost savings, offsetting the high battery cost.

ISE has committed to investment towards development of battery-electric technology for transit buses, with the Los Angeles MTA having indicated interest in a parallel and supportive investment.

Comparing the Technologies:

This table provides an ad hoc quasi-quantitative comparison of the technologies:

	Total Efficiency	Infrastructure Cost Effectiveness	Vehicle Price	Emissions	Domesitic Fuel	Overall Rating
Trolley Bus	57%	$2M	$1M	Low	97%	Medium
Battery Bus	51%	$250k	$750k	Low	97%	High
Fuel Cell Hybrid Bus	34%	$250k	$1.5M	Low	86%	Medium
HHICE Bus	25%	$250k	$700k	Low	86%	Med-high
Ethanol Bus	24%	$30k	$350k	Medium	90%	Med-high
CNG Bus	24%	$150k	$400k	Medium	85%	Low-med
Diesel Bus	28%	$20k	$330k	High	40%	Low

Note that the Fuel Cell Bus rates highly in many respects, but there is no assurance on the price or on durability. The Battery Bus is rated most highly, but until someone makes one and demonstrates safety and durability it is a questionable entry. The HHICE and the Fuel Cell Bus, as well as the electric and ethanol vehicles, offer the possibility of operation solely from domestic fuel. Thus these are the real "alternate fuel" pathways, and warrant the highest level of attention and funding.

Summary:

ISE suggest serious statewide commitment towards:

- Hydrogen generation from sustainable resources, with substantial funds committed in collaboration with leading firms to make possible large scale production such that tens of buses, even a whole agency, will be powered from sustainably sourced hydrogen.
- HICE engine development by the most skilled and capable development laboratories directed towards efficient and durable high power hydrogen engines.
- Substantial co-funding of development of high voltage, high energy density battery packs with assured safety suitable for public transit applications in the most environmentally challenged city centers.
- Support for battery, HHICE and ethanol fueled transit buses, as well as the strongly supported Z-bus fuel cell bus programs.