Attachment 1: Description of Emissions Reduction Measure Form

Title: *Electrification and Efficiency Improvements of Freight Transport*

Type of Measure (check all that apply):

☑ Direct regulation
☑ Monetary Incentive
☐ Voluntary
☐ Other Describe:
☐ Market-based compliance:
☐ Non-monetary incentive
☐ Alternative Compliance Mechanism

Responsible Agency: California Air Resources Board, California Transportation Commission, Business Transportation and Housing Agency

Sector:

☑ Transportation
☐ Other Industrial
☐ Agriculture
☐ Sequestration
☐ Electricity Generation
☐ Refineries
☐ Cement
☐ Other Describe:

2020 Baseline Emissions Assumed (MMT CO2E): 33.5 MMT CO2e (2004)

Percent Reduction in 2020: 18% (6.2 MMT CO2e, 2004)

Cost-Effectiveness ($/metric ton CO2E) in 2020:

Description:

Numerous improvements could be made to the freight transport system in California to electrify diesel powered equipment and increase the efficiency of the ships, trains and trucks that carry cargo throughout the state. These electrification and efficiency measures could be funded through a combination of incentive programs and requirements to substantially reduce GHGs from the transport sector.

Port Electrification[1]
Numerous aspects of port operations could be electrified to reduce GHGs, in addition to the proposed Green Ports measure on Shoreside Power. Depending on the source of electricity, 2-4 pounds of CO2 are saved by each kilowatt-hour replacing diesel fuel. The trucks, cargo-handling equipment, tugs and locomotives serving the port could all be electrified to some extent.

The Port of LA announced an initiative in January 2007 to develop electric tractors to haul containers to and from local destinations.[2] Specifications have already been made for an electric

[1] Port Innovation Workshop Final Report, Rocky Mountain Institute, April 2007

drayage truck with a maximum speed of 25 mph, 60,000 lb. towing capacity, and a 40 mile range on a single charge. The electric trucks developed through this effort could be used at many other facilities served by short haul or drayage trucking.

Electrified tugs could plug in to charge at dock and use stored electric energy to perform ship assist operations. Fast-charging systems have already been commercialized for use at airports (for ground support equipment) and other industrial settings, powering over 15,000 vehicles in North America.

Cranes that are already powered by electricity could be further optimized to save energy. Virtually all ship-to-shore cranes are equipped with regenerative breaking to capture energy while lowering containers. However, this energy often goes unused for lack of storage or load sharing. We recommend optimization of cranes to fully utilize regenerative power. Other cargo-handling equipment can be electrified, at least partially. RailPower Technologies, for example, offers a retrofit hybrid system for rubber-tired gantries.

Yard hostlers may be the most promising piece of yard equipment to electrify, since these are the greatest source of GHGs from yard equipment. Yard hostlers idle up to half the time, often pull minimal loads rather than a full container, and operate at low speeds. These characteristics make yard hostlers amenable to similar technology used to electrify airport ground support equipment.

Rail Electrification

Technology exists to electrify both switching and line haul locomotives. The Green Goat is just one of several battery electric hybrid options for switching locomotives. All switching locomotives should be converted to hybrids. Numerous electric rail options are also available for line haul locomotives. Nearly all railroad main lines in Europe are electrified; freight trains in many of these countries run on the same electrified tracks as passenger trains which require less power.[3] Electric trains are more than three times more efficient than diesel locomotives according to a Finnish study, showing substantial CO2 emission benefits.[4] Recent research shows the following alternative rail choices available:

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[2] http://www.portoflosangeles.org/Press/REL_Electric_Tow_Tractor_Demonstration_Project.pdf

[3] Bhargava, Bharat, " Railway Electrification Systems and Configurations," Power Engineering Society Summer Meeting July 1999, IEEE, p. 445-50.

[4] Union of the Electric Industry, "Electricity for More Efficiency: Electric Technologies and their Energy Savings Potential," July (2004). The Finnish study can be found at: http://lipasto.vtt.fi/yksikkopaastot/freight_railway_average.htm

	Commercial Applications?	Use w/ existing infrastructure?	Ton-mile/kWh[5]	Cost per Mile (single track estimates)
Linear Induction Motors (LIM) on the vehicle	TRANSIT	NO[6]	N/A	$100+ million (transit applications)
LIM on the Track	NO	YES	5-10	$10-20 million[7]
Electromagnetic Suspension Maglev	TRANSIT	NO	5-10	$70-170 million[8] (double track cost)
Electrodynamic Suspension Maglev	NO	NO	5-10	$45.5 million[9]
Electric Rail	YES	YES	8-10	$9-13 million[10]
Electric Cargo Trams (CargoRail™)	NO	NO	N/A	$40-54 million[11]
Automated Shuttle Car Concept	YES[12]	NO	N/A	N/A

Improved Freight Logistics

Software programs monitoring cargo transport delivery schedules can minimize the miles that a truck drives empty and ultimately remove many empty trucks from the road. Shippers, in particular, can use logistics software to ensure full loads to maximize operating efficiency. Chassis pooling, required by the Port of Virginia, is another method that should be employed to reduce unnecessary truck trips.[13]

Intelligent Container Design[14]

Efficiency and design improvements to containers could result in substantial greenhouse gas reductions. The container itself is typically 10-25% of the gross weight of a container loaded with cargo, and 20% of containers are shipped empty. Container design has not changed in almost 50 years. Clear targets for redesign include weight reduction and technology to facilitate logistics, such as tracking devices, as well as improved design for refrigeration. The most significant gains from redesign are the following:

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[5] The ton-mile/kWh figures are estimates since it is hard to determine efficiency without pilot tracks under weight. Direct use of electricity will likely have higher efficiency. Efficiency will differ based on loads and speeds. Electric applications also lose efficiency in creating and transferring electricity to the vehicle.

[6] Transit applications have been dedicated lines only. Likely lower grade steel rails not capable of withstanding heavy freight applications. All the concepts would require new guideway construction.

[7] Does not include costs to apply metal reactive plates to locomotives and railcars.

[8] Low cost figure based on the Transrapid dual guideway system built in Shanghai, China for high-speed transit. The high cost figure is based on the cost/mile for the low-speed Linimo transit line in Nagoya, Japan.

[9] Does not include cost of the vehicles estimated at $800,000 each, according to General Atomics.

[10] Cost estimates are from early 1990's SCAG study of electrifying the Alameda Corridor. Costs include cost of implementing electric infrastructure and 12-14 electric locomotives. Cost figures were put in 2007 dollars with inflation calculator. Total costs were divided by 20 miles to derive cost per mile estimates.

[11] Includes the cost of 180 to 285 vehicles needed per mile at $120,000 per vehicle.

[12] The concept has been used in the Steel industry for heavy applications.

[13] RMI, April 2007.

[14] Information provided by Laura Schewel, Rocky Mountain Institute, Personal Communication, September 21, 2007.

- Reduced loads and increased efficiency for ships, trucks, and trains that carry containers;
- Reduced loads and increased efficiency for cargo handling equipments at ports, rail-yards, and warehouses;
- Improved logistics because of advanced tracking/scanning technology built into the container resulting in reduced wasted time and associated energy use, unnecessary miles traveled, engine idling, etc.;
- Reduced emissions of climate-changing refrigerant compounds and improved efficiency in refrigeration;
- Improved facility of security scanning and related logistical benefits;
- Easier adoption of smaller engines or advanced energy technologies like hybrid and fuel cells because of reduced loads;
- Improved ease of recycling or non-container reuse to reduce the waste caused by shipping and storing empty containers resulting from the trade imbalance; and
- Fewer trips necessary to carry the same amount of freight because of reduced tare weights.

Nationwide adoptions of a lightweight container (~30-50% weight reduction) could reduce at least 1 million tons of CO2e (assuming that 5% of Class 8 trucks carry new containers and 20% of freight trains carry new containers). Also, there is significant potential to reduce greenhouse gas emissions from the volatilization of HFCs via alternate refrigeration and improved efficiency of the refrigerated containers. Refrigerated transport is responsible for around 14 million tons of CO_2-equivalent emissions in the US.

It should also be noted that other equipment at container terminals could be "lightweighted" to save fuel or energy and reduce GHGs. For example, Super-post-Panamax cranes can weigh 1,400 metric tons; reducing this unnecessary weight would cut energy use.[15]

Locomotive and Ship Efficiency[16]

Significant GHG reductions could be achieved through the use of more efficient trains and ships. Existing rail technologies could yield 13% fuel reductions, while advanced technology could yield even greater reductions of 30 percent. In fact, the Swiss railways forecast up to 60% efficiency gains through their R&D on lightweighting, cutting drag and friction and optimizing operations.

Marine transportation could save over 30% of fuel through improved hull designs, drag reductions, better engines and propulsors, and other improvements. The shape of a vessel's hull can be modified to best fit its operational and size characteristics, achieving fuel savings of up to 15%. The drawbacks are that hull modifications can be costly, depending on the nature of the work.[17]

Bulbous bows have been used for decades on large vessels. This is essentially a ball attached to the front of the hull, which reduces wave resistance through the "interference effect"—

[15] RMI, April 2007.
[16] Based on Winning the Oil Endgame: Innovation for Profits, Jobs and Security, Rocky Mountain Institute, p. 79.
[17] Bray, Patrick J. The bulbous bow - what is it? *Marine Engineering Page*, January 2003. Available online at: http://members.shaw.ca/diesel-duck/library/articles/bulbous_bows.htm. Last visited on June 21, 2004.

decreasing friction.[18] Many large commercial vessels use the bulbous bow, including an 11 deck car and passenger ferry in Sweden, which has been operating since 1996.[19]

Emission reduction calculations and assumptions:

CARB estimates the following total emissions of CO2e in 2004:[20]

On Road : All diesel vehicles – Distillate:	29.0 MMT CO2e
Rail – Distillate:	3.2 MMT CO2e
Water – Distillate	0.6 MMT CO2e
Water - Residual Fuel Oil	0.7 MMT CO2e
Total Freight Related Emissions[21]	***33.5 MMT CO2e***

The following reductions would occur if these measures were in place:

Measure	***Estimated Reductions (MMT CO2e, 2004)***
1) Improve freight logistics, reducing heavy-duty diesel truck fuel by 2 %	0.58
2) Electrify 10% of the heavy-duty diesel truck fleet, assuming that CO2 is reduced by a factor of 3.5 for these trucks.	2.03
3) Reduce container weight for 50 percent of the heavy-duty truck fleet, such that average fully loaded container weight is reduced by 10% (and therefore fuel use is reduced by 10%)	1.42
4) Electrify 20% of cargo rail, such that CO2 is reduced by a factor of 3.5	0.45
5) Reduce container weight for 20 percent of freight rail containers, such that average fully loaded container weight is reduced by 10% (and therefore fuel use is reduced by 10%)	0.05
6) Improve Rail efficiency by 45%	1.23
7) Improve Marine Vessel efficiency by 30%	0.39
Total	***6.15***

Cost effectiveness calculation and assumptions:

Implementation barriers and ways to overcome them:

Potential impacts on criteria pollutants:

Emissions associated with the freight transport industry include NOx, SOx, VOC, and PM, all of which would presumably be reduced.

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[18] Rainer, Grabert. *Hull Form Opti misation of Ferries Using CFD*. Available online at: http://www.sva-potsdam.de/news/CFD-Opt.pdf. Last visited on June 23, 2004.

[19] Ship-Technology. *Stena Jutlandica Train, Vehicle, and Passenger Ferry*. Available online at: http://www.ship-technology.com/projects/jutlandica/. Last visited on June 30, 2004.

[20] DRAFT California Greenhouse Gas Inventory (millions of metric tonnes of CO2 equivalent) - By IPCC Category, Last updated 8/22/2007.

[21] Note that some emissions within these categories may be unrelated to freight transport; however, we believe these to be a very minor proportion of the total.

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