



## **GREEN URBAN TRANSIT**

**HERZLIYA – TEL AVIV – RISHON LEZION**

**HYBRID BUSES/CABS SIMULATION AND TEST PROPOSAL**

submitted to

Mr. Gideon Ezra – Minister of Environment Protection

By

Prof. Arie Lavie, Prof. Herbert Fox and Dr. Ilan Maoz

Tel.: 972-26452086, Fax: 972-2-6452489, E-mail: [arlavie@zahav.net.il](mailto:arlavie@zahav.net.il)



**C.T.I. – Creative Technologies Israel Ltd.**  
49 Dagan St.  
93856 Jerusalem  
Israel

**סי.טי.אי. – קריאטיב טכנולוג'ים ישראל בע"מ**  
רח' דגן 49  
ירושלים 93856  
ישראל

### **List of submitted copies**

1. Mr. Shimon Peres - President of Israel
2. Mr. Ehud Olmert - Prime Minister of Israel
3. Mr. Rony Bar-On - Minister of Finance
4. General (Ret) Shaul Mofaz - Minister of Transport and Road Safety
5. Ms. Yael Gelman - Mayor of Herzliya
6. Mr. Ron Huldai - Mayor of Tel Aviv - Yafo
7. Mr. Meir Nizan - Mayor of Rishon Lezion

Tel.: 972-26452086, Fax: 972-2-6452489, E-mail: [arlavie@zahav.net.il](mailto:arlavie@zahav.net.il)

## 1. INTRODUCTION

The present proposal is aiming to introduce Green Urban Transit based on new hybrid electric buses in various routes in Israel, and specifically in Herzliya-Tel Aviv-Rishon Lezion. Such purchases have been and are being currently considered in many cities in USA, including New York, because of the need to conserve diesel fuel, because the hybrids produce significantly less air pollution and because these buses may offer savings in maintenance costs. Following there are presented the achieved results by New York City Transit (NYCT), where hundreds of hybrid green buses operate.

The Clean Fuel Solution - Hybrid Electric NYCT:

- Hybrid Electric buses combine a diesel engine and electric drive components
- Improved performance
  - Significant emissions reduction
  - Increased fuel economy
  - Smooth and quiet operation
- Avoids the infrastructure costs of CNG - no special fuel handling is required

### Orion VI/BAE Hybrid Bus in New York



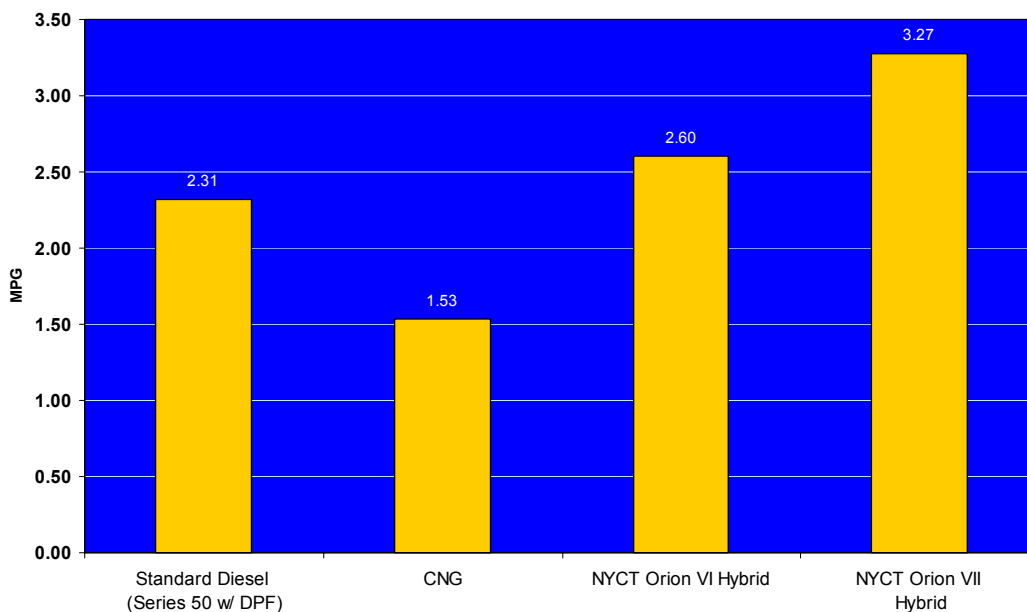


**C.T.I. – Creative Technologies Israel Ltd.**  
 49 Dagan St.  
 93856 Jerusalem  
 Israel

**סי.טי.אי. – קריאטיב טכנולוג'ים ישראל בע"מ**  
 רח' דגן 49  
 ירושלים 93856  
 ישראל

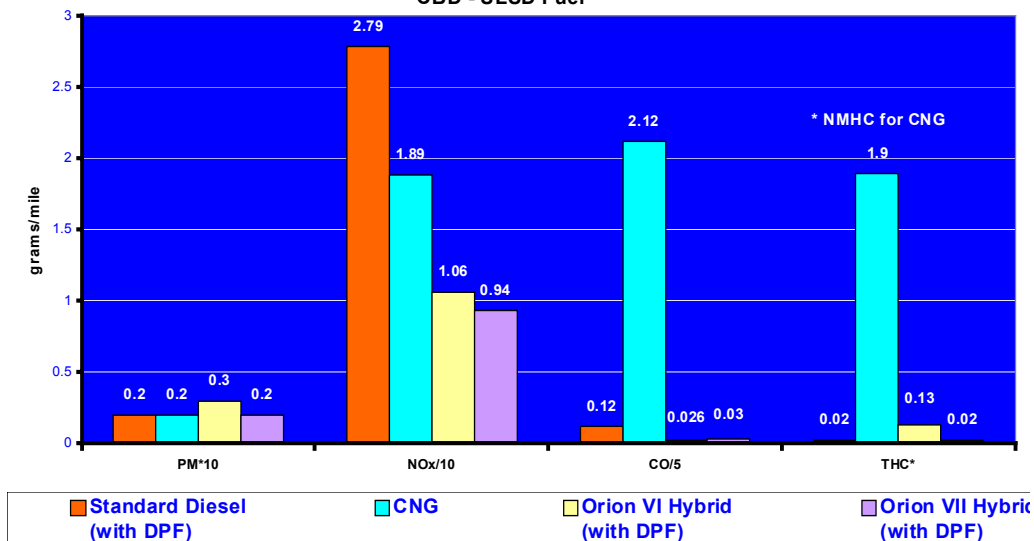
## Hybrid Bus Fuel Economy (MPG)

### In-Service Fuel Economy at NYCT



## Hybrid Emissions Results

### Standard vs Hybrid Emissions CBD - ULSD Fuel



Tel.: 972-26452086, Fax: 972-2-6452489, E-mail: [arlavie@zahav.net.il](mailto:arlavie@zahav.net.il)



**C.T.I. – Creative Technologies Israel Ltd.**  
49 Dagan St.  
93856 Jerusalem  
Israel

**סי.טי.אי. – קריאטיב טכנולוג'ים ישראל בע"מ**  
רח' דגן 49  
ירושלים 93856  
ישראל

The project team, proposed here, has already carried out a simulation of some buses that might be selected for use in these Israeli cities, including the buses introduced in New York In order to choose an optimal bus for operations in Israel, at least two such vehicles should be purchased and tested. However, there are many hybrid buses available on the market these days. As a consequence simulation is in order to assist in the selection process. The simulation we are currently performing is based on PSAT (Powertrain System Analysis Toolkit) software developed by the United States Department of Energy Argonne National Laboratory, is validated code and compares well with tested vehicles. It permits a variety of duty cycles to be employed so that various operations can be compared for these buses. This permits the best use of funds for the potential long term replacement of most of the buses within the country.

This proposal consists of two phases:

Phase 1: Simulation and test design of various hybrid-electric buses and cabs as following suggested.

Phase 2: Test of 2 hybrid-electric buses as to be recommended following phase 1.

At first we selected four possible hybrid electric buses for simulation to be used as Inter-City bus Herzelia-Tel Aviv or Tel-Aviv-Rishon Lezion. These are all 60 ft, articulated vehicles:

- # NABI 60 LFW (diesel)
- # New Flyer DE60LF (hybrid)
- # New Flyer DE60LF-BRT (hybrid)
- # Wrightbus StreetCar RTV (hybrid)

This first was chosen so that a comparison of results with a straight diesel could be obtained. The others were selected as typical of those available for purchase and use in Israel. The purpose of this proposal is to expand the original scope of work and look at additional simulations in two distinct areas. The first would be to add to the number of buses simulated in the first step. This would permit more vehicles to be assessed and provide a wider choice to select buses for operations within Israel.

The suggested Inter-City buses are presented also in our other proposal to develop “Green Transportation Corridor” submitted to the Prime Minister of Israel.

Tel.: 972-26452086, Fax: 972-2-6452489, E-mail: [arlavie@zahav.net.il](mailto:arlavie@zahav.net.il)



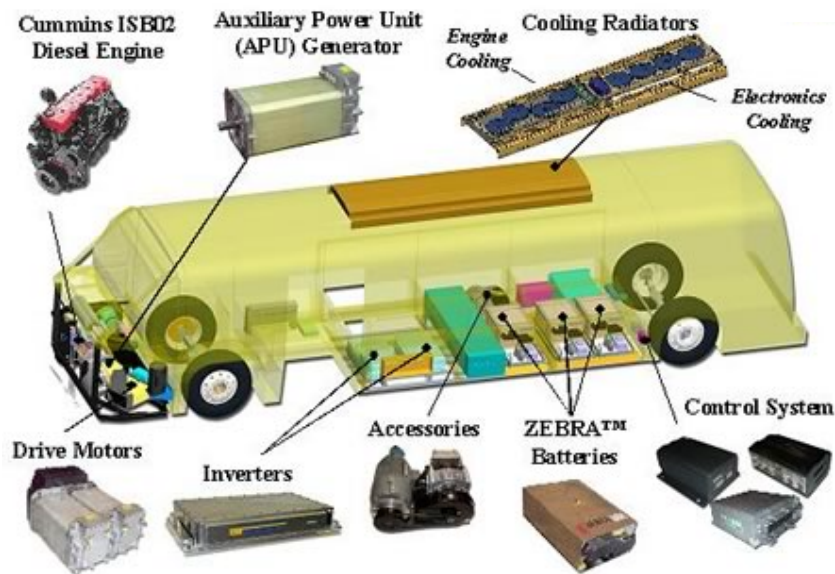
C.T.I. – Creative Technologies Israel Ltd.  
49 Dagan St.  
93856 Jerusalem  
Israel

סי.טי.אי. – קריאטיב טכנולוג'ים ישראל בע"מ  
רח' דגן 49  
ירושלים 93856  
ישראל

## UK “STREETCAR” HYBRID BUS FOR RAPID TRANSIT



### SIEMENS Diesel Hybrid-Electric Drive System



Tel.: 972-26452086, Fax: 972-2-6452489, E-mail: [arlavie@zahav.net.il](mailto:arlavie@zahav.net.il)



**C.T.I. – Creative Technologies Israel Ltd.**  
49 Dagan St.  
93856 Jerusalem  
Israel

**סי.טי.אי. – קריאטיב טכנולוג'ים ישראל בע"מ**  
רח' דגן 49  
ירושלים 93856  
ישראל

The second part of this new proposal would be to look at what other world cities are doing to deal with issues of global climate change in their mass transit systems that look beyond bus transit. Here we refer, in particular, to new policies being adopted in New York City by both the Mayor and the New York Transit Authority to require all taxi cabs operating within city limits to be hybrid vehicles. This, of course, leads to a much cleaner environment within center city especially when we realize that hybrids operate optimally at non-highway speeds, typical of urban traffic. As before, we should be emphasize that the team proposed for this effort plans to work closely with the Ministry of Environment Protection to be sure that needs are met. In addition a full economic study will be provided within phase 1 of the proposed project to analyze the economic aspects when hybrid-electric buses and cabs are introduced for green urban transit in Israel.

The remainder of this proposal is outlined as follows:

- # In Section 2 we identify the buses to be selected for additional simulation and the nature of the cabs to be selected for hybrid simulation in the city center. Potential outputs are identified for this work.
- # Section 3 provides a discussion of the various deliverables.
- # In Section 4 a budget and schedule are provided.



**C.T.I. – Creative Technologies Israel Ltd.**  
49 Dagan St.  
93856 Jerusalem  
Israel

**סי.טי.אי. – קריאטיב טכנולוג'ים ישראל בע"מ**  
רח' דגן 49  
ירושלים 93856  
ישראל

## **2. PROJECT DETAILS**

In this section we briefly address the simulation software to be used, the buses to be simulated, the cabs to be modeled and the outputs to be derived. This will offer a scope of work to be delivered to the Ministry of Environment Protection.

### **2.1 Simulation software**

As noted in our “Green Transportation Corridor: proposal, we selected PSAT (Powertrain System Analysis Toolkit) for this project. For completeness here, it is perhaps worthwhile to summarize some of the characteristics of this package. Because of time and cost constraints, designers cannot build and test each of the many possible powertrain configurations for advanced vehicles. Thus, developing fuel cell and hybrid electric vehicles (HEVs) requires accurate, flexible simulation tools. Argonne National Laboratory of the United States Department of Energy (USDOE) undertook a collaborative effort to develop the Powertrain System Analysis Toolkit © (PSAT) under the direction of and with contributions from Ford, General Motors, and DaimlerChrysler. PSAT is sponsored by USDOE.

After a thorough assessment, DOE selected PSAT as its primary vehicle simulation tool to support FreedomCAR and Fuels Partnership activities. PSAT has been used for numerous studies to assist DOE in identifying future research directions regarding HEVs as well as Plug-in HEVs. In addition, PSAT received an R&D 100 Award in 2004, ranking it among the 100 best newly available products and technologies from around the world. PSAT is currently used by more than 300 researchers worldwide in more than 60 companies and universities.

PSAT is a "forward-looking" model that simulates fuel economy and performance in a realistic manner, taking into account transient behavior and control system characteristics. It can simulate an unrivaled number of predefined configurations (conventional, electric, fuel cell, series hybrid, parallel hybrid, and power split hybrid). Because of its forward architecture, PSAT component interactions are "real world."

Because of its accurate dynamic component models, PSAT can be implemented directly and tested at the bench scale or in a vehicle (using its extension for prototyping, PSAT-PRO). This ability supports an ambitious development goal for PSAT — to be transportable from the virtual world of component modeling and simulation to the emulated environment of component control in hardware-in-the-loop (HIL) testing in PSAT-PRO and then to the physical environment of full powertrain control in a vehicle in Argonne's Advanced Powertrain Test Facility.

This capability, when combined with the engineering, development, and testing resources at Argonne, substantially enhances DOE's ability to assess the potential of advanced automotive technologies and streamline the development process for promising technologies. Moreover,

Tel.: 972-26452086, Fax: 972-2-6452489, E-mail: [arlavie@zahav.net.il](mailto:arlavie@zahav.net.il)



**C.T.I. – Creative Technologies Israel Ltd.**  
49 Dagan St.  
93856 Jerusalem  
Israel

**סי.טי.אי. – קריאטיב טכנולוג'ים ישראל בע"מ**  
רח' דגן 49  
ירושלים 93856  
ישראל

PSAT has provided significant benefits to industry vehicle designers and university researchers as evidenced by their growing use of PSAT for both production-oriented and research design activities.

### Key Features

- Forward-looking model
- Written in MATLAB, Simulink, and StateFlow to ensure modularity and flexibility
- Wide range of vehicle applications including light- (two- and four-wheel-drive), medium-, and heavy-duty vehicles
- User-friendly graphical user interface written in C#
- Complete Simulink models and data sets provided
- Multiple-option component model libraries
- Designed for co-simulation environments

### 2.2 Buses selected for simulation in Part 2

We have selected four additional hybrid electric buses to supplement our simulation project proposed in section 1 above. These are all 40 ft vehicles:

- # New Flyer hybrid 40 ft bus (with Allison hybrid parallel transmission)
- # ISE hybrid 40 ft bus (with Siemens series diesel hybrid-electric drive)
- # Wright-Group hybrid single deck bus
- # Wright-Group hybrid double deck bus

Note the unique double deck Wright bus. This can serve in many of the same ways that the longer 60 ft articulated vehicles do. We will compare results here with those obtained from the original simulation project and use a traditional diesel 40 ft bus (similar to what is currently operated in Jerusalem, probably MAN) as the baseline.

Following some information regarding the Wright Group Hybrid Electric – HEV buses is provided. Offering quiet, low-emission drivelines, the hybrid-electric range has been designed and developed to meet the industry's ever stricter emissions targets. Now available as single deck, double deck and StreetCar RTV, the range provides operators with an economically viable, environmentally friendly alternative.

Tel.: 972-26452086, Fax: 972-2-6452489, E-mail: [arlavie@zahav.net.il](mailto:arlavie@zahav.net.il)



**C.T.I. – Creative Technologies Israel Ltd.**  
 49 Dagan St.  
 93856 Jerusalem  
 Israel

**סי.טי.אי. – קריאטיב טכנולוג'ים ישראל בע"מ**  
 רח' דגן 49  
 ירושלים 93856  
 ישראל

<b>Pulsar Gemini HEV</b>	
<b>Body Length(s)</b>	10.3m
<b>Maximum Capacity</b>	82
<b>Maximum Seated</b>	43/21
<b>Maximum Standees</b>	18

<b>Electricity</b> (Traditional style single deck)	
<b>Body Length(s)</b>	10.3m
<b>Maximum Capacity</b>	57
<b>Maximum Seated</b>	26
<b>Maximum Standees</b>	31

<b>Pulsar HEV</b>	
<b>Body Length(s)</b>	10.3m
<b>Maximum Capacity</b>	58
<b>Maximum Seated</b>	28
<b>Maximum Standees</b>	30



### 2.3 Taxi cab simulation

As noted earlier in Section 1, some major cities in the United States are requiring all taxi cabs to transition to hybrid transmissions over the next several years. The purpose of such regulations is to help improve the environment, decrease the amount of greenhouse gases emitted and generally provide for a better air quality.

In the United States, there are three such cabs available for use; these are made by Toyota, Ford and Honda. In this component of the work scope we would simulate these vehicles and compare their performance to the typical Mercedes cabs that now operate throughout Israel. In addition to looking at performance, some computation will be included to estimate the overall improvement in emissions should policies similar to those in New York be adopted in Jerusalem or Tel Aviv.

While we do not wish to overburden this preliminary proposal with results from other studies, it is instructive to see some data from other hybrid simulations. These, provided by the PSAT developers, and shown in Exhibits 1 and 2, below, present fuel economy and state-of-charge for

Tel.: 972-26452086, Fax: 972-2-6452489, E-mail: [arlavie@zahav.net.il](mailto:arlavie@zahav.net.il)



**C.T.I. – Creative Technologies Israel Ltd.**  
 49 Dagan St.  
 93856 Jerusalem  
 Israel

**סי.טי.אי. – קריאטיב טכנולוג'ים ישראל בע"מ**  
 רח' דגן 49  
 ירושלים 93856  
 ישראל

both the Toyota Prius and the Honda Insight under a variety of driving cycles.

### Toyota Prius Results

Drive cycles	Fuel consumption mpg		Percent difference	State of charge		Percent difference
	Test	Simulation		Test	Simulation	
Japan 10-15	44.9	45.1	0.4	0.580	0.583	0.5
EUDC	44.0	43.8	0.4	0.605	0.593	2.0
FHDS	48.2	46.7	3.2	0.571	0.573	0.3

### Honda Insight Results

Drive cycles	Fuel consumption mpg		Percent difference	State of charge		Percent difference
	Test	Simulation		Test	Simulation	
Japan 10-15	57.9	58.8	1.5	0.610	0.611	0.4
NEDC	60.6	60.2	0.6	0.602	0.583	3.6
FHDS	74.2	75.3	1.4	0.588	0.589	0.2
FUDS	58.3	57.8	0.8	0.706	0.720	2.0

Following is a description of the Toyota CAMRY hybrid car recently launched for sale in 2008. It should be emphasized that the CAMRY is a good option for city cab and its price is low.

## CAMRY 08

**Commonly chosen.  
Uncommonly engineered**

VISIT THE CAMRY DISCOVERY CENTER -  
ENGINEERING HAS NEVER BEEN THIS ENTERTAINING.

**+ EXPERIENCE EVERYTHING INSIDE**



  
**Camry**  
 \$18,570 MSRP [1]

  
**Camry LE**  
 \$20,025 MSRP [1]

  
**Camry SE**  
 \$21,240 MSRP [1]

  
**Camry XLE**  
 \$25,000 MSRP [1]

  
**Camry Hybrid**  
 \$25,200 MSRP [1]

Tel.: 972-26452086, Fax: 972-2-6452489, E-mail: [arlavie@zahav.net.il](mailto:arlavie@zahav.net.il)



**C.T.I. – Creative Technologies Israel Ltd.**  
49 Dagan St.  
93856 Jerusalem  
Israel

**ס.י.טי.אי. – קריאטיב טכנולוג'ים ישראל בע"מ**  
רח' דגן 49  
ירושלים 93856  
ישראל

## 2.4 Scope of work

2.4.1 At phase 1 each of the vehicles selected will be modeled within the PSAT framework. Outputs will include

- # Fuel economy
- # Emissions
- # State of charge, as required
- # Operations under several duty cycles, e.g., traditional cycles used in the United States, plus those derived for application to Israeli cities
- # Additional data that might be useful as derived from application of the PSAT software.
- # Measures of environmental improvement for the taxi cab fleet.
- # Economic aspects of introducing hybrid electric buses
- # Test design of 2 hybrid electric buses to be recommended for purchase
- # Preliminary considerations for operating Green Urban Transit Herzelia-Tel Aviv-Rishon Lezion

2.4.2 At phase 2 two Hybrid-Electric buses will be purchased and tested according to the design prepared in phase 1.



**C.T.I. – Creative Technologies Israel Ltd.**  
49 Dagan St.  
93856 Jerusalem  
Israel

**סי.טי.אי. – קריאטיב טכנולוג'ים ישראל בע"מ**  
רח' דגן 49  
ירושלים 93856  
ישראל

### **3. DELIVERABLES**

The major deliverables for this effort will include a report detailing the following typical items:

- # Details of the duty cycles selected.
- # Emission results for each bus, compared and contrasted; note that these include particulates, CO<sub>2</sub>, unburned hydrocarbons and NO<sub>x</sub>.
- # Emission results for each taxi cab, compared and contrasted; note that these include particulates, CO<sub>2</sub>, unburned hydrocarbons and NO<sub>x</sub>.
- # Fuel economy for each of the vehicles compared and contrasted.
- # State of charge and requirements therefor for each of the buses and taxis.
- # Overall estimates for potential environmental improvement: quantity of CO<sub>2</sub> unburned hydrocarbons and NO<sub>x</sub> saved.
- # Economic aspects study regarding possible operation of Green Urban Transit
- # Test design of 2 electric buses to be purchased and tested in Israel.
- # Analysis of environmental aspects when “Green Urban Transit” is operated in Herzelia-Tel Aviv-Rishon Lezion.

Other results will be developed based on discussion with the Ministry of Environment Protection to be sure that we meet the needs of the Ministry.



**C.T.I. – Creative Technologies Israel Ltd.**  
49 Dagan St.  
93856 Jerusalem  
Israel

**סי.טי.אי. – קריאטיב טכנולוג'ים ישראל בע"מ**  
רח' דגן 49  
ירושלים 93856  
ישראל

#### **4. SCHEDULE AND BUDGET**

- 4.1 The simulation and test design project will prolong 12 months. The total working effort in the simulation and test design project will be \$200,000.
- 4.2 Thereafter one Inter-City Hybrid Bus and one City Hybrid Bus will be purchased and tested according to the test design in phase 1. The cost of the test (including purchase of the two buses) will be \$2,500,000.

Tel.: 972-26452086, Fax: 972-2-6452489, E-mail: [arlavie@zahav.net.il](mailto:arlavie@zahav.net.il)