



# Analytical Support for the Think Line of Zero-Emission Vehicles

DOE supports development of battery electric and fuel cell vehicles

ENERGY EFFICIENCY AND RENEWABLE ENERGY

OFFICE OF TRANSPORTATION TECHNOLOGIES



## Transportation FOR THE 21ST CENTURY

### Background

Electric vehicles (EVs) were recognized as a potential alternative to petroleum-powered cars and trucks during the oil crisis of the 1970s. Several decades of government/industry collaboration have resulted in significant improvements in EV technology. While full-size EVs are now very reliable and efficient, both their purchase price and replacement batteries are still too costly to be fully accepted by consumers. Also, their range is generally insufficient because of the poor energy density of the batteries, and the time for battery recharging is too long.

Recently, however, a separate line of smaller, low-speed vehicles called LSV's (low speed vehicles) or NEV's (neighborhood electric vehicles) have begun to compete in certain sectors of the commercial vehicle market. TH!NK vehicles were designed to meet the needs of niche markets, such as in small towns and on college campuses, where their zero emissions and quiet operation support good environmental quality. The U.S. Department of Energy was involved in certain energy savings aspects of the TH!NK technology, particularly for the chassis and for the propulsion system.

The National Renewable Energy Laboratory's (NREL's) vehicle systems analysis team worked together with the Transportation Design and Manufacturing Company (TDM), which was under a tight schedule to design the TH!NK technology for the Ford Motor Company. NREL's team introduced math-based energy saving ideas early in the design stage. These technologies, integrated into the product-development process, enabled the FORD/TDM team to rapidly incorporate innovative designs and produce a high quality product with minimum energy use.

### The Technology

NREL's team helped industry size the motor and minimize the vehicle weight

without sacrificing safety or performance on the TH!NK *Neighbor* vehicle. ADVISOR, an NREL-developed, vehicle-systems analysis program, was used for motor sizing and evaluation of voltage reduction without range reduction. Behavioral Modeling Extension (BMX) from PTC enabled the team to perform design synthesis and produce CAD designs that were correct the first time. This process was introduced in the chassis design for multifunctional attribute balancing, and halved the time for the definition and development stage. Topology Optimization and Probabilistic Design System from ANSYS, Inc., were used, respectively, to form the optimum shape of components based on the available space and loading, and to achieve six-sigma quality designs by incorporating manufacturing and material variations into the analysis and design stage. This results in a lighter weight more energy efficient product meeting all of the performance targets, and an improved process that can be applied to other vehicle designs.

The TH!NK *Neighbor* offers a 72-volt system, a top speed of 25 mph, and hill-climbing torque. Its zero-emission electric power accelerates from 0 to 20 mph in 6 seconds using electronic speed control with an accelerator pedal. The *Neighbor* achieves a 30-mile range on a single charge. A typical charge is 4 to 6 hours.

### Commercialization

The TH!NK *Neighbor* electric vehicle is offered with two or four seats and is available this year through Ford Division dealers in selected markets. Safety features include a high-profile roof, headlights, and taillights. Its convenience and low price will be attractive to consumers who want a mode of transportation for residential and community roadways.

### Benefits

- Each TH!NK vehicle saves more than 100 gallons of gasoline per year
- TH!NK EVs produce zero emissions
- The vehicles use recyclable batteries and thermoplastic body panels
- Optimizing the vehicle for energy savings/efficiency up-front has major impacts
- Math-based tools can accelerate the time to market for energy efficient designs



The low-speed, zero-emission TH!NK Neighbor vehicle

### Contacts:

#### Robert Kost

Office of Transportation Technologies  
(202) 586-2334  
Robert.Kost@ee.doe.gov

#### Keith Wipke

National Renewable Energy Laboratory  
(303) 275-4451  
keith\_wipke@nrel.gov