BATTERIES

Practical electric car battery likely by 1990

The probability that at least one of the batteries now being developed will be incorporated into a commercially successful electric vehicle by 1990 is greater than 75%, predicts William J. Walsh of Argonne National Laboratory's energy and environmental systems division.

But, Walsh told his audience at the American Physical Society meeting in Washington, D.C., which of the batteries under development eventually will reach the market in electric vehicles is much harder to predict. At least 37 different batteries have been suggested for vehicle applications, and all have problems to overcome before they will be practical.

The probability of any particular battery's reaching successful commercial development is less than 50% in every case, Walsh says. "In reality, each of these battery development efforts is a high-risk enterprise with major electrical performance, cycle life, or cost barriers," he says.

Although he predicts that vastly improved electric vehicles will be on the market as early as 1985, Walsh also says, "The gasoline-powered vehicle will probably continue to predominate [the market] until gasoline becomes scarce or much more expensive. Market penetrations of millions of electric vehicles are likely by 2000."

Besides improvements in batteries, the next 10 years likely will bring other advances in electric vehicle technology. Among these are efficient motor/controller systems; improved aerodynamics, rolling resistance, and transmission efficiency; and greater use of lightweight components.

The leading battery contenders for electric cars remain the ones that have looked most promising for the past several years. These are lead-acid, nickel-iron, and nickel-zinc batteries for development by 1985 and zinc-chlorine, lithium-metal sulfide, and sodium-sulfur using a ceramic electrolyte by 2000.

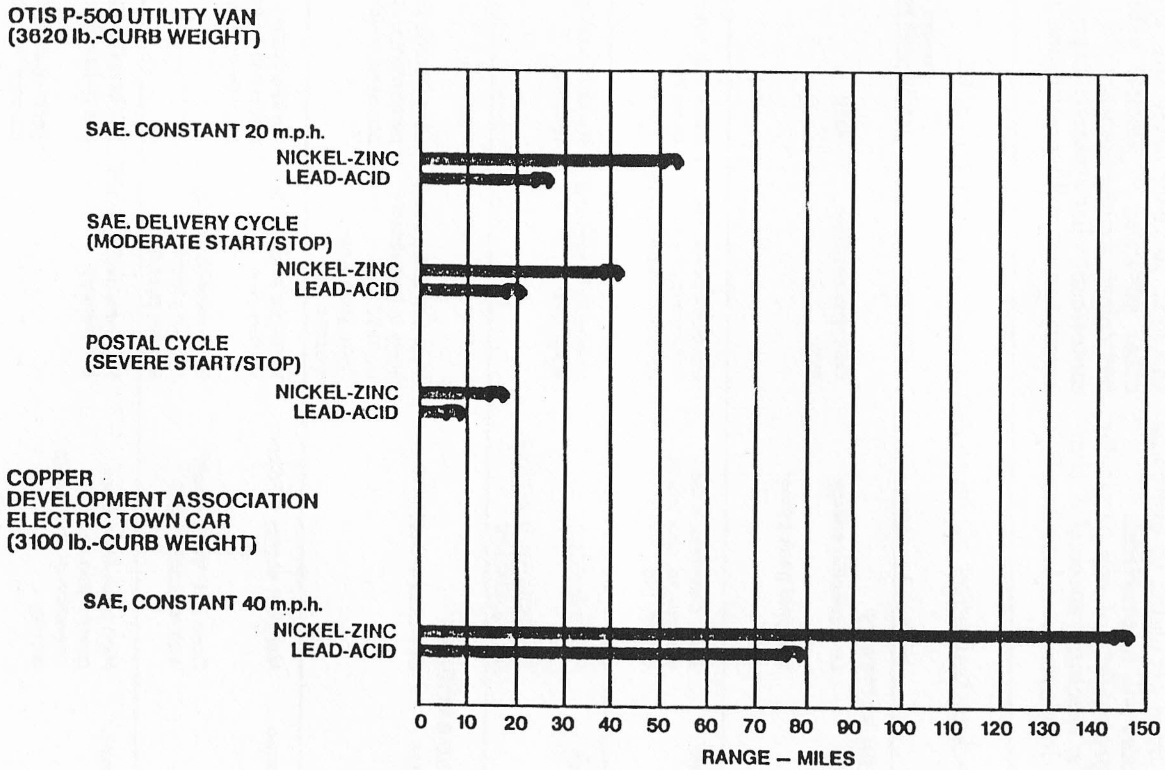
Few of the other battery candidates are likely to be commercialized successfully by the end of the century, Walsh says, unless major technical breakthroughs greatly improve their prospects. Among the others, he picks as most promising sodium-sulfur using a glass electrolyte, zinc-bromine, iron-air, aluminum-air, and lithium-titanium disulfide. ◻

Contending batteries all have advantages and drawbacks

Type	Inherent drawbacks	Advantages	Needed technological advances	Comments
NEAR-TERM BATTERIES				
Lead acid	Low specific energy Marginal peak power	Only type available now	None	Best suited for commercial fleets with a range of <100 miles Environmental problems with lead mining and battery manufacture could be harmful
Nickel/zinc	ZnO_2 dissolves in the electrolyte, shortening battery life	Excellent power and volumetric energy density characteristics	Major improvement in cycle life	Leading candidate for near-term transportation applications Little nickel is available in U.S.
Nickel/iron	High initial cost Hydrogen gas is evolved during charging	Inherently rugged and long-lived	Reduce gassing during charging	Invented by Edison in 1901; now in mature state of development Nickel shortages would affect more severely than nickel/zinc
ADVANCED BATTERIES				
Lithium/iron sulfide	Operates at >400° C	Most compact battery likely to be available by 1990 Safe, even when crushed	Long lifetime and high performance not yet achieved in same battery	Most promising of intermediate-term batteries First road tests slated for 1979
Zinc/chlorine	Marginal energy efficiency Does not "scale-down" well for vehicle use	Materials available and inexpensive Good specific energy and long lifetime appear possible	Serious hazard of chlorine release in an accident must be overcome	Better suited for electric utility load leveling than for transportation
Sodium/sulfur	High peak-to-average power ratio requires operation at low energy density Sodium hazard in an accident very great	Materials available and inexpensive	Lower corrosion of positive electrode Improve durability of ceramic electrolyte Establish sodium safety in an accident	Better suited for electric utility load leveling than for transportation

NASA's work with Kimberly Clark, a paper manufacturer, indicates that the separator material can be mass-produced using known production techniques at an acceptable cost. Electrode costs, however, must be reduced further. Some progress has already been made in reducing the cost of the nickel electrode, but additional work on the zinc electrode is needed.

One interesting area to be explored is fast charging. NASA envisions recharging an electric vehicle battery pack at a service station in 20 minutes while the driver sips a cup of coffee. This would mean electric vehicles with unlimited range. Although preliminary indications are that a 20-minute charge is technically feasible, the full implications of fast charging are yet unknown.



NASA NICKEL - ZINC BATTERY TECHNOLOGY:

AN ENERGY BOOST FOR ELECTRIC VEHICLES

National Aeronautics and Space Administration

Lewis Research Center
Cleveland, Ohio

ANL/OEPM-80-17

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ANNUAL REPORT FOR 1980 ON RESEARCH, DEVELOPMENT, AND DEMONSTRATION OF NICKEL-IRON BATTERIES FOR ELECTRIC VEHICLE PROPULSION

Contract No. 31-109-38-4141

by

Westinghouse Electric Corporation

ARGONNE NATIONAL LABORATORY

ARGONNE NATIONAL LABORATORY, ARGONNE, ILLINOIS

Operated for the U. S. DEPARTMENT OF ENERGY
under Contract W-31-109-Eng-38

1.0 EXECUTIVE SUMMARY

The basic program objective is to accelerate the development of nickel-iron batteries and demonstrate improved performance features in electric vehicle battery systems. The Near term EV Battery Development goals based on the DOE/ETV-1 performance to be achieved by FY 1986 are:

56 Wh/kg	gravimetric energy density at C/3 rate
100 wh/l	volumetric energy density
104 w/kg	power density at 50% state of charge
800 cycles	life at 80% DOD cycles
70 $/kwh	1977 $ OEM selling price

The development approach was to utilize established Westinghouse technology that is capable of meeting the performance, life and cost objectives. The primary features of the Westinghouse design are the use of low cost raw materials, minimal use of nickel, and utilization of established manufacturing processes. A typical example is the use of sintered steel fiber electrode substrates that provide for a cell design with less than 50 percent the nickel content of other cells containing conventional sintered nickel electrodes.

Performance improvements achieved since initiation of contract, and demonstrated in cells and multi-cell modules at Westinghouse, include: 1) >30% increase in gravimetric energy density to 61 Wh/kg, 2) 70% increase in volumetric energy density to 120 Wh/l, and 3) a 5% increase in power density to 105 W/kg. In addition, a conceptual design has been established for a multi-cell modular package that can further enhance these performance parameters by providing additional 9% weight and 15% volume reductions.

The demonstrated performance at NBTL has indicated that an electric vehicle with characteristics similar to DOE ETV-1, with a Westinghouse nickel-iron battery, could attain a 100 mile range on the SAE J227a "D" cycle.

ANL/OEPM-80-10

ANL/OEPM-80-10

ANNUAL REPORT FOR 1980 ON RESEARCH, DEVELOPMENT, AND DEMONSTRATION OF LEAD-ACID BATTERIES FOR ELECTRIC VEHICLE PROPULSION

Contract No. 31-109-38-4206

by

C&D Batteries Division

of

Eltra Corporation

ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue, Argonne, Illinois 60439

ARGONNE NATIONAL LABORATORY, ARGONNE, ILLINOIS

Operated for the U. S. DEPARTMENT OF ENERGY
under Contract W-31-109-Eng-38

TABLE 1

ANL TECHNICAL GOALS

		ISOA	ADVANCED
1.	Battery Capacity (kW-hr)*	20-30	30-40
2.	Battery Dimension (HxWxL cm)	29.5 x 40.6 x 264	
3.	Specific Energy* (W-hr/kg)	40	60
4.	Specific Power (W/kg)		
	Sustaining	20	30
	Peak (15 sec. avg.)	100	150
5.	Duty Cycle		
	Charge (hr)	4 - 8	4 - 8
	Discharge (hr)	2 - 4	2 - 4
6.	Cycle Life	800	1000
7.	Cost/Energy ($/kW-hr)**	50	40
8.	Energy Efficiency (%)	60	60
9.	Typical Installation Voltage	96 - 120V	96 - 120V

* 3 hr rate discharge
** based on 1978 price of lead

ANL/OEPM-80-5 ANL/OEPM-80-5

DEVELOPMENT OF NEAR-TERM BATTERIES FOR ELECTRIC VEHICLES

Summary Report
October 1977—September 1979

ARGONNE NATIONAL LABORATORY

ARGONNE NATIONAL LABORATORY, ARGONNE, ILLINOIS

Prepared for the U. S. DEPARTMENT OF ENERGY
under Contract W-31-109-Eng-38

Table III-1. Testing of Cells at NBTL for June 1978 to October 1979

Contractor	System	Number of Cells[a]	Nominal Rated Cell Capacity Ah
Eltra, C&D	Lead-Acid	9	165
ESB	Lead-Acid	15	180
Globe-Union/GE	Lead-Acid	6	174
Globe-Union	Lead-Acid	5	250
Eagle-Picher	Ni/Fe	6	280
Westinghouse	Ni/Fe	6	220
Eagle-Picher	Ni/Zn	20	225
ERC	Ni/Zn	34	240
Gould	Ni/Zn	20	400
Yardney	Ni/Zn	24	250

[a]These cells have been tested or are under test at the NBTL.

ANL/OEPM-80-11

ANL/OEPM-80-11

ANNUAL REPORT FOR 1980 ON RESEARCH, DEVELOPMENT, AND DEMONSTRATION OF LEAD-ACID BATTERIES FOR ELECTRIC VEHICLE PROPULSION

Contract No. 31-109-38-4207

by

Exide Management and Technology Company

ARGONNE
NATIONAL
LABORATORY

ARGONNE NATIONAL LABORATORY, ARGONNE, ILLINOIS

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SUMMARY AND CONCLUSIONS

The following summary may be drawn as a result of the original Phase A study and the Phase B study reported herein:

(1) Useful mathematical models for the performance of grid-pairs have been developed for orthogonal grids and for radial grids composed of linear elements.

(2) Experimental results for the potential distribution (voltage drops) in a pasted orthogonal (ACGW) grid pair were within 25 percent of values calculated from the model.

(3) The calculated voltage drop between the positive and negative plates of an EVR radial grid pair is at least 0.1 volt lower than that through an orthogonal grid pair of the same weight and overall dimensions.

(4) An experimental non-orthogonal (radial) grid with some non-linear elements, designed and cast at Battelle, and pasted at Exide, had voltage drops of 34 to 48 percent less than a positive orthogonal (ACGW) grid on a pseudo-normalized dimension/weight basis. (Pasted weight was 3.6% larger for the Battelle radial grid with some non-linear elements, but the plate area was 3.8% greater.)

In conclusion, radial grid designs offer the prospect of improved performance for electric vehicle applications because of improved potential and current density distribution for a fixed mass, and given set of overall plate dimensions. Conversely, for a given performance criterion, such as a given voltage drop under load at a fixed rate of discharge, a radial grid can be designed having less mass and smaller dimensions.