ABSTRACT

The results of the GM Sunrayce USA and 1990 World Solar Challenge will be presented. It will include solar array measurements, performance data and vehicle specifications, as well as highlights of the two events. Plans for the next intercollegiate solar car race sponsored by the U.S. Department of Energy (DOE), called Sunrayce '93, will be updated. Results of an economic assessment of PV-assisted electric cars is also summarized.

INTRODUCTION

Three years ago at the IEEE Photovoltaic Specialists Conference held in Las Vegas, the GM Sunraycer was displayed and the team proudly described their accomplishments in the 1987 World Solar Challenge. Since then much has happened. GM Sunrayce USA was announced three months later. Within a year and a-half, thirty-two of North America's best universities built solar cars and, in July 1990, raced from Florida to Detroit. Four months after that, six of the best Sunrayce teams, including the three winners, traveled to Darwin to race across the Australian continent that stretched from Darwin to Adelaide. This year's event had thirty-six competitors from around the world, including eleven entries from Japan, eight from the U.S., and five from Europe. In total, sixty-two different solar racing teams competed in these two events in 1990.

Sunrayce 1990 was won by the team from the University of Michigan. Their "Sunrunner" was impressive. Painted bright yellow, it was a well designed and reliable solar car. The Michigan team drove Sunrunner the entire distance from Florida to Detroit, and then from Darwin to Adelaide, without a design failure of any kind. Its powerful 1140 watt array provided enough energy to maintain steady speeds of 35 to 40 miles per hour under mid-day sunlight.

In second place was a cleverly designed car by the team from Western Washington University, called "Viking XX". They used their solar array to maximum advantage by including as part of their design strategy the ability to drive the car in two directions. Its large slanted array was fixed at approximately 15 degrees from the horizontal. At noon, the car was turned around and driven backwards so that the array would be pointed toward the western sky. This enabled the solar array to face the sun more directly for longer periods of the day. The team originally built their solar array out of hundreds of 14% terrestrial grade cells which generated 1560 watts of electricity under full
sunlight. After winning Sunrayce, the team built a new solar array made out of 17-18% aerospace grade cells which generated 1683 watts of electricity in Australia.

Viking XX achieved the highest recorded speed during Sunrayce. It was clocked at 54 mph at Indianapolis Speedway during the eighth day of the race. The University of Maryland's "Pride of Maryland", which placed third overall, achieved the second highest recorded speed. The Pride of Maryland was clocked at 52 mph at Daytona Speedway to win the pole position for the start of Sunrayce.

WORLD SOLAR CHALLENGE (WSC)

The 1990 WSC was won by "The Spirit of Biel" from the Engineering University of Biel, in Switzerland. Biel's winning time was 46 hours and eight minutes (40.6 ave. mph), one hour and 14 minutes behind Sunraycer's record established in 1987 (41.7 ave. mph). Biel's array was comprised of laser grooved aerospace cells that were connected by overlapping them in shingle style. The combination of high-efficiency cells with a high packing density (97.5%) resulted in an impressive 170 watts per square meter. The sleek, colorful, 401 lb solar racing car was clocked at 63 mph during qualification trials and cruised at 45 mph under mid-day sun.

Second place was captured by an entry from Japan's Honda Corporation. This immaculate, well engineered car was similar in shape to GM's Sunraycer, but with more frontal area. Named "Dream" after the first Honda motorcycle, it was the pre-race favorite because of its huge corporate backing and impressive statistics (304 lbs, 45-48 mph cruising speeds). However, Honda used a relatively small battery and was unable to keep up with the Spirit of Biel under the heavy cloud conditions experienced during the first day of the race.

Michigan's Sunrunner won the third place trophy. The Sunrunner team raced consistently and reliably, just like they did in Sunrayce. Their accomplishment was not easy though. Viking XX and "Phoebus III", an entry built by a Japanese team from the Hoxan solar cell company, were very close the entire race. Sunrunner crossed the finish line with Phoebus III less than five minutes behind them!

A total of six university teams that were in Sunrayce traveled to Australia to compete in the WSC. All of them placed in the top eleven out of a field of thirty-six international competitors. Performance statistics from both races are contained in Tables 1 and 2. The first and second place winning solar cars from each race are shown in Figures 1-4.

Hans Tholstrup, Director of the World Solar Challenge, said in an article in the November 26th, 1990 issue of Australia's Time magazine that the World Solar Challenge was the most important race in the world. He calls solar car racing "brain sport" because it is a race of scientists using concepts and technologies slightly ahead of their time. They also help educate the world that there are alternatives, so I think of it as "racing for the future."

SUNRAYCE '93

On August 19, 1991, the DOE announced Sunrayce '93, an intercollegiate competition of solar-powered cars. Sunrayce '93 is being instituted as an ongoing educational program that will culminate every two years with a cross-country race. The first race will be held June 20-26, 1993, to coincide with the week of the summer solstice. It will start in Texas and finish approximately 1600 kilometers (1000 miles) later in Minnesota. The U.S. Environmental Protection Agency, the National Renewable Energy Laboratory, the Society of Automotive Engineers, and General Motors Corporation will join DOE in sponsoring and organizing the event. This program is open exclusively to colleges, universities, trade schools, and other higher educational institutions in North America. Up to 36 schools will be selected to participate in the 1993 event based on a proposal selection process.

GM Sunrayce USA was the first intercollegiate solar car race held in North America. Based on the students' outstanding accomplishments in building their solar cars and the success of this design competition in motivating students to apply math, science, and engineering skills to the solar car challenge, an expanded program is being instituted. DOE is repeating this exciting educational experience as part of a long-term commitment to support science education, strengthen our Nation's
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<thead>
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<th>POS</th>
<th>SCHOOL NAME</th>
<th>WEIGHT (lbs/kg)</th>
<th>SOLAR ARRAY Power (watts)</th>
<th>BATTERIES Size (kWhr)</th>
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<tbody>
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Battery Key: AgZn = Silver Zinc  
Pb/A = Lead Acid  
Ni/H2 = Nickel Hydrogen  
ZnBr = Zinc Bromide
### TABLE 2
1990 AUSTRALIAN WORLD SOLAR CHALLENGE

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<tr>
<th>POS NO.</th>
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<th>ARRAY POWER (watts)</th>
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Battery Key: AgZn = Silver Zinc  
Pb/A = Lead Acid  
NiZn = Nickel Zinc
Figure 1. Michigan's "Sunrunner"
1st place, GM Sunrayce USA

Figure 2. "Viking XX"
2nd place, GM Sunrayce USA

Figure 3. "Spirit of Biel"
1st place, 1990 WSC.

Figure 4. Honda's "Dream"
2nd place, 1990 WSC.
international competitive position, and develop clean, efficient energy alternatives.

The theme of Sunrayce '93 is "Education, Energy, and the Environment." The goal is to make science education exciting. Accordingly, we hope that Sunrayce '93 will provide hundreds of students throughout North America the chance to challenge the future "hands-on," to display their efforts to the public, and to receive recognition for their accomplishments.

**PV-ASSISTED ELECTRIC VEHICLES**

Solar car competitions not only provide educational benefits and increase public awareness of the potential of solar energy, but the advanced technologies are directly applicable to passenger electric vehicles. For example, the same engineers that designed and built the Sunraycer, which won the 1987 World Solar Challenge, are now designing and building GM's new Impact electric vehicle.

Is the use of photovoltaics on a passenger electric vehicle (see Figure 5) economically viable? To answer that question the DOE contracted JPL to conduct a study to assess the feasibility and calculate the payback periods of adding PV modules to an electric vehicle.(1) A computer model was generated that looked at 3240 different cases. It included eight locations, three array types, three vehicle types, three battery types, five vehicle use patterns and three electricity rates. In certain cases, such as in sunny regions where the vehicle is parked outside, the payback period occurs in less than one year. Obviously, if you drive only at night or park in an underground parking lot, there is no payback.

The largest cost driver in this application is battery life extension. If you can increase the life of a $1200 battery pack from two to four years it will quickly pay for a $600 PV array. The study also found that the harder the car is driven the better the payback. There is less economic value to the application if you drive 15 miles or less each day because with light use the batteries last longer and the solar array isn't used to its full capacity. The best payback resulted in cases where the car was driven 50 miles or more.

**REFERENCE**