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# Ovonic Metal Hydride Technologies for Photovoltaic Energy Storage Applications

Dennis A. Corrigan

Energy Conversion Devices

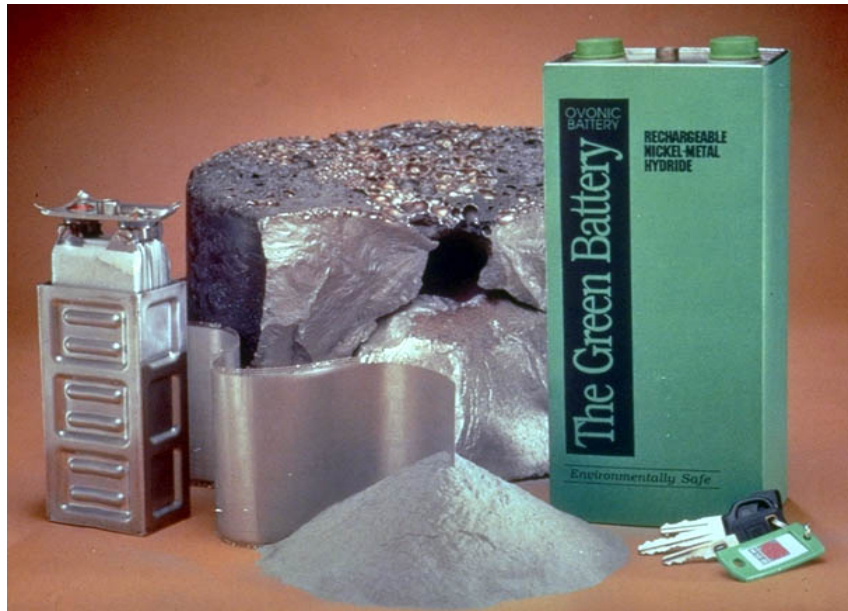
Rochester Hills, Michigan



# Ovonic Metal Hydride Technologies

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## Ovonic™ NiMH Battery

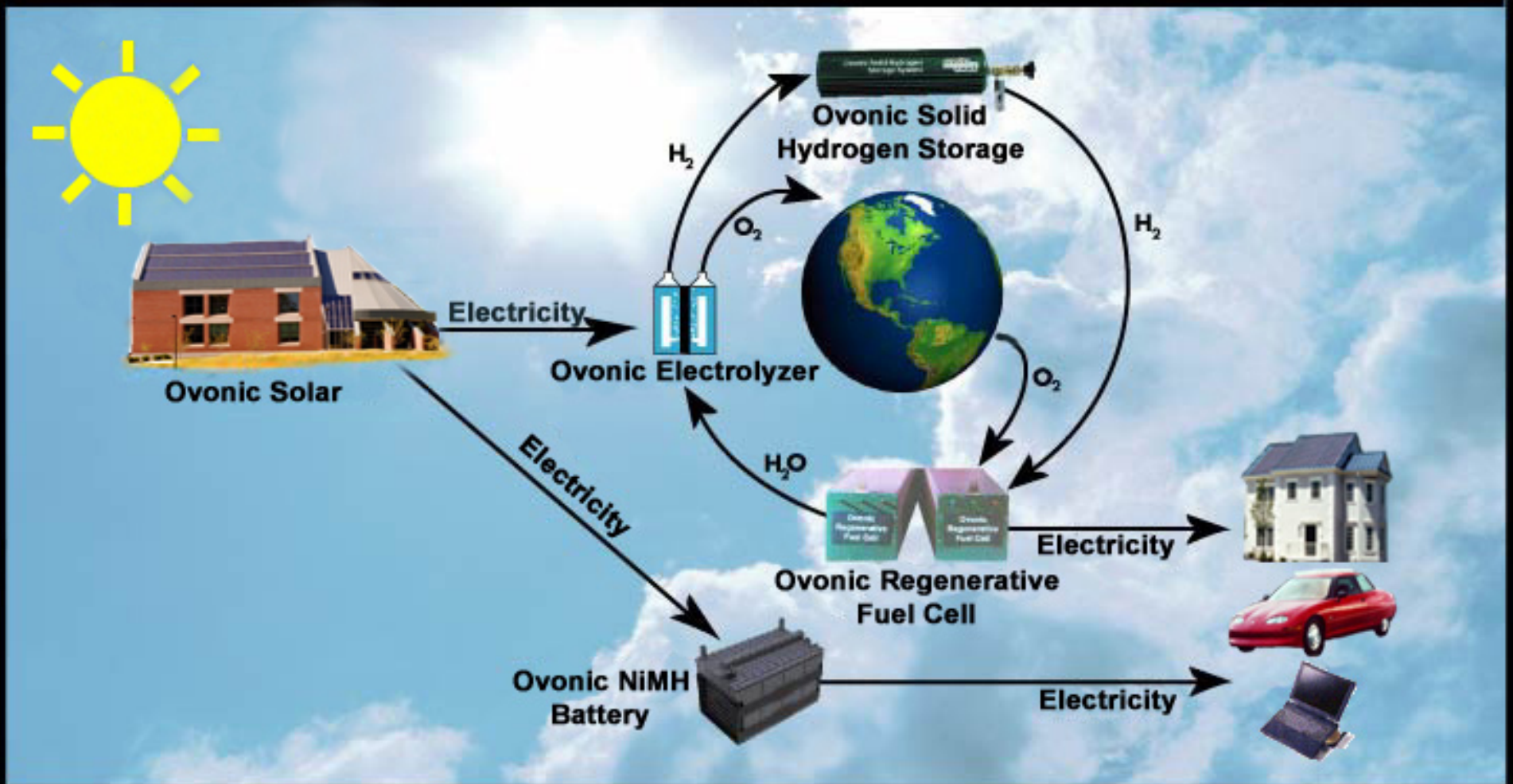


Hydrogen stored as a solid can transferred between battery electrodes to provide electrical energy as an output.

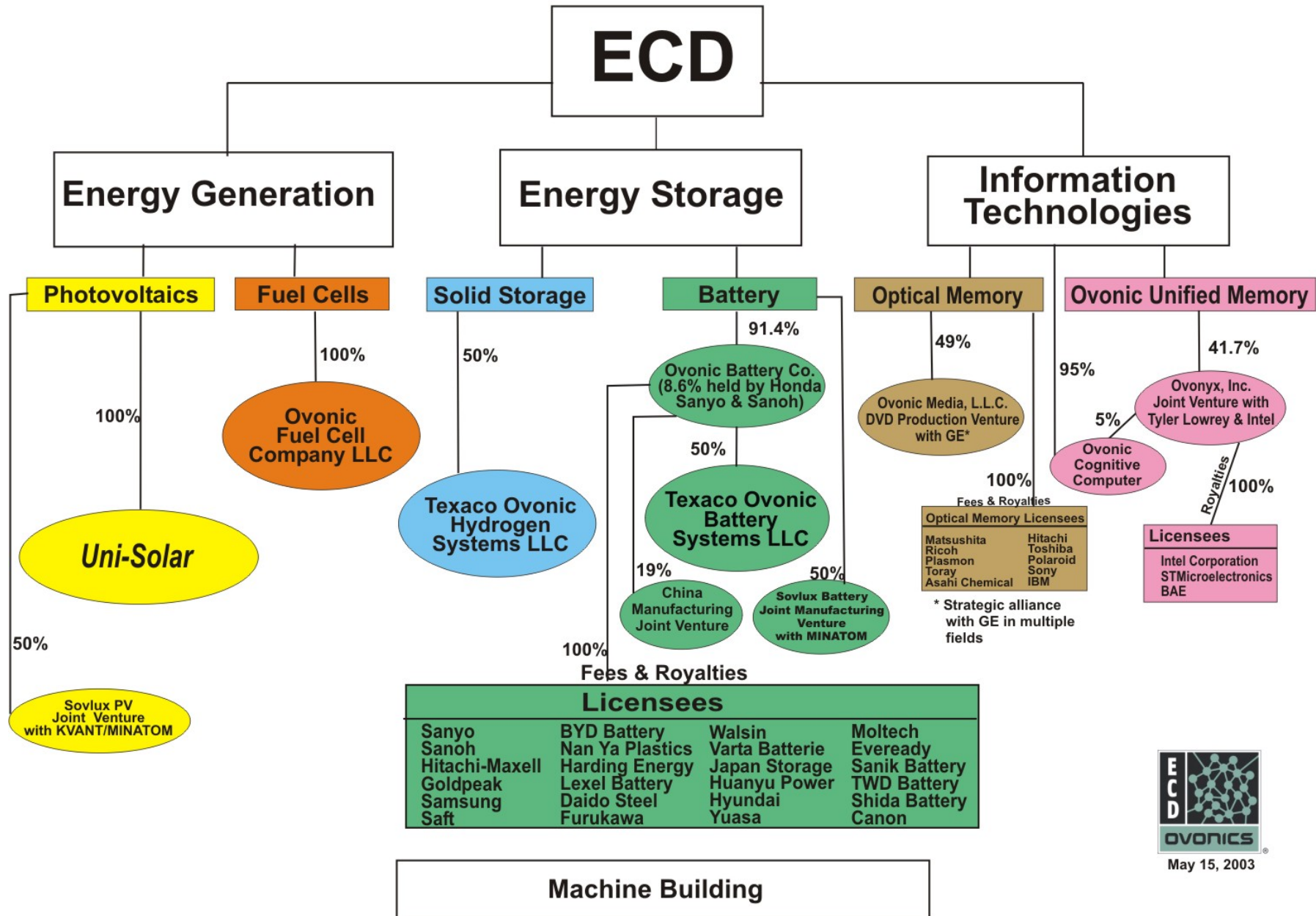
## Ovonic™ Hydrogen Storage System



Hydrogen stored as a solid can be released to provide fuel for fuel cells or heat engines.



# Core Businesses and Strategic Alliances



May 15, 2003



# Uni-Solar 30 MW PV Production Facility

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# Uni-Solar PV Product Competitive Advantages

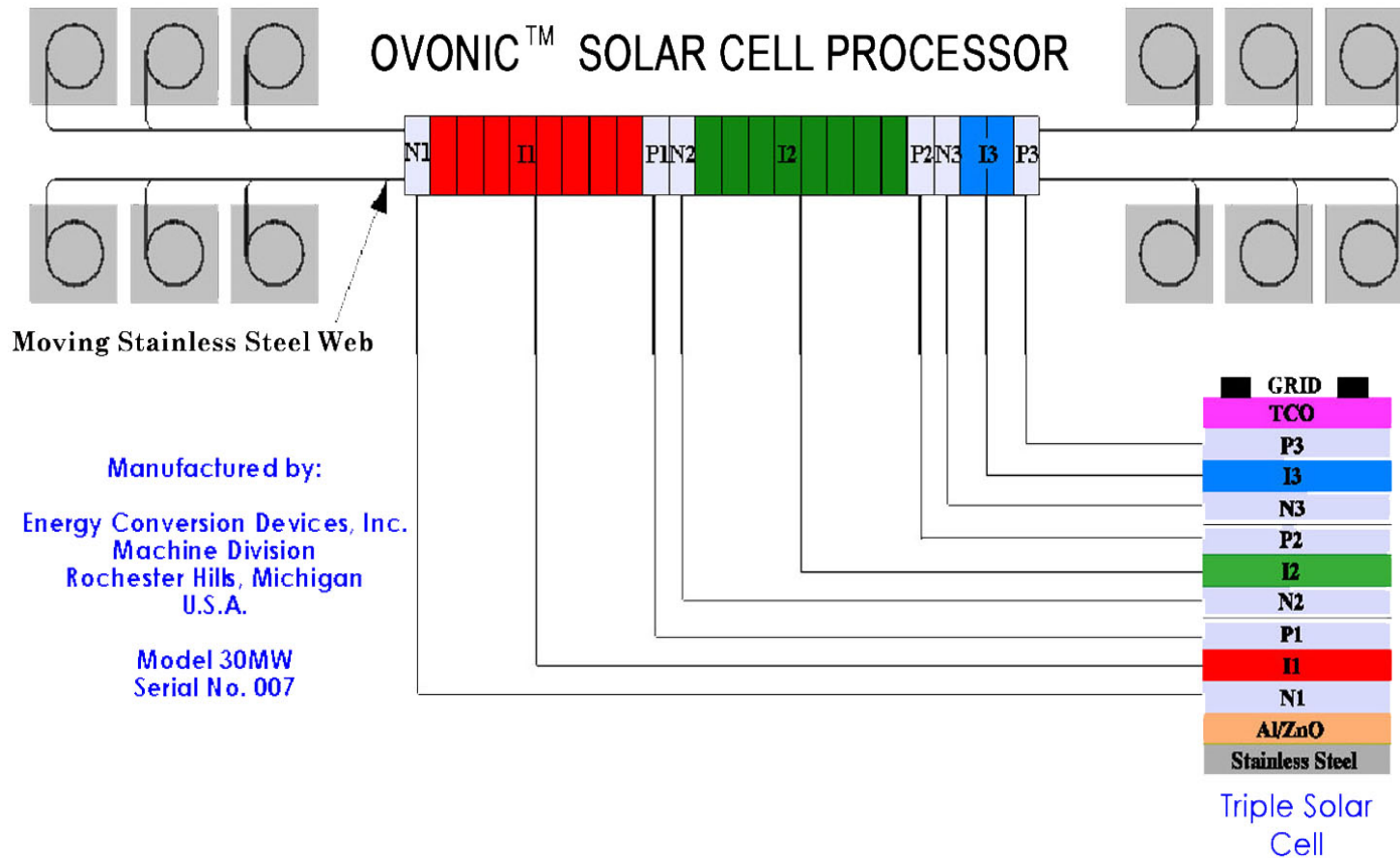
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- ◆ Low material cost achieved by using thin-film amorphous silicon
- ◆ Multijunction approach to improved energy conversion efficiency
- ◆ Low manufacturing cost achieved by using the roll-to-roll production process
- ◆ Flexible, lightweight and rugged products
- ◆ Superior performance at high temperatures and low light levels
- ◆ Proprietary technology protected by over 136 U.S. patents and 264 foreign patents



# Uni-Solar Triple Junction Amorphous Silicon PV Cells

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Schematic of 30MW Continuous Roll-to-Roll Ovonic  $\alpha$ -Si PECVD Processor



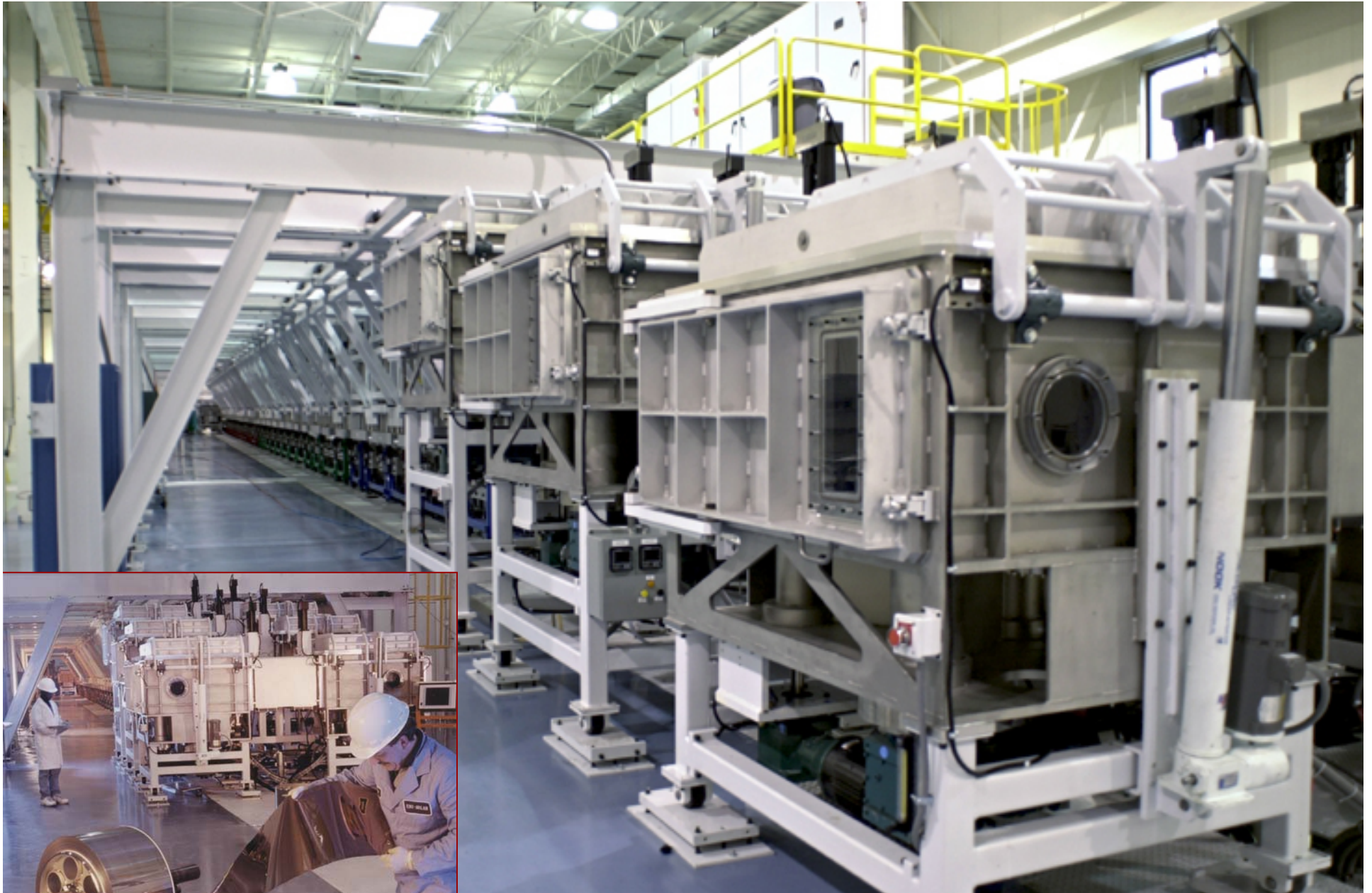
# Uni-Solar PV Production Facility

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**30MW Machine – Chambers (L) Doors (R)**





**Uni-Solar 30 MW State-of-the-Art  
Thin-film PV Manufacturing Process**

# 500 KW “SOLAR MINE” PV SITE



- Powers ChevronTexaco oil field operations in Bakersfield, California.
- One of the largest American PV installations US and the largest amorphous silicon solar cell array in the world.



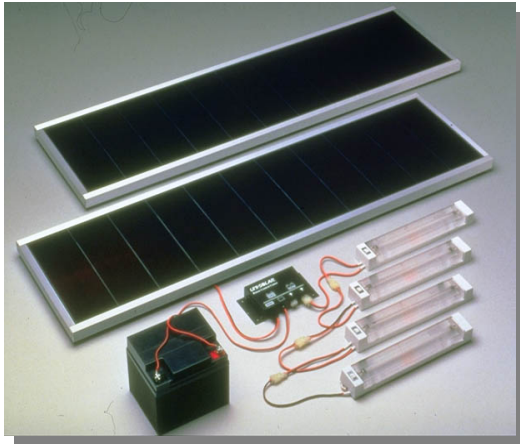
- Annual Energy Generation:  
902,000 kWh
- Annual Avoided Emissions:

CO <sub>2</sub>	930 tons
SO <sub>2</sub>	6,345 pounds
NO <sub>x</sub>	5,816 pounds



# Diverse Solar Energy Applications

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# Solar Power for Rural Electrification

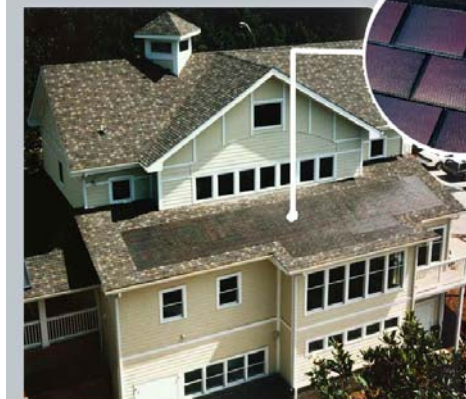
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# Uni-Solar PV Roof Integrated Products

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# Uni-Solar PV Roof Integrated Products

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## Value Proposition Commercial & Industrial

### PV Laminate systems for roofing membranes

- ✓ *UNI-SOLAR*® products are **easier to install** on commercial building's requiring fewer man-hours for installation.
- ✓ *UNI-SOLAR*® products are **flexible and low weight** (less than 1 lbs/sq ft) compared to more than 5 lbs/sq ft for the competition



# Texaco Ovonic Battery Systems

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**New Volume Manufacturing Facility in Springboro, OH**

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**TEXACO OVONIC BATTERY SYSTEMS**



# Ovonic Battery Products

OVONICS@work®



## ➤ *Advantages of Ovonic NiMH Batteries*

- ❖ **High Power**
  - 1000 W/kg (HEV)
- ❖ **High Energy Density**
  - 80 Wh/kg (EV)
- ❖ **Excellent Cycle Life**
  - Life of vehicle
- ❖ **Rugged and Safe**
  - Abuse tolerant
- ❖ **Environmentally Safe**
  - No cadmium, lead or mercury
- ❖ **Low Lifecycle Cost**



Ovonic® Family of Batteries 10Ah to 110Ah





# Automotive Battery Applications

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## NiMH Production EVs



## NiMH Production HEVs



TEXACO OVONIC BATTERY SYSTEMS



# Stationary Battery Applications

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## ➤ Stationary power

- ❖ Uninterruptible Power Supply
- ❖ Telecommunications
- ❖ Distributed Generation Applications

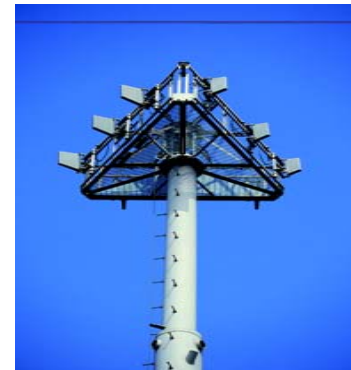
**Ni<sup>+</sup>GEN**<sup>™</sup>



## ➤ Demand for reliable off-grid power systems for critical institutions:

- ❖ Telecommunications systems
- ❖ Medical facilities
- ❖ Financial institutions
- ❖ Municipal water supplies and other infrastructure

**Ni<sup>+</sup>COM**<sup>™</sup>



**Ni<sup>+</sup>GUARD**<sup>™</sup>





# Ovonic Metal Hydride Production

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Rare Earth Ovonic Joint Venture 



# Texaco Ovonic Hydrogen Systems, LLC

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- 50-50 Joint Venture with ChevronTexaco
- Mission to develop and commercialize Ovonic Solid Hydrogen Storage Systems for Portable Power, Onboard Storage & Bulk Storage/Infrastructure





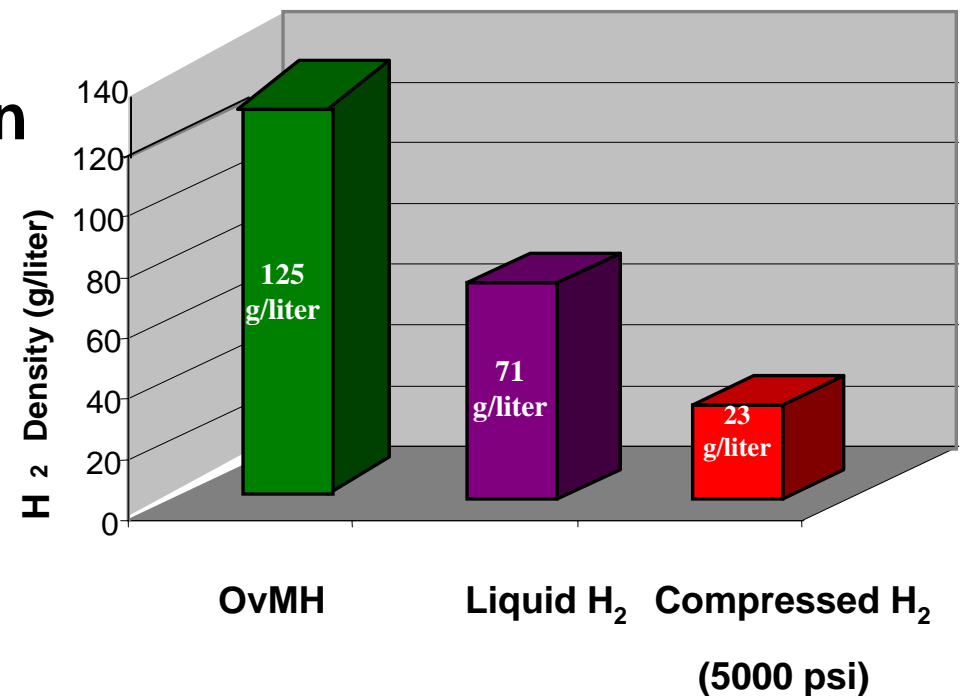
# Hydrogen Storage Products & Technology

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- **Ovonic™ Solid Hydrogen Storage provides key advantages over liquid hydrogen and compressed hydrogen storage:**



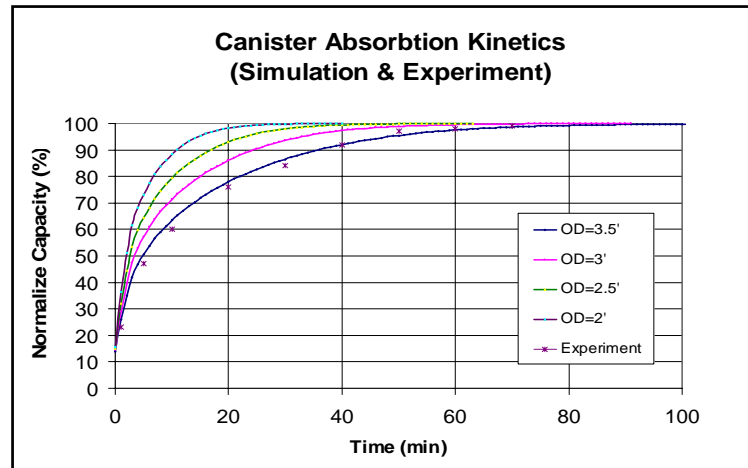
- ❖ **Safe**
- ❖ **Compact**
- ❖ **Reversible**
- ❖ **Low pressure operation**
- ❖ **Fast refueling**
- ❖ **Long cycle life**
- ❖ **Tailorable pressure**
- ❖ **Packaging flexibility**
- ❖ **Onboard waste heat utilization**





# Ovonic™ Solid H<sub>2</sub> Portable Canisters

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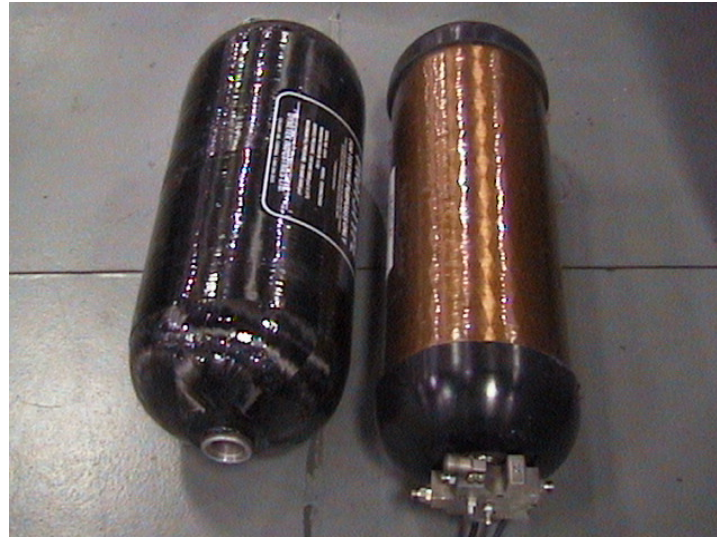


- **Size: 3.5" (OD) x 14" (length), 2 liters**
- **Weight: 6.5 kg**
- **Charging Pressure: 250 psig**
- **H<sub>2</sub> Capacity: 74-82 g reversible depending on air flow rate/temperature**
- **Cycle life: 500 cycles demonstrated**
  - Capacity degradation less than 10%
  - No degradation of burst pressure
  - Wall stress within DOT specified limit
- **Flexible design & packaging**



**Ready for  
Commercialization**

**Left: Ovonic Tank, 3.0 kg capacity @ 1500 psi**



**Right: Typical 5000 psi Tank, 0.78 kg capacity**

**(One kg Hydrogen = One gallon gasoline)**

- ***Ovonic Onboard Vessel***
  - ❖ **Fast refueling (approximately 10 minutes)**
  - ❖ **Compact and low pressure**
  - ❖ **Ready for OEM experimental vehicle testing and validation**



# Ovonic™ Solid Hydrogen Bulk Storage (10 kg H<sub>2</sub>)

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## ➤ *Ovonic Bulk Storage System*

- ❖ Ability to store high density hydrogen directly from an electrolyzer without mechanical compressor
- ❖ Tailorable, scalable to customer specifications
- ❖ Ready for validation and demonstration





# The Practical Solution for Hydrogen Infrastructure

*Ovonic Solid Hydrogen Systems*



## 1 Centralized / Local Hydrogen Production from Conventional / Solar Power



*Ovonic Solid  
Hydrogen Storage*



## 2 Bulk Transport of Ovonic Solid Hydrogen by Ordinary Means



## 3 Ovonic Hydrogen Storage and Distribution at Retail Stations



- *Hydrogen generated through thin-film photovoltaics (solar electricity)*
- *Electrolyzer producing hydrogen and oxygen from water and sunlight*
- *Primary hydrogen storage at retail site with hydrogen dispenser*



- *Fuel Cell or ICE powered vehicle with onboard solid hydrogen*



**2002 Ovonics  
Hydrogen Prius**

## Ovonics Technology Enables an All-Hydrogen ICE Vehicle

Texaco Ovonics Hydrogen Systems  
Ovonics™ Solid Hydrogen Storage

