

Sides used in Secretary of Energy  
opening remarks at the SEAB meeting

DOE SEAB meeting  
Washington DC  
31 January, 2012

# Innovation in Energy

New materials and transportation  
efficiency

# New materials and manufacturing methods can change the landscape of energy solutions

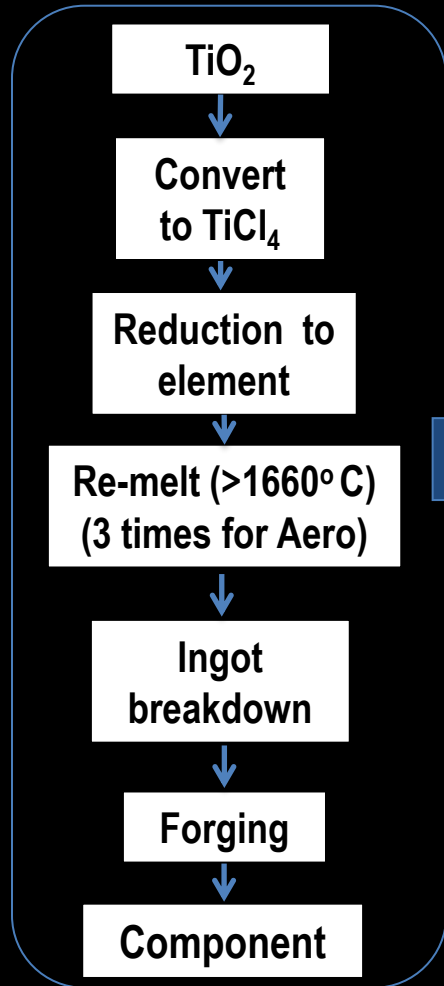


In 1884, the price of aluminum was \$1/oz and the price of gold was \$20/oz. The highest skilled craftsman working on the Washington Monument was paid \$2/day.

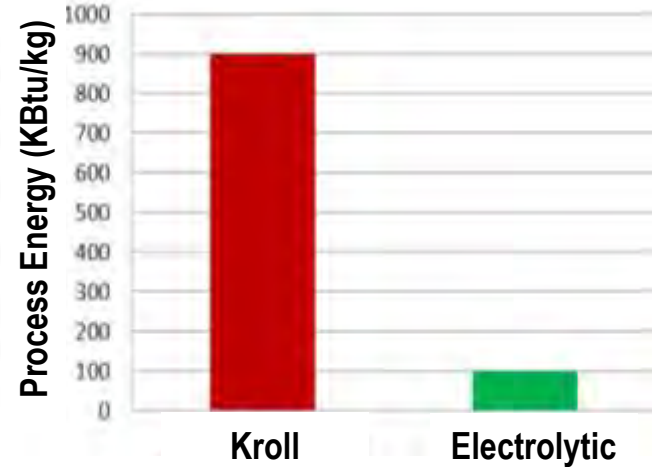
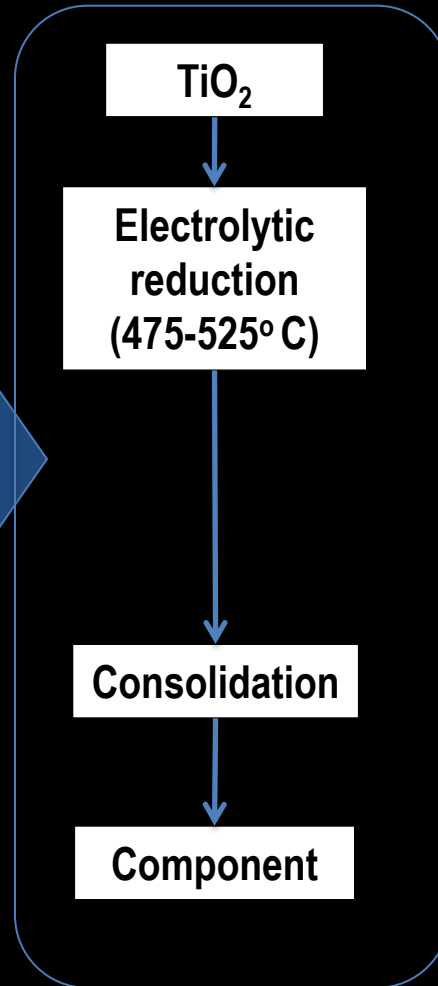
Today's prices: Al = 6¢/ oz Au ~ \$1776/oz.

# Next Generation Processes Example: Titanium

## Kroll (conventional)



## Electrolytic (next generation)



- 9x reduction of process energy
- Potentially 5x savings
- Process product (titanium powder) permits new generation additive manufacturing

Airplanes have become much more energy efficient.



First Boeing KC-135 tanker, the prototype to the 707.

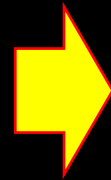


The Boeing 787 uses only 30% of the fuel as the 707.



# Out-of-the-Autoclave Composites

**Autoclave (conventional)**



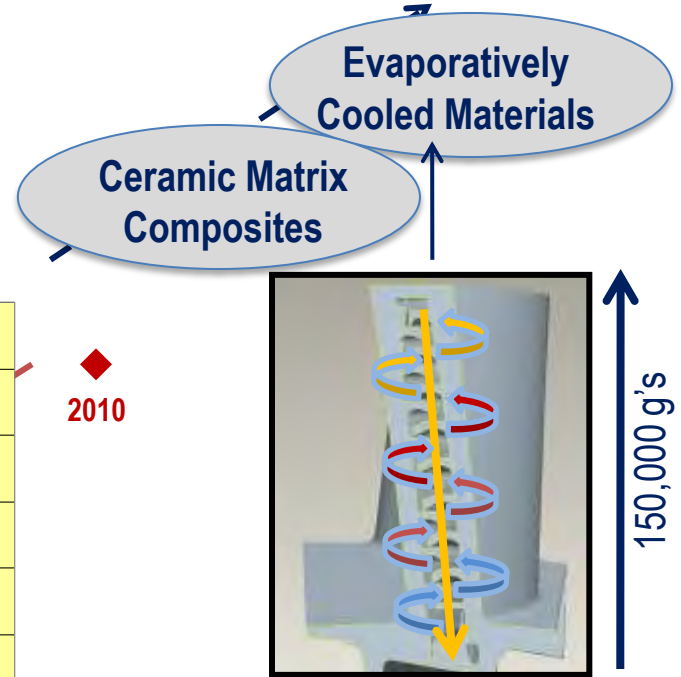
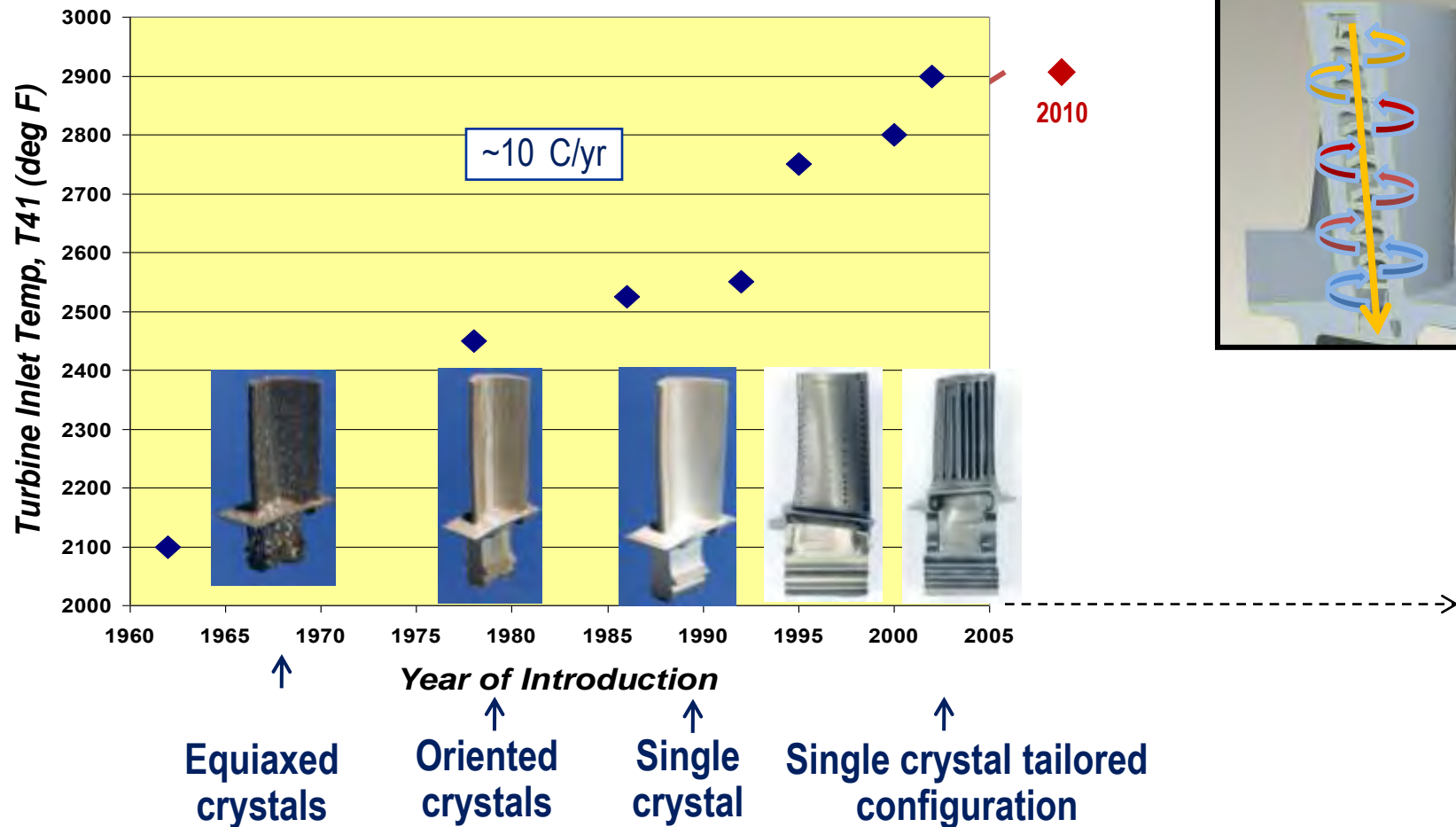
**Out-of-the-Autoclave**



The manufacturing of inexpensive carbon composites that can be molded as a thermo-plastic?

# Jet engines have become 50% more efficient

Increase in turbine inlet temperature enabled by changes in SIZE and CONFIGURATION of nickel alloy STRUCTURE and NOT Chemistry







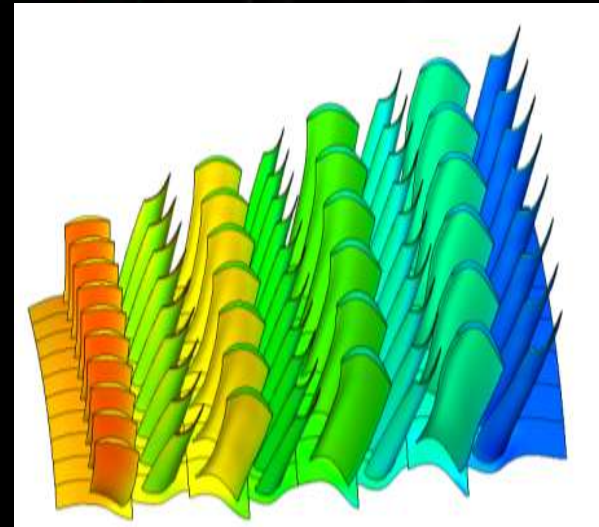
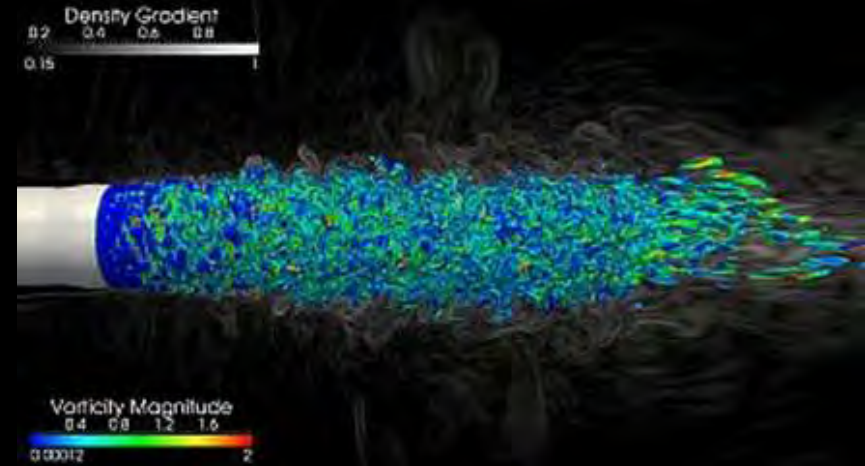
# DOE supercomputers helped design fuel efficient, low noise jet engines



- General Electric simulated the interactions of 8 blade rows in a turbine and the exhaust nozzle.
- Combustion occurs at  $> 1000^{\circ}\text{C}$ . Turbulent airflows are used to cool the turbine blades.

New discoveries of secondary, time fluctuating, high entropy, vortical flows near the hub casing of the turbine.

- The results stimulated GE to purchase its own supercomputer.





# Evolution of Advanced High Strength Steels in Automotive Applications

**Jody N. Hall**

General Motors Company

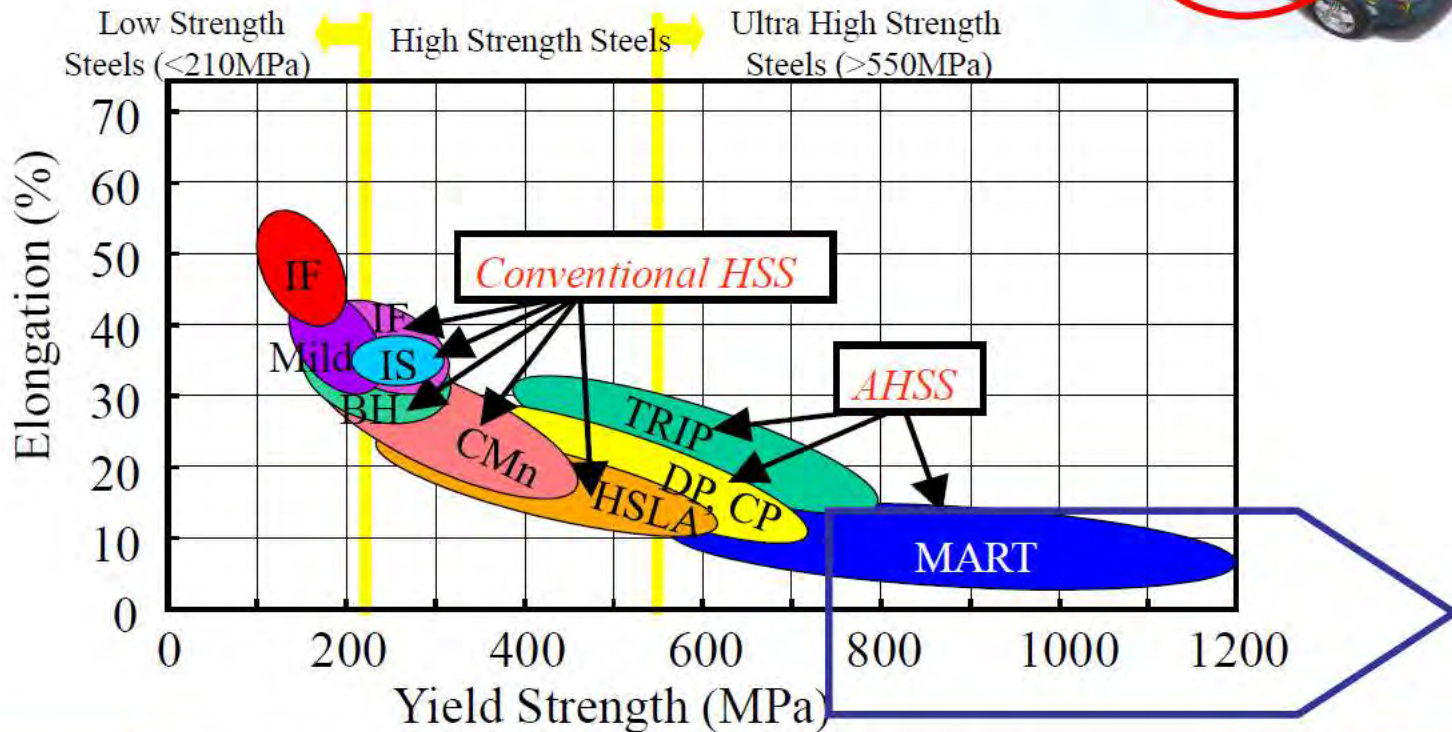
Chair, Joint Policy Council, Auto/Steel Partnership

May 18, 2011

# Safety

## Steels for Passenger Compartment Zone

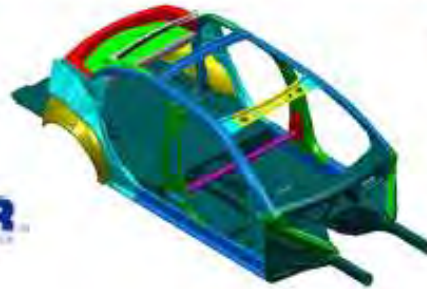
- Highest Strength
- Martensite, and Boron Steels Preferred



# The application of high strength steels in automobiles

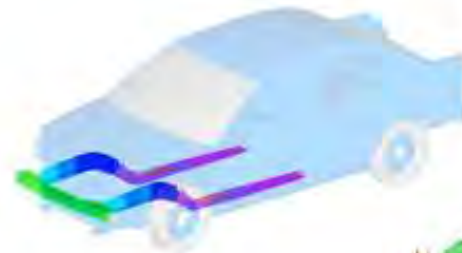


## Domestic (Auto/Steel Partnership) DOE-Funded Engineering Projects 22% to 32% Weight Reduction, 2002-2009



### Future Generation Passenger Compartment

- 30% mass reduction \*
- Improved crash performance
- At no additional cost



### Lightweight Front-End Structures

- 32% mass reduction \*
- At no additional cost



### Lightweight Rear Chassis

- 24% mass reduction \*
- At no additional cost



### Lightweight Closures

- 22% mass reduction \*
- At no additional cost



**USCAR**

**FreedomCAR**  
Fuel Partnership

**USAMP**

FreedomCAR Goals  
50% mass reduction  
same cost

\* Mass Reductions  
versus actual OEM  
donor vehicles



The Hyundai Elantra, a 5 passenger mid-size 148 hp (1.8 liter engine) car weighs ~2700 lbs and is rated at 29 mpg city and 40 mpg highway.

The 2013 Chrysler Dodge Dart is 68% high-tensile strength steel. Preliminary tests with a 160-hp, 1.4 L turbo-charged engine with 184 ft-lbs. of torque is anticipated to have even better EPA ratings.



Joe Veltri, Chrysler vice president tries to sell me a car

Ford has a 1.2 L engine with 135 hp and is developing a 900 cc turbocharged engine with 127 hp

# Supercomputers Lead to Savings

Fuel savings between 7 and 12 percent



# Innovation in Energy

New materials and transportation  
efficiency

Power electronics



# Power Conversion & Energy Storage

Today



10,000 lbs



Future



100 lbs

And  
Smart!



\$100/kWh

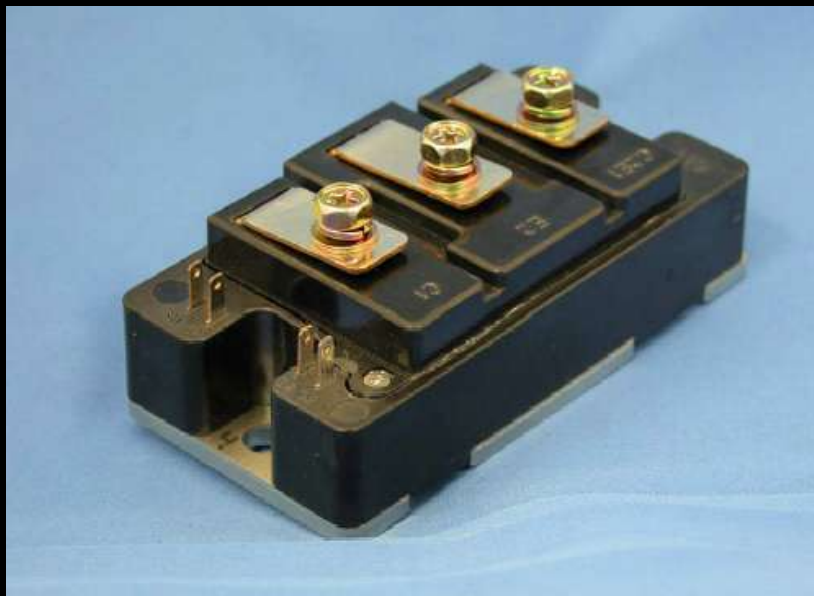


\$100/kWh

Anywhere  
In the  
world

**2010: 30% of all electric power flows through power electronics**  
**2030: 80% of all electric power will flow through power electronics**

SiC power modules operate at 1200V and 880 amps. (1MW)



1.2 kV/100A SiC  
module



Internal view: 2 80 A SiC  
MOSFETs and 2 50 A SiC JBS  
diodes

New “soft” magnetic materials with ultra-high coercivity,  
high switching speeds, low conductivity .

New “hard” magnets with ultra-high field remanence with  
low rare earth content.

# High field magnets with less rare earths materials

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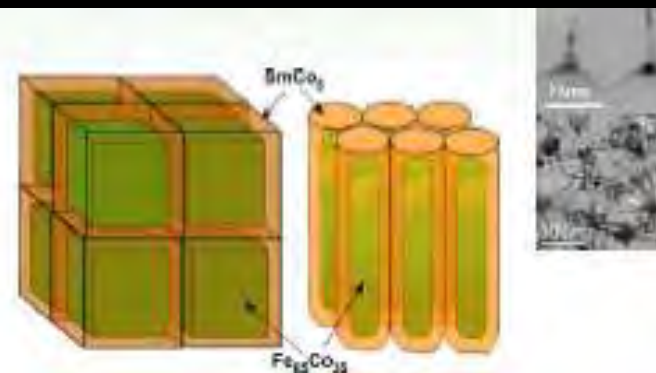
**Metal Joining**

**Magnetic Materials**

## Hard on Soft Nanoparticle

**"Scalable Exchange Coupling"**

**$BH_{\max} = 50-100 \text{ MGOe}$**



# Innovation in Energy

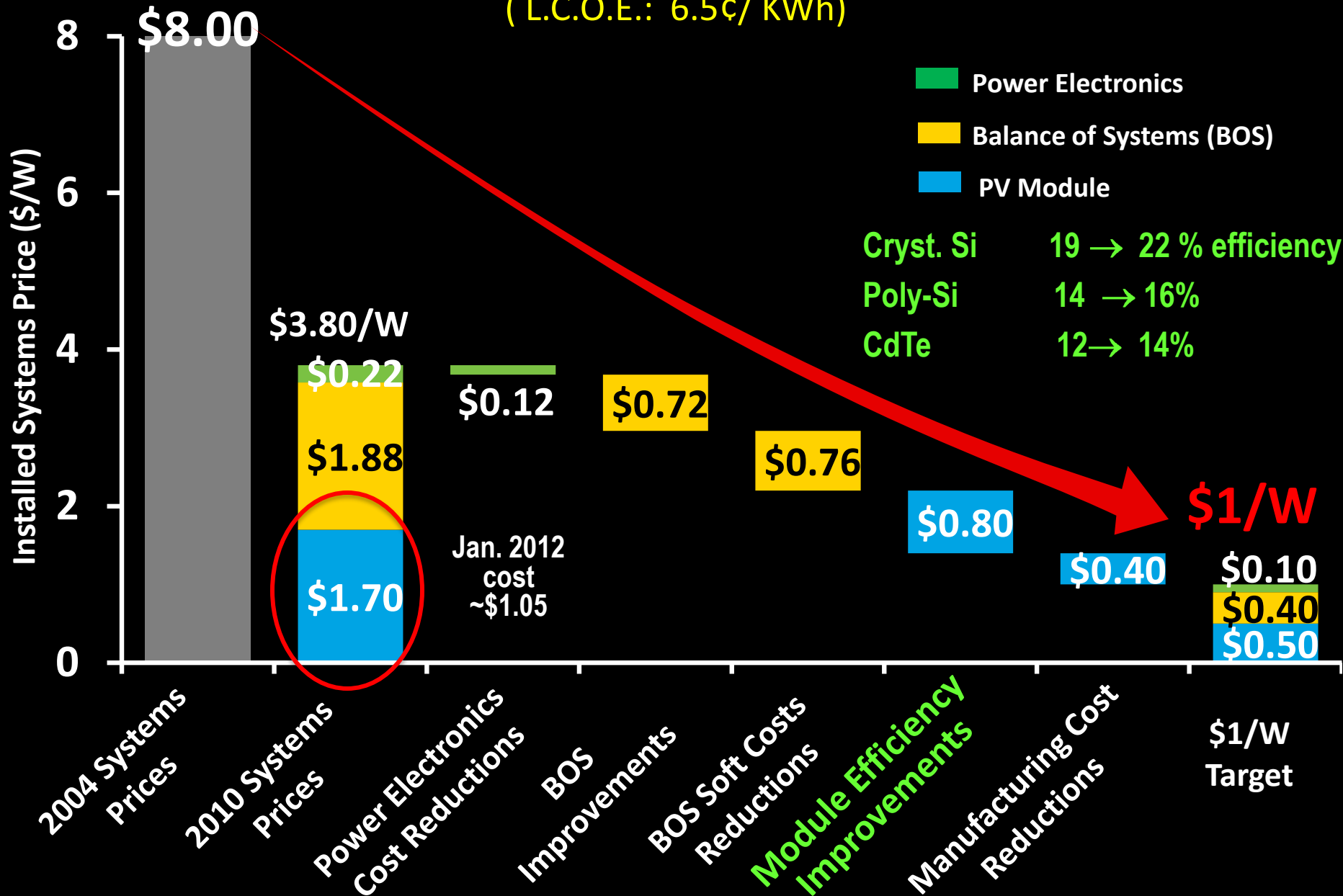
New materials and transportation  
efficiency

Power electronics

Solar photo-voltaics

# SunShot goal: Cost Competitive Solar by 2020

( L.C.O.E.: 6.5¢/ KWh)







is the 3<sup>rd</sup> largest photo-voltaic producer in the world. Founded by an Australian citizen with a Ph.D degree in electrical engineering from the University of New South Wales.



- Suntech imports raw silicon crystal material from *U.S. suppliers*, **manufactures solar cells in a automated facility in China**, and is building assembly plants worldwide, including the U.S.
- Suntech is focused on driving down manufacturing costs *and* holds the current record for a polycrystalline solar efficiency (16.5%).
- **Bell Labs invented the silicon solar cell; China is now “Henry Ford-ing” us/U.S.**



# Silicon Crystal Growth

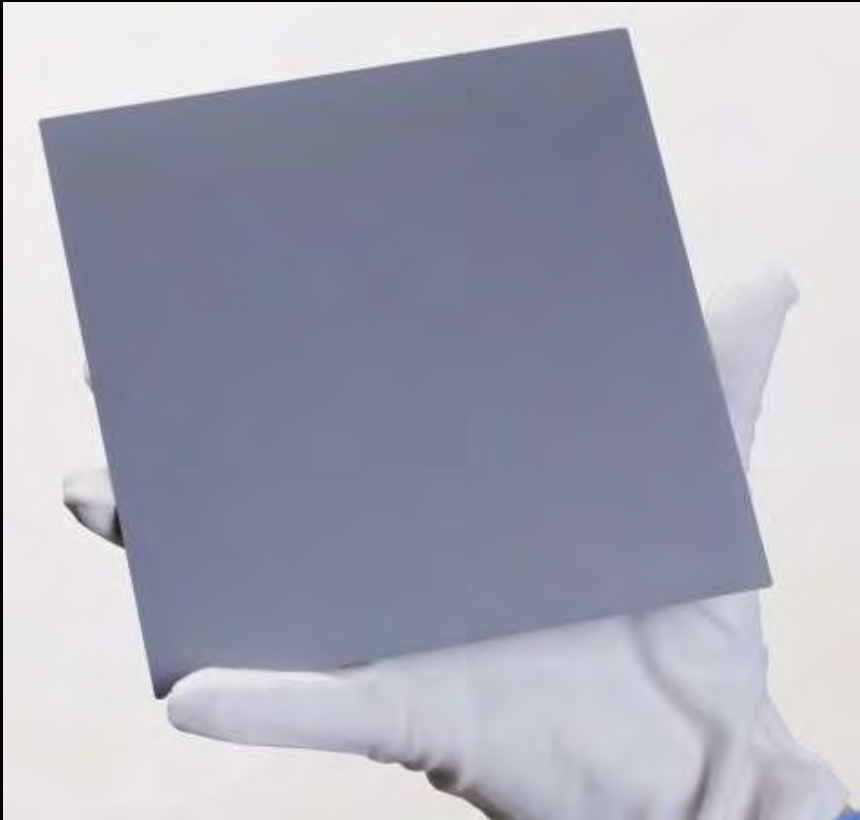
Czochralski growth



Directional solidification



# Casting Single Crystal Wafers



In 2007, the DOE supported research of BP Solar in the U.S. to make large single crystals of silicon in directional solidification method. A proto-type version of this technology achieved 20% efficiency, better than many CZ mono wafers in production.

Before the technology was taken to the manufacturing scale, intense competition with Chinese manufacturers caused BP Solar shut down operations in the US.

This technology has been improved in China. JA Solar and may soon go into production of single crystal silicon using directional solidification.

# Innovation in Energy

New materials and transportation  
efficiency

Power electronics

Solar photo-voltaics

Batteries

# Reclaiming Leadership in Advanced Batteries



Research discoveries made by scientists at Argonne National Lab allowed them to, develop a new lithium-manganese ion battery.

- 50-100% cathode energy density increase
- Less costly to manufacture
- Safer

Recent discoveries by an Argonne - U. Illinois – Northwestern collaboration: **Doubling** of energy density has been demonstrated in the lab.

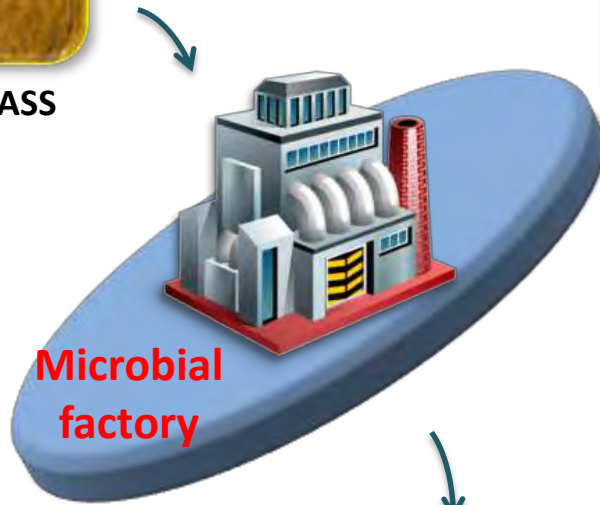
# Approaches to bio-fuel production

- Ligno-cellulose  $\Rightarrow$  ethanol
- Ligno-cellulose  $\Rightarrow$  drop-in fuels
  - Sunlight  $\Rightarrow$  biofuels

# JBEI-INDUSTRY COLLABORATION: SIMPLE SUGARS AND STARCHES TO DROP-IN FUEL PRECURSORS (AMYRIS)



BIOMASS



Microbial  
factory



CHEMICALS



BIOFUELS



JBEI collaborating with Amyris on novel pathways to produce precursors to diesel and jet fuel

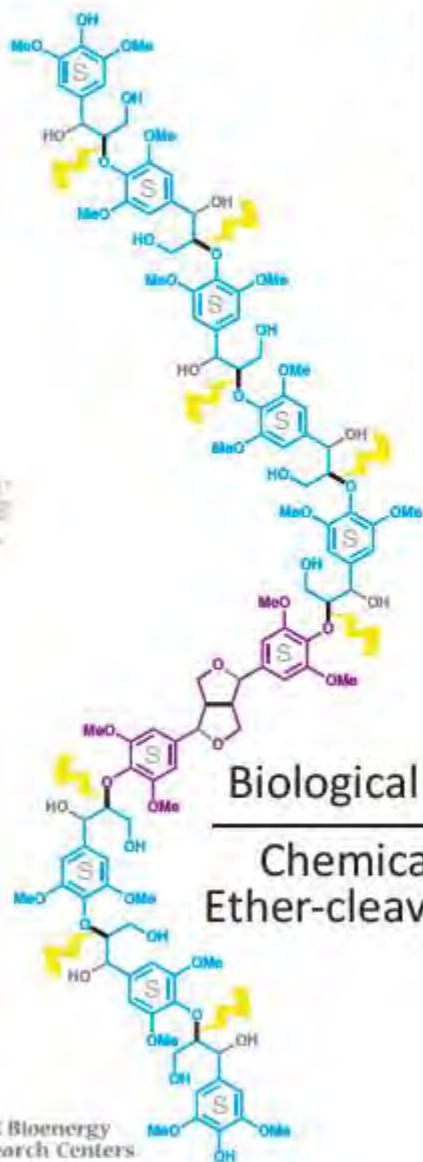
Amyris commercializing licensed technology from UC Berkeley

## Outcomes

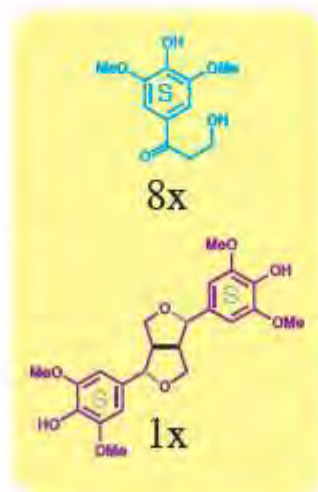
- Developing high-performing alternatives to petroleum-sourced fuels and chemicals
- First worked on anti-malarial drug artemisinin; biofuel work started in 2007
- Developed production facilities in Brazil and building a facility in Illinois
- *Commercialization of biofuel derived from biomass*



Lignin can be easier to breakdown and convert into valuable co-products by genetically designing points in the molecule that can be cleaved by enzymes or chemicals.



Biological or  
Chemical  
Ether-cleavage



# Pine trees engineered to produce biofuel in addition to providing pulp for paper

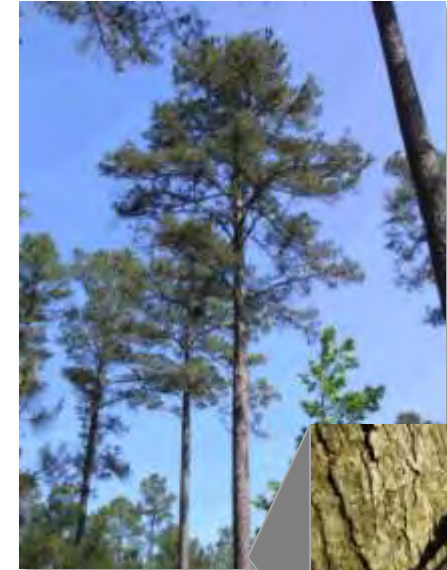
## The Technology:

- ▶ Increase storage capacity of turpentine molecules
- ▶ Increase the production from 3% to 20%
- ▶ Improve the quality of the produced fuel

## The Impact:

- ▶ “Bolt-on” to an existing industry - Loblolly pine is already a commercial crop grown on 10M acres for paper
- ▶ Potential to produce 4 B million gallons of fuel per year per 1 M acres of forestland

Loblolly pine



Tapping pine trees

***E. coli* and yeast are also being engineered  
to produce precursor turpenes**

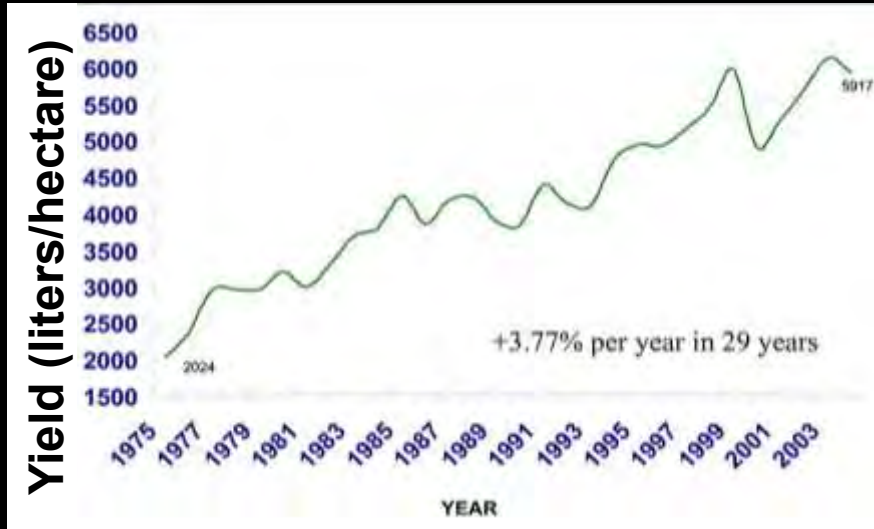
Lowering the cost of biomass harvesting, storage and shipment is a critical issues



Wheat & corn are shipped world-wide at ~\$100/ton prices.  
Biofuel feed stocks before concentration is less valuable.



# Sugar Cane-to-ethanol yield per hectare in Brazil have increased 3x in ~30 years



Leaves are left in the field



Stalks are transferred to larger trucks



America has the opportunity to lead the world in clean energy technologies and provide a foundation for future prosperity.

We remain the most innovative country in **the world ... but “Invented in America” is not good enough.**

**“Invented in America, Made in America,  
Sold Worldwide”**

# How to promote domestic manufacturing

- Regulations (mileage, appliance efficiency, pollution standards, etc.) drives innovation.
- Fiscal Policies (R&D tax credits, Master Limited Partnerships, other tax laws) that help companies that take the long term-view and to help guide on-shore investments.
- Corporate and labor leadership.
- Government role as an “early adopter” and other methods to create market draw.