



NREL National Renewable Energy Laboratory

*A national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy*

Innovation for Our Energy Future

NREL Overview

to

Ammonia Conference

Golden, Colorado

Dale Gardner

**Associate Director, Renewable
Fuels Science & Technology**

Oct 9, 2006



Major DOE National Laboratories

NREL is Operated for the U.S. Department of Energy by
Midwest Research Institute and Battelle



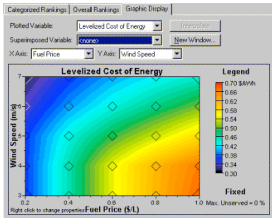
- ◆ NNSA (Defense Program)
- ▼ Office of Science
- Office of Energy Efficiency and Renewable Energy
- ✦ Office of Nuclear Energy
- ▶ Office of Fossil Energy

National Renewable Energy Laboratory

- Only national laboratory ***dedicated*** to renewable energy and energy efficiency R&D
- Research spans fundamental ***science*** to ***technology*** solutions
- ***Collaboration*** with industry and university partners is a hallmark
- We focus on research that is ***market relevant***



Integrated Energy System Engineering & Testing



Strategic Energy Analysis



Renewable Electricity Science & Technology



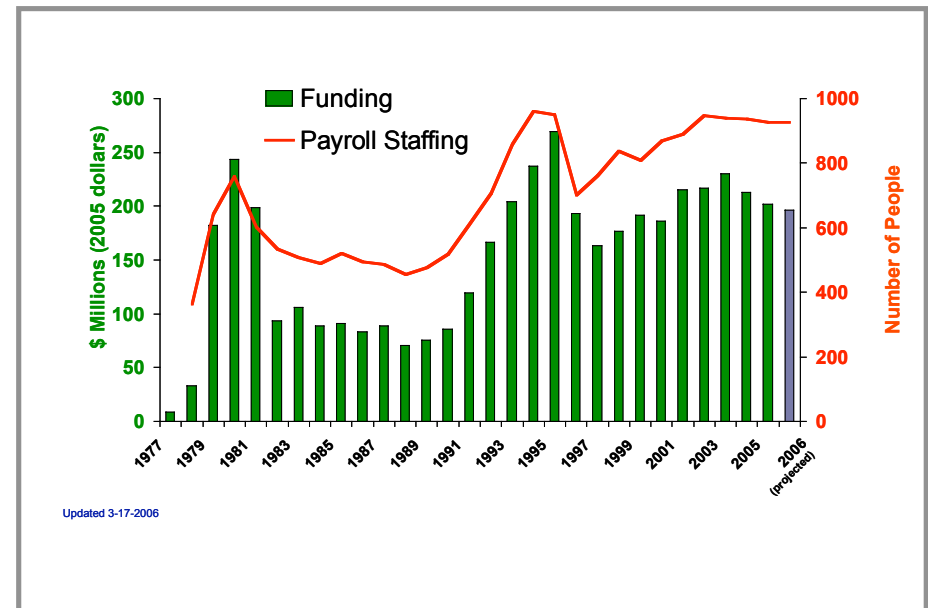
Renewable Fuels Science & Technology

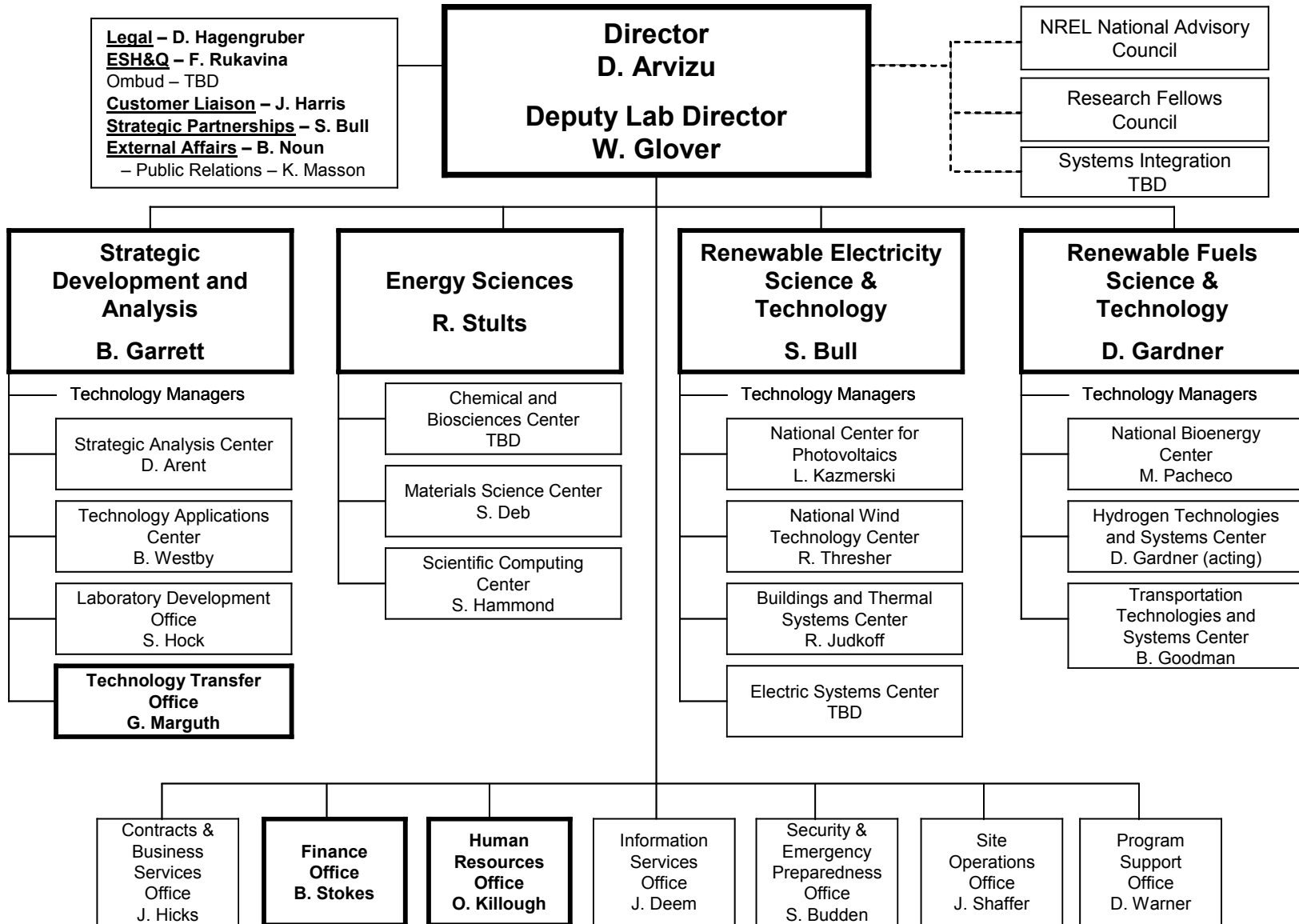


Foundational Science

NREL Funding, Staffing, Facilities

- **Average funding ~ \$200M over last several years**
- **Payroll staff ~ 900 (1,100+ on campus – post docs, visiting researchers, students, interns, etc)**
- **Locations**
 - **Main Site (all but Wind)**
 - **Wind Site (15 miles north)**
 - **Leased Space**





*Bolded titles indicate Executive Management Council

SOLAR



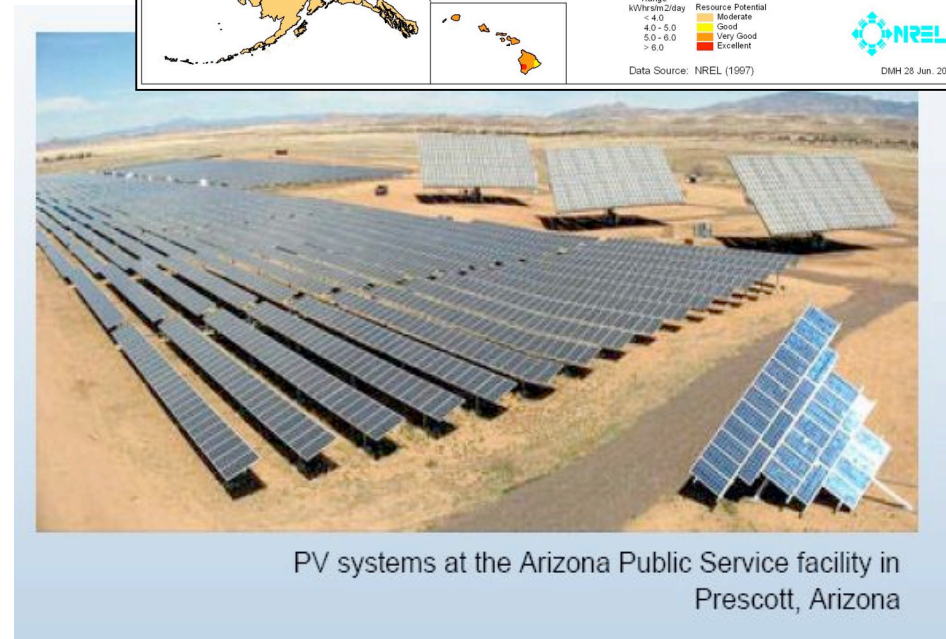
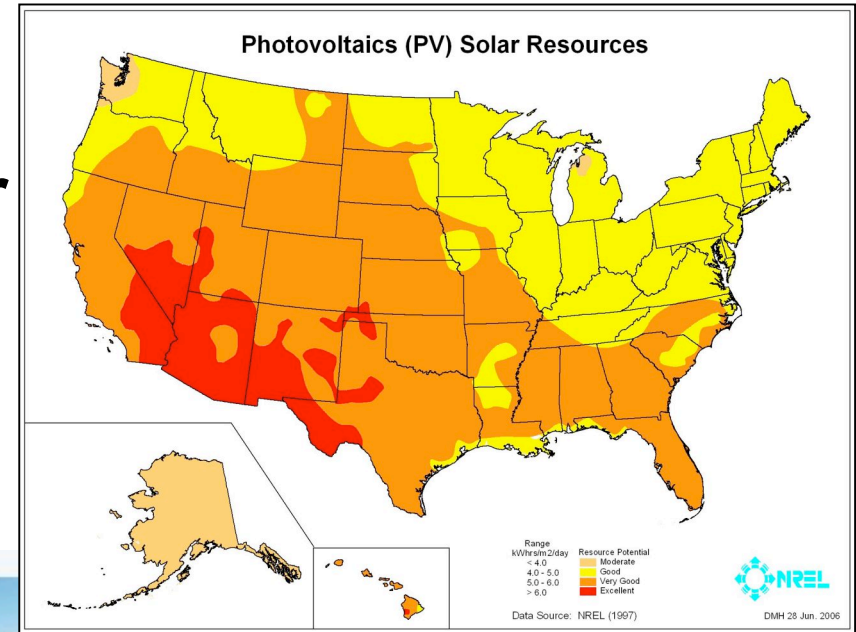
Solar Energy Status

- **Concentrating Solar Power**

- 9 parabolic trough plants
- 350 MW capacity
- \$.12-.14 / kWh

- **Photovoltaics (PV)
(aka solar cells)**

- <1 GW grid connected capacity
- > \$.30 / Kwh
- Small systems --
\$10,000 / kW

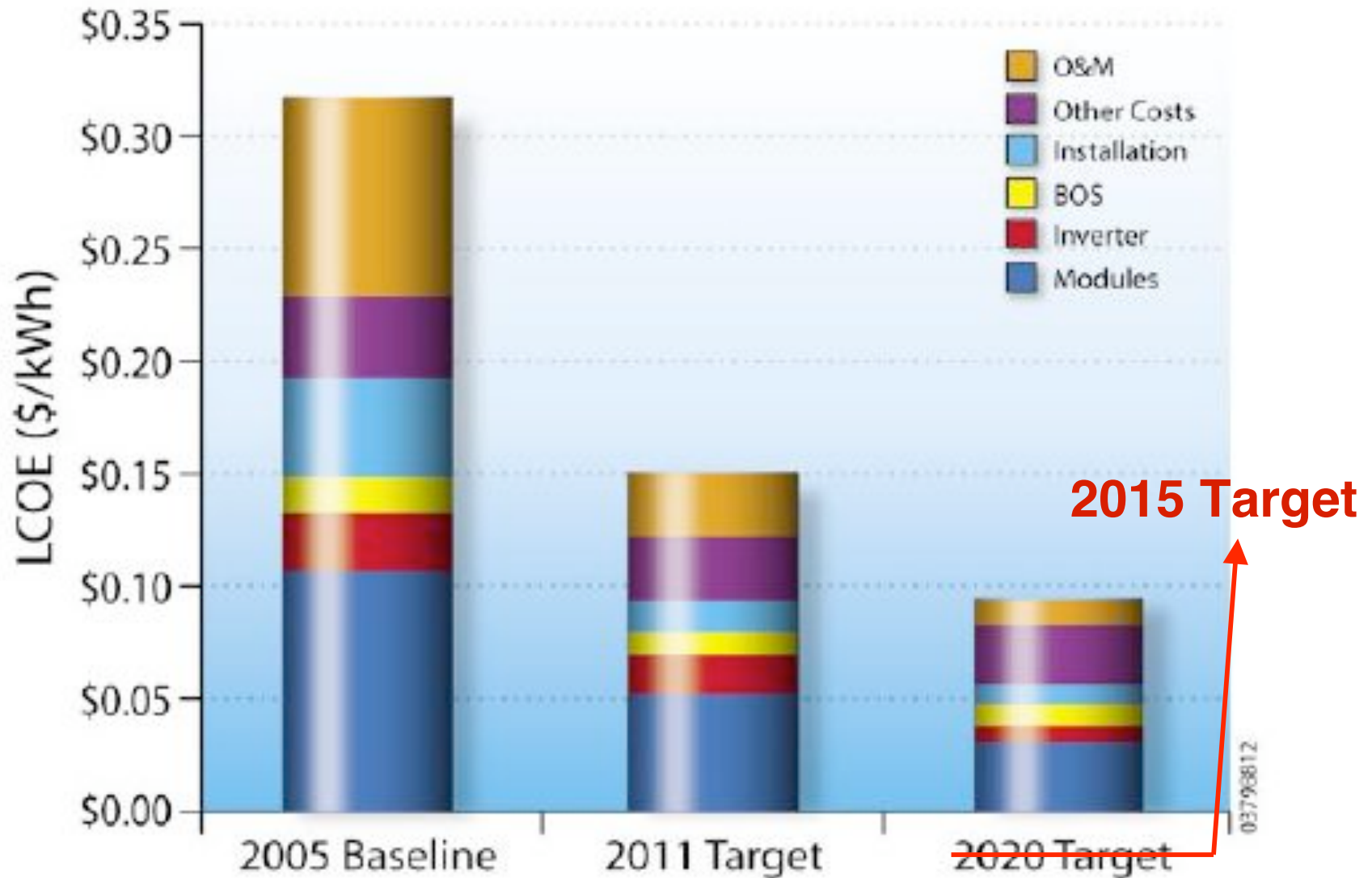


Solar Energy Outlook

- **Cost goals:**
 - PV < \$.10 / kWh by 2015
 - CSP = \$.05 / kWh by 2012
- **PV R&D Focus:**
 - **Efficiency (current systems at 15-20%)**
 - 40% -- demonstrated in the lab
 - > 50 - 60% -- new breakthroughs
 - **Manufacturability**
 - Currently built like computer chips
 - Need “news print-like” capability

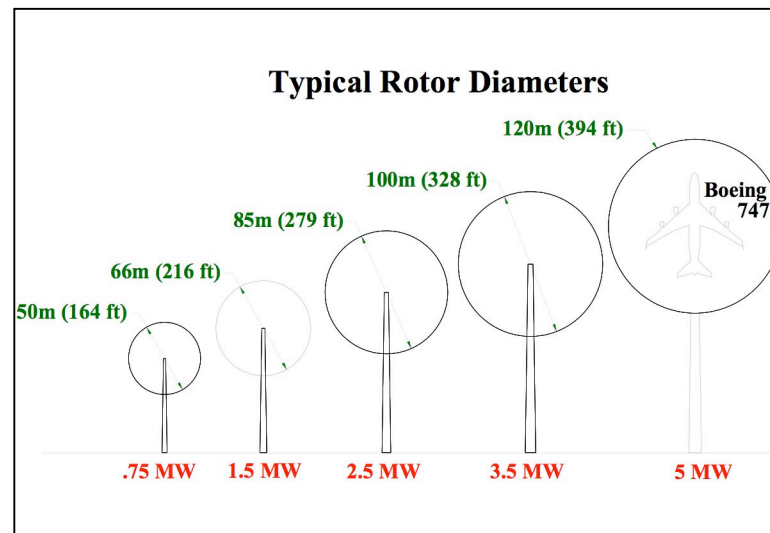


Solar America Initiative



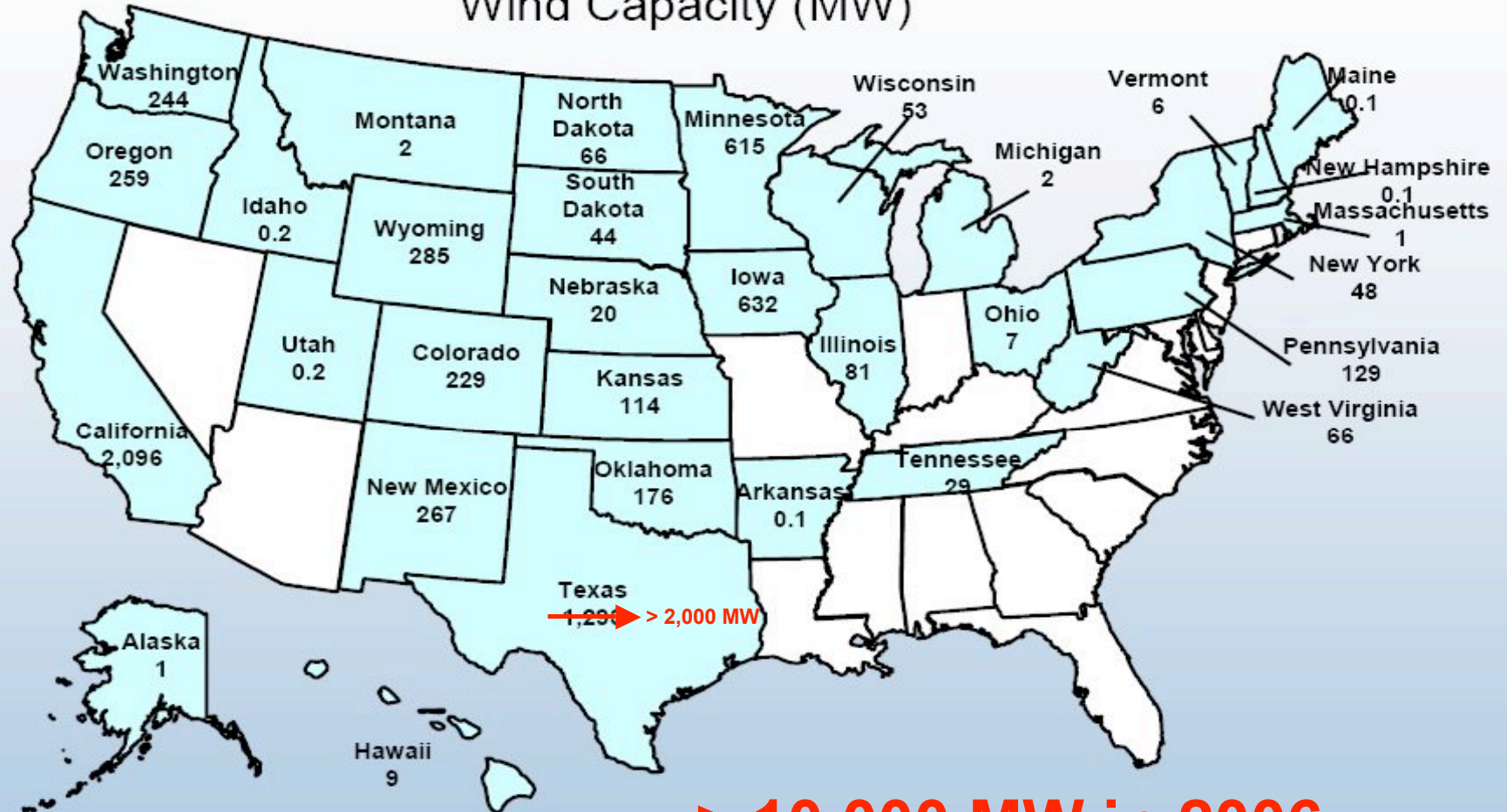


WIND



Wind Energy Status

Wind Capacity (MW)



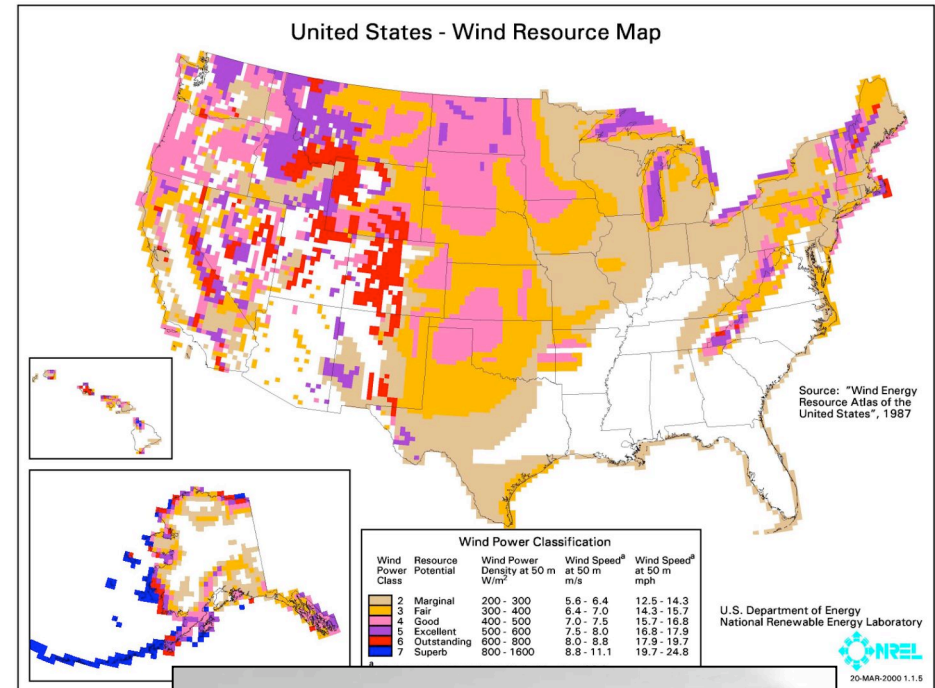
> 10,000 MW in 2006

6770 MW as of 12/31/04

Current cost is 4 to 6¢/kWh in best regimes (unsubsidized)

Wind Energy Status (cont)

- **\$.04 - .06 / kWh in best regions (≥ 15 mph)**
- **> 7 GW installed**
- **Growing number of wind farms in midwest and west**
- **Increasing home and business installations**
- **Policy**
 - **Production Tax Credit**
 - **State-led mandates**
- **Europe leading the way**
 - **Large turbines (up to 5 MW)**
 - **Off-Shore wind farms**



Wind Energy Outlook

Low Wind Speed Turbine (LWST) goals

- 13 mph regions
- \$.03 / kWh by 2012

Off-Shore Technology goals

- Solve unique challenges
 - Corrosion
 - Stability
 - Hurricanes
- \$.05 / kWh by 2012





Hydrogen & Fuel Cells



President's Hydrogen Fuel Initiative



- **Originally announced in 2003, then restated as part of 2006 Advanced Energy Initiative (AEI)**
 - **\$1.2B over FY04 – FY08**
 - **“Make it practical and cost-effective for large numbers of Americans to choose to use clean, hydrogen fuel cell vehicles by 2020”**
 - **“Reduce our oil demand by over 11 million barrels per day by 2040 – approximately the same amount of crude oil America imports today”**
- **Budget \$289M in FY07, and increase of \$53M over FY06**

Production



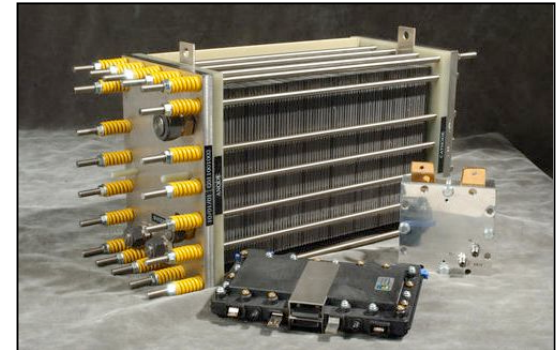
- **\$2.00 - \$3.00/gge**
(pathway independent)

Onboard Storage



- **300 mile range**

Fuel Cells



- **Cost - \$35/kw**
- **Durability – 5,000 hours**



DOE Hydrogen Program

Hydrogen

Status

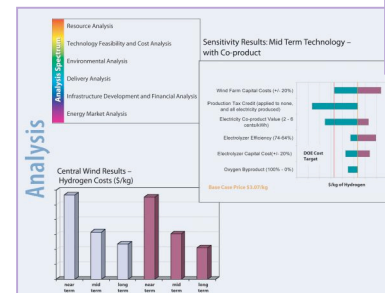
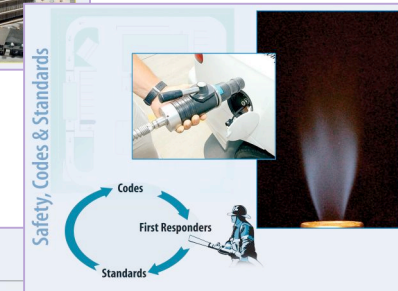
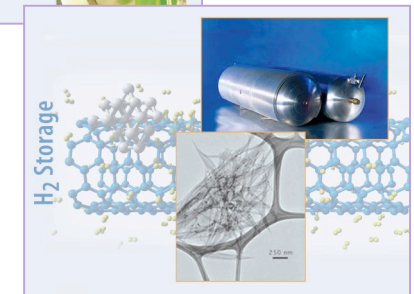
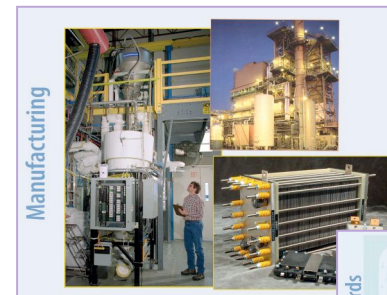
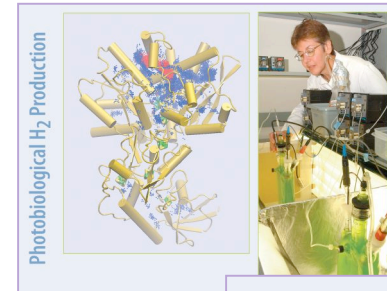
Working with industry to develop technologies in quantities large enough, and at costs low enough, to compete with traditional energy sources.

Potential

- Technology Readiness by 2015
- Infrastructure in-place and FCVs in the showrooms by 2020

NREL Research Thrusts

- Renewable hydrogen production, delivery analysis, storage, and manufacturing
- Fuel cell membranes and catalysts
- Safety, codes, and standards
- Demonstrations





Biomass





Biomass Status

Power

- **Current largest biomass use**
- **Much of it at wood/pulp mills**

Ethanol

Corn ethanol

- ~ 100 commercial plants
- 4 billion gallons (2005)
- ~\$1.35/gallon of gas equiv (gge)

Cellulosic ethanol

- No operational biorefineries
- Projected commercial cost ~\$2.30/gge



Rated at 21 MW and providing the San Francisco Bay Area with baseload capacity, the Tracy Biomass Plant uses wood residues discarded from agricultural and industrial operations.

Biodiesel

- **From seed oils, greases, waste oils**
- **120 million gallons (2005)**
- **Price varies widely, but competitive with petro-diesel**

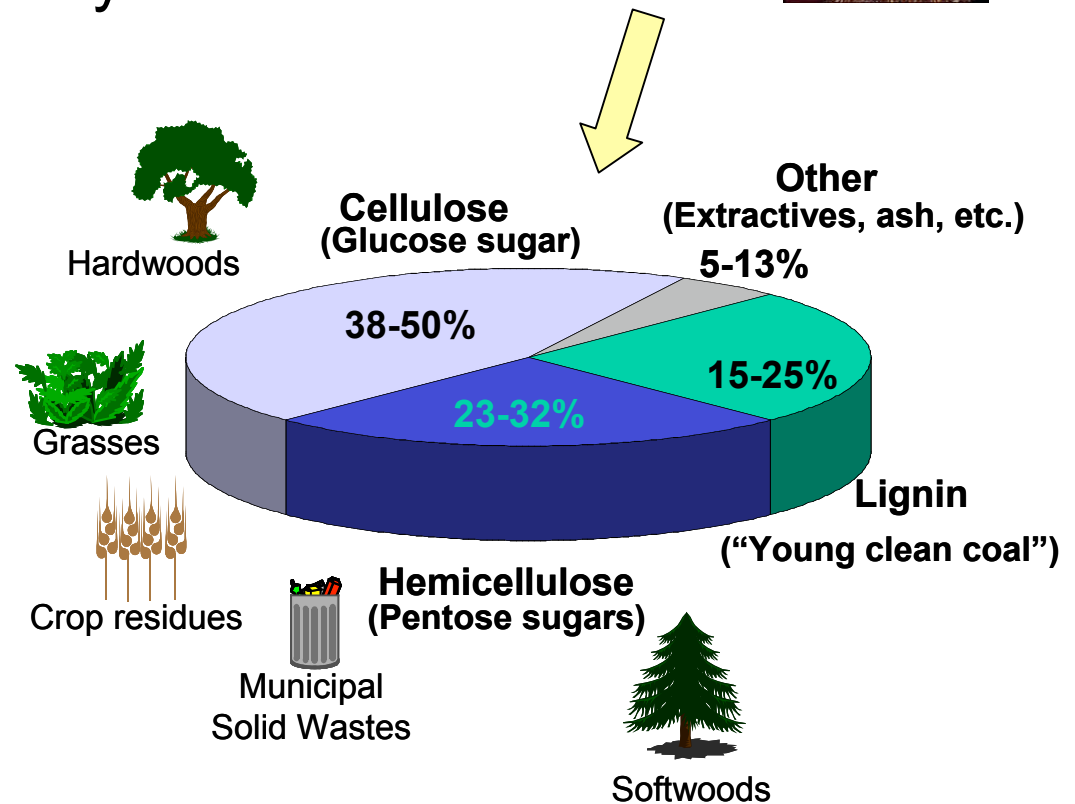
■ 2012 Goal

- Make cellulosic ethanol practical and competitive within six years (\$1.07/gallon ethanol).

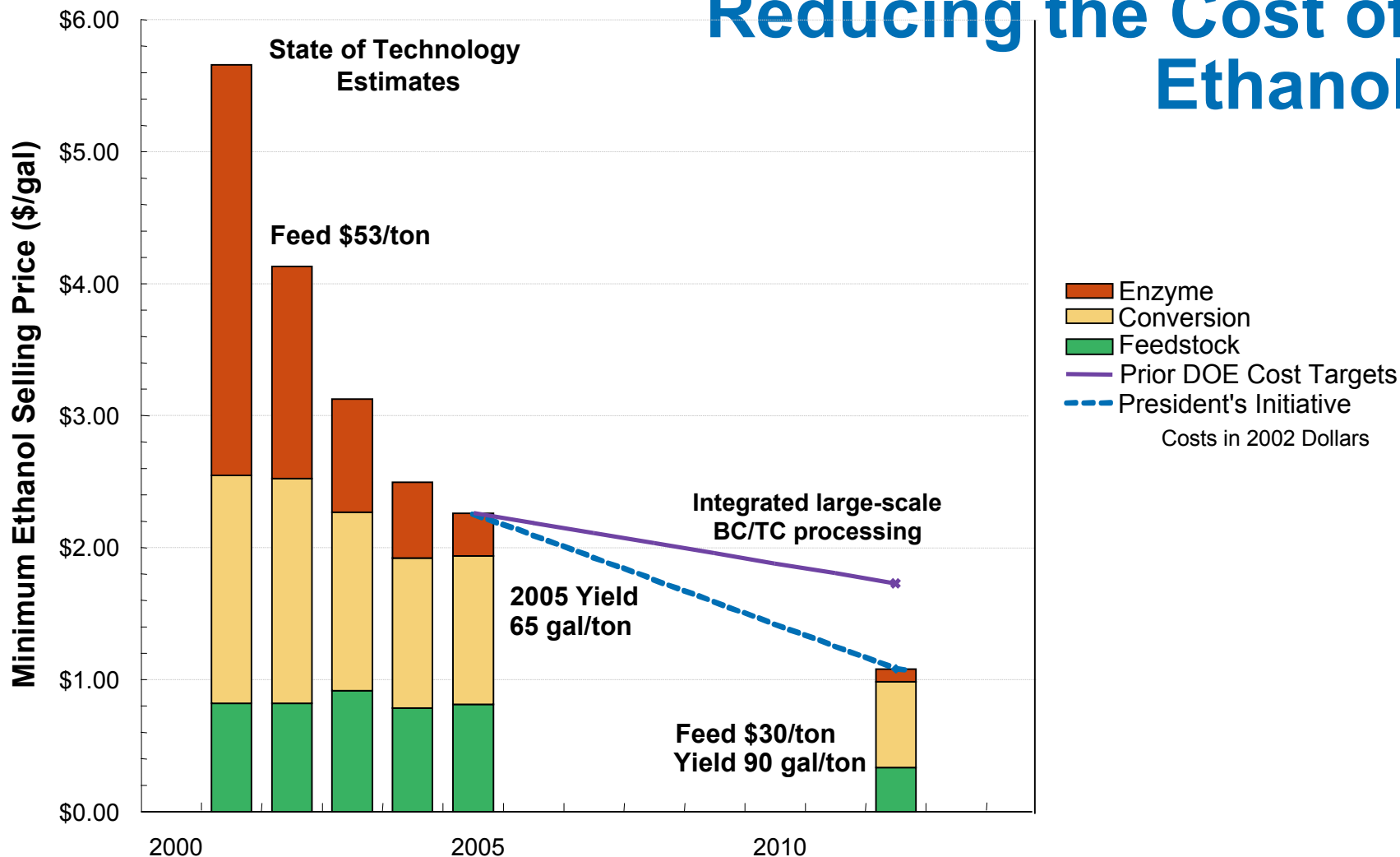


■ 2030 Goal

- Replace 30% of our current gasoline consumption with ethanol (60 billion gallons).



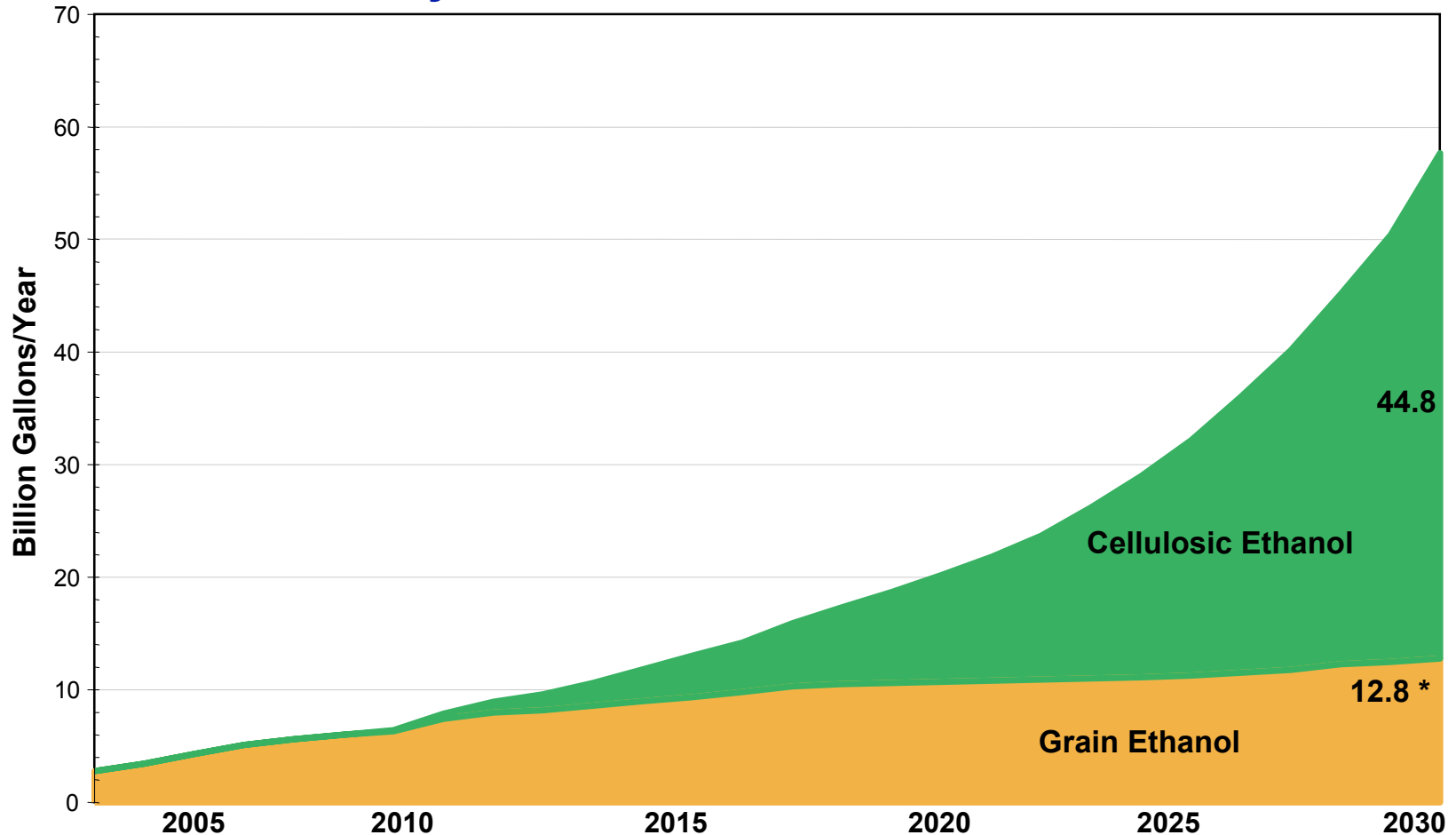
Reducing the Cost of Ethanol



* **Note:** Basic feedstock considered in this analysis is corn stover, which is the most likely feedstock source for reaching the 2012 cost goal. However, other cellulosic biomass feedstocks could have similar costs.

Reaching 60 Billion Gallons of Biofuels by 2030

A Scenario for Growth of Ethanol to Supply 30% of 2004 U.S. Gasoline Demand by 2030



* Note: This number could be higher. The National Corn Growers Association predicts that as much as 18 billion gal/yr could be produced from grain. Major changes to land use, exports, etc could also have substantial impacts. Regardless, significant cellulosic ethanol will be required to meet the 2030 goal and future national needs.

NREL Focus Areas

- **Cellulosic ethanol**
 - Biochemical Conversion processes
 - Thermochemical Conversion processes
- **Biomass/biofuels analysis**
- **Industry partnerships**
- **Validation**
- **High-energy density biofuels**



Ammonia R&D at NREL

IR 100 (now R&D 100) Award in 1982

- **Dr. Tom Reed**
- **“Oxygen High-Pressure Gasifier”**
- **Downdraft gasifier at modular scale (~ 100 tons/day) for on-farm production of methanol (fuel) and ammonia (fertilizer)**

