Differences in Research Among Academia, Government Laboratories, and Industry

Presented to

Rice University Graduate Student Association

M. Jonathan Haire, Ph.D.

Distinguished R&D Staff

Oak Ridge National Laboratory

Oak Ridge, Tennessee 37831

Rice University

Houston, Texas

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Managed by UT-Battelle
for the Department of Energy

OAK RIDGE National Laboratory

Welcome to ORNL

ORNL Video

http://www.ornl.gov/ornlhome/video/video.shtml

Government Laboratory Culture

- **Great Science**
- **Safety**
- **Security (if national security related)**

Freedom to Pursue Own Ideas

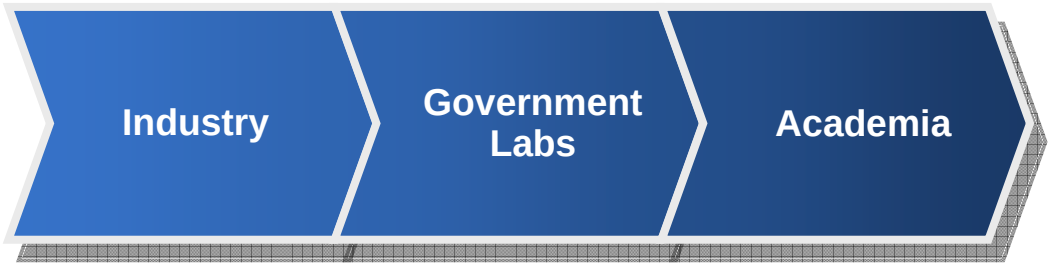
Drivers

Own Company	Industry	Government Labs	Academia
• Large profit	• Profit	• Support national technical initiatives driven by sponsoring agencies in turn driven by administration policies	• Education driven

Research Activities

Own Company	Industry	Government Labs	Academia
	• Market driven; little choice regarding work assignment, focused research	• Mission oriented – driven by National needs • Small development funding • Core/base funding is provided (theoretically) • National labs have consulting contracts with academia: joint appointments • Student internships • User facilities	• Graduate programs • Research initiated by individual Professor interest

Publish or Perish?

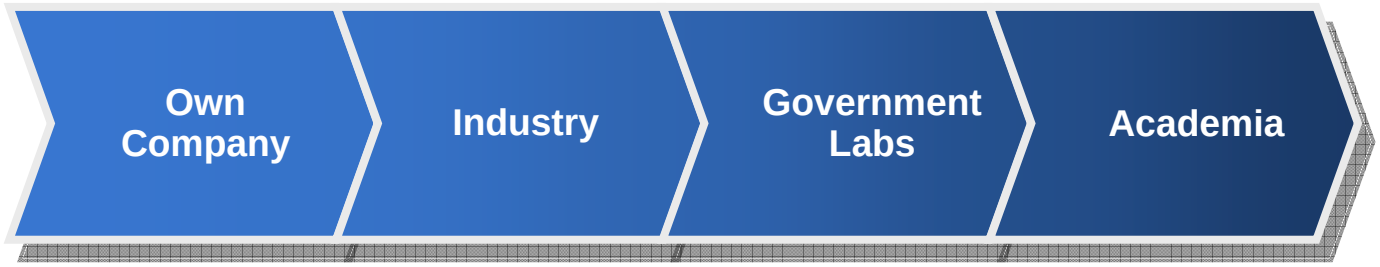


- Publication not important at all: Sometimes discouraged (trade secrets)
- Emphasis is on patents or new products

- Encouraged to document work in open literature
- Published where customers are likely to see it
- Papers can be viewed as marketing tools
- Serve to communicate results to scientific community

- Pathway to promotion
- National and international recognition
- Institutional recognition
- Necessity

Impact on Science and Technology



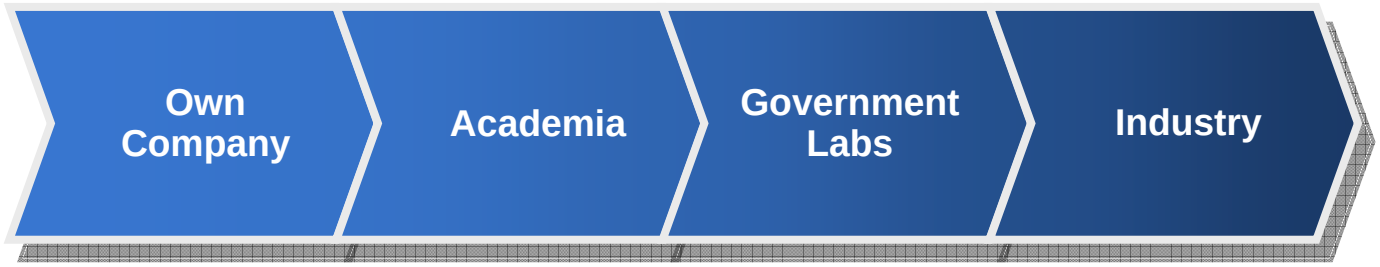
- Small business innovative research (SBIR) grants

- Uses Science & Technology to produce products and services for profit
- Market driven technology development
- Research aimed at short-term/low risk

- DOE, DoD advisory committees
- Large-scale experiments
- Experiments that academia or industry can not do because of:
  - Cost
  - National security
  - Unique expertise required
  - Long-term/high risk

- Membership in national academies provides leadership in science and technology direction
- e.g., National Academy of Science

Scale of Research



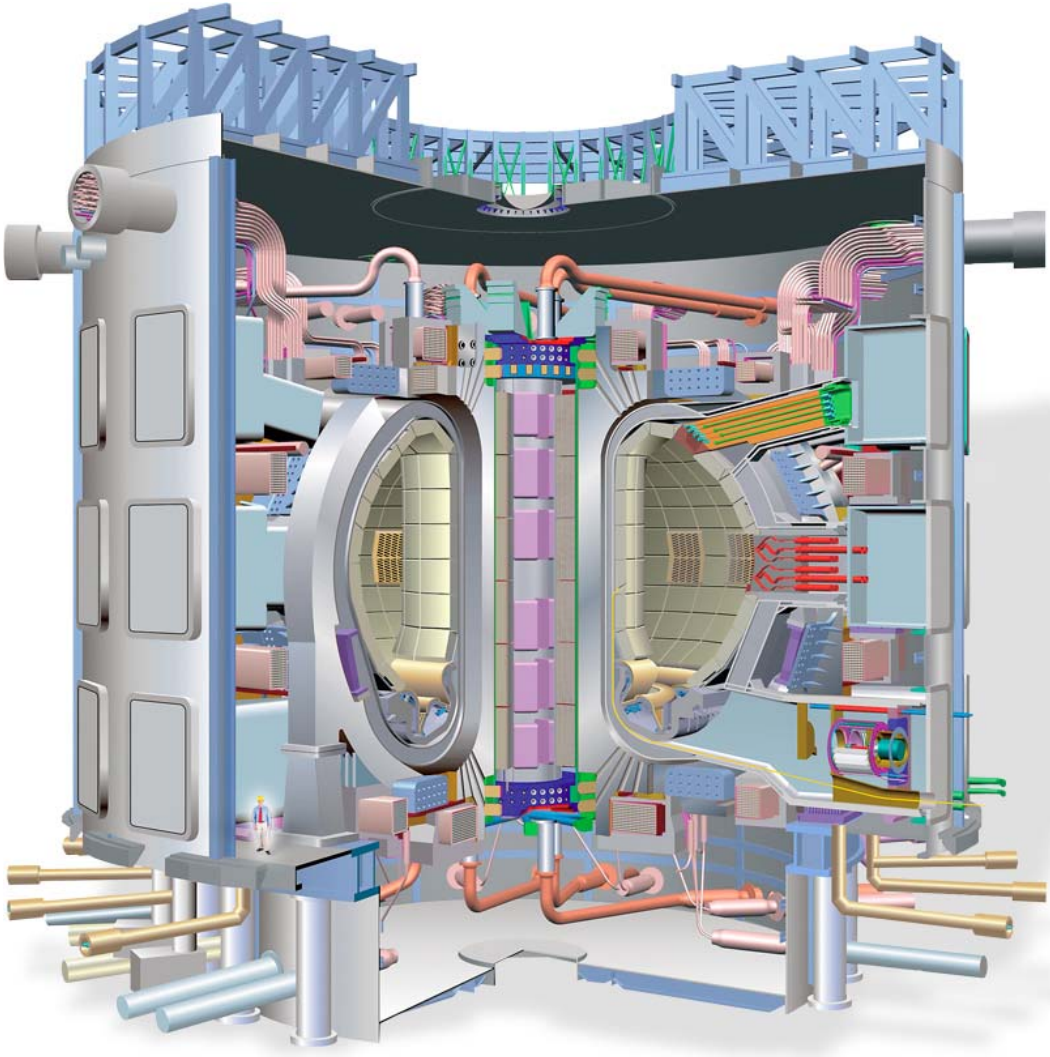
- Virtually no research
- Bench- scale
- Bench-scale prototype
- Large-scale
- Highly regulated R&D
- Bench-scale to pilot plant

Government/ industry partnerships

e.g., advanced nuclear reactors

Multi-nation collaborative research addresses problems common to both countries

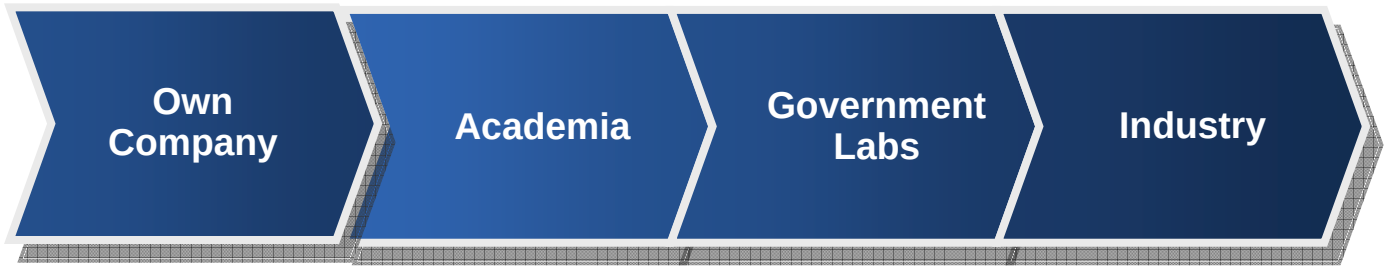
Cut-Away View of the ITER Machine



The High Flux Isotope Reactor (HFIR) Facility at ORNL

The Spallation NEUTRON Source (SNS) Facility at ORNL

Teaming (egos)



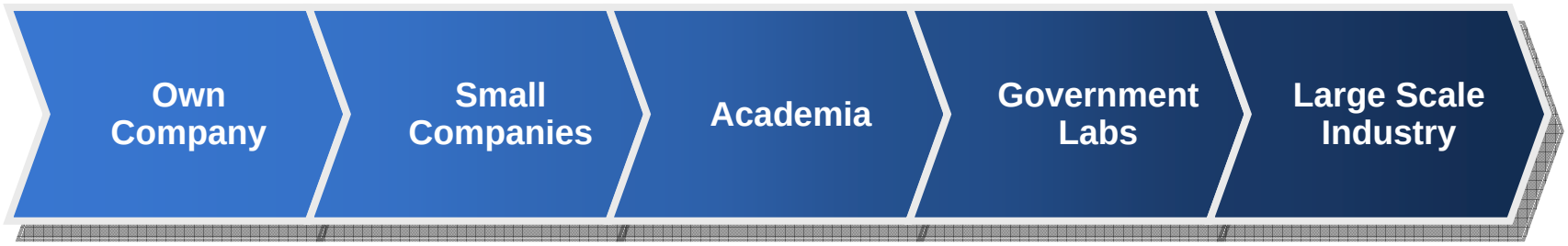
- Only when necessary

- Difficult

- Easy
- Can form a team in a heart beat
- Internationally known experts available at finger tips
- Government/ industry partnerships
- International collaboration

- Forced focus teams
- Little teaming across companies
- Industry institutes

Job Security



- ~95% fail within first three years

- Beltway bandits
- Job shop piecework

- Obtaining tenure is questionable now

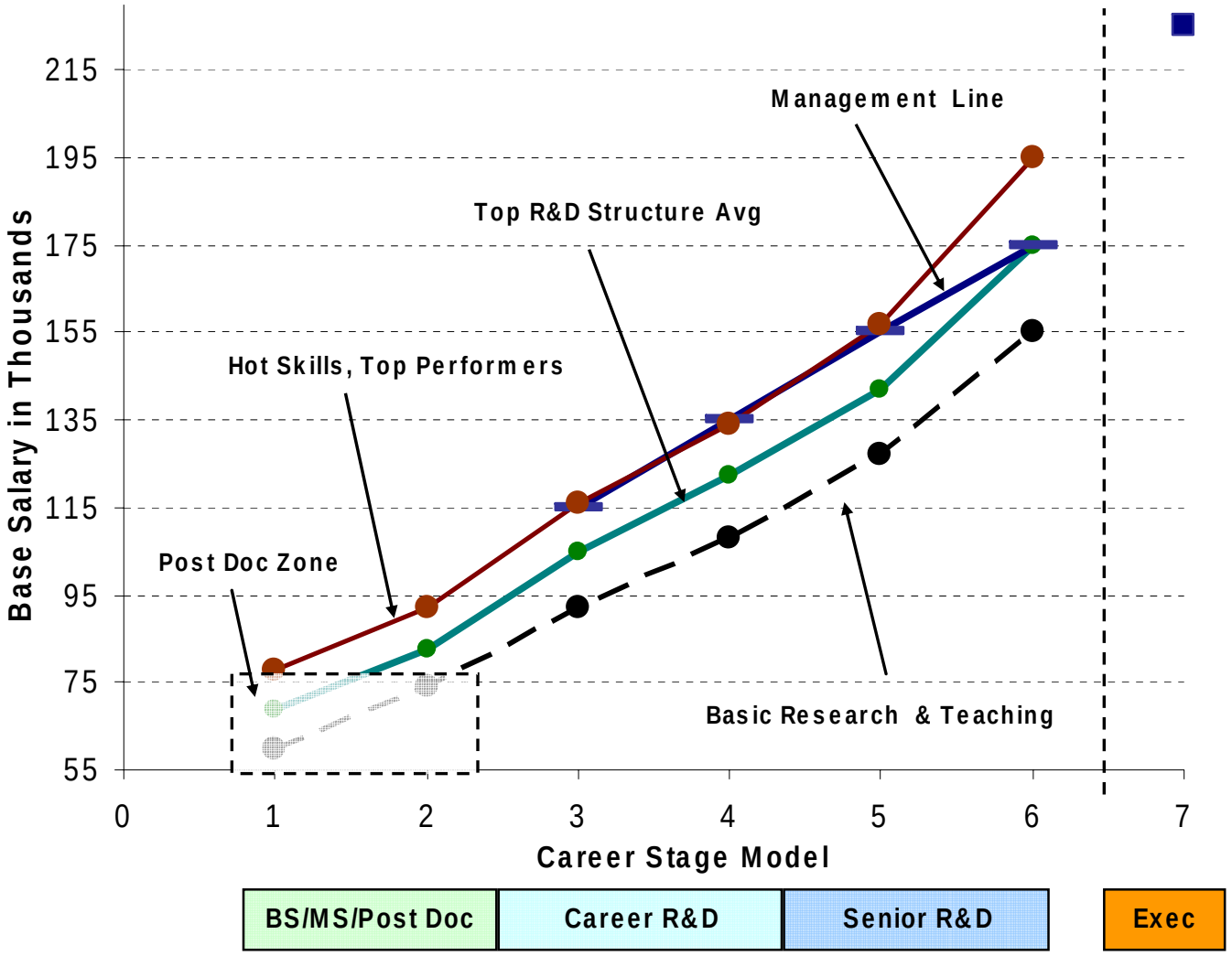
- Must be flexible: career will change direction 2 or 3 times

- e.g. Exxon

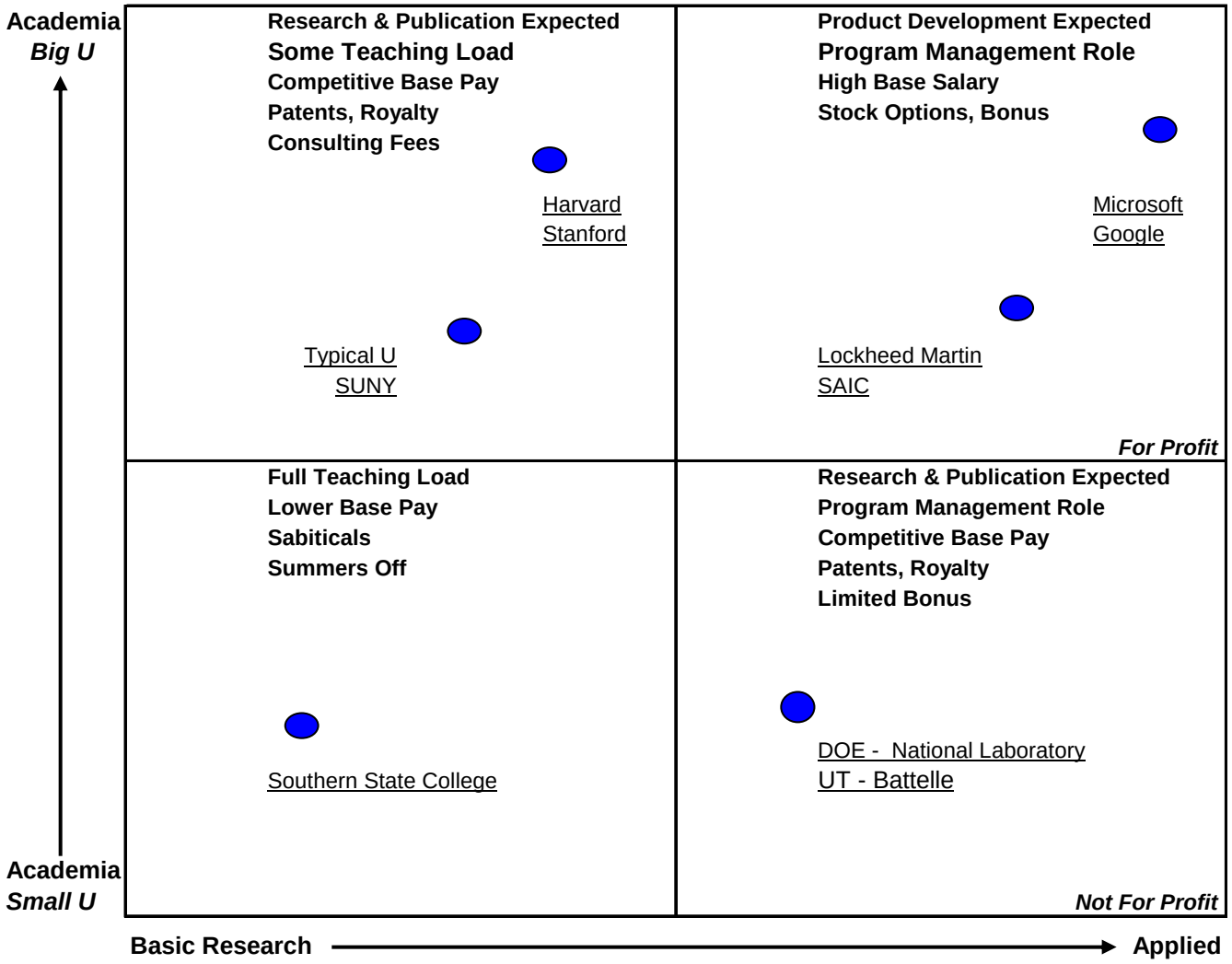
Different Types of Government Labs

- ***Single purpose*** **– National Renewable Energy Lab (NREL)**
- ***Multi-purpose*** **– Oak Ridge (ORNL), Argonne (ANL), Brookhaven (BNL)**
- ***DOE-defense labs*** **– Los Alamos (LANL), Sandia (SNL), Lawrence Livermore (LLNL)**
- ***Dept. of Defense labs*** **– Wright Patterson Air Force Base, Navy Research Lab**
- ***NASA labs/centers*** **– Johnson Space Center**

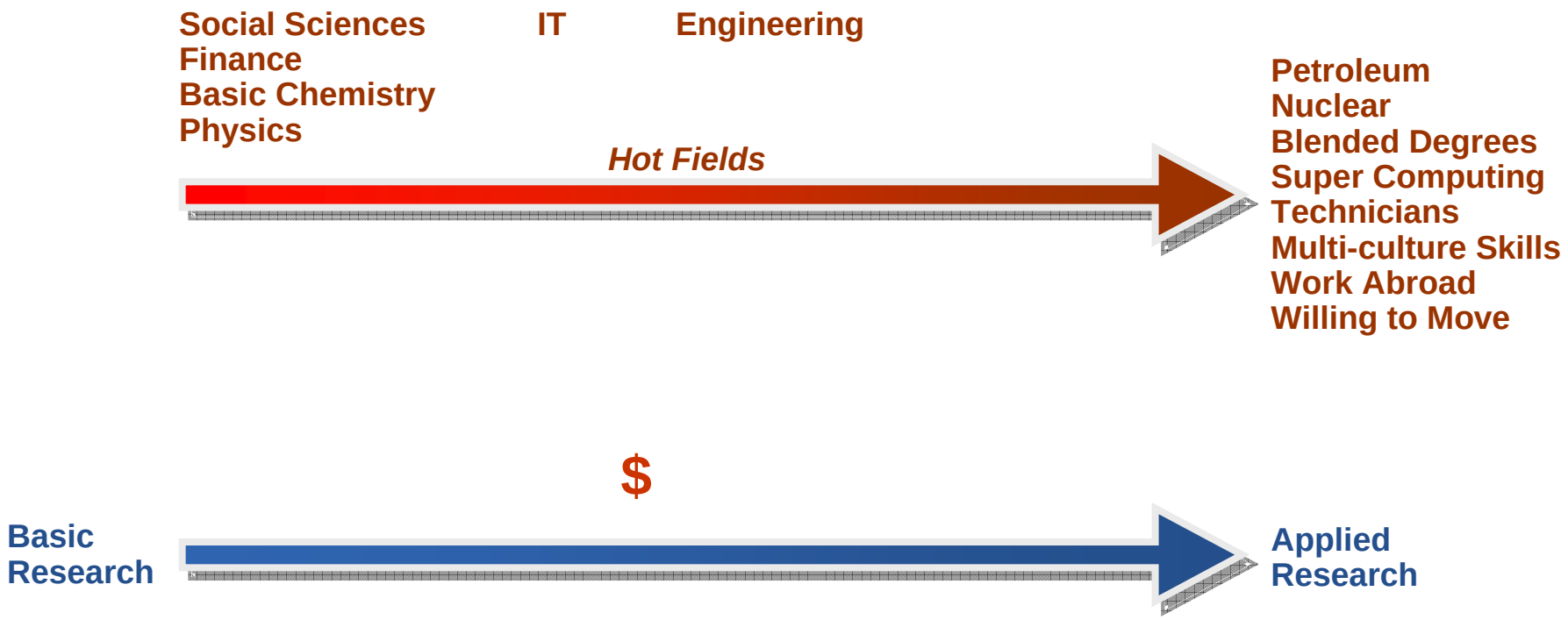
Total Rewards



Salary



Total Rewards



Student Internship Programs

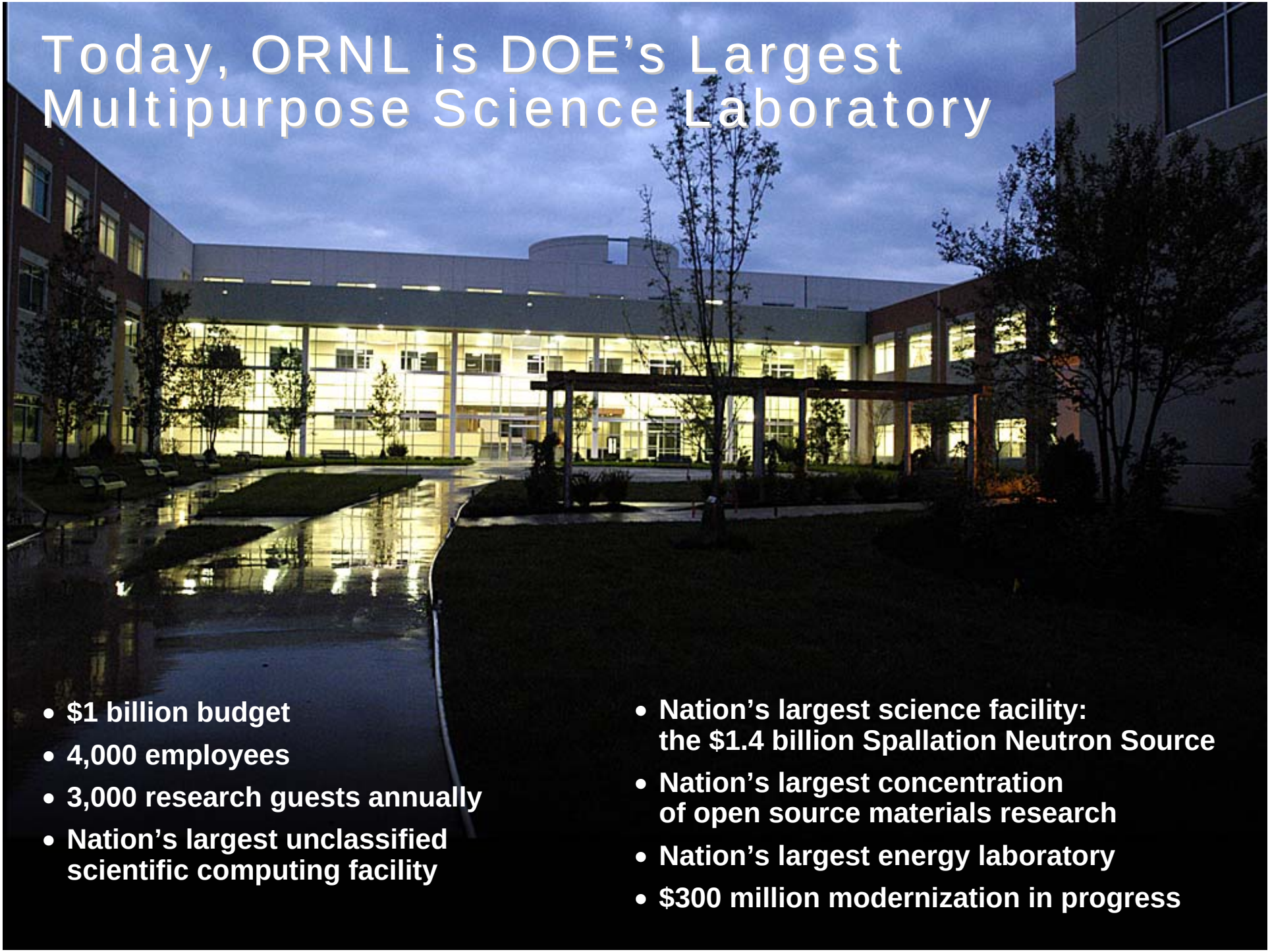
http://www.ornl.gov/sci/nuclear_science_technology/nstip/nesls.htm

ORNL Job Page

http://jobs.ornl.gov

BACK UP SLIDES

Today, ORNL is DOE's Largest Multipurpose Science Laboratory



- $1 billion budget
- 4,000 employees
- 3,000 research guests annually
- Nation's largest unclassified scientific computing facility

- Nation's largest science facility: the $1.4 billion Spallation Neutron Source
- Nation's largest concentration of open source materials research
- Nation's largest energy laboratory
- $300 million modernization in progress

ORNL is Managed and Operated by UT-Battelle

UT-BATTELLE
Limited Liability Company

The University of Tennessee
Knoxville, Tennessee

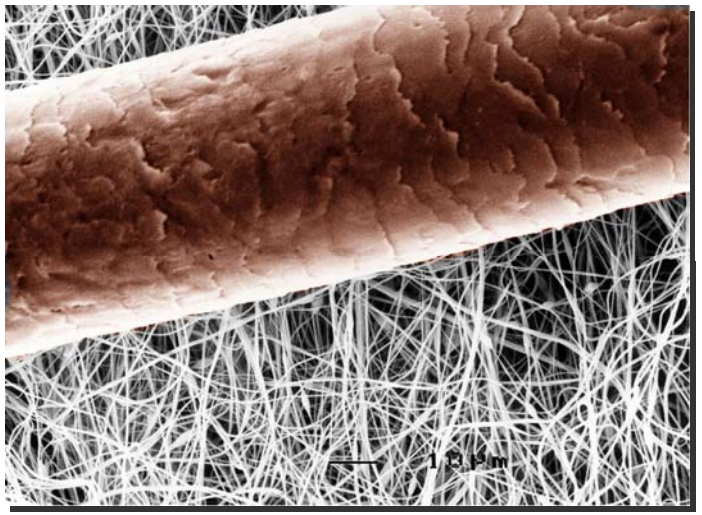
Battelle
Columbus, Ohio

OAK RIDGE National Laboratory

The Next Scientific Frontier at ORNL is the Nanoscale

Research and technology development at the level of individual atoms and molecules

- **A national research priority for Federal investment**
- **Strongly linked to the missions of the Department of Energy**
- **An exciting new field for cutting-edge science and engineering**
  - **Novel properties and phenomena**
  - **Extraordinary potential for new technologies**



Characteristic dimensions less than 1/1,000th the diameter of a human hair

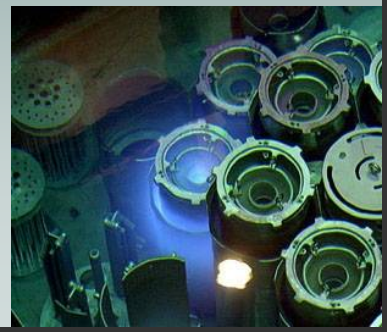
We are Developing and Deploying World-Class Tools for Nanoscale R&D

Spallation Neutron Source

- High-intensity neutrons for materials research at the nanoscale
- 1.4 MW of beam power on target
- 16 instruments

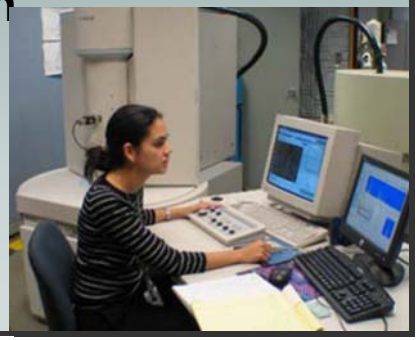
High Flux Isotope Reactor

- The nation's leading research reactor
- World-class instruments for neutron scattering R&D



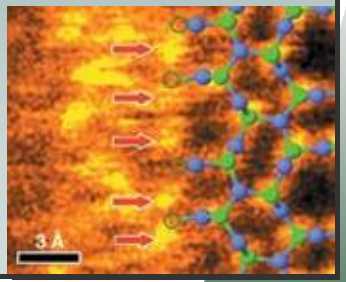
Center for Nanophase Materials Sciences

- $65M facility began operating in October 2005
- User program launched with 42 projects



Ultrahigh-resolution microscopy

- Advanced Microscopy Laboratory
- Aberration-corrected electron microscope
- World-record resolution: 0.6 Å



OAK RIDGE National Laboratory

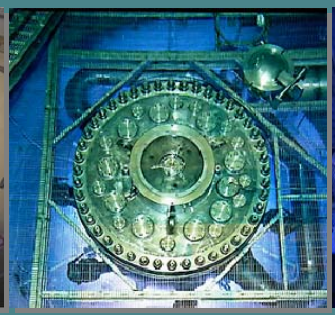
Oak Ridge will Lead the World in Neutron Scattering

- **Spallation Neutron Source**
  - **Total cost: $1.4 billion**
- **Upgraded High Flux Isotope Reactor**
- **Joint Institute for Neutron Sciences**

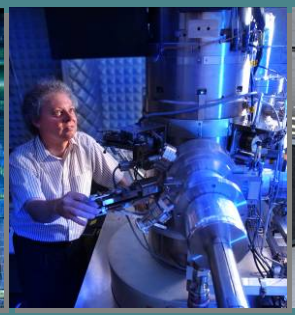
We are Unrivaled in Advanced Materials

DOE's largest materials and condensed matter programs	Special strengths in advanced alloys and ceramics, correlated electron materials, macromolecular systems, and carbon-based materials
SNS and HFIR offer transforming capabilities	Structure and dynamics, large-scale structures, spins, neutron and neutrino physics
World-class capabilities for nanoscale science	Synthesis, nanoscale characterization, spin-sensitive and other probe spectroscopies
Leadership-class computing	Predictive simulation of materials and molecular interactions
Unmatched characterization capabilities	Electron microscopy, mass spectrometry, local electron probes, physical and chemical properties measurement

DOE's first nanoscience center



World's foremost capabilities for neutron science



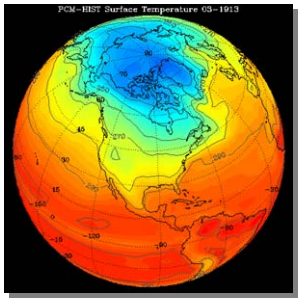
Record-setting electron microscopes

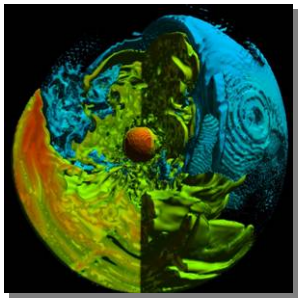
Leadership-class computing

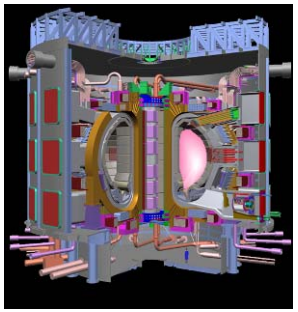
OAK RIDGE National Laboratory

We are at the Forefront in Computing and Simulation

- **Leading the partnership to develop the National Leadership Computing Facility**
  - **Leadership-class scientific computing capability**
  - **100 teraflops by 2006; 250 teraflops by 2007**
- **Attacking key computational challenges**
  - **Climate change**
  - **Nuclear astrophysics**
  - **Fusion**
  - **Materials sciences**
  - **Biology**
- **Providing access to our computational resources through high-speed networking**



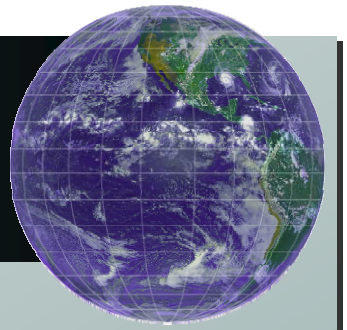




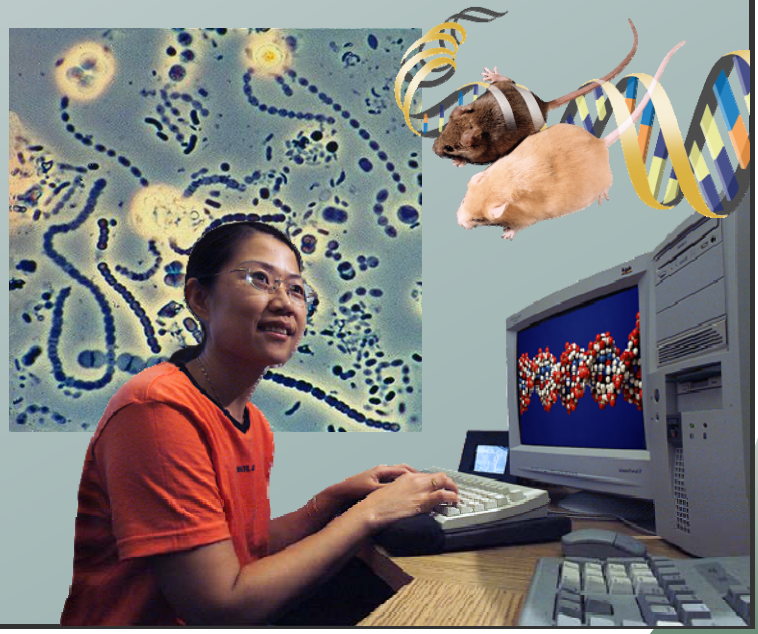
OAK RIDGE National Laboratory

Our Systems Biology Research Extends from the Molecule to the Ecosystem

Understand biological systems and apply new knowledge to energy, environmental, and human health challenges



- **Identify the composition and function of "molecular machines"**
- **Use biological processes to**
  - **Produce clean energy**
  - **Sequester carbon**
  - **Help clean up the environment**
- **Understand how living organisms react to their environments**
- **Determine the genetic basis for complex traits**



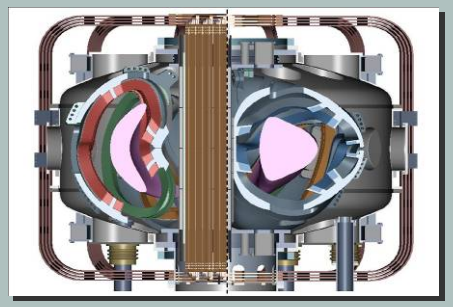
OAK RIDGE National Laboratory

We Apply our S&T Resources to National and Homeland Security

- **Detecting, preventing, and reversing the proliferation of weapons of mass destruction**
- **Deploying integrated systems for incident awareness, detection, and response**
- **Providing technology for detecting explosives at the part-per-trillion level**
- **Delivering enhanced protection and new capabilities to first responders and warfighters**

OAK RIDGE National Laboratory

We Address the Energy Challenges of the Present . . . and the Future

Generation	Distribution	Consumption
Fossil **Fission** **Renewables** **Fusion**	**Transmission technology** **Hydrogen** **Distributed energy resources**	**Buildings** **Industry** **Transportation**
		

Supporting DOE's strategic goals
for energy security and independence

ORNL has a Large and Diverse Nuclear Science and Technology Program

Comprehensive and diverse capabilities

- **Nuclear Security Technologies**
- **Nuclear Systems Analysis, Design, and Safety**
- **Fuels, Isotopes, and Nuclear Materials**

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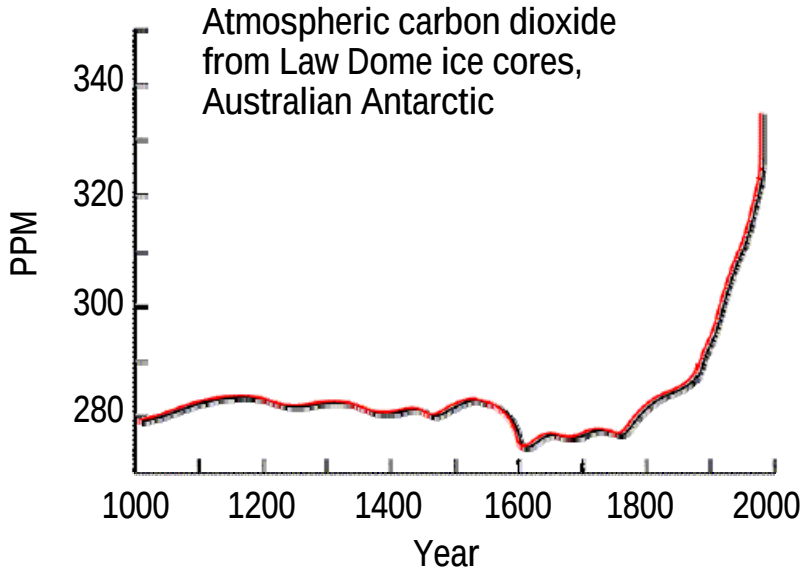
BACK UP SLIDES

What is Driving our Energy Concerns?

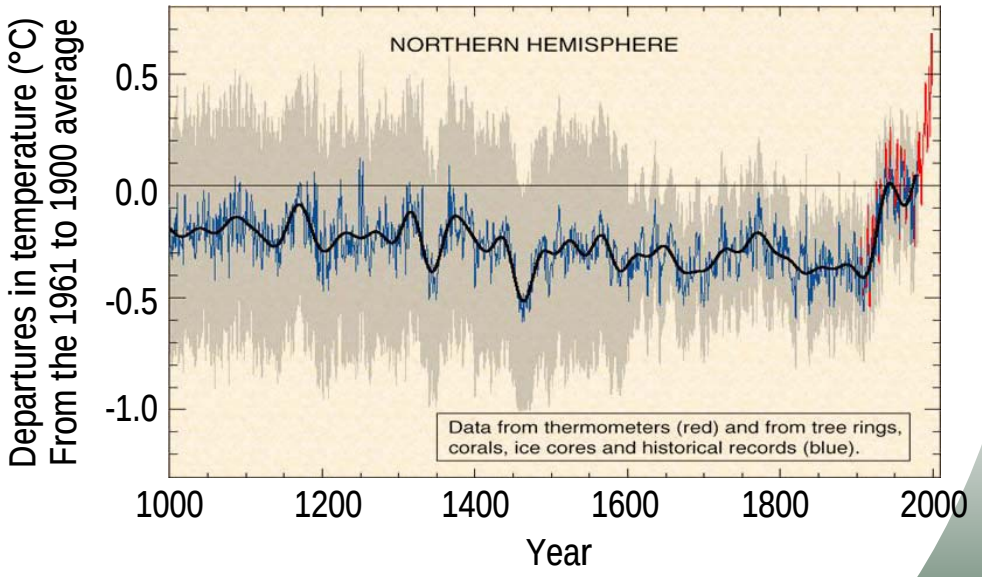
National security
- Economic health through energy systems
- Reliable fuel supplies and energy production
- Infrastructure vulnerability

International stability
- Demand increases in developing nations
- Assured fuel supplies
- Population and standard of living growth

Environmental integrity
- Particulate emissions
- Greenhouse gas emissions
- Global warming

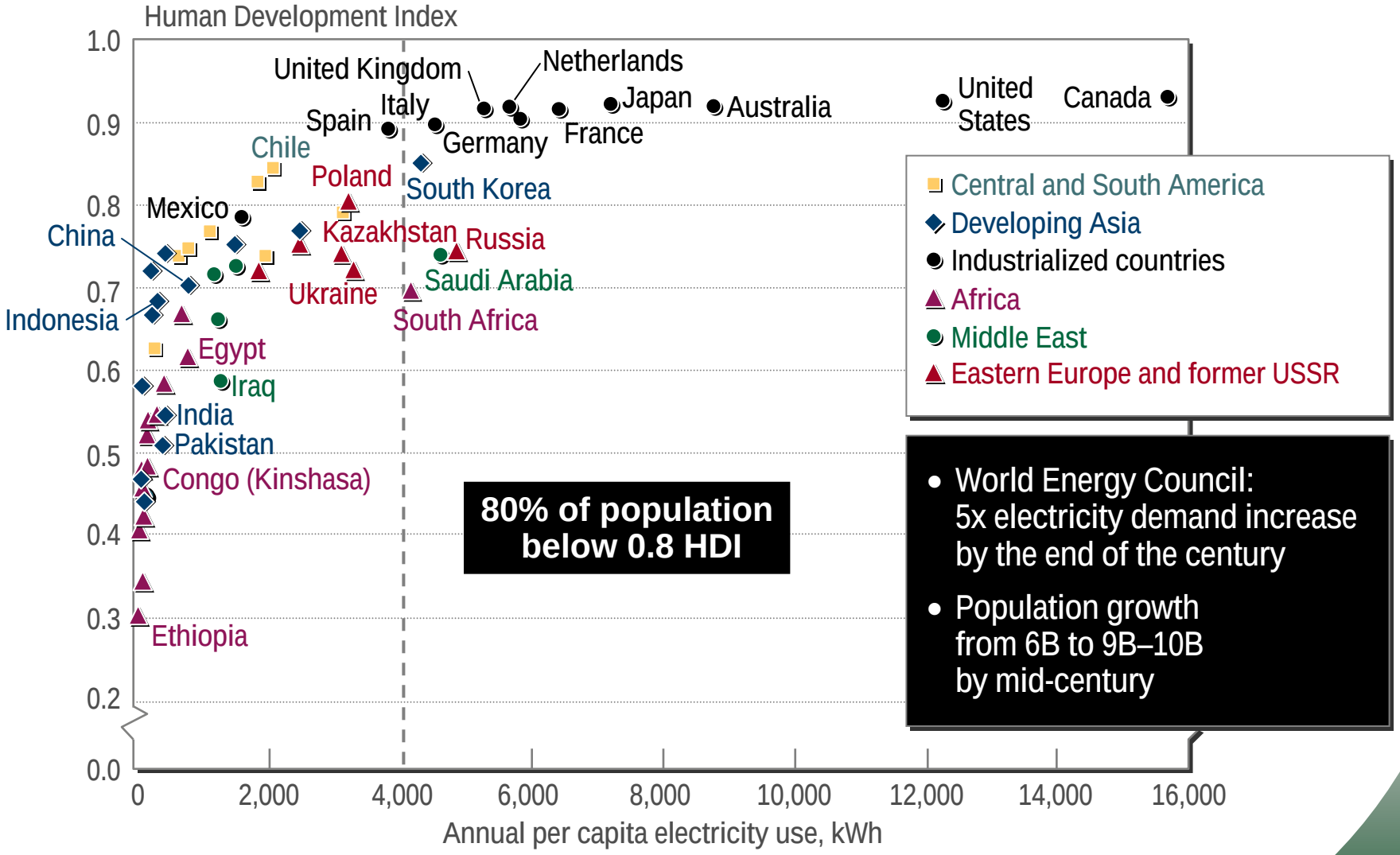


Source: B. Geerts and E. Linacre
http://www-das.uwyo.edu/~geerts/cwx/notes/chap01/icecore.html



http://www.grida.no/climate/ipcc_tar/wg1/069.htm

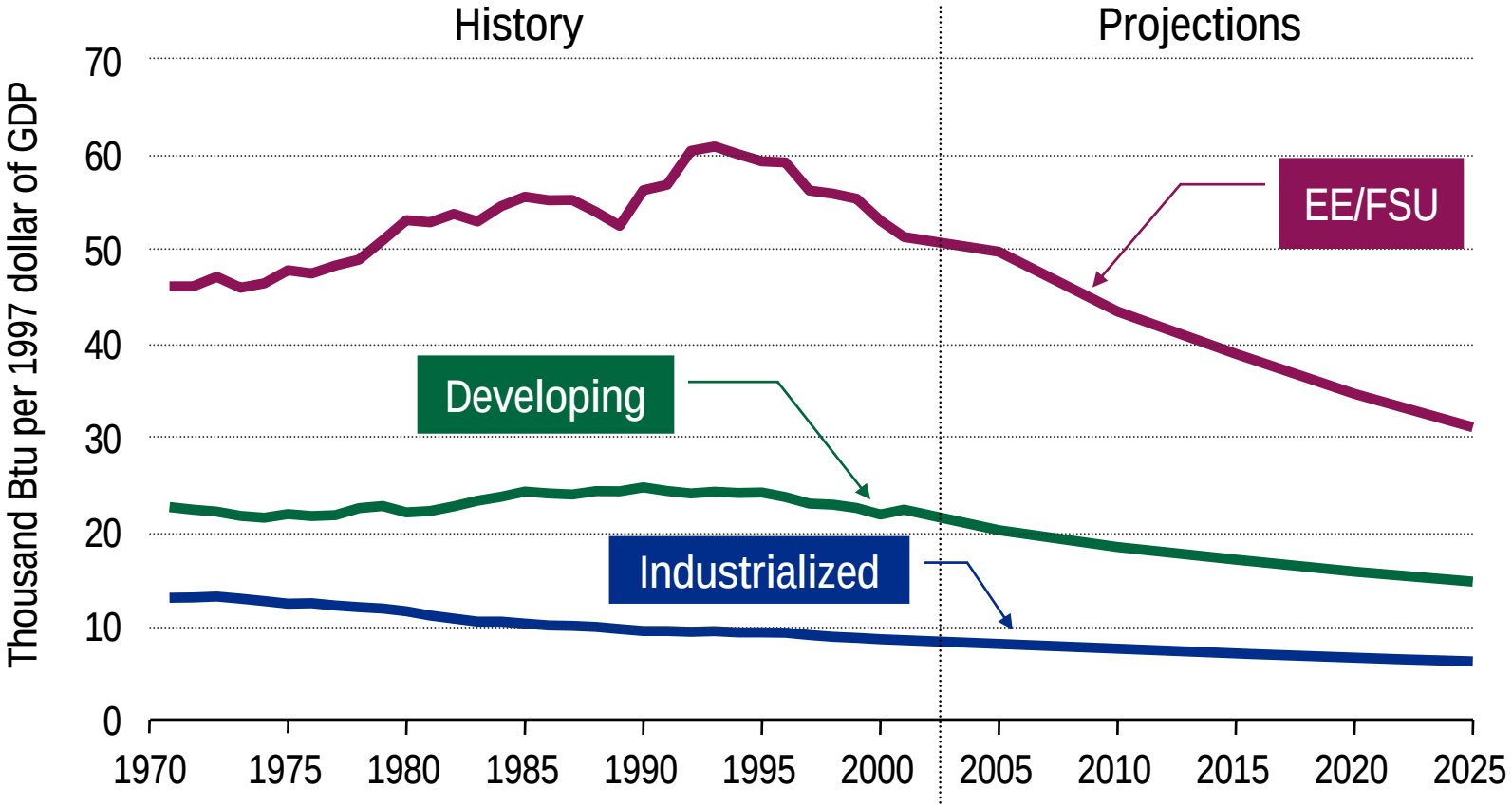
Global Distribution of Electricity and Development



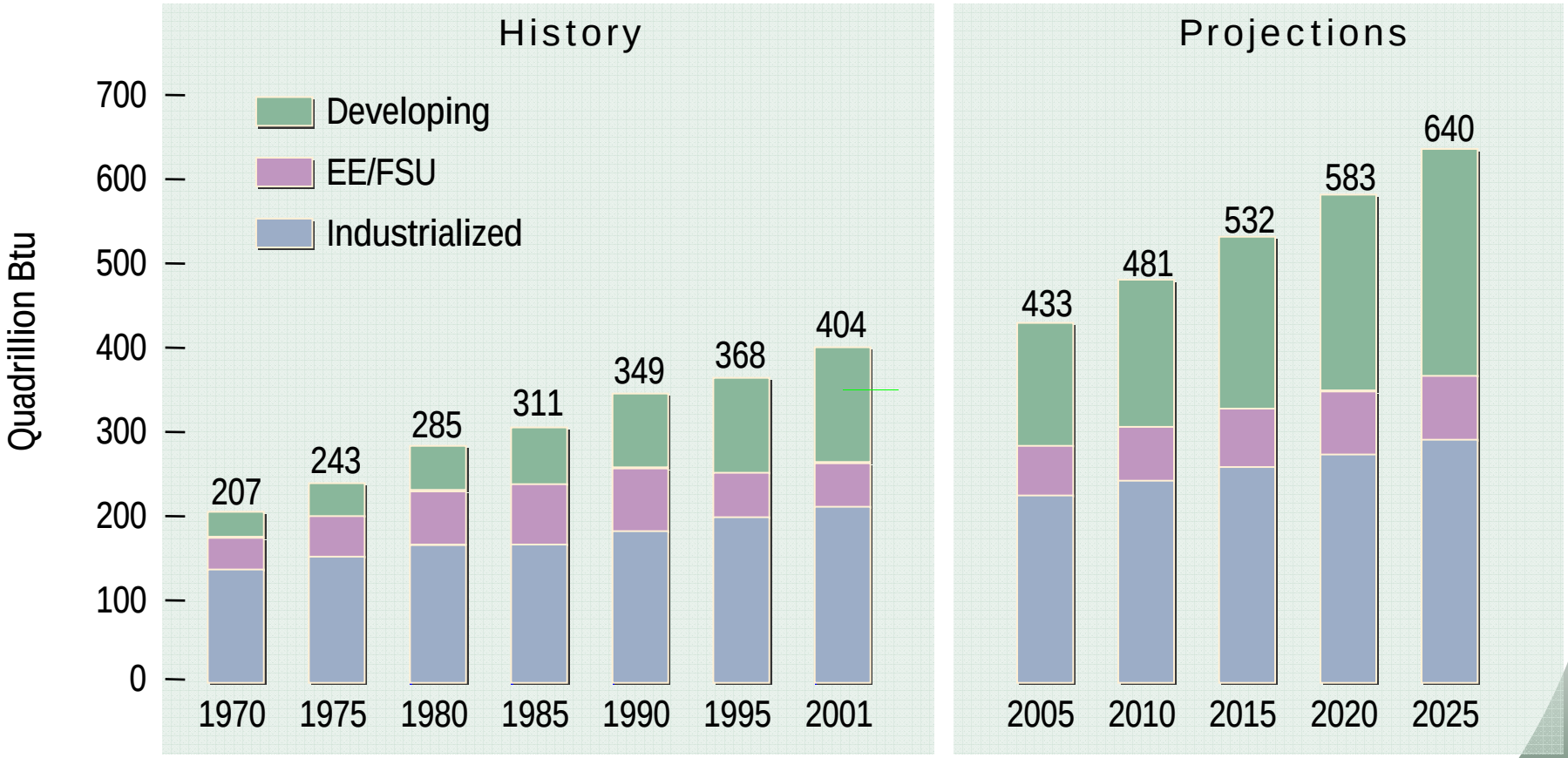
Source: Pasternak, "Global Energy Futures and Human Development: A Framework for Analysis"

Energy Intensity by Region, 1970–2025

How efficient are we in our energy use?

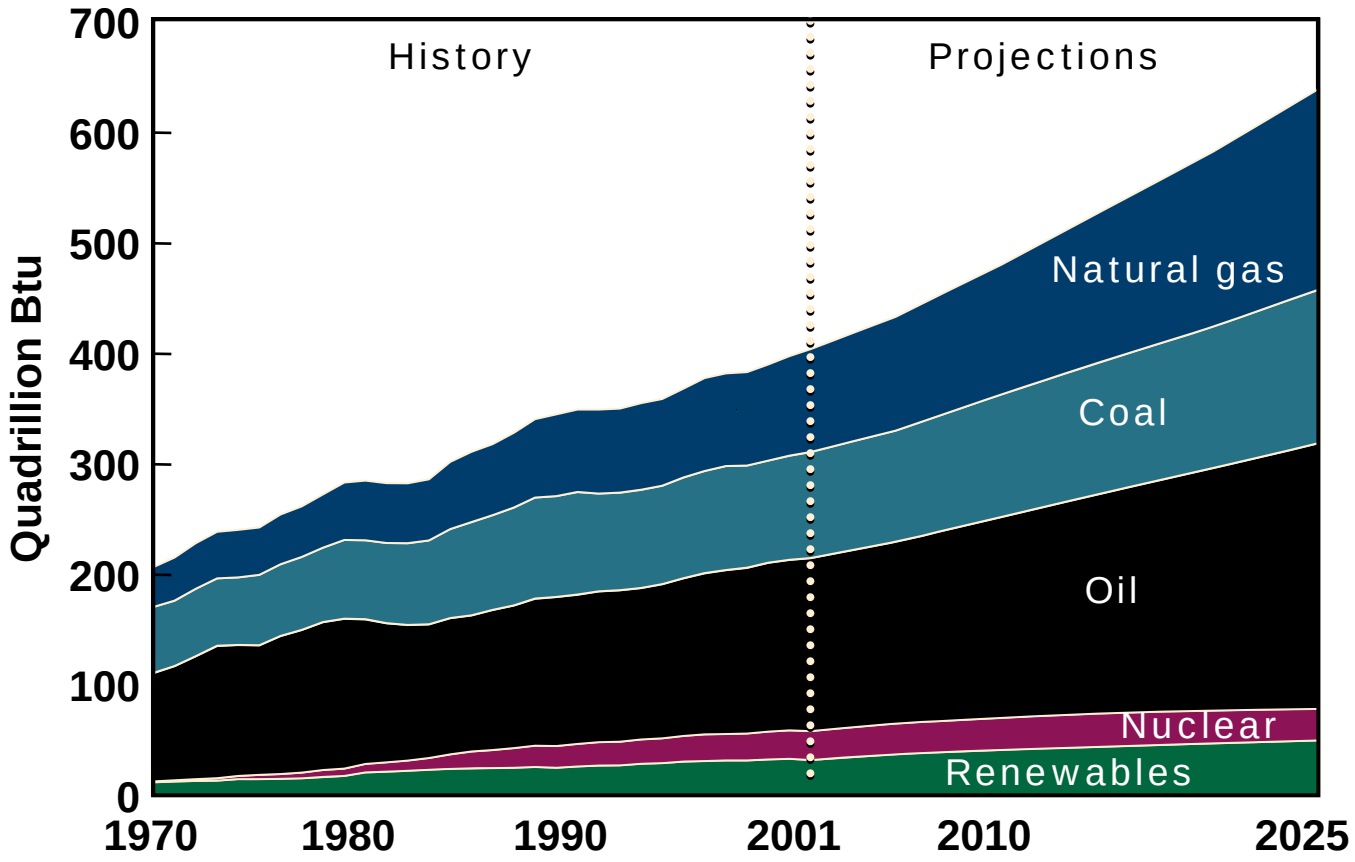


World Commercial Energy Consumption, 1970–2025



Source: EIA, *International Energy Outlook 2003*

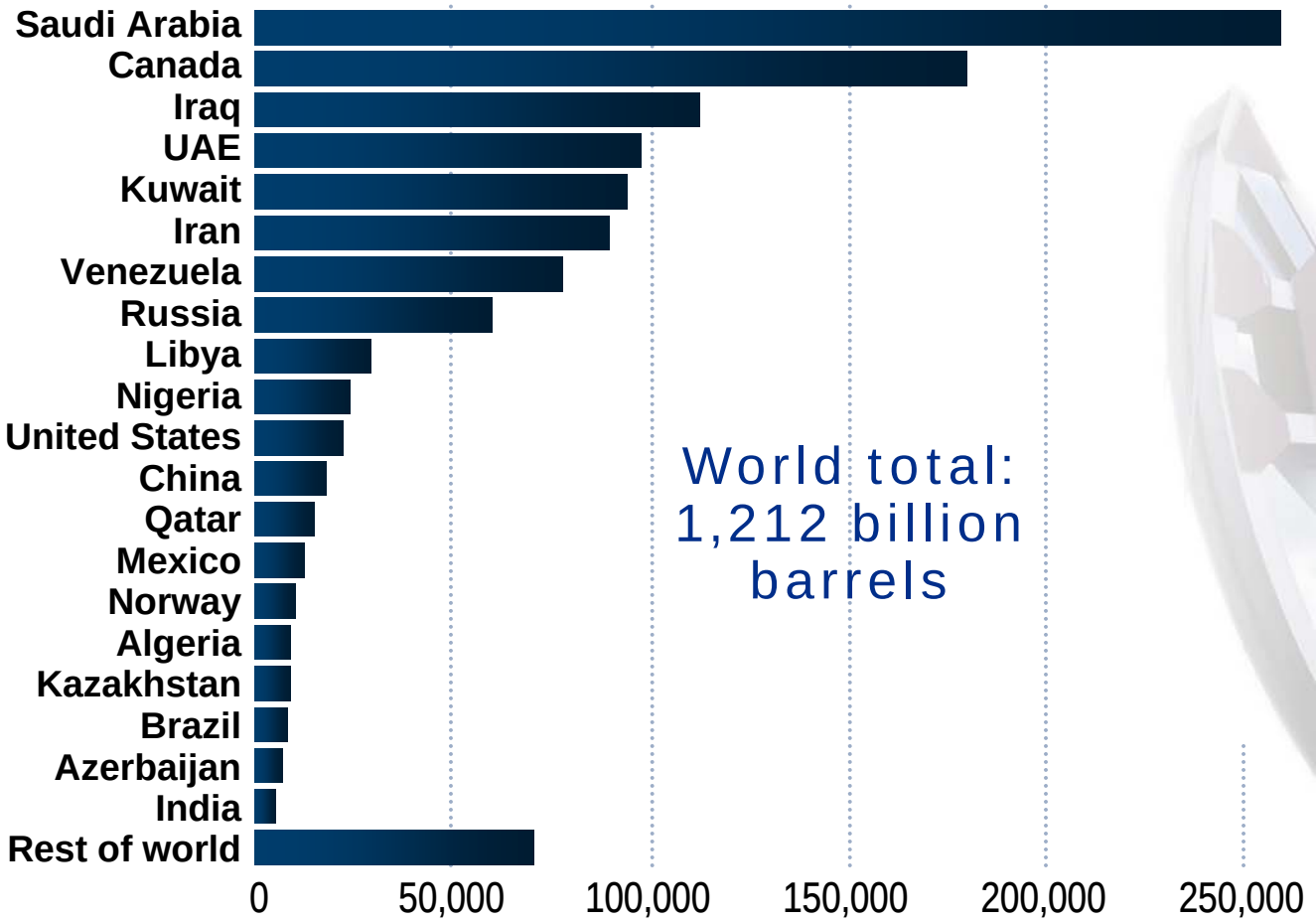
World Energy Consumption by Fuel, 1970–2025



- **Industry has invested in energy infrastructure that will last for 25–50 years**
- **It will be difficult to move away from fossil fuel consumption**

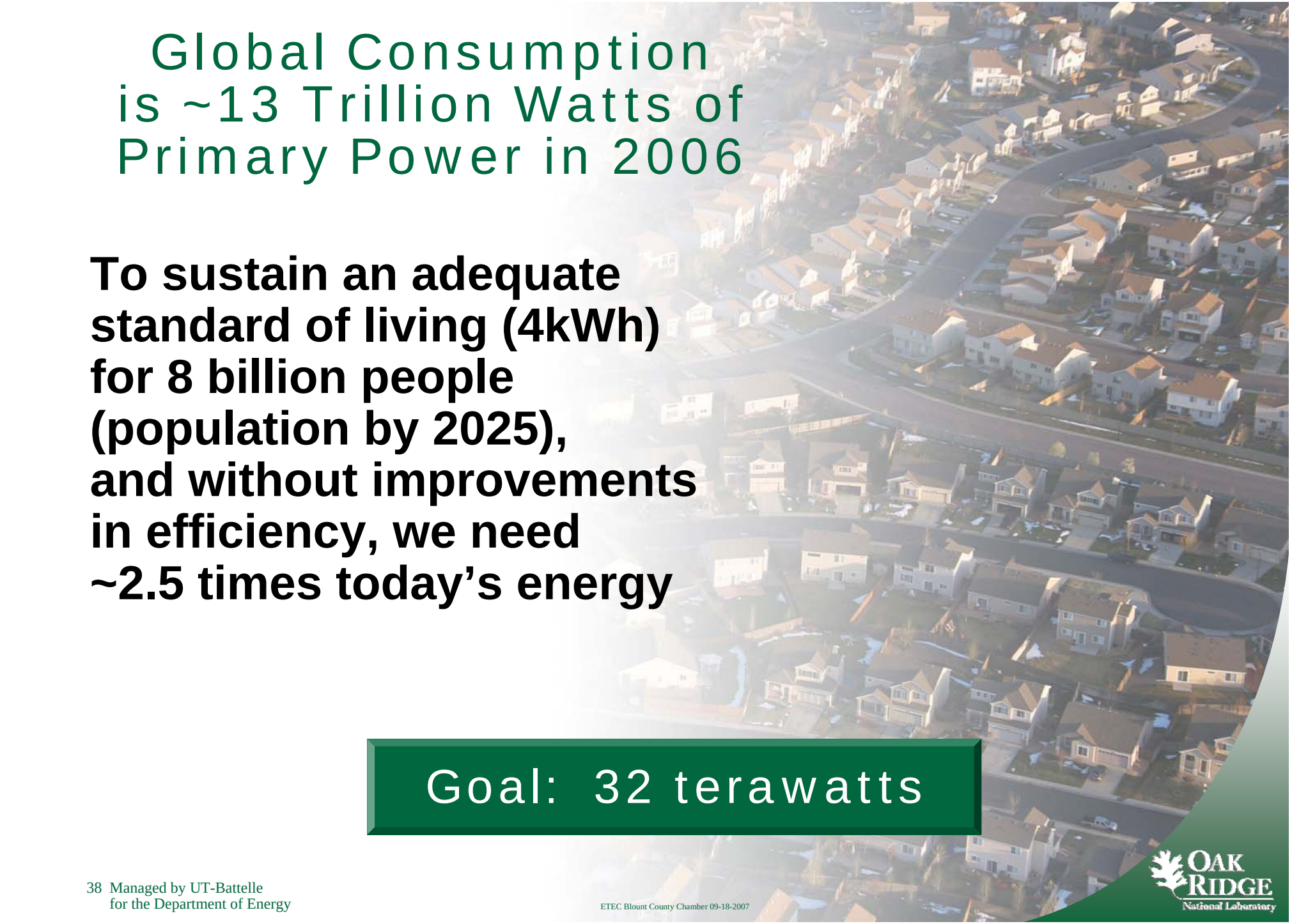
A $15 trillion energy infrastructure supports 3.5 billion people

World Oil Reserves by Country as of January 1, 2003



World total: 1,212 billion barrels

Global Consumption is ~13 Trillion Watts of Primary Power in 2006



To sustain an adequate standard of living (4kWh) for 8 billion people (population by 2025), and without improvements in efficiency, we need ~2.5 times today's energy

Goal: 32 terawatts

An Economic Opportunity

- **Clean energy (improved environment)**
- **Secure resources**
- **Robust electric power grids**
- **Fuel for transportation**
- **Efficient vehicles, machines, and appliances are increasingly value-added products**

32 terawatts of global power demand translates to a $38 billion/day market at $0.05 kWh

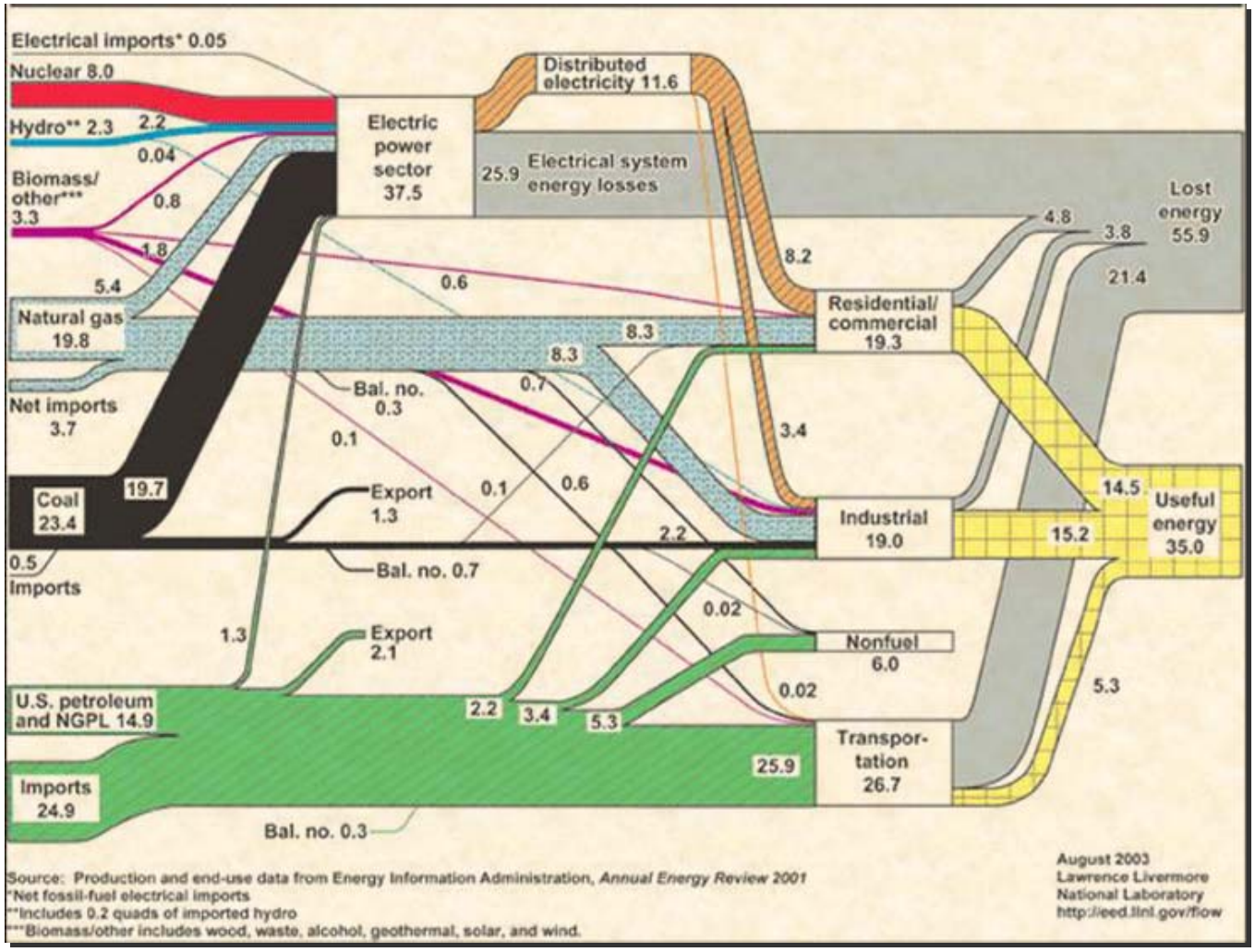
Energy Security Requires Broad Energy Investment: Maintain Diversity!

To achieve a sustainable, secure, clean energy future, all non-emitting energy options must be utilized:

- **CO_2 capture and storage (sequestration)**
- **Clean coal**
- **Nuclear**
- **Hydrogen and fuel cells**
- **Renewable energy (wind, solar, biomass)**
- **Efficiency and conservation**
- **Water/energy relationship**
- **Judicious use of oil and gas**

How do we get there?

U.S. Energy Security is Accomplished by Diversity



Net primary resource consumption ~ 97 Quads in 2001

The United States is increasingly vulnerable to import disruption

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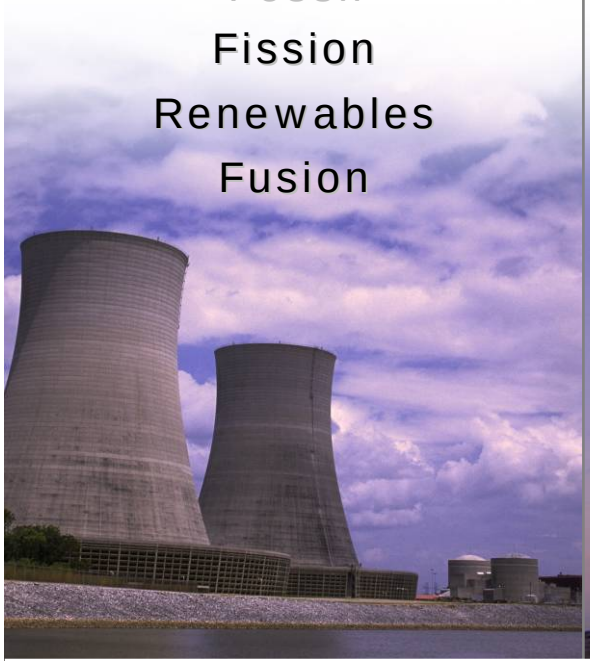
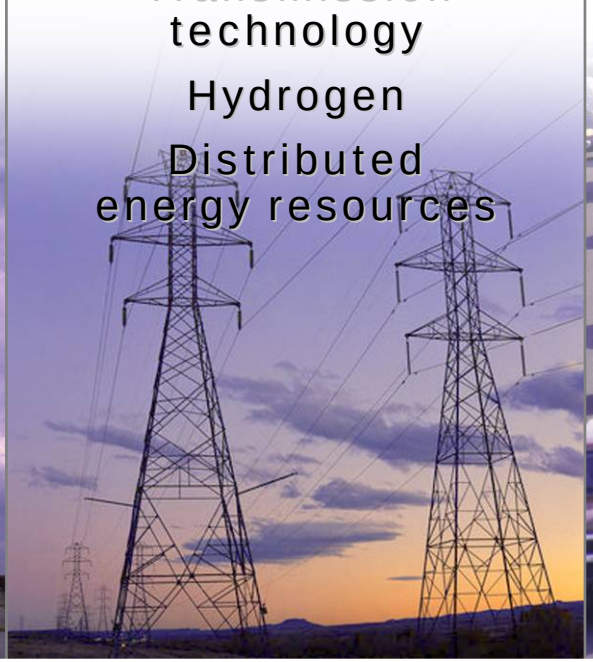
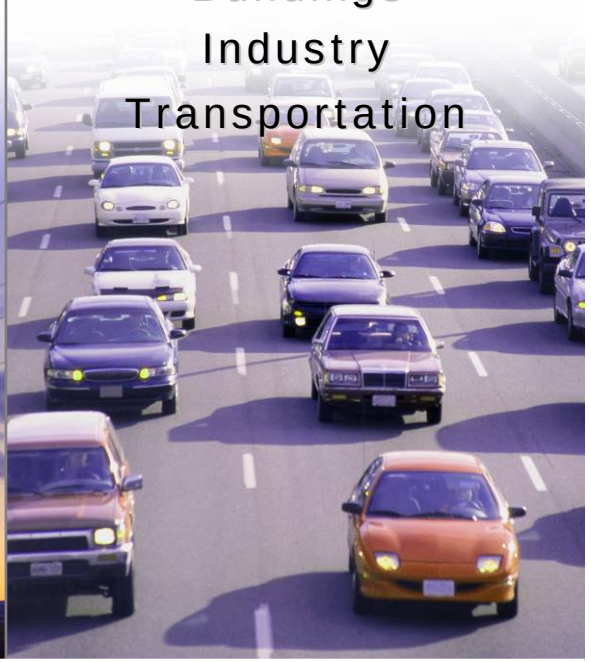
ORNL Energy Technology Research Cuts Across the Entire Energy Spectrum

Generation	Distribution	Consumption
Fossil	Transmission technology	Buildings
Fission	Hydrogen	Industry
Renewables	Distributed energy resources	Transportation
Fusion		

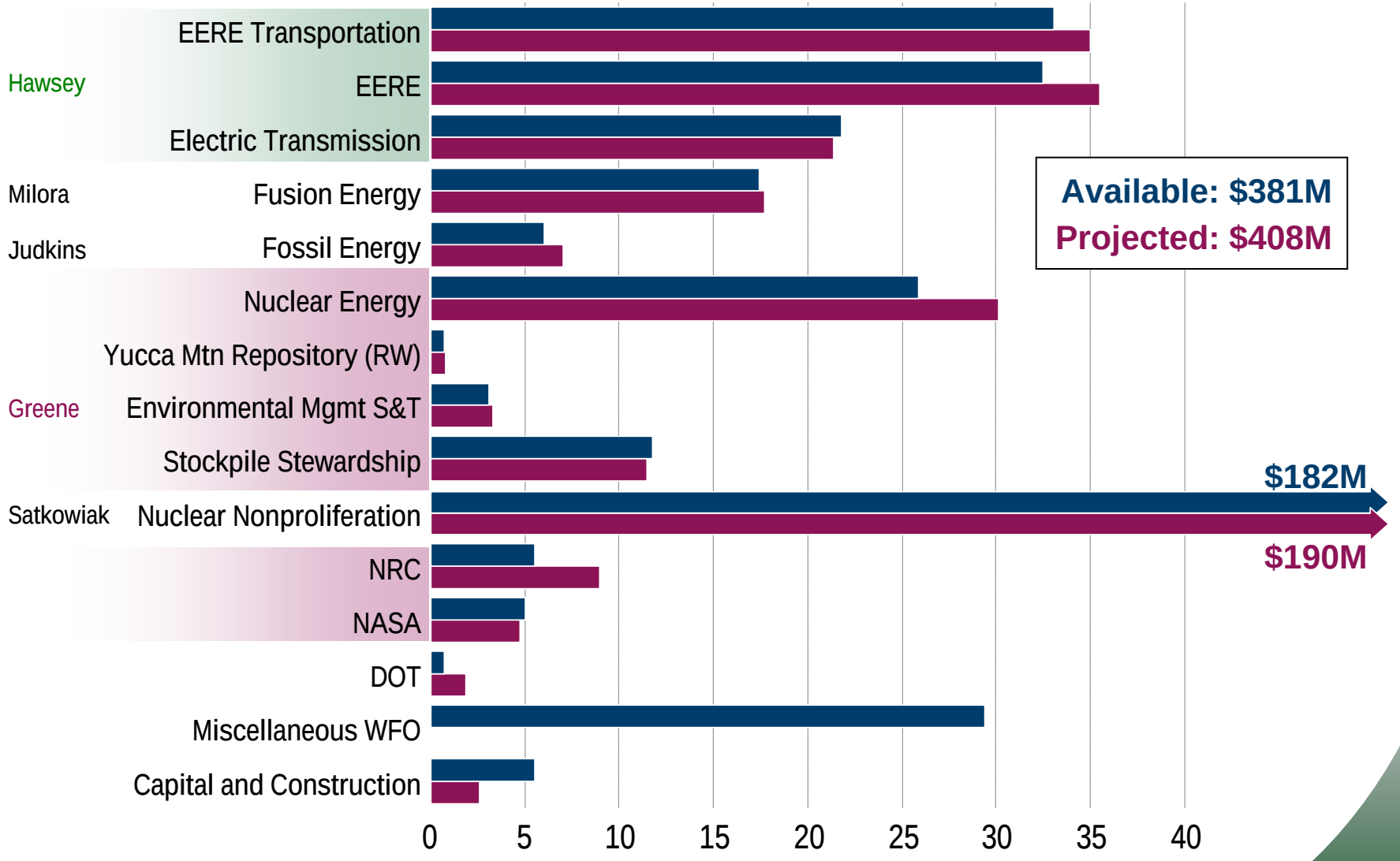






Supporting DOE's strategic goals
for energy security and independence

Energy and Engineering Sciences
FY07 New BA ($M)



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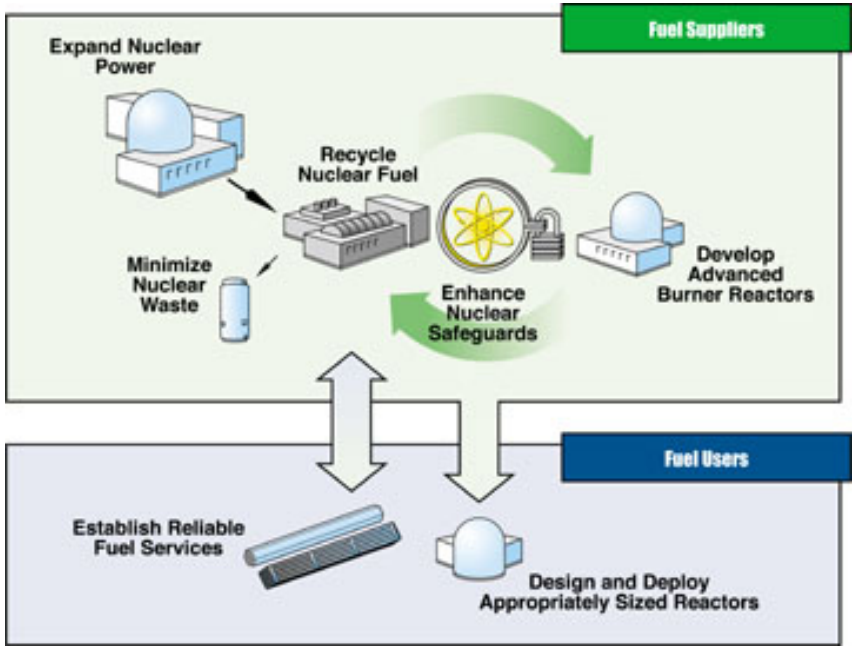
Global Nuclear Energy Partnership (GNEP): Safe and Secure Expansion of Nuclear Power

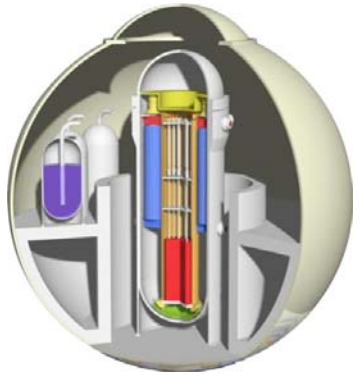
"Promoting the growth of clean, carbon-free nuclear power to meet the growing electricity demand that enhances energy security while promoting non-proliferation is a must in the U.S. and internationally."

– George W. Bush

- **Advanced proliferation-resistant reprocessing**
- **Advanced burner reactors for waste transmutation**
- **Advanced safeguard technologies**
- **Reliable fuel services**
- **Small exportable reactors**



Fuel lease concept



Exportable, right-sized nuclear reactor

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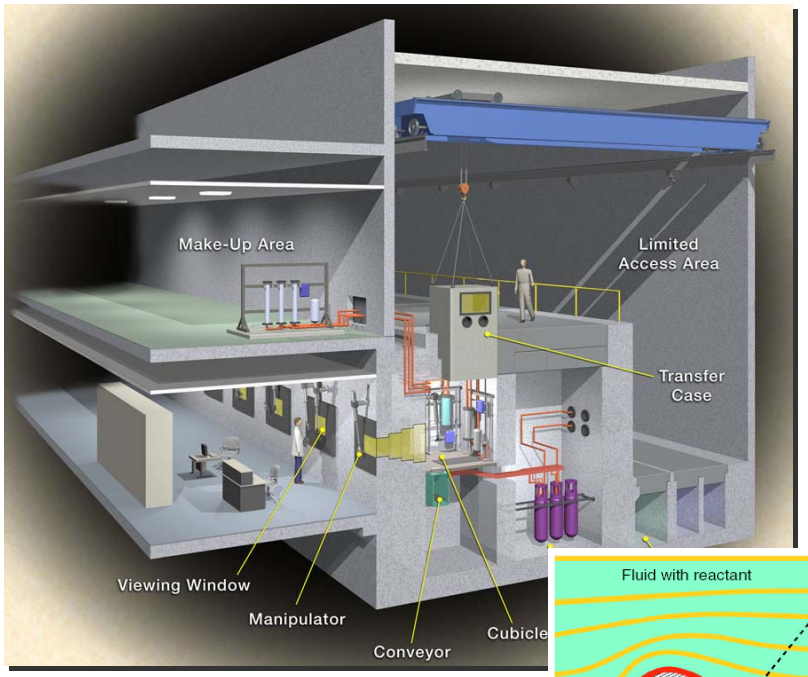
ORNL: R&D Support for GNEP

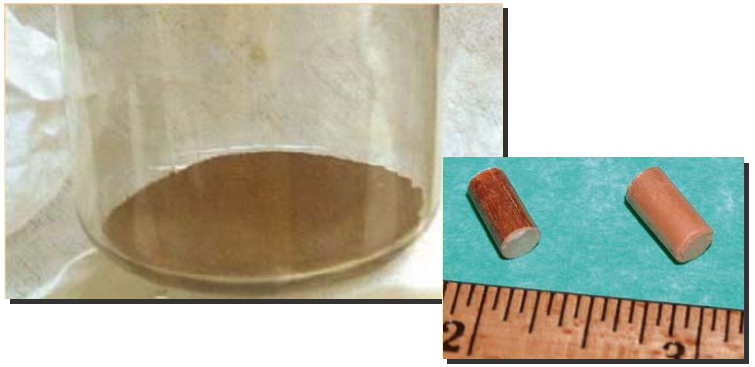
Fuel reprocessing R&D at REDC

- **Process testing for separating waste materials from useful nuclear material**
- **Location for integrated reprocessing and fuel fabrication demonstrations ($12M in FY07)**



Fabrication process R&D

Development of advanced nuclear fuel



Advanced nuclear simulations

Using ORNL's Leadership Computing Facility for next-generation nuclear technology development