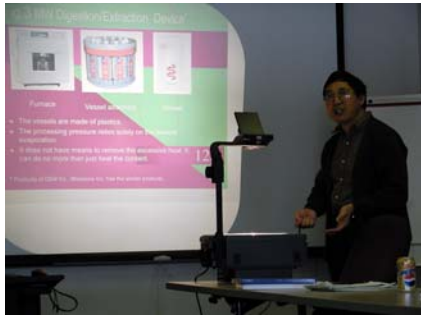
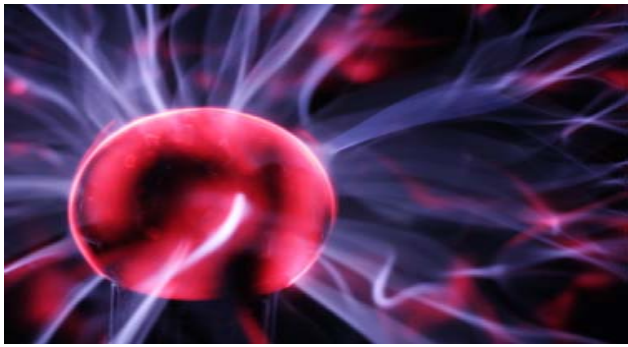
An Unprecedented Opportunity for DOE's Science, Technology and Engineering Community to Work Synergistically and Closely Together on the "Perfect Storm" of Energy, Economic, and National Security Problems





If you want to go fast; go alone; if you want to go far; go together

African Proverb as told by Al Gore, Nobel Prize Reception, 2008

Gil Weigand
Oak Ridge National Laboratory

Energy Independence Defined

Energy Independence herein refers to a sufficiently diversified domestic and international energy supply such that no significant negative economic, policy, technology, and/or national security impact results from energy actions not directly within U.S. control

Energy Policy is not Discussed

There is little doubt that any “technology push” needs to be accompanied by a “policy push” if we are to achieve our energy, environmental, economic, and national security goals;

Here's the "Perfect Storm" of Problems… and an Approach for DOE!

- *Energy Security*
  -- Solution: Energy independence

- *Energy for Environmental Sustainability*
  -- Solution: Reduce GHG emissions by 80% from 1990 levels by 2050

- *Deep Reductions in Nuclear Weapons and Keep a Deterrence, Simultaneously*
  -- Solution: Mitigate aging effects in nuclear weapons stockpile

These Problem's Common and Transformational Technology Elements

- **Materials**
  - **Large materials diversity in systems for Solar, Wind, Batteries/EV, Nuclear Energy, Bio-Mass, Carbon Sequestration, Nuclear Weapons, Non-Proliferation**
  - **Achieving high efficiency and performance in systems requires better understanding of issues of material behavior, manufacture, and design at molecular and atomic levels**
  - **Innovation, design, or life extension needs to deal with either inventing new materials or replacing current materials with comparable or better materials**
- **Simulation and Computers**
  - **Integrated systems simulation is required today for rapid progress and to transform basic understanding into realizable products**
  - **Transformational energy and weapons solutions require advanced materials modeling**
  - **Innovation and big advances in materials understanding require big computers**
  - **Today computers have reached the power to study materials behavior with the detail and precision that was reached just a few years ago when computers became key to unlocking the human genome or changing forever the way airplanes are designed**
- **Advances must be experimentally validated & demonstrated**
  - **end-to-end validation including manufacturing**
  - **Requires systems design and engineering for "proof of concept" demonstrations**
- **Efforts are Multi-Discipline / Multi-Science**
  - **Requires diverse teams of scientists and engineers**

- To Drive Innovation:

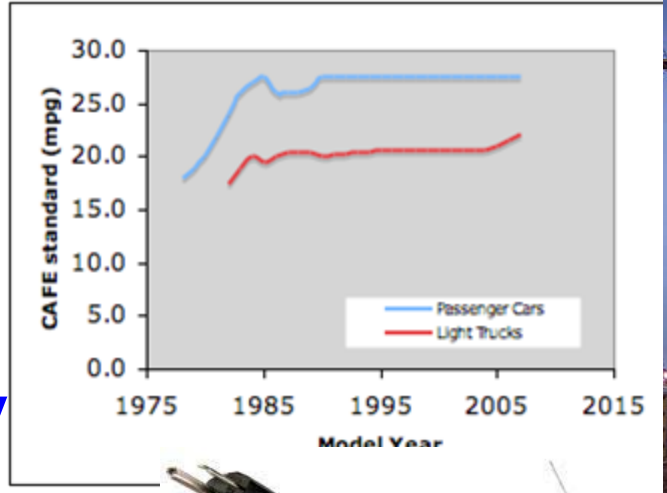
  DOE should organize joint, collaborative, and cross-office scientific and technical efforts around two themes: materials and scientific computing; DOE is a global leader in both

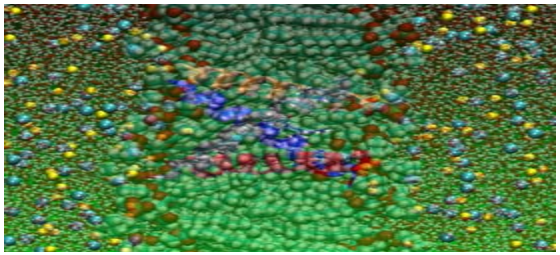
and

- DOE should implement ARPA-E to drive end-to-end development and deployment of innovative solutions
  - In 2007 National Academy of Science “Gathering Storm” report: Create a “lean and agile” entity modeled on DARPA
  - Authorized in “America Competes Act of 2007” with Statutory Goals of *enhancing the economic and energy security of the United States…*

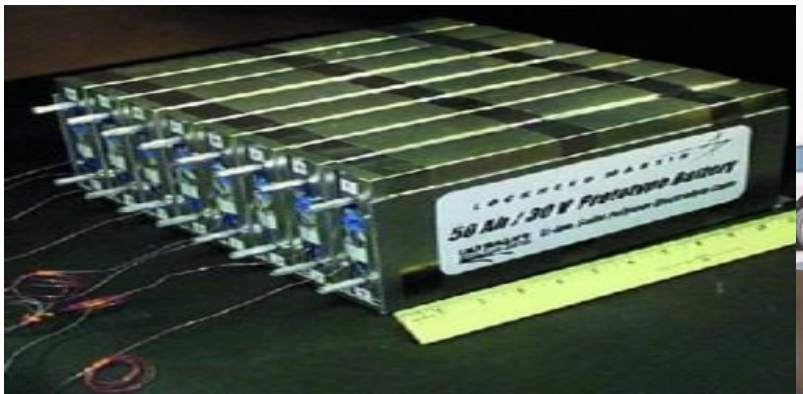
Conventional Wisdom

Objective: Energy Security

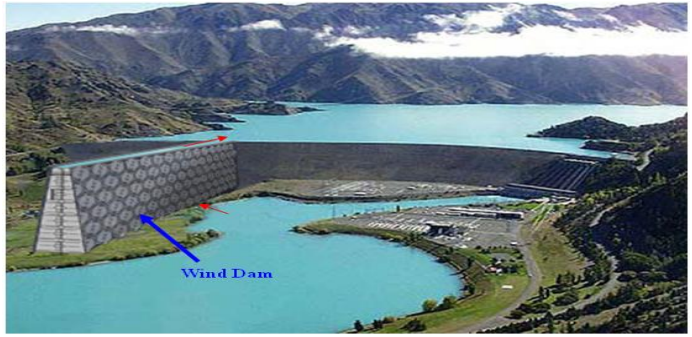


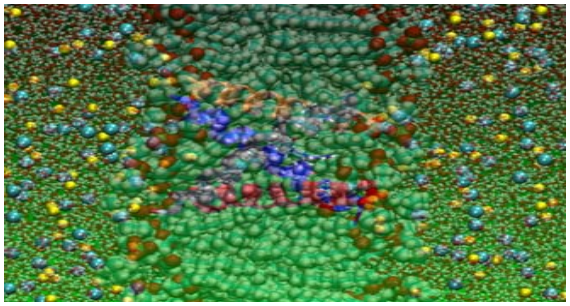


Solution: Energy Independence

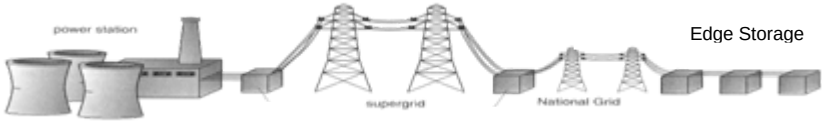


Conventional Wisdom



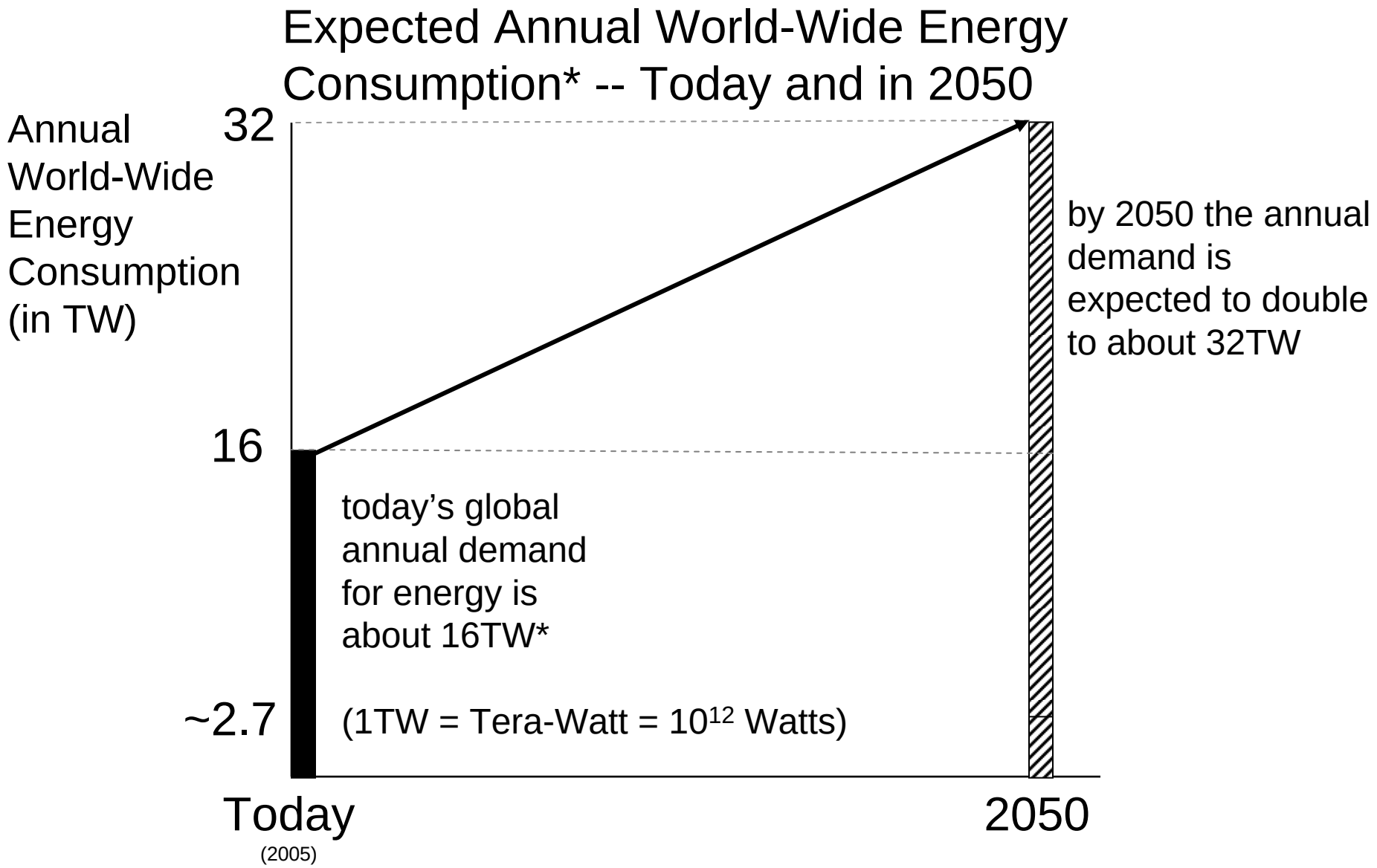


Objective: Energy for Environmental Sustainability



Solution: Reduce GHG emissions by 80% from 1990 levels by 2050

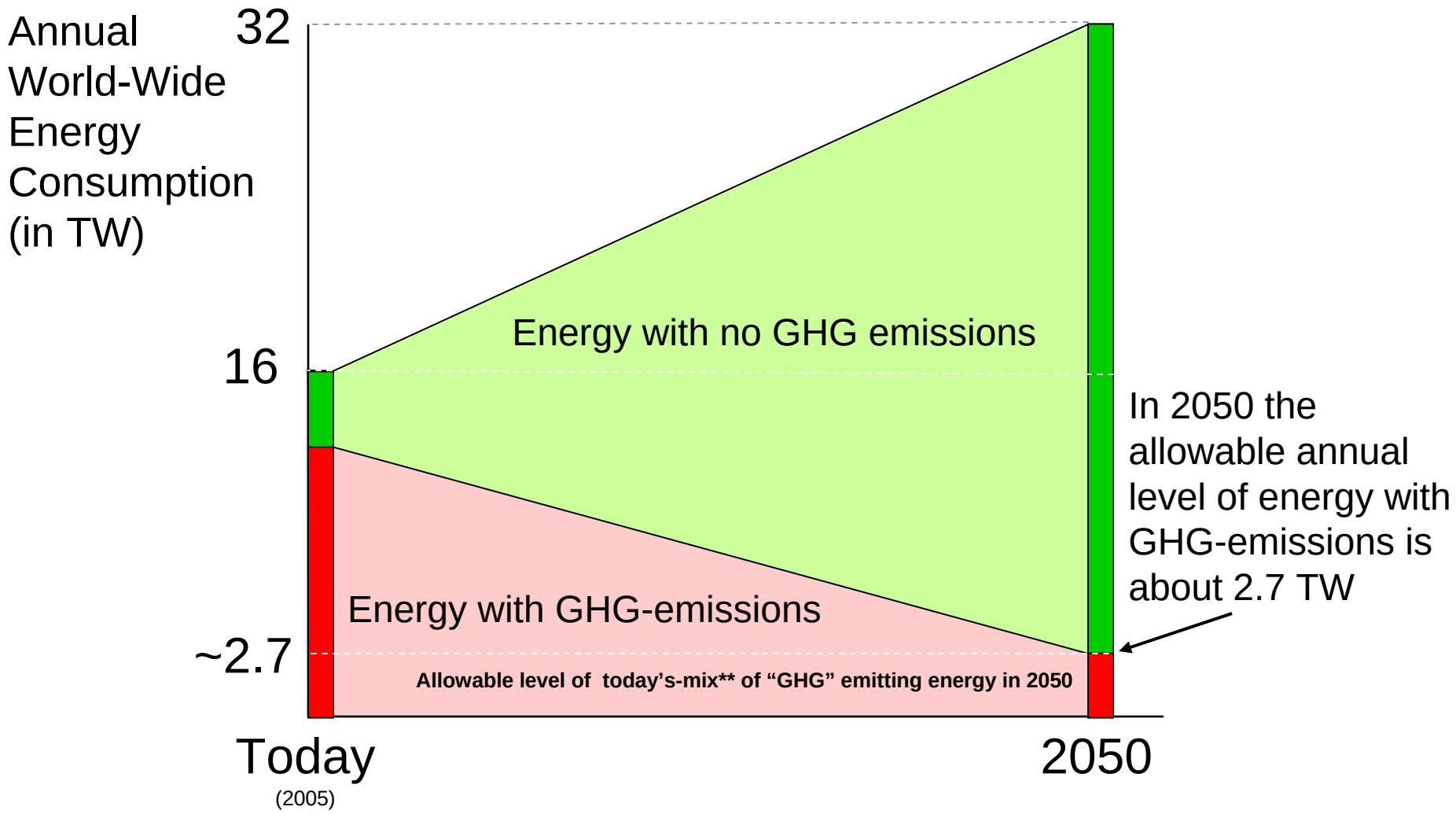
Objectives Meet Reality



* U.S. Department of Energy, Energy Information Administration

USA consumption = ¼ of World-Wide

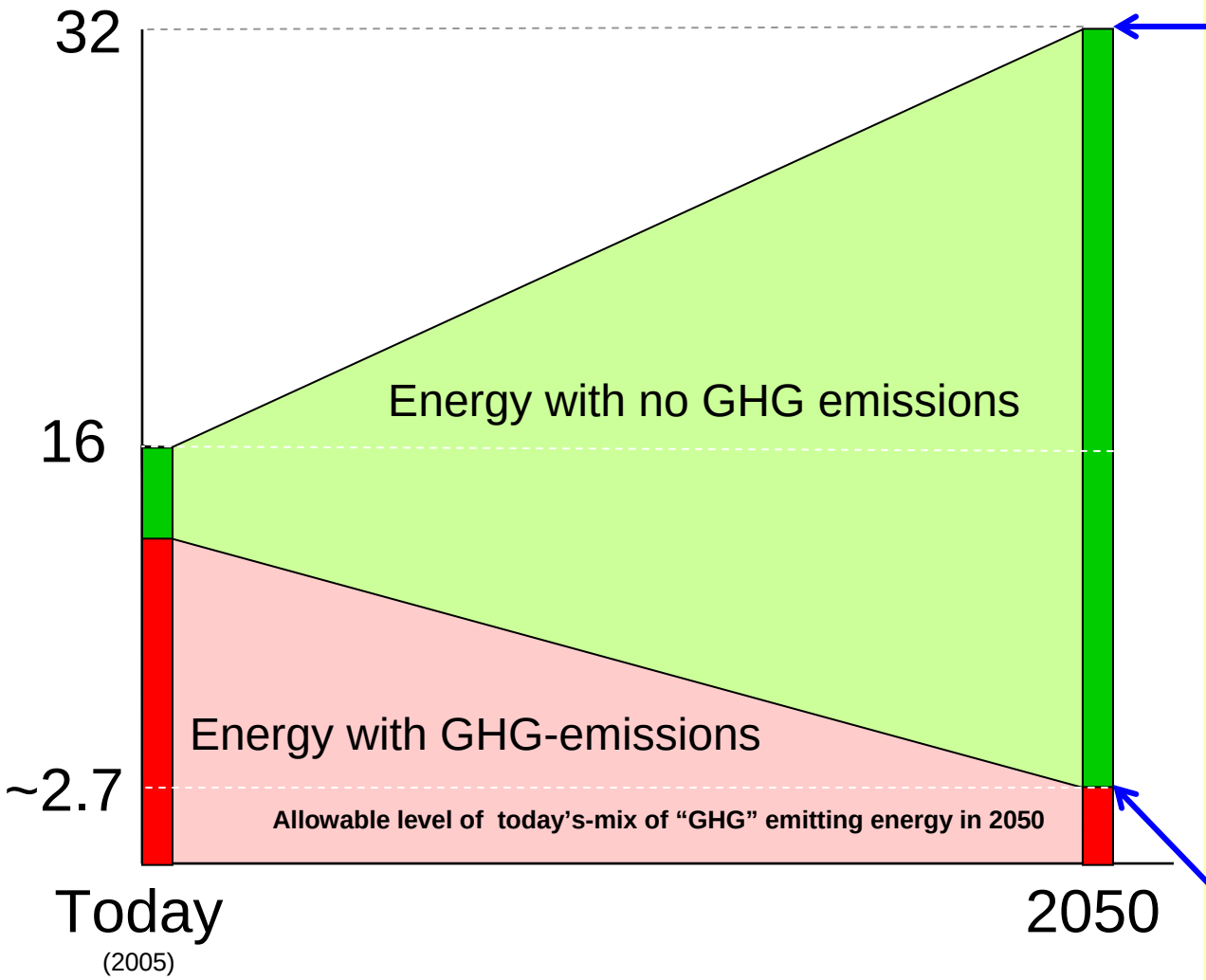
Scope of the Problem, in General Terms, for Achieving a World-wide Goal of an 80% Reduction from the 1990 levels of GHG emissions by 2050



* U.S. Department of Energy, Energy Information Administration ** today's mix (2005): 86.5% fossil, 7% renewables, 6.3% nuclear, U.S DOE, EIA

Achieving a World-wide Goal of an 80% Reduction from the 1990 levels of GHG emissions by 2050

--Objectives Meet Reality--



every day starting today and ending in 2050 complete construction of:

--one million square feet of solar panels,

--either one Hover Dam or about 200 square miles of wind turbines, and

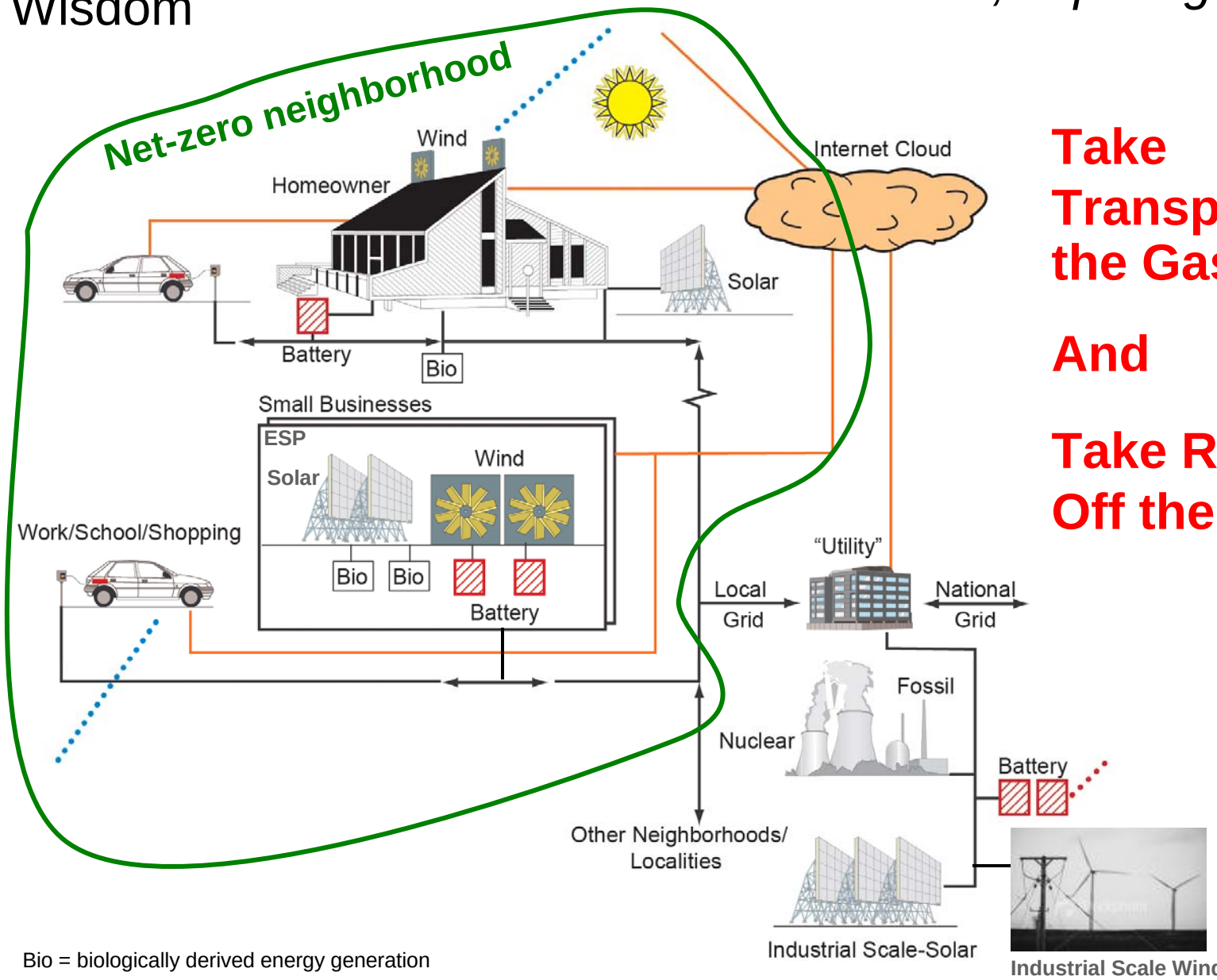
--one 1GW nuclear plant

USA consumption = ¼ of World-Wide

Renewables Environmental Paradox: Objectives Meet Reality

The Not So Conventional Wisdom

Consumer-Side Energy Implementation
-- it's the "killer micro-utilities" –
--focus local; impact global--



Take Transportation Off the Gasoline Grid

And

Take Residential Off the Grid

Bio = biologically derived energy generation

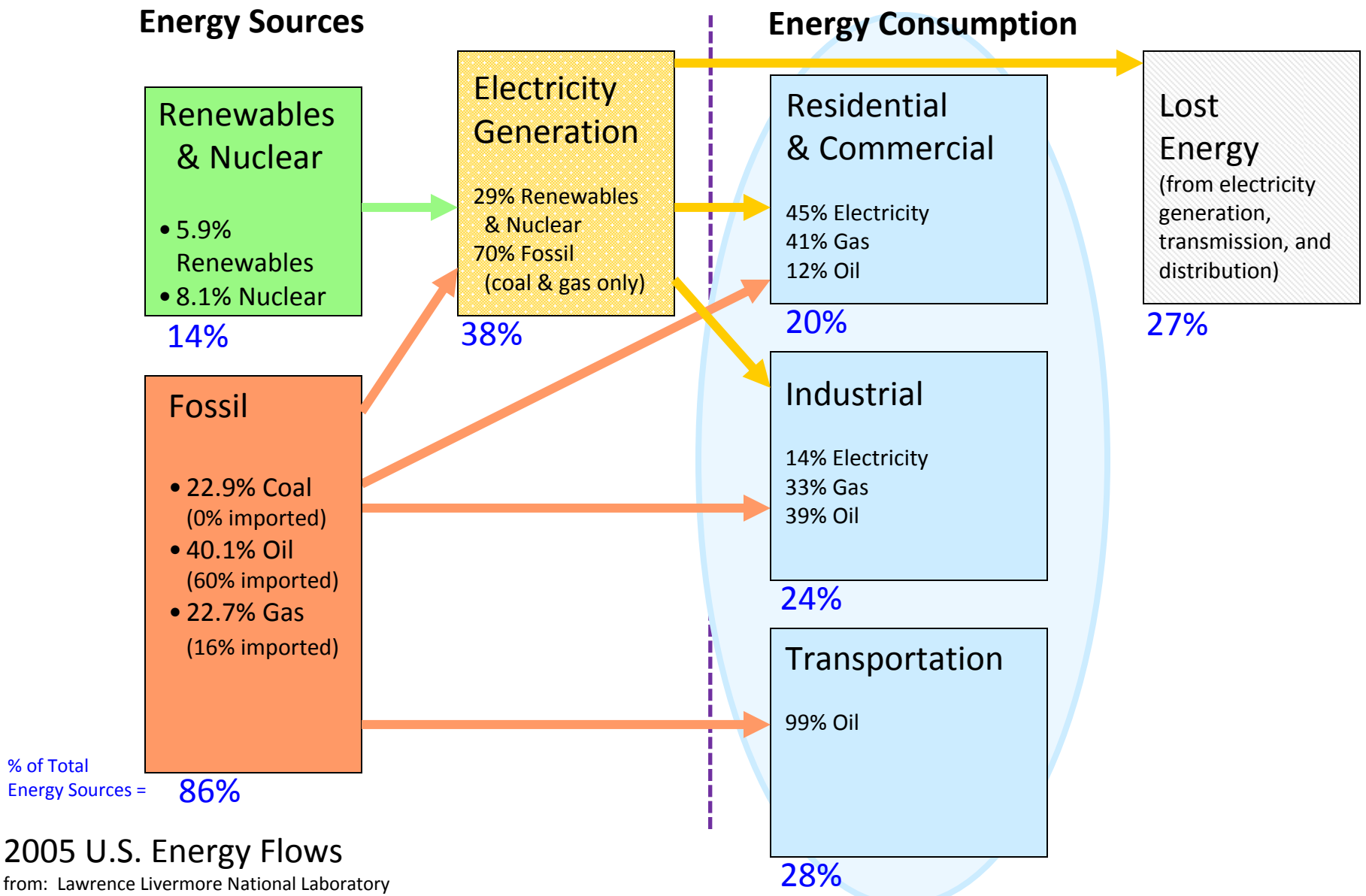
A Game-Changing Proposal

Consumer-Side Implementation – it's the "killer micro-utilities"

At 50% market penetration this proposal achieves advancement of the President's agenda:

- Environmental Security Imperative—reduces total U.S. CO2 emissions by about 30%
- National Security and Energy Security Imperative—reduces oil imports by about 80%
- Economic Security Imperative—increases U.S. jobs that can not be outsourced

U.S. Energy Consumption

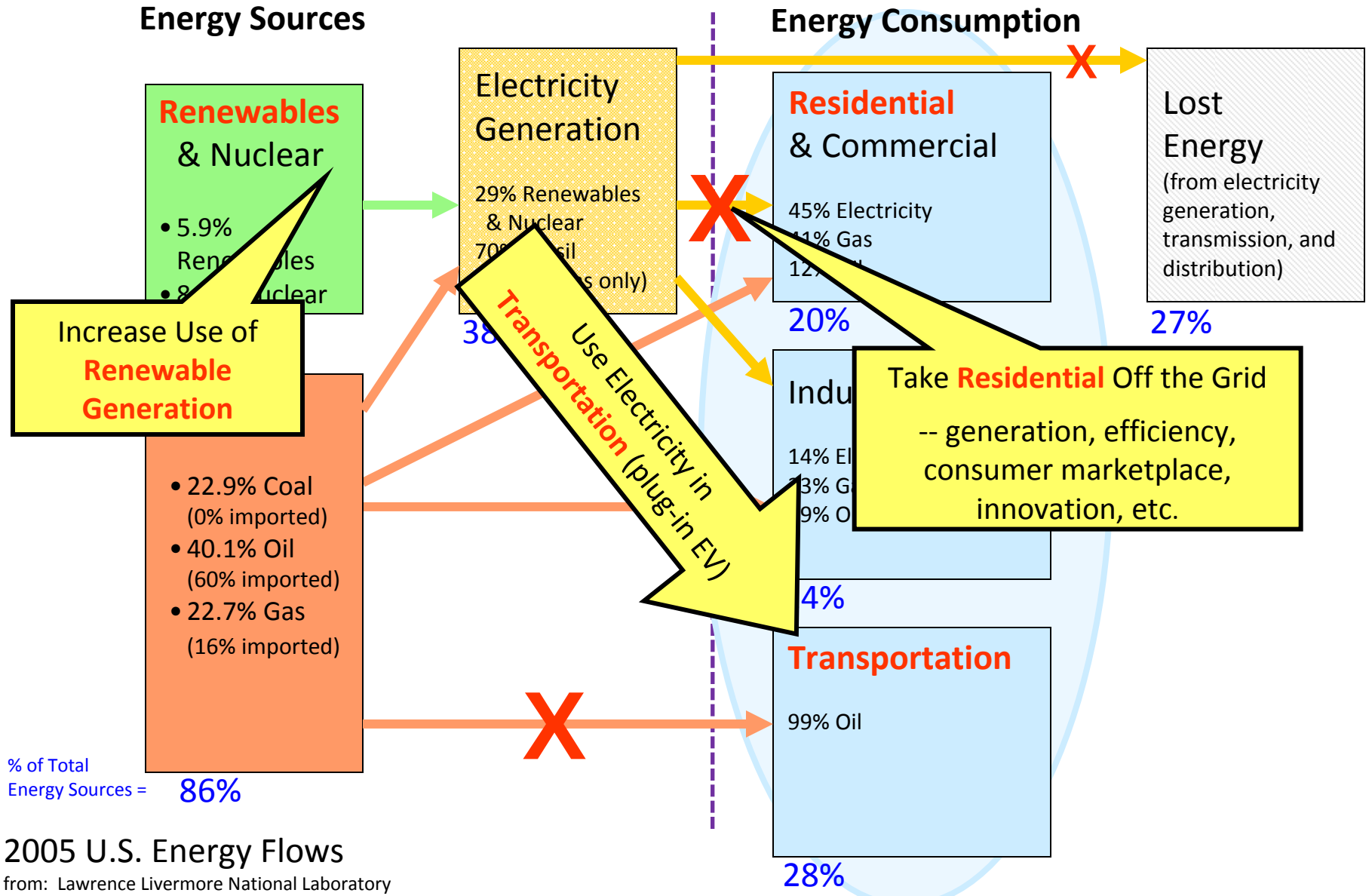


2005 U.S. Energy Flows

from: Lawrence Livermore National Laboratory

(Total U.S. energy sources = approximately 100 Quadrillion BTUs <=> 50 million railroad cars full of coal or 50 billion gas-tanks full of gasoline)

Opportunity for ARPA-E
-- Consumer-Side Energy Initiative --



2005 U.S. Energy Flows

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(Total U.S. energy sources = approximately 100 Quadrillion BTUs <=> 50 million railroad cars full of coal or 50 billion gas-tanks full of gasoline)

A Consumer-Driven Implementation

1. Take the Transportation Sector off the “Gasoline-Grid”
2. Take the Residential Sector off the electric grid

At 50% market penetration this achieves advancement of President’s agenda:

- Environmental Security Imperative—reduces total U.S. CO_2 emissions by about 30%
- National Security and Energy Security Imperative—reduces oil imports by about 80%
- Economic Security Imperative—increases U.S. jobs that can not be outsourced

Key Strategies For ARPA-E Implementation:

- create neighborhoods/localities that are at least net-zero residential energy using renewable energy sources
- create a national energy marketplace, driven by consumer-side generation inspired by internet principles e.g. store and forward
- electrify transportation; create consumer/distributed electrical storage to pre-position energy near where it will be consumed
- Move energy commerce from the centralized control model (the old AT&T model where consumers could not attach equipment to the grid) to the internet model – information (energy) is ubiquitous and autonomous (plug and play)

A Consumer-driven Implementation (continued)

Technical Driver Actions Proposed for ARPA-E:

- the creation of grid-enabled consumer-side energy generation appliances
  - **"500 mile" battery** – initial effort focuses on ion/air thin film nano-technology
  - **50% efficient photovoltaic cells** – 10x20 foot panel at consumer prices to be purchased at consumer home improvement stores. No more difficult to install than a sprinkler system
  - Consumer micro wind turbines and biomass generator systems
- create a business services layer to provide consumer-side generation and efficiency services and options
- standards and protocols which enable for the consumer an autonomous, ubiquitous energy economy
- widespread use of information products and services to drive efficiency and "generation commerce" for net-zero neighborhoods
- advanced interchangeable energy storage products (batteries) for both fixed storage and transportation
- The "iCar"– can be considered a mobile energy (distributed) storage unit that can be used for transportation. When plugged into the grid, energy can be withdrawn as required by the system per consumer controls and driving statistics. The iCar is a transformational purpose-built new concept based on marketplace driven requirements rather than an evolutionary car.

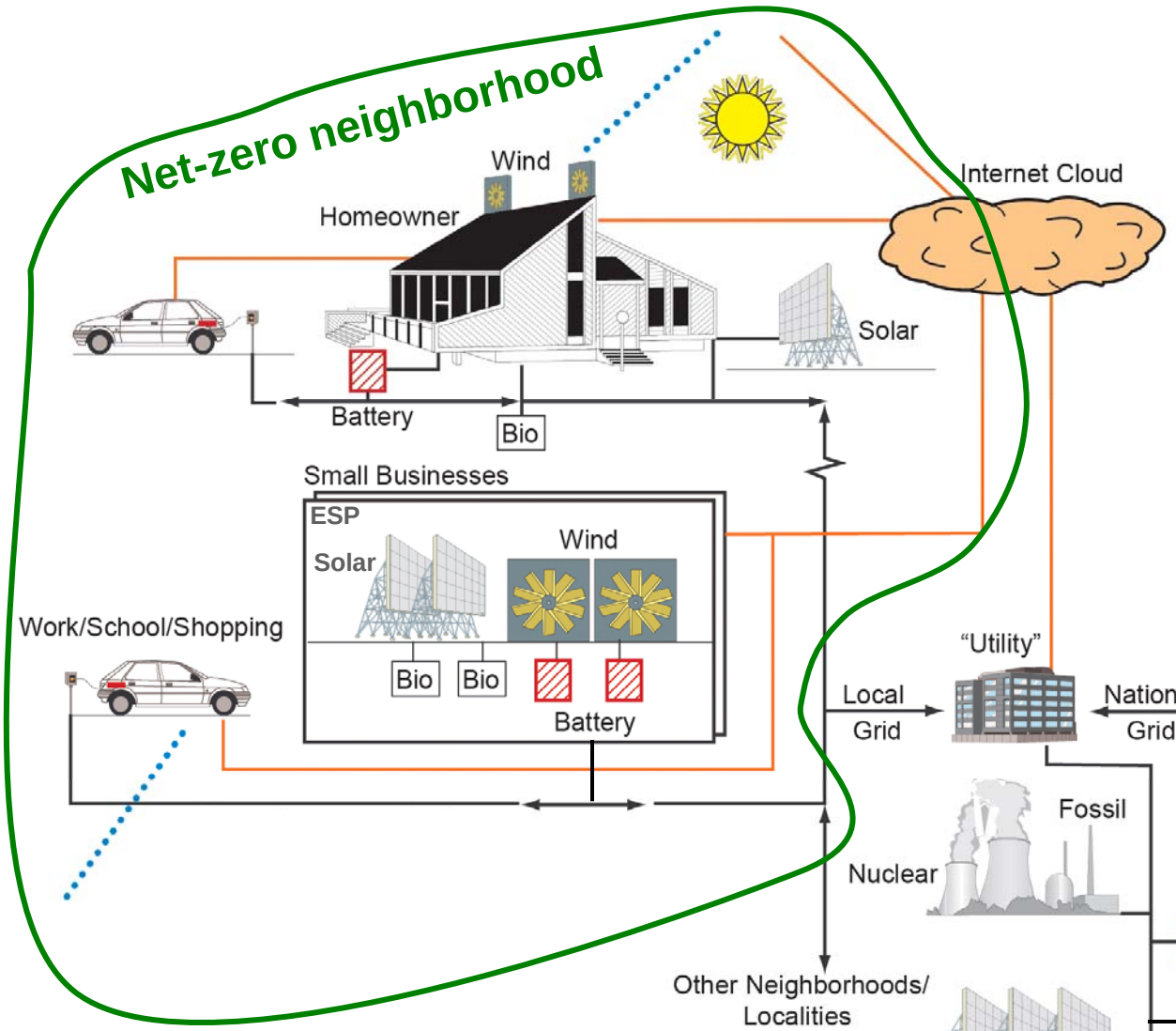
Consumer Spending Is About 70% Of The U.S. Economy

- **Take Transportation Off the Gasoline Grid**
- **Take Residential Off the Grid**

The consumer-market, particularly the residential and transportation sectors, is one of the largest forces for change in the US in terms of size, marketplace reach, purchasing power, extreme democracy, political influence, fast-paced innovation, and speed-to-market.

ARPA-E Consumer-Side Energy Implementation

Elements and Structure for Taking Transportation Off the Gasoline Grid and Taking Residential Off the Grid



Industrial Scale Wind

Energy Service Providers (ESPs) reside in neighborhoods and integrate edge* facilities with their own facilities. Edge energy storage (batteries) is highlighted to emphasize that it may be mobile or stationary. In both cases, energy storage is highly integrated into the existing electrical grid infrastructure

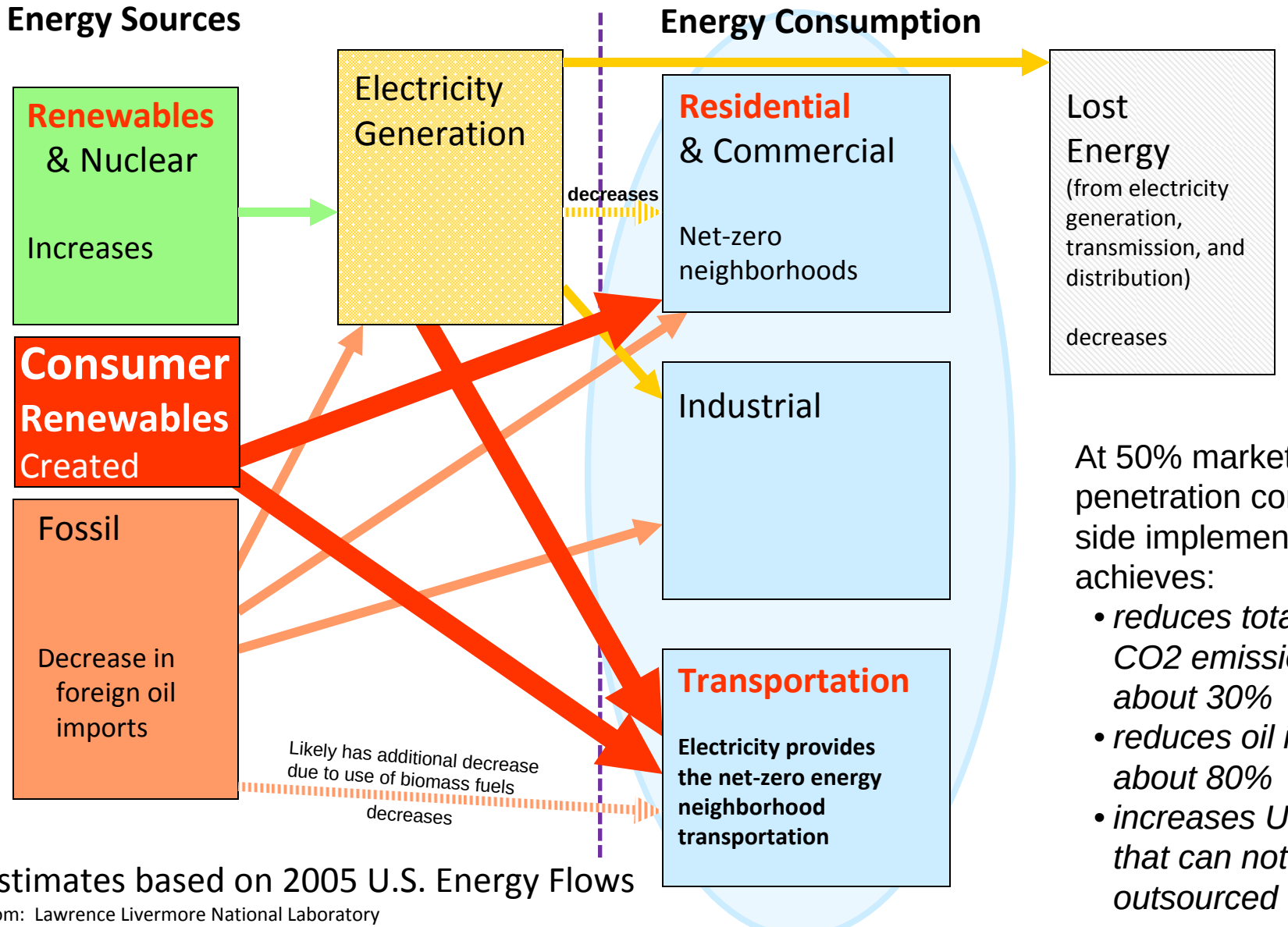
Note: Complements Cap and Trade; Creates new U.S. jobs

* term of art meaning near the consumer

Bio = biologically derived energy generation

Opportunity for the Nation

--Consumer-Side Renewables--



At 50% market penetration consumer side implementation achieves:

- *reduces total U.S. CO2 emissions by about 30%*
- *reduces oil imports by about 80%*
- *increases U.S. jobs that can not be outsourced*

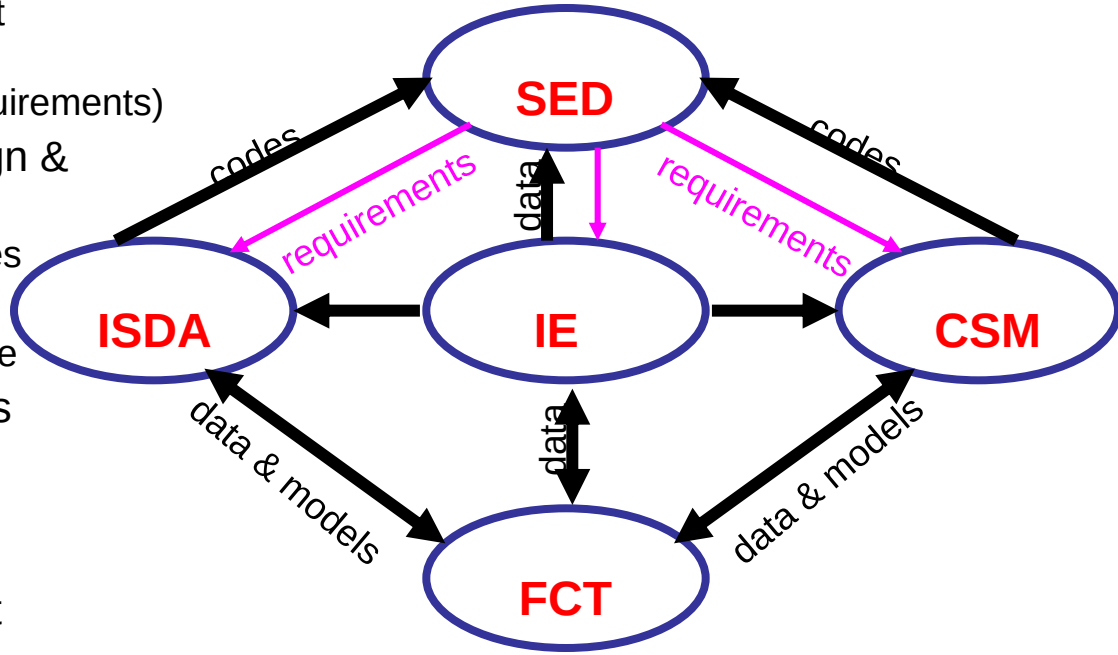
Estimates based on 2005 U.S. Energy Flows

from: Lawrence Livermore National Laboratory

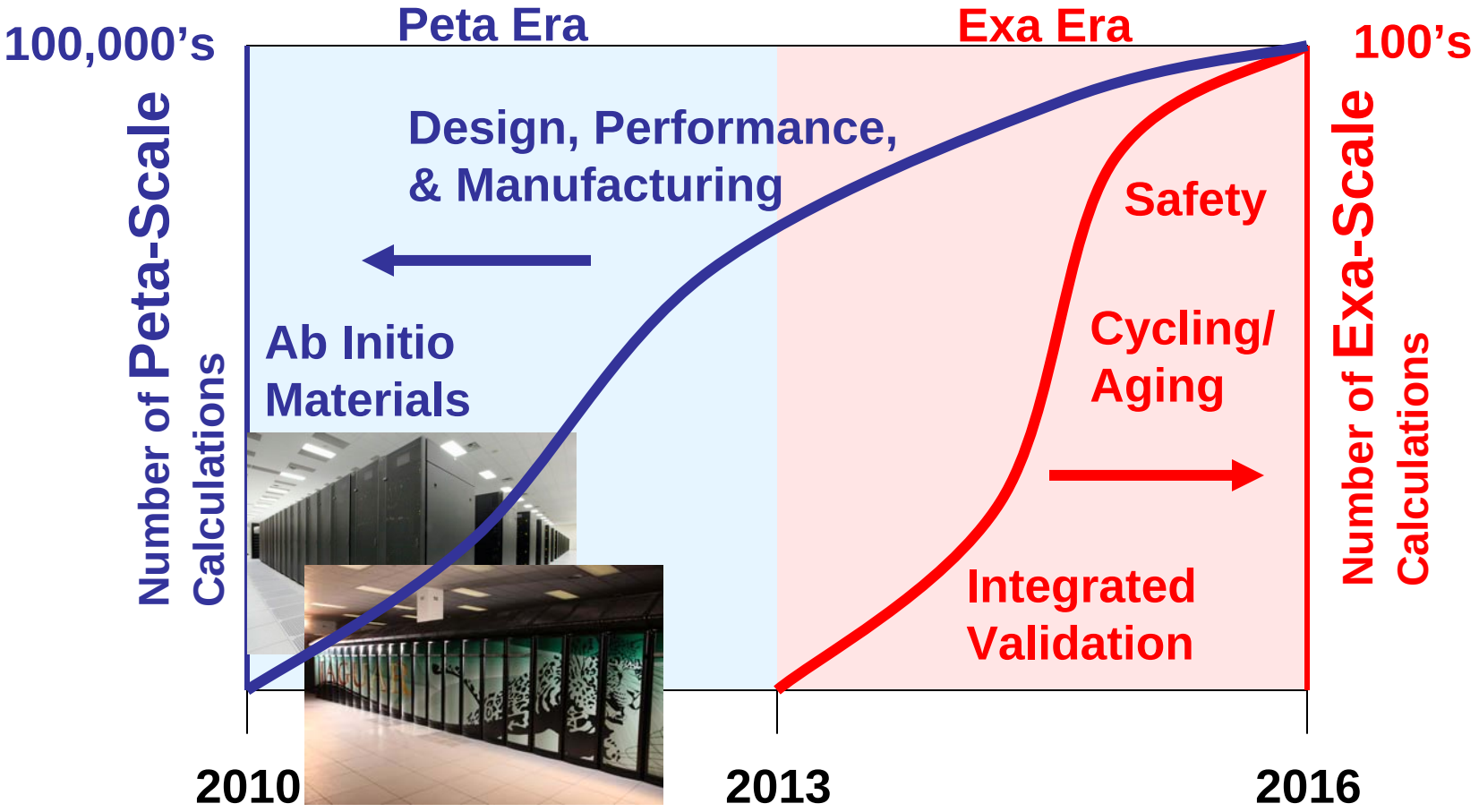
(Total U.S. energy sources = approximately 100 Quadrillion BTUs <=> 50 million railroad cars full of coal or 50 billion gas-tanks full of gasoline)

Program Elements for Advanced Energy Storage

- SED -- System Engineering and Design
  - Systems Requirements (Product Requirements)
  - Proof-of-Concept (Validate Requirements)
- ISDA -- Integrated System Design & Analysis
  - Performance and Analysis Codes
  - Systems Analysis, UQ
  - Scalable algorithms and software
- CSM -- Component and Systems Manufacturing
  - Manufacturing Codes
  - Materials Synthesis
- FCT -- Fundamental Component Technology
  - Theory, Experiment, and Simulation
  - Applied Mathematics and Computer Science
- IE – Integrated Experiments
  - Integrated, multi-physics experiments
  - Validation tests

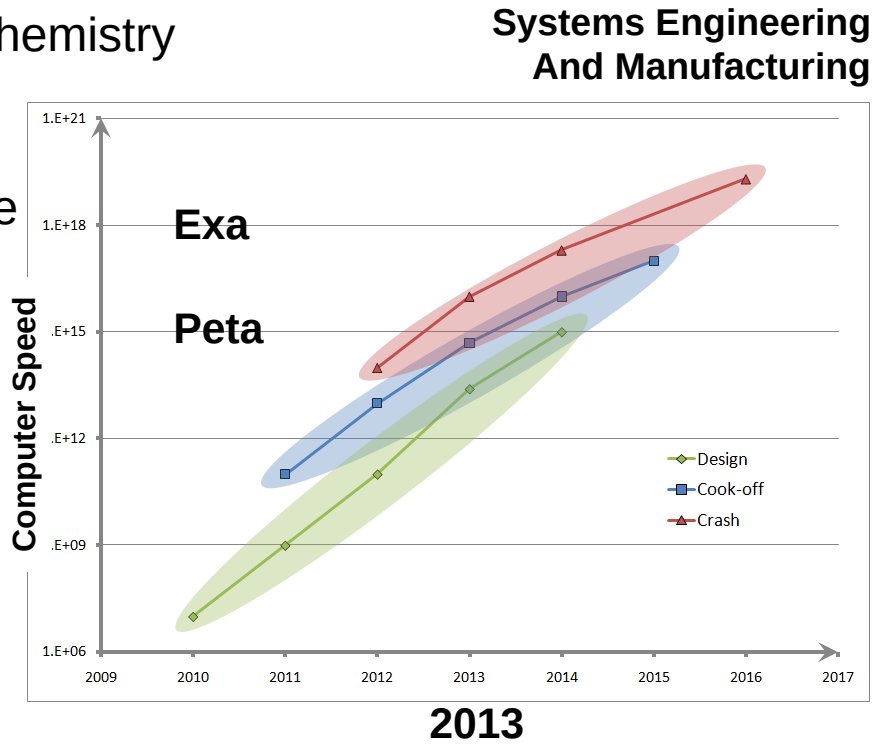


Battery500 & Photovoltaic50 Science-Based Requirements



Required Code Suites—Battery500

- Materials (ab initio)
  - Polymer electrochemistry
  - Catalysis
  - Solubility
  - Electrode / Anode
- Design/ Performance
  - Charge
  - Storage
  - Discharge
  - Cycling/Aging
- Safety
  - Crash
  - Thermal insult
  - Puncture/penetrations
  - Thermal runaway
- Manufacturing
  - Vapor deposition
  - Thin film process control
  - Structural integrity



The Proposed Consumer-Side Implementation Will Complement Cap & Trade

- Consumer/Distributed storage replaces peak load contingency requirements
  - Enables retirement of inefficient energy plants
- Enables full time operation of best-performing plants
  - Pre-position energy for peak use demands
  - Taking residential off the grid makes that capacity available to power transportation
    - Reduces CO2 emissions from transportation
    - Reduces dependency on imported oil
- Use smart grid infrastructure and edge storage (consumer side) to pre-position energy near where it will be consumed
- Zero-emissions generation from renewable sources becomes a reliable (24x7) source of energy
- ESPs create U.S. jobs that can not be outsourced
- Potentially reduces consumer impact of electrical utility rate increases

Military Applications

- **Military Advantage (joint with DoD)** — save lives and reduce fuel costs
  - Powering plug-in electric drive fighting vehicles as a front line, force projection, mobile & fast strike option
    - 500-mile battery technology for electric vehicles
    - Advanced battery technology for individual autonomy and lethality
    - A mobile strike capability could be a net-zero energy locality
  - Mobile and extensible power grid
    - Portable Smartgrid
    - Island critical resources
  - Cut/Shorten the energy logistics tail
    - Local energy generation
      - Ruggedized versions of the consumer-side generation products, e.g., solar pump, wind pump, or biomass pump
  - Batteries for powering electric drive vehicles for military transportation
  - A military base can be a net-zero energy neighborhood
  - Renewable generation for military logistics, e.g., mobile headquarters
    - "Fuel logistics represent a significant portion (~70%) of the tonnage the army ships into battle."*
    - Ruggedized versions of the consumer-side generation products, e.g., solar pump, wind pump, or biomass pump

* Report of the Defense Science Board Task Force on DOE Energy Strategy, "More Fight – Less Fuel," February 2008, http://www.acq.osd.mil/dsb/reports/2008-02-ESTF.pdf

More Information?

- White Paper
  - "Transformational Technologies for Impacting the Transportation and Residential Energy Sectors"

- Copy of this talk

Email to Gil Weigand

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- give me a business card