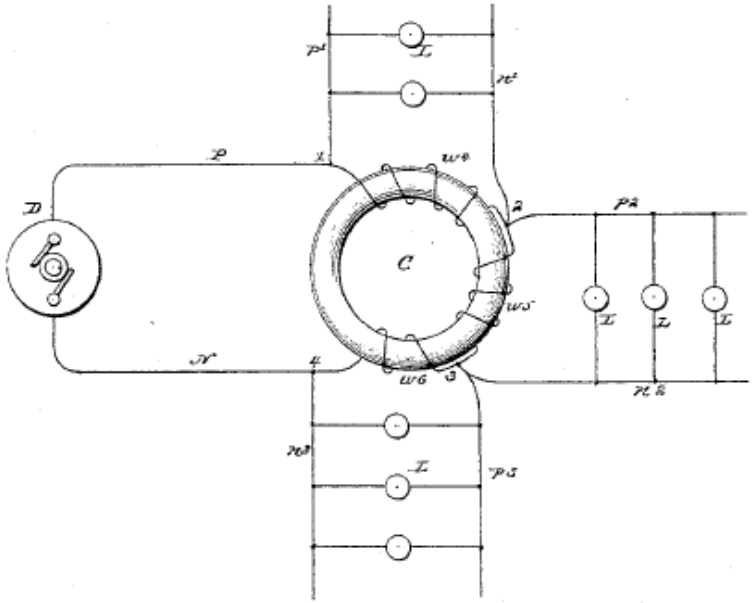
Progress in Energy Efficiency

IEEE SusTech 2013

Portland, OR



Apparatus of Electrical Conversion and Distribution (US 387,117)
W. Stanley, Jr. (Westinghouse)
31 July 1888 – **125 years**

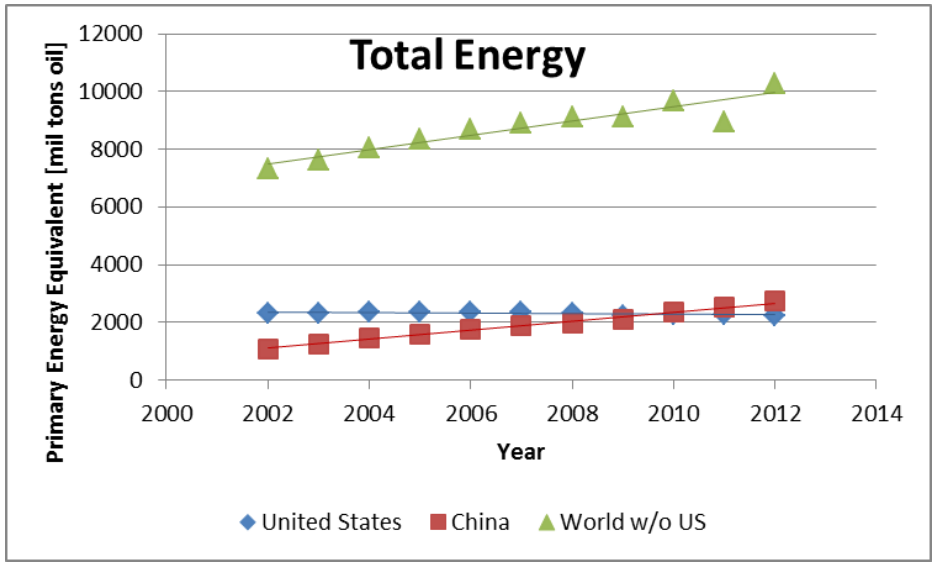
Dan Donahoe

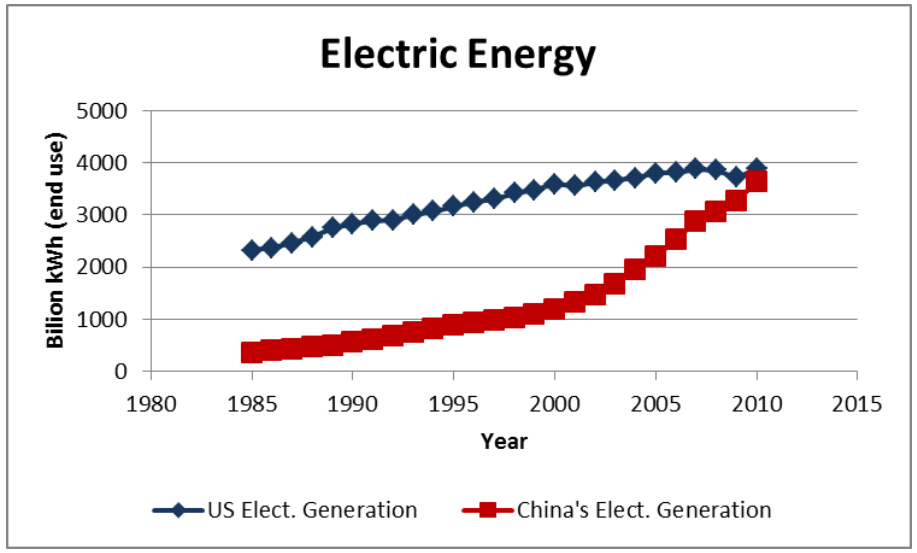
August 2, 2013

Energy Efficiency & Sustainability

- UN's three pillars of sustainable development [1]
  - Economic development
  - Social development
  - Environmental protection
- Answering all three of these pillars, energy efficiency:
  - lowers recurring costs, promoting economic development,
  - may create less lifetime environmental impact,
  - technology enhances workforce (by fostering transferrable skills).
- Engineering perspective of efficiency must include:
  - history of technology,
    - Electrification in 20th century is on-going with updates such as Smart Grid
    - Internet, ERP and other data base software, cellular & smart phone communication
  - political and economic changes,
    - Business Process Reengineering (off-shoring) & Globalization (end of Cold War)
  - and legal constructs regulating commerce (domestic and international).

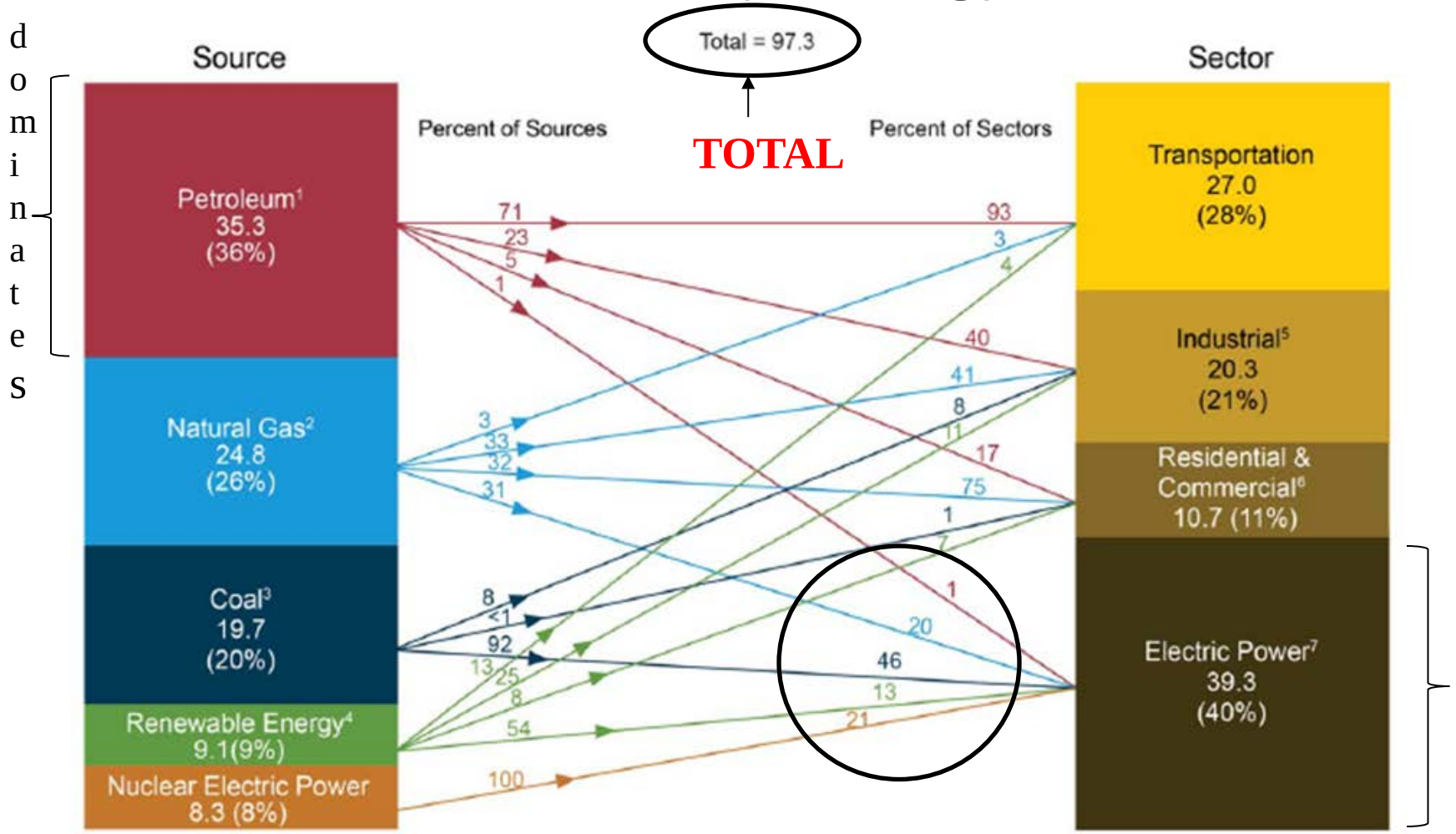
World Energy Consumption





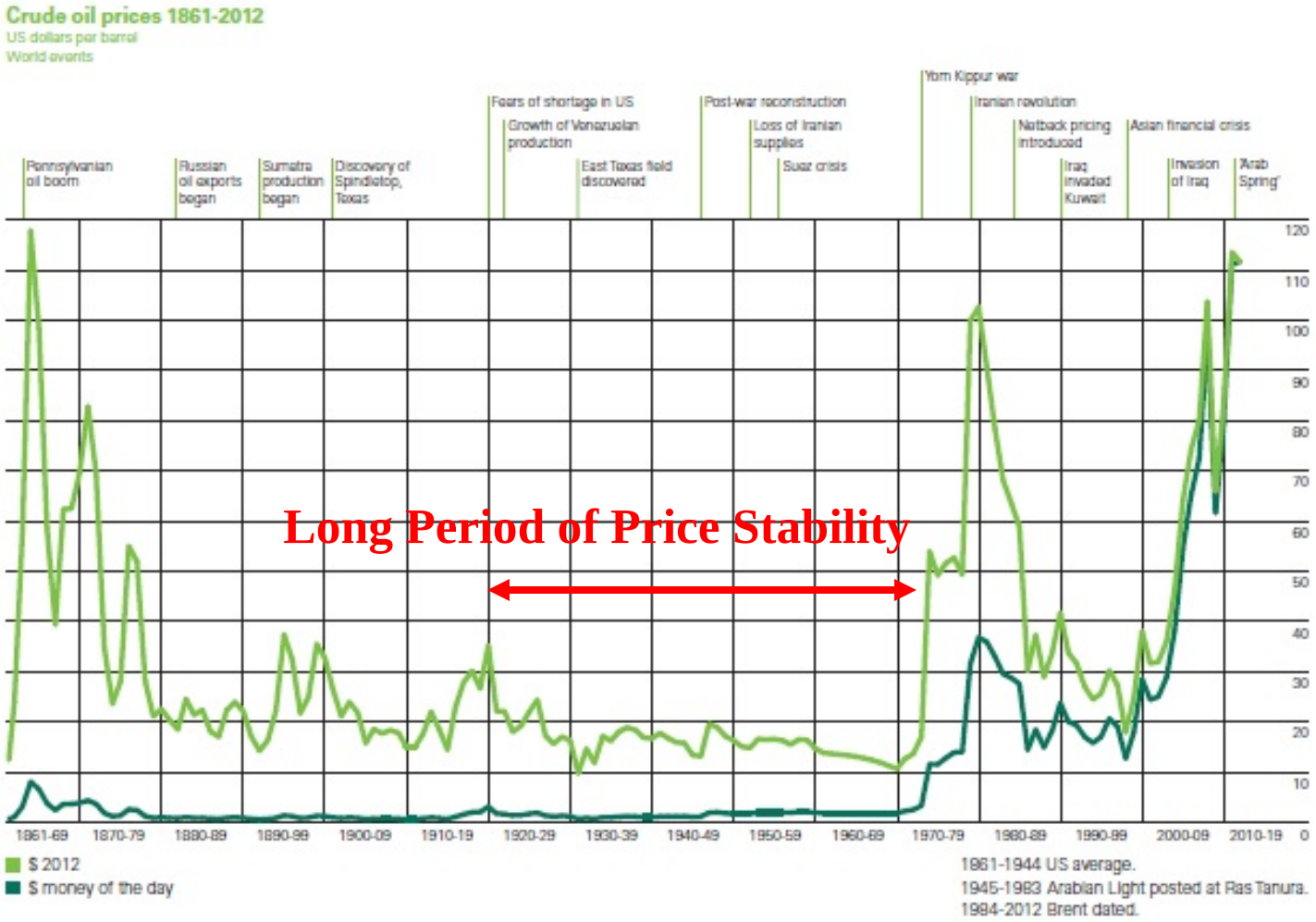
- China doubling world's total energy rate of growth over last decade (2002-2012) [2,3,4]
  - US total energy growth rate is almost flat
  - Statistical correlation coefficient of US energy consumption to China's energy consumption (2001 to 2012) is -0.57, an inverse relationship.
    - Apparent trade-off of US energy with China's (explanation to follow, but note date of upward turn in China data)
- Electric demand correlation coefficient of US to China is 0.82, a strong correlation over period of interest (2001 to 2010)

US Primary Energy [5]



- 1 "**quad**" is 1 quadrillion BTU = 1E15 BTU = 1.05E18 J = 0.29E12 kWh
- Since oil is the largest primary energy source (35 quads), it drives policy,
- but today's electric power is the primary energy end use (39 quads)

Oil Price ➔ Energy Efficiency Legislation



BP Statistical Review of World Energy, June 2013 [6]

Reading Legislation (EPCA 1975)

Statue at Large

PUBLIC LAW 94–163—DEC. 22, 1975 89 STAT. 871

Public Law 94–163
94th Congress

codified → Title 42 Chapter 77

such as promoting energy efficiency

An Act

To increase domestic energy supplies and availability; to restrain energy demand; to prepare for energy emergencies; and for other purposes.

Dec. 22, 1975
[S. 622]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Energy Policy and Conservation Act".

Energy Policy and Conservation Act.
42 USC 6201 note.

TABLE OF CONTENTS

Sec. 2. Statement of purposes.
Sec. 3. Definitions.

- Law is "codified" into topical "titles" by the Office of Law Revision Council of the US House of Representatives and published by the Government Printing Office's (GPO) Federal Digital System. Prefer: http://www.law.cornell.edu/lii/get_the_law (shown on next slide)
- In US Code, Title 42 is "The Public Health and Welfare" and Chapter 77 is "Energy Conservation", Subparagraph III is "Improving Energy Efficiency"
- These laws are implemented using rules and regulations by agencies (aka "administrative law")

42 USC 6201 Compare Original vs. Today

STATEMENT OF PURPOSES

SEC. 2. The purposes of this Act are—

(1) to grant specific standby authority to the President, subject to congressional review, to impose rationing, to reduce demand for energy through the implementation of energy conservation plans, and to fulfill obligations of the United States under the international energy program;

(2) to provide for the creation of a Strategic Petroleum Reserve capable of reducing the impact of severe energy supply interruptions;

(3) to increase the supply of fossil fuels in the United States, through price incentives and production requirements;

(4) to conserve energy supplies through energy conservation programs, and, where necessary, the regulation of certain energy uses;

(5) to provide for improved energy efficiency of motor vehicles, major appliances, and certain other consumer products;

(6) to reduce the demand for petroleum products and natural gas through programs designed to provide greater availability and use of this Nation's abundant coal resources; and

(7) to provide a means for verification of energy data to assure the reliability of energy data.

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USC › Title 42 › Chapter 77 › § 6201 PREV NEXT

42 USC § 6201 - Congressional statement of purpose

There is 1 Update Pending. Select the tab below to view.

USC-prelim | US Code | Notes | Updates | Authorities (CFR)

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The purposes of this chapter are—

(1) to grant specific authority to the President to fulfill obligations of the United States under the international energy program;

(2) to provide for the creation of a Strategic Petroleum Reserve capable of reducing the impact of severe energy supply interruptions;

(3) Repealed. Pub. L. 106-469, title I, § 102(2),Nov. 9, 2000, 114 Stat. 2029;

(4) to conserve energy supplies through energy conservation programs, and, where necessary, the regulation of certain energy uses;

(5) to provide for improved energy efficiency of motor vehicles, major appliances, and certain other consumer products;

(6) Repealed. Pub. L. 106-469, title I, § 102(2),Nov. 9, 2000, 114 Stat. 2029;

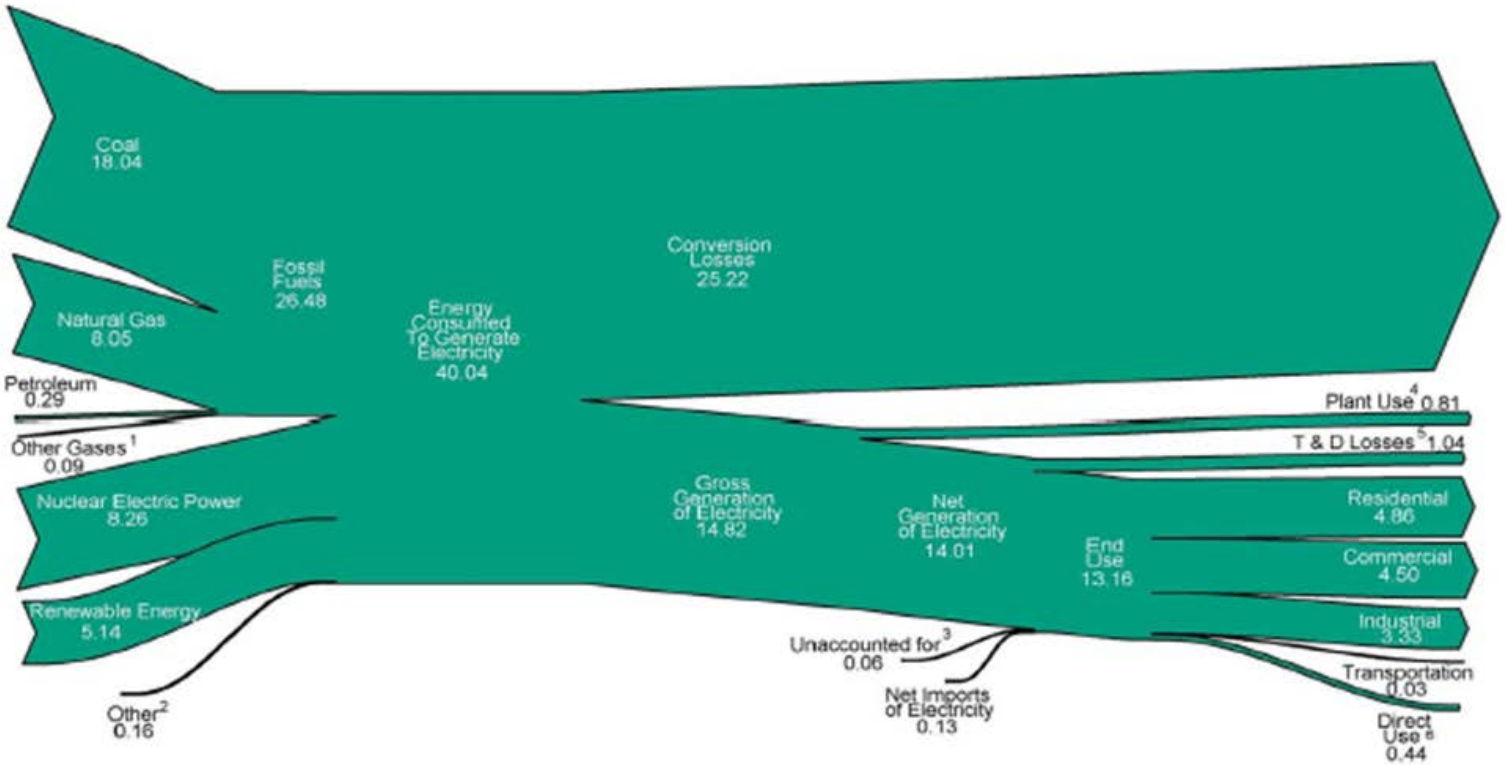
(7) to provide a means for verification of energy data to assure the reliability of energy data; and

(8) to conserve water by improving the water efficiency of certain plumbing products and appliances.

DoE Energy Conservation Statutory Authorities and Rules (partial list) [8]

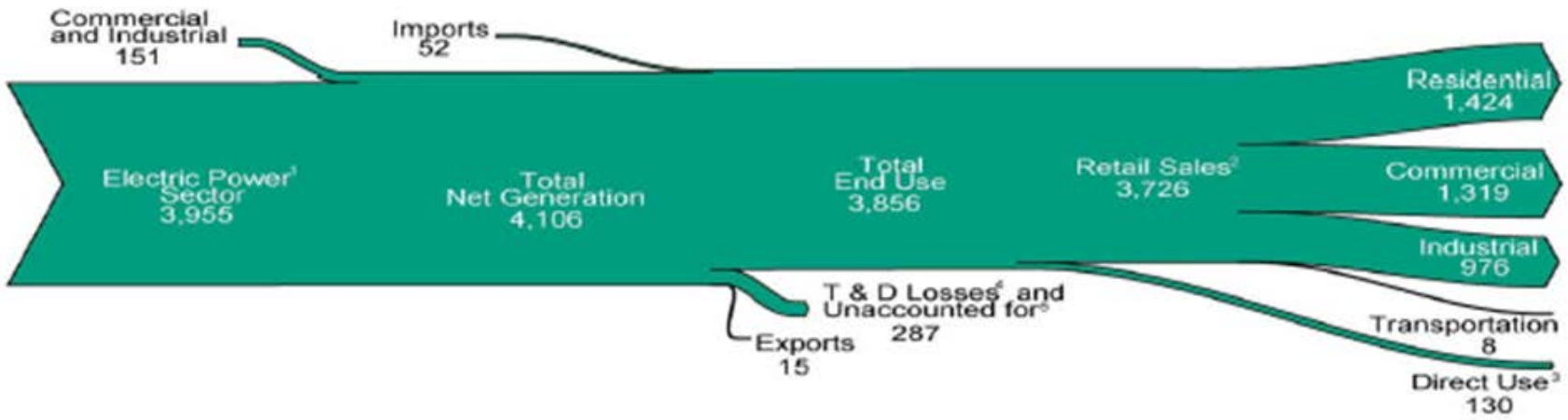
- Statutory Authorities (US Code Title 42 Chapter 77 Subchapter III “Improving Energy Efficiency”)
  - Energy Policy and Conservation Act PL 95-163
  - National Energy Conservation Policy Act, PL 95-619
  - National Appliance Energy Conservation Act, PL 100-12
  - National Appliance Energy Conservation Amendments, PL 100-37
  - Energy Policy Act of 1992, 102-486
  - Energy Policy Act of 2005, PL 109-58
  - Energy Independence and Security Act of 2007, PL 110-140
  - See code for more recent updates
- Regulations [28]
  - CFR Title 10, Chapter II, Part 430 for appliances
  - CFR Title 10, Chapter III, Part 431 for commercial & industrial equipment
  - CFR Title 10, Chapter II, Part 429 for certification and compliance

Conversion Efficiency [9]



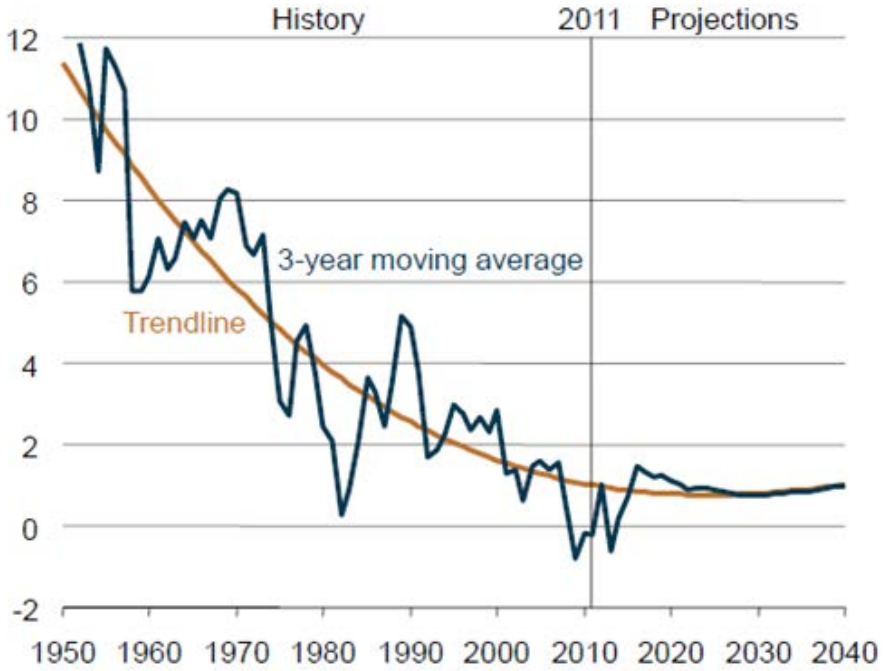
- "**Most of energy management is thermal management**," Cheryl Martin, Deputy Director of ARPA-E [10].
  - Current net **35 %** primary to electrical conversion efficiency, "the elephant in the room"
  - Natural Gas Combined Cycle (NGCC) has **51%** [11] and promises of **60%** efficiency [12]

Electrical End Use in billion kWh [13]



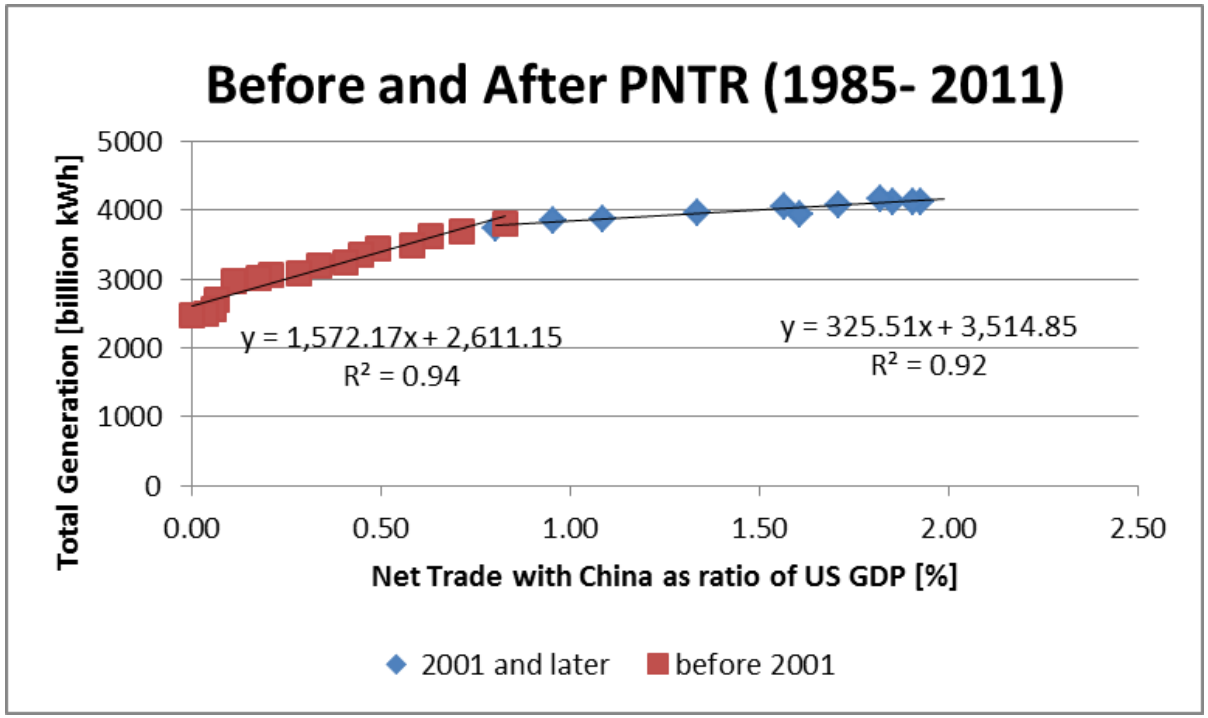
- Electrical energy load can be reduced by more efficient buildings and appliances.
  - Heart of early energy conservation approaches
  - Lighting is 18% of electric load. SSL could reduce that by one third.
  - Data centers is a growing portion of the load (~2%)
- Or using distributed renewable sources for Net Zero [14]
  - market sectors (residential, commercial and industrial) have differences in demands placed on the grid by time of peak power and geographic distribution [15].
- Claimed energy efficiency progress on the next slide.

Apparent Progress in Electrical Energy Efficiencv



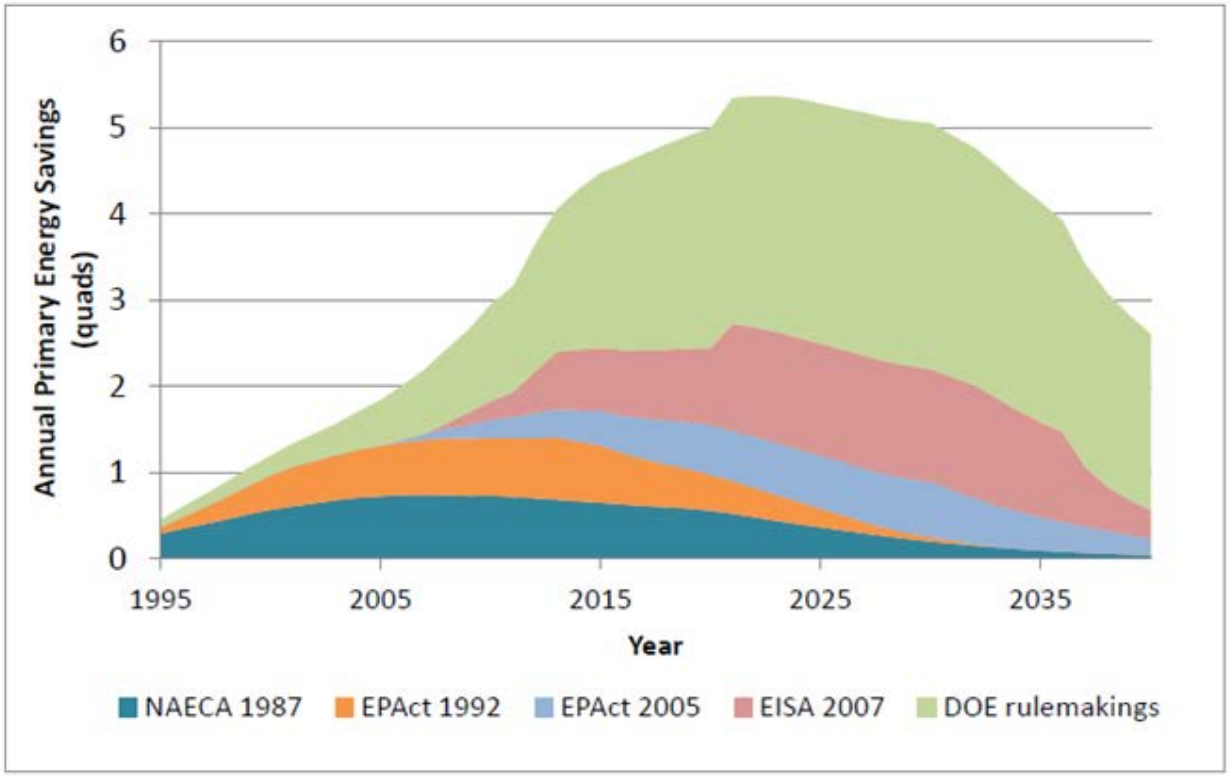
- The first Edison electric plant was installed in 1882. The country reached 50% national electrification in 1922, 90% in 1947 and approached 100% during the 1960s [16].
- The growth of electrical demand has been contained to under 1% per year attributed to efficiency, but this is not the only reason for slowed electrical generation [17]
  - China's electricity demand growth may top 9% in 2013 [18]

Energy Efficiency; Often Not Physics



- Much of "efficiency" improvement due to off-shoring [13,19,20]
  - Using pre-2001 correlation, US would be 5700 billion kWh (Δ ~ 1600 billion kWh)
- Electrical generation vs. net trade to China (normalized with US GDP)
  - Change before PNTR and after PNTR
  - Permanent Normalized Trade Relations (PNTR) with China via Public Law 106-286 dated October 10,2000.

LBL Estimate of Efficiency Gains



- This [21] is a useful estimate of savings, but the estimate may be confounded.
  - For example, see Compliance Certification Enforcement http://energy.gov/gc/compliance-certification-enforcement.

Cloud Computing and Data Centers

- The use of Data Centers has been growing.
  - Many are concerned with the high power demands of data centers and the growth of data centers [24].
  - Data centers are approximately 2% of US electricity demand [22, 23].
  - Cloud Computing is touted as an energy saving technology [26]
- Several technologies have dramatically improved the efficiency of data centers.
  - HVAC design using economizers and ducting
  - Wider [ASHRAE] standards for environmental conditions
  - Improved power delivery, including UPS efficiency [27]
  - Higher server loading (virtualization)
  - More efficacious IT architecture (e.g., new HP Moonshot)

Conclusions

- Energy efficiency is a core approach to sustainability.
- Political events, legal constructs and market changes define energy efficiency needs.
  - Engineers must be humble and understand the theory of operation of older technology in order to define improvements
    - (Historical operation defines improvement in efficiency.)
  - and be nimble to respond to changing needs
  - and work across conventionally defined disciplines.
- Much opportunity for fundamental innovation remains.

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