Estimating the Impact (Energy, Emissions and Economics) of the U.S. Fluid Power Industry

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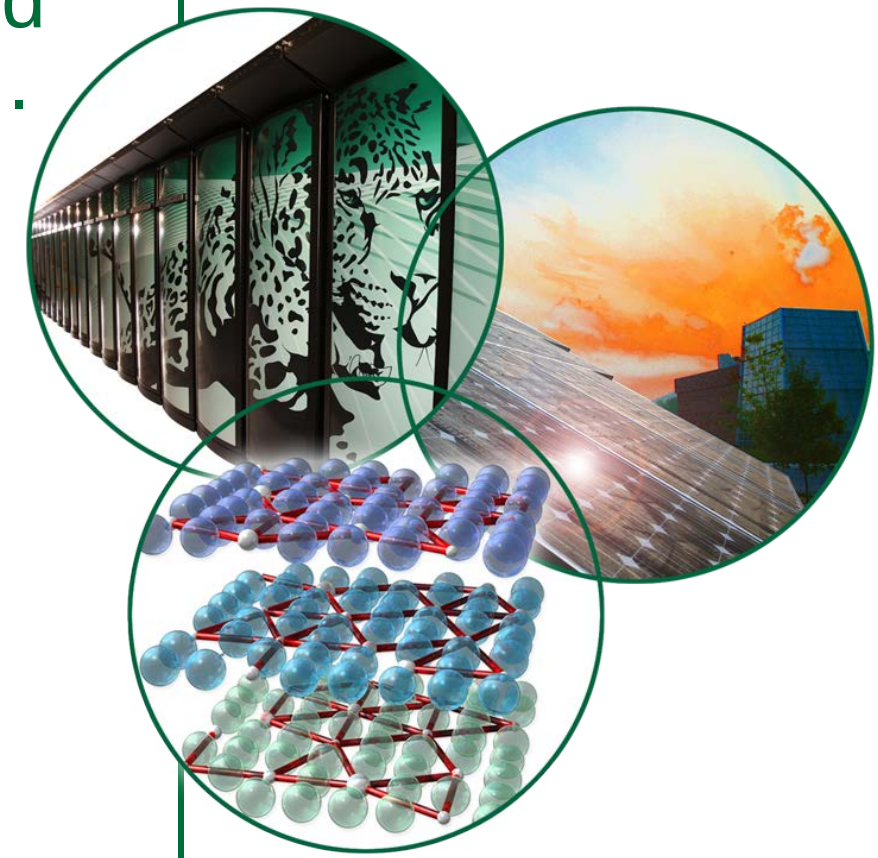

U.S. DEPARTMENT OF ENERGY

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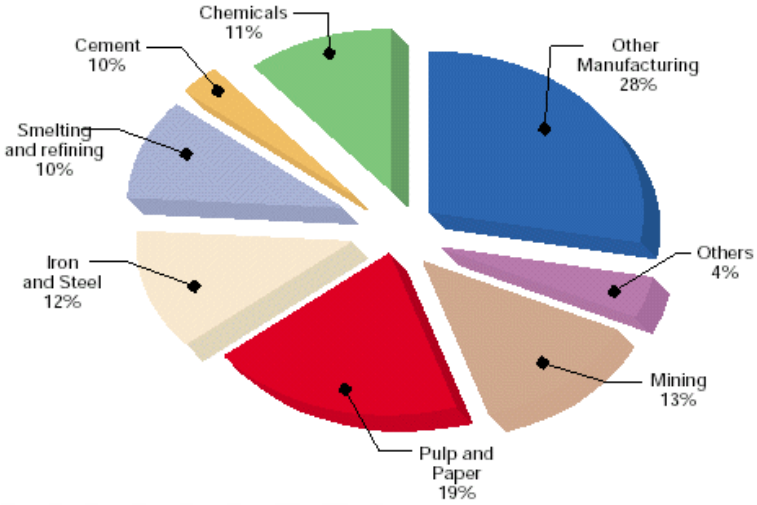
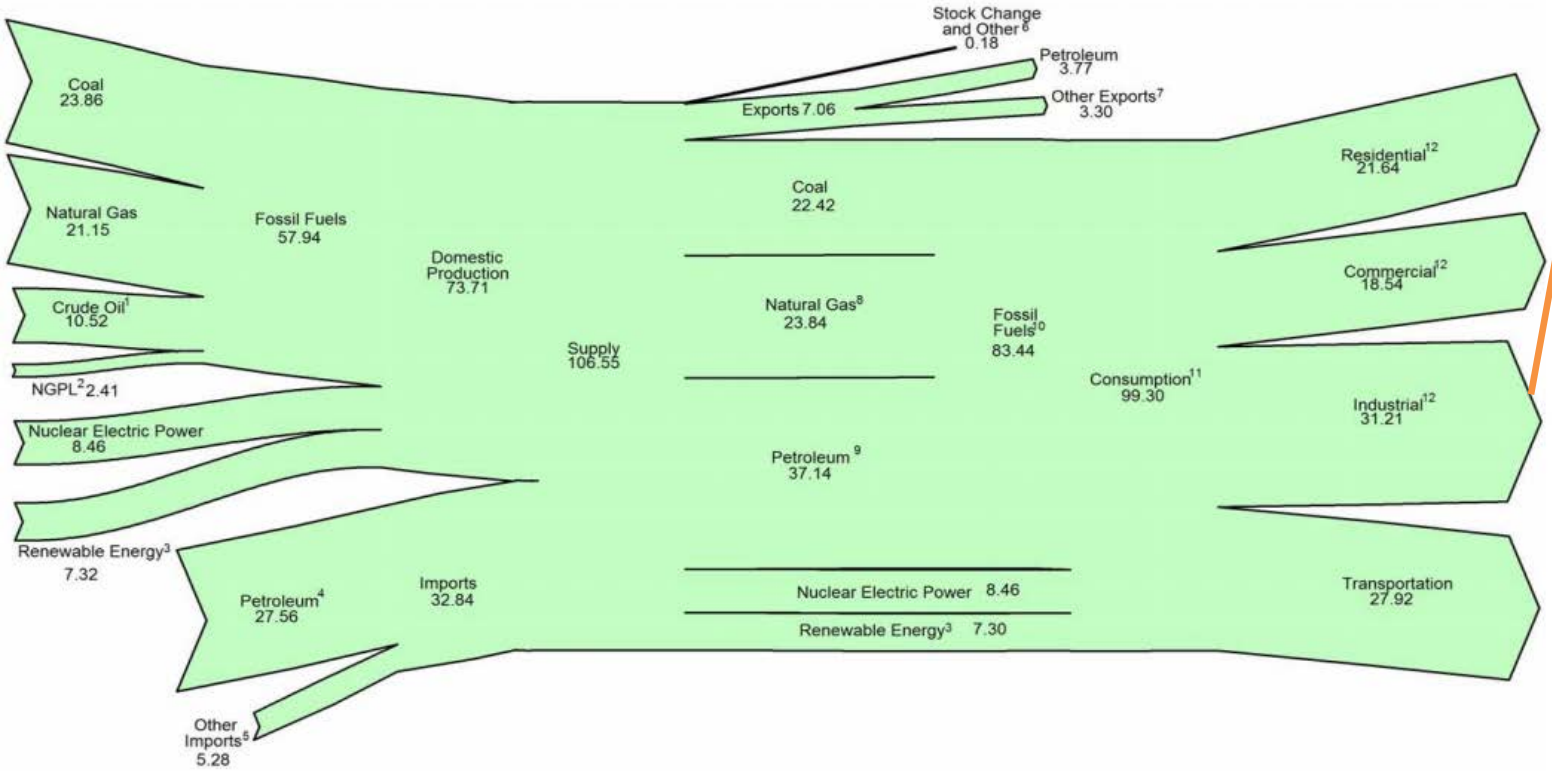
Outline

- Fluid Power Study
  - How much energy does US consume?
  - Where does it go?
  - How much is devoted to fluid power?
  - What is the impact of energy efficient fluid power
- Discuss U.S. interest in manufacturing investment
  - Many recent DoD and DOE programs in manufacturing
- How do we position fluid power industry for sustained support?
  - Leverage recent work on Energy study and CCEFP
  - Capitalize on existing focus on manufacturing
  - Discuss how to get agencies (DOE, NIST, Dept. of Commerce) to engage fluid power industry
    - ORNL is interested in helping facilitate this interaction
      - ORNL has discussed fluid power study with DOE EERE
      - DOE's EERE has stated an interest in signing an MOU with NFPA

Energy Flow

- U.S. consumes approximately 100 Quads/year (1 Quad = 1e[15] Btu, 1 Btu = 778 ft-lb)
  - 69% is of our energy is produced domestically
  - 80% is of our energy is based on fossil fuels
- Goes to 4 main markets: residential, commercial, industrial and transportation
- Basic question: How much energy (and $) is spent on fluid power?





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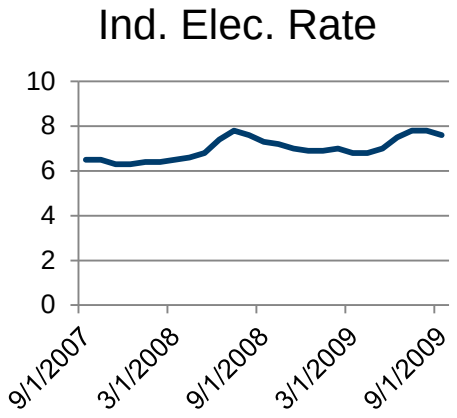
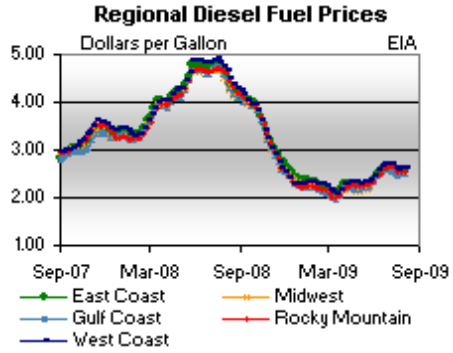
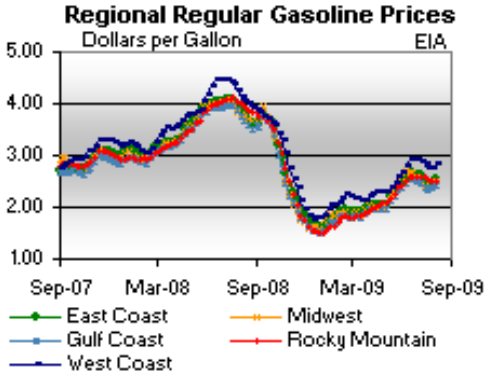
Impact: Cost of Energy

- How much does a Quad cost?
  - Electricity
    - U.S. industrial average cost is $.0678/kW-hr (April 09)[1]
    - Equivalent to $19.87B/Quad (3412 Btu/kW-hr)
  - Gasoline
    - 2009 average cost $2.36/gal[2]
    - Equivalent to $20.45B/Quad (115,400 Btu/gal)
  - Diesel
    - 2009 average cost $2.46/gal[2]
    - Equivalent to $19.87B/Quad (128,700 Btu/gal)







- How much energy is devoted to fluid power?

[1] http://www.eia.doe.gov/cneaf/electricity/epm/table5_6_a.html#_ftn1
[2] http://www.eia.doe.gov/steo

Fuel graphs: http://tonto.eia.doe.gov/

2010 DOE/ORNL/NFPA Energy Study

- In 2010, DOE ITP (now AMO) contracted ORNL to conduct a fluid power study
  - Objective was establish a ballpark estimate on *market size*, *energy consumed*, *emissions generated* and *existing efficiency levels*
  - ORNL teamed with the NFPA and 31 industrial partners spanning all major application areas
  - Industrial partners provided proprietary data on systems, energy consumption, duty cycles and efficiencies.

DOE Fluid Power Study

- Segmented industry into 4 areas
  - Mobile Hydraulics, Industrial Hydraulics, Pneumatics, Aerospace
- Results:
  - Industry is huge manufacturer as well as supporter of manufacturing
    - >$17.7B in component sales, > $226B in system sales
  - 1.9 to 2.9 Quads of energy (2% to 3% of U.S. energy is consumed driving fluid powered components
    - Mobile Hydraulics: Between 0.4 and 1.2 Quads/yr producing between 26 and 92 MMT of CO2
    - Industrial hydraulics projected at 1.1 Quads/year (but weakest data, highest efficiency)
    - Pneumatic equipment consumed approximately 0.5 Quads
    - Aerospace 0.02 Quads due to transportation of embedded equipment
  - Average efficiency < 21%
- These estimates are *huge* which led to much scrutiny at DOE.
  - Main objective was to provide order of magnitude estimate
    - Is it ~0.1 Quad, 1 Quad, 10 Quad???
  - Our secondary objective was to educate DOE and other agencies

What is potential impact of efficiency?

- Ballpark estimate of impact:
  - Case studies show much of this energy is recoverable
    - Hybrid hydraulics, displacement controls, regeneration, weight reduction, new fluids
  - 5% increase in efficiency (21% to 26%) from Best Practices = 0.4 Quads of potential energy savings (i.e. $8B/year in energy savings)
  - 15% increase in efficiency (21% to 36%) from R&D = 0.8 Quads of potential energy savings (i.e. $16B/year in energy savings)

$$W = \eta_1 \mathrm{E}_1 = \eta_2 \mathrm{E}_2$$

$$\triangle E = \mathrm{E}_1 - \mathrm{E}_2$$

$$= \mathrm{E}_1 \left(1 - \frac{\eta_1}{\eta_2}\right)$$

There are presently no DOE programs on Energy Efficient Fluid Power

So what's next?

Manufacturing initiative development

January: Plan to Win the Future by Investing in Advanced Manufacturing Technologies

June: Launch of Advanced Manufacturing Partnership

January: Blueprint to Support U.S. Manufacturing Jobs

March: Announce National Network for Manufacturing Innovation (NMMI)

2011 **2012**

May: DARPA BAA, Open Manufacturing

June: DOE FOA, Innovative Manufacturing Initiative

Feb: DOE announces first Manufacturing Demonstration Facility at ORNL (AM/CF)

Aug: Commerce Dept. announces first NNMI in Youngstown ($69M over 3 years)

Fluid power: Foundational technology for manufacturing (i.e. components manufactured in U.S., components and systems used for U.S. manufacturing)

NNMI Objective

- The Obama Administration has proposed $1B of discretionary funding for 15 National Networks for Manufacturing Innovation
  - *Lead agency is Office of Secretary of Defense (OSD), Manufacturing and Industrial Base Policy. However, this is a multi-agency program (DOE, NASA, NSF, NIST and Dept. of Commerce)*
- Objective is to
  - *Accelerate innovation* by investing in industrially relevant manufacturing technologies
  - *Bridge the gap* between the laboratory and product development (TRL 4 to TRL 7)
  - Provide companies *access to cutting edge capabilities* and equipment
  - Accelerate innovation in industrial relevant manufacturing technologies with *broad applications*
  - Serve as a *network for sharing of knowledge and best practices*
  - Conduct applied R&D and development projects (user facilities) to *reduce the cost and risk of commercializing new technologies*
  - Conduct *education and workforce development* at all levels (K-12 and community colleges)
  - Sustainable within 5 years

Example Focus Areas

- Manufacturing Process
  - Additive manufacturing for low-cost, low-volume production using digital designs
  - Shipping electrons rather than parts
- Advanced Materials
  - Lightweight materials, low-cost carbon fiber that will improve fuel efficiency and performance in next generation auto, aircraft, ships and trains
- Enabling Technology
  - Development of low-cost sensors (wireless) into manufacturing processes to improve productivity, optimize supply chain, reduce waste energy, water and material.
- Industry
  - Improved biomanufacturing processes to enhance safety, quality and consistency of bioproducts such as pharmaceuticals or chemicals, rapid on-line sensing for process optimization, control and cost-effective production

Pilot Institute

- Competition for pilot institute targeted at additive manufacturing
- Awarded to the National Center for Defense Manufacturing and Machining (NCDMM)
  - Approximately 13 teams competed (i.e. need to have a strong team).
  - NCDMM team consisted of 40 companies, 9 research universities, 5 community colleges and 11 non-profit organizations
  - Located in Western Pennsylvania, Northeast Ohio and Northern West Virginia.
    - Focus on regional hubs
  - The National Additive Manufacturing Innovation Institute (NAMII) will receive $30M in initial federal funding with an additional $39M in cost share form industry and the states.
    - Industry cost share is their providing in-kind work (i.e. they have skin in the game), equipment or funds in
  - NAMII announced first round of projects at DMC in Orlando on 11/27/12

Why Fluid Power NNMI?

- Heavy in manufacturing
  - Fluid power is a baseline industry in manufacturing
  - Innovations directly address “broad application” requirement
- Can leverage other NNMI’s
  - Additive manufacturing, carbon fiber, sensing…
- High impact
  - Innovations in design and control impact broad spectrum of applications
- Many elements already exist
  - K-12 activities with education, many companies (Bimba) active with FIRST
  - Workforce retraining at MSOE
  - CCEFP has provided a foundation in universities
  - NFPA/CCEFP has strong consortium of industries in manufacturing and transportation
  - *Focus is on jobs*

Future activities

- How do we position fluid power industry?
  - Leverage recent work on Energy study and CCEFP
    - Have industry define what they want and need from an institute
  - Industry needs to engage DOE and other key agencies
    - Standards (NIST), Efficiency (DOE), Workforce (Dept. of Commerce)
      - ORNL is interested in helping facilitate this interaction
      - ORNL has discussed fluid power study with DOE EERE (Danielson)
      - ORNL helped facilitate a discussion between DOE EERE and NFPA.
- What's next (beyond NNMI)?
  - Establish an MOU between NFPA/CCEFP and DOE
  - Have industry engage DOE/NIST/Dept. of Commerce
    - What are high value problems
    - Potential for workforce development
  - Initiate program in energy efficient fluid power that includes roadmap for R&D and Best Practices

Discussion

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