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Energy Efficiency Economics

Obstacles and Opportunities

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Talk objective: Teach a man to fish

Nov. 13th, 2016

Energy Efficiency Economics

SC16: EE HPC WG Workshop

- **Justifying energy efficiency**
  - Must show benefits
  - Constrained design optimization
- **Obstacles**
  - Schedule, budget, etc.
  - Accounting rules
  - Expanding operating envelope
- **Opportunities**
  - Costs of time and energy
  - More computing within constraints
  - New life for old facilities
- **Global IT limited by energy**
- **Summary**

Justifying Energy Efficiency

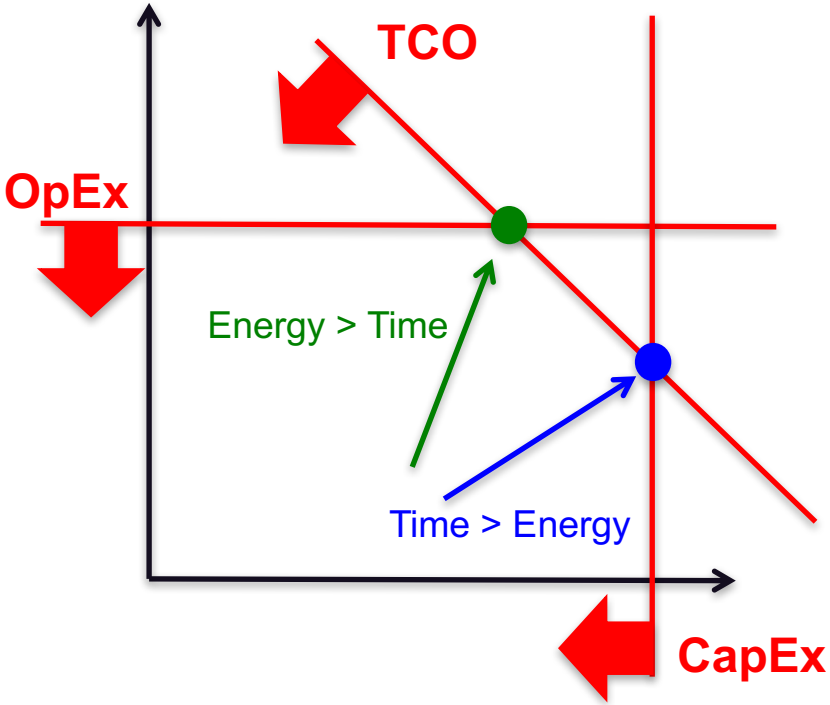
Energy efficiency argument must show benefits

- **Saving energy isn't convincing by itself.**
- **Saving time and/or money may be. So can performance improvements.**
- **Example 1:**
  - Liquid cooling may reduce energy use by 25%
  - Great, but will it save money? Can it be ready in time?
- **Example 2:**
  - CPU race to idle reduces wasted energy
  - Great, but do rapid power transients cause problems elsewhere?
- **Example 3:**
  - Reducing energy use reduces operating costs
  - Great, but it's more valuable to maximize throughput
- **How does one argue for deploying energy efficient technologies?**
  - That's what the rest of this talk is about: *Winning* this argument

Constrained design optimization

- **Constraints are obstacles**
  - Operating expense constraint
  - Capital expense constraint
  - Total cost of ownership constraint
- **Objectives are opportunities**
  - Time more valuable than energy
  - Energy more valuable than time
- **Different designs may result**
- **Full economic view needed**
  - Facilities, platform, energy, time, …

Know your constraints and objectives!



Obstacles

Basics of facilities and platforms

- **Facilities**
  - Long lead time for approvals, design and build
  - Once built, define operating envelope (MW)
  - Must evolve with the computing demand
  - Design and build process to expand capabilities requires years
  - Upgrading power feed could take even more time and money

- **Commodity technology systems**
  - Price/performance optimized, rapid deployment (weeks)
  - Usually fit existing facilities
- **Advanced technology systems**
  - Optimized for capability, push frontiers of computing, complex
  - Long lead time allows for needed facility upgrades

Schedule as an obstacle

- **Insufficient lead time is a constraint on what can be done**
- **Example:**
  - Commodity technology system with energy efficient liquid cooling option
  - Contract to deployment: a couple of months
  - However, the facility preparation for liquid cooling requires plumbing
  - Procurement, design & build to modify the facility: many months
  - Outcome: energy efficient technology doesn't fit schedule, not deployed
- **Suggestion:**
  - Simplify and shorten site preparation for energy efficient platforms
  - Pre-fabricated site preparation kits may help rapid deployments
- **Beware of local regulatory requirements**
  - Longer path may be required by your organization
  - Work to make shorter path acceptable

Budget as an obstacle

- **Site preparation requires money**
- **Example:**
  - Site has air cooling, but preparing for liquid cooling requires too much money
  - Outcome: energy efficient technology doesn't fit budget, not deployed
- **Suggestion:**
  - Seek cost effective site preparation for energy efficient platforms
  - Justify facility upgrades on the basis of capability amortized over time
  - Pre-fabricated site preparation kits may help reduce costs
- **Beware of local regulatory requirements**
  - Costlier path may be required by your organization
  - Work to make reduced cost path acceptable

Accounting as an obstacle

- **Accounting rules force sub-optimal solutions**
  - "Color of money" constraints
- **Example:**
  - Overall budget split into CapEx and OpEx
  - Separate funding streams force separate optimizations
  - Energy efficient option adds to CapEx, reduces OpEx
  - CapEx optimization can't recover OpEx savings (different color of money)
  - Outcome: energy efficient option not chosen
- **Suggestion:**
  - Request specific top-level guidance that *best value in the TCO sense* is the goal
  - Find accounting mechanism to recover OpEx savings

Economics of energy efficiency as an obstacle

- **Energy efficiency may increase net costs**
- **Example:**
  - Energy efficient option increases platform cost 5% of CapEx
  - Site preparation for energy efficient platform adds another 5% of CapEx
  - Overall extra cost is 10% of CapEx
  - Lifetime OpEx savings are 25% of OpEx
  - However, lifetime OpEx is only 24% of CapEx, so savings are only 6% of CapEx
  - Overall: Energy efficiency increases TCO by 4% of CapEx
  - Outcome: Energy efficient option not chosen
- **Suggestion:**
  - Carefully consider bottom line impacts
  - Analysis should not miss other costs and benefits, such as performance or reliability
  - Be aware of trends, such as OpEx growing in relative importance

Opportunities

Costs of time and energy

- **Combined cost of time and energy as objective**
- **Example:**
  - Time is money: time on the computer, time in the facility, people's time, lost time
  - Energy is money, defined by complex legal language of the energy contract
  - Total cost is the sum of the two
  - Objective: Minimize total cost within schedule, budget, and physical constraints
- **Note:**
  - Time to solution may be strongly constrained by deadlines
- **Suggestion:**
  - Saving energy costs without increasing time to solution is preferable
  - Carefully analyze how your institution values time vs. energy costs

Performance maximization objective

- **HPC is bought for *High Performance* Computing**
- **Example:**
  - In many cases, time is much more valuable than energy
  - Saving energy isn't seen as a worthy objective
  - Maximizing performance is valued
- **However:**
  - Maximizing performance without energy efficiency requires more power & cooling
  - Existing facilities limit power & cooling
  - Provisioning more is expensive: new power feeds, new cooling, new facility, time
- **Suggestion:**
  - Energy efficiency maximizes performance within the existing operating envelope
  - This argument aligns with institutional objectives even if energy is free
  - Motivate energy efficiency by performance improvements within physical constraints
  - This argument can also justify system replacements with new, more efficient ones

Expanding operational envelope

- **Advancing frontiers of computing requires investments**
- **Example:**
  - Advanced technology system requires more power & cooling
  - Liquid cooling is also driven by high power densities
  - Power & cooling facility upgrades may cost >20% of platform
  - Forced by advanced technology requirements
    - Liquid cooling is a *must*
  - Facility investments are amortized over several platforms

- **Beyond upgrades of a facility:**
  - Even larger investments in power feed to the facility and electricity generation
  - Expanding operational envelope further encounters increasing costs
  - Costs eventually limit expansion
  - Energy efficiency improvements deliver more performance without further expansion

New life for old facilities

- **27-year old facility**
- **Existing air cooling**
  - With structural airflow constraints
- **Liquid cooling option is costly**
  - Site preparation cost ~10 % of platform
  - Platform LC option cost ~5%
- **Rationale for choosing LC**
  - *Deliver 250% computing in old facility*
  - Path for future platforms
  - Expectation of more robust performance and improved reliability due to cooler CPUs
- **Bottom line: No choice**
  - Air cooling could not deliver capability

Global IT Limited by Energy

Global IT poised to consume global electricity supply

- **World's information processing demand grows exponentially**
  - HPC is just a small portion
  - Personal devices, networks, data centers, other communications need power
  - Exponential capability growth demands energy
- **Energy efficient technologies are the key**
  - The entire IT industry is strongly driven by this objective
  - Energy efficient packaging (e.g. power delivery, power conversion, etc)
  - Energy efficient controls, at all levels (circuit to data center)
  - Energy efficient cooling (liquid, air)
- **Energy efficiency requires economic justification at every turn**
  - Decisions are made on the basis of bottom line impacts
  - Make your case by identifying specific benefits to your institution

Rebooting the IT Revolution: A Call to Action, SIA and SRC report, Sep. 2015

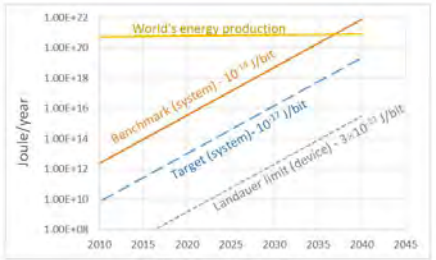


Fig. A8. Total energy of computing.

Energy efficiency is the key to more performance

- Energy efficiency isn't an end in itself
- Energy efficiency must be justified economically
- In HPC, saving time is usually more valuable than saving energy
- However, operating envelope constraints are critical
- Energy efficiency can be economically superior to expansion of the operating envelope
- This observation applies to individual institutions as well as globally

Maximizing performance under constraints requires energy efficiency