The Global Economic Imperative of the Efficiency of Everything*

John A. “Skip” Laitner

In Conversation with Participants of the Networked Devices Workshop
G20 Energy Efficiency Action Plan

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In many ways this talk builds on the confirmation of a Higgs-like Particle

- The idea of the Higgs, a new particle that is critical to the Standard Model of Particle Physics, was first developed in 1964.
- The Large Hadron Collider (LHC), the most complex machine ever built by human beings, conceived in the 1980s and began operation in 2009.
- The collaborative effort and imagination of both theoretical and experimental physicists enabled the development of the LHC and confirmation of the Higgs boson-like particle in July 2012.
- Except that we don’t have 48 years to get it right...
Some Opening Perspectives

- The productivity benefits from what my colleague Jeremy Rifkin calls “Second Industrial Revolution” technologies are diminishing.
- My own research indicates, and the evidence clearly suggests, that among the biggest reasons for those diminishing returns is the inefficient use of resources – especially the inefficient use of energy, but also capital.
- A social and economic transformation is clearly needed to sustain the national and international economies – driven both by purposeful effort and targeted investments which drive large-scale upgrades in energy efficiency.
- ICT-enabled services (intelligent efficiency) is the critical link between today’s economy and tomorrow’s future.
The Quick Roadmap Ahead

- We have (especially over the long haul) the problem of a lagging economy.
- There is a critical need to understand energy as work, rather than energy as commodities sold that are sold on the market.
- Beyond energy is the huge problem of the inefficient use of capital.
- The good news is that ICT-enabled services can become the catalyst to build a more robust, resilient, and sustainable economy.
Lagging Trend in the Global Economy’s Productivity

The inefficient use of resources, and especially energy, constrains a more robust future economic activity.

Source: OECD Economic Outlook May 2014 - Long-term baseline projections
Two Views on Energy

- **Energy as a commodity** tracked by agencies like the U.S. Energy Information Administration and the International Energy Agency; or

- Energy as **the capacity to do useful work**.

- **Comment:** To ensure the appropriate development of innovation that catalyzes sustainable economic activity, the emphasis needs to be on **energy as work**.
86% of energy is wasted in US

With a similar magnitude of inefficiency at the global level

Source: Laitner
http://www.aceee.org/blog/2013/08/thinking-big-about-energy-efficiency
The Lagging Efficiency of Capital

- While we clearly need to focus more heavily on significantly greater rates of Energy Efficiency improvement, we cannot afford to neglect our efficiency of our infrastructure.

- Consider the following three indicators:
  - The nation’s electric utility grid? ~50% capacity
  - Our highways at peak? ~5% capacity
  - Data server utilization? ~5 to 15% utilization

- If we are to emphasize real momentum in moving toward sustainability, the average efficiency of all capital should be nudged toward 90%.
An Emerging Thought Experiment
ICT Investment Patterns in the US 1970-2012

What if we had kept investing at the rate we did ~1996 to 2002?


# A Thought Experiment: ICT’s Potential $600 Billion Boost to U.S. GDP in 2013

<table>
<thead>
<tr>
<th>Thought experiment for 2013</th>
<th>GDP benefit (billion 2005 $)</th>
<th>Source of scenario assumptions</th>
<th>Working notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intelligent efficiency in buildings</td>
<td>17</td>
<td>Laitner (2010), GeSI (2012), Rogers et al. (2013)</td>
<td>Energy efficiency with a net 550,000 jobs times 35% ICT share at $86,000 GDP per job</td>
</tr>
<tr>
<td>Decreasing traffic congestion by 50%</td>
<td>114</td>
<td>Sweet (2013)</td>
<td>Congestion cut by half w/elasticity of -0.022; total jobs 56% of population</td>
</tr>
<tr>
<td>ICT investment up 50%</td>
<td>272</td>
<td>Cardona et al. (2013)</td>
<td>ICT investment has output elasticity of 0.05.</td>
</tr>
<tr>
<td>Accelerating Industrial Internet</td>
<td>200</td>
<td>Annunziata-Evans (2012)</td>
<td>Labor productivity was 1.5% higher in 2013.</td>
</tr>
<tr>
<td>Reduced ozone pollution</td>
<td>185</td>
<td>Graff Zivin &amp; Neidell (2011)</td>
<td>Labor productivity up 4.2% with 13% lower ozone affecting 1/3 labor force</td>
</tr>
<tr>
<td>Total GDP impacts</td>
<td>600</td>
<td>Sum of the five thought experiments net of interactive effects</td>
<td>Assuming a ~75% factor to minimize interactive effects and possible double counting</td>
</tr>
</tbody>
</table>

*Source:* Author estimates starting with Woods and Poole data for 2014, following assumptions and referenced bibliographic resources in the body of this report.
A Thought Experiment: ICT’s Potential $600 Billion Boost to U.S. GDP in 2013

With the further benefit of a 1.1 Billion Barrel Energy Efficiency Gain Driving a $79 Billion Energy Savings


Economic and Human Dimensions Research Associates

**Typical Annual Expenditures 2013, with program expenditures and ICT-related investments beginning in ~1998**

- **Total Energy Purchases:** $1,392
- **Policy and Program Expenses:** $2
- **Energy Efficiency/Renewable Energy Investments:** $16
- **Energy Bill Savings:** -$94
- **Net Costs of Energy Services:** $1,313

Driving a Net Gain of 8.2 MM Jobs, a $600 Billion Gain in GDP, and Creating a More Secure and Resilient Economy


Economic and Human Dimensions Research Associates ::::
Sometimes the need to step back and recall.

Table 5. Computer characteristics, 1946 and present

<table>
<thead>
<tr>
<th></th>
<th>Electronic Numerical Integrator and Computer (ENIAC)</th>
<th>Typical laptop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>1946</td>
<td>2014</td>
</tr>
<tr>
<td>Performance</td>
<td>5,000 addition problems/sec.</td>
<td>2.1 billion operations/sec.</td>
</tr>
<tr>
<td>Power use</td>
<td>150,000 watts</td>
<td>65 watts</td>
</tr>
<tr>
<td>Weight</td>
<td>30 tons</td>
<td>5.6 pounds</td>
</tr>
<tr>
<td>Size</td>
<td>8' x 3' x 100'</td>
<td>15.2” x 10.2” x 1”</td>
</tr>
<tr>
<td>What is inside</td>
<td>17,840 vacuum tubes</td>
<td>1.2 billion transistors</td>
</tr>
<tr>
<td>Cost</td>
<td>$487,000</td>
<td>$430</td>
</tr>
</tbody>
</table>

*Source: Author estimates based on a variety of sources.*

Intelligent Efficiency?

Offering just two of so many different examples. . . If we’re willing to really look!
Optimizing our Nation’s Traffic Signals

- There are an estimated 311,000 traffic signal systems throughout the United States today.
- Stop and start driving and poorly timed signals cause unnecessary fuel consumption on roads and highways.
- Retrofitting these systems with smart sensors and dynamic programming techniques can improve traffic flow so that we reduce our highway fuel consumption 5-10% per year.
- The cost? About $10-12 per household. The savings? Perhaps $150 per household per year – possibly more!
- This is even before we thinking about the trains of driverless cars...
Developing Intelligent Industrial Efficiency

- With new information technologies and advanced sensors and controls, for example. . .
- Both Schneider Electric and Rockwell Automation, but also others. . .
- Offer services to manufacturing firms that can reduce electricity use by up to 40 percent and reduce oil and gas requirements by up to 35 percent.
The Very Long Story Short?

- Optimal intelligent efficiency designs are still emergent. It is difficult to know with any certainty how an ideal ICT-enabled system or network might really function.

- Early prescriptive standards which focus prematurely on minimizing device energy use may exclude the development of more robust systems that lower costs, improve economic performance, and reduce greenhouse gas emissions.

- Rather than focus purely on devise minimization we need to focus squarely on the net benefits of system optimization.
Perhaps Our Ultimate Economic and Intelligent Efficiency Resource?

• Recalling the comment of early Twentieth Century UK essayist, Lionel Strachey, who remarked: “Americans guess because they are in too great a hurry to think.”

• Jerry Hirschberg, founder and former CEO of Nissan Design, who noted that: “Creativity is not an escape from disciplined thinking. It is an escape with disciplined thinking.”

• And Henry Ford once said, “Thinking is the hardest work there is which is the probable reason why so few engage in it.”
The difficulty lies not with the new ideas, but in escaping the old ones. . . .

John Maynard Keynes
THE DIFFICULTY IS TO ESCAPE THE OLD IDEAS
Selected References


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And again, look for our report at: