The Price of Light

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"I look to the diffusion of light and education as the resource most to be relied on for ameliorating the conditions, promoting the virtue and advancing the happiness of man."

--Thomas Jefferson to Cornelius Camden Blatchly, 1822
Household expenditures on light

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Nordhaus, 1996
Earliest tool: “Oldowan chopper” 2.6 million years ago

Definite signs of domesticated fire by the Australopithecus, Africa, 1.42m BC

Torches, Fire in Caves, Peking Man, 500,000 years ago

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Lamps

- Fat burning lamps from Paleolithic era, 40,000 - 15,000 BC
- Sesame oil lamps in Babylonia, 2000 BC
- Pottery and bronze lamps with the Greeks, 700 BC
- Wick technology lamps in Rome, 100 BC

Greek pottery lamp
400-300 BC

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- 3000 BC, Egypt and Crete
- Tallow, middle ages
- Whale Oil, 1700s, 1800s
“We are subjected to the intolerable competition of a foreign rival, who enjoys superior facilities for the production of light that he can inundate our national market at reduced price. The rival is no other than the sun. Our petition is to pass a law shutting up all windows, openings and fissures through which the light of the sun is used to penetrate our dwellings, to the prejudice of the profitable manufacture we have been able to bestow on the country.”

-- Bastiat (1845)
1792: William Murdock uses coal gas illumination in his Cornwall home.

When he saw that his family survived, he started a business.

1800 - 1825 most of the large cities in Europe were lit by Murdock’s town gas invention

Welsbach gas mantle, 1882
“The discovery of petroleum in Pennsylvania gave kerosene to the world, and life to the few remaining whales.”

--Louis Stotz, (1932)
- Prof Benjamin Silliman’s 1855 experiments
- 1870 Kerosene lamp
- Coleman lantern (modern)
### Some of Silliman’s results

<table>
<thead>
<tr>
<th>Fuel (fl oz)</th>
<th>Apparatus</th>
<th>Fuel Rate</th>
<th>Fuel Price</th>
<th>Lum Hrs/kBtu</th>
<th>Cts/ kLum-Hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Town Gas (Cu Ft)</td>
<td>Scotch Fish Tail</td>
<td>4</td>
<td>0.40</td>
<td>31.9</td>
<td>22.8</td>
</tr>
<tr>
<td></td>
<td>Argand Burner</td>
<td>10</td>
<td>0.40</td>
<td>37.8</td>
<td>19.2</td>
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<tr>
<td>Sperm Oil</td>
<td>Carcel’s Lamp</td>
<td>2</td>
<td>1.95</td>
<td>23.0</td>
<td>40.1</td>
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<tr>
<td>Colza Oil</td>
<td>Carcel’s Lamp</td>
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<td>1.56</td>
<td>23.0</td>
<td>32.1</td>
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<tr>
<td>Camphene</td>
<td>Camphene Lamp</td>
<td>4</td>
<td>0.53</td>
<td>16.9</td>
<td>14.9</td>
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<tr>
<td>Silvic Oil</td>
<td>Diamond Lamp</td>
<td>4</td>
<td>0.39</td>
<td>12.4</td>
<td>14.8</td>
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<tr>
<td>Rock Oil (kerosene)</td>
<td>Camphene Lamp</td>
<td>3.4</td>
<td>0.06</td>
<td>14.6</td>
<td>2</td>
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</table>
- 1840: de Moleyn’s filament lamp
- 1860: Demonstration of an electric discharge lamp to the Royal Society of London
- 1876: Wallace’s 500 candlepower arc lamps at the Centennial Exposition in Philadelphia
- 1879: Swan, England and Edison, America, invented practical filament based “glow lamps.”
- 1882: Edison’s Pearl Street Substation
- 1920s: High pressure Hg vapor and Na discharge lamps
- 1930s: Hg vapor fluorescent lamps
- 1931: Na vapor lamp
- 1980s: Marketing of the compact fluorescent bulb (68 lumen/Watt)
Fig. 1. Labour price of light. Figure shows the number of hours work necessary to pay for 1,000 lumen-hours of illumination (1,000 lumen hours is approximately the light produced by a standard 75 watt incandescent bulb in about 1 hour). Note the break in scales between Babylonian times and the last two centuries. (Source: Nordhaus (1996).)
<table>
<thead>
<tr>
<th>Device</th>
<th>Stage of Technology</th>
<th>Lumen/Watt</th>
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<tbody>
<tr>
<td>Fire</td>
<td>Wood</td>
<td>0.00235</td>
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<tr>
<td>Lamp</td>
<td>Neolithic</td>
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<tr>
<td></td>
<td>Babylonian</td>
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<td></td>
<td>Whale Oil (1820)</td>
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<td></td>
<td>Sperm Oil (1855)</td>
<td>0.0784</td>
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<td></td>
<td>Camphene (1855)</td>
<td>0.0575</td>
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<td></td>
<td>Kerosene (1855)</td>
<td>0.0498</td>
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<tr>
<td></td>
<td>Kerosene (1880)</td>
<td>0.1590</td>
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<td>Coleman (1993)</td>
<td>0.3651</td>
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<tr>
<td>Candle</td>
<td>Tallow</td>
<td>0.0757</td>
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<tr>
<td></td>
<td>Sperm</td>
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<tr>
<td>Gas</td>
<td>Murdock (1827)</td>
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<td></td>
<td>Argand Burner (1880)</td>
<td>0.2464</td>
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<td></td>
<td>Welsbach (1916)</td>
<td>0.8685</td>
</tr>
</tbody>
</table>

Nordhaus, 1996

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Filament Lamp Efficacies

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Nordhaus, 1996, plus extensions
“Last year (1974) the streetlights on the lines of the Boston Edison system alone consumed 250,000 barrels of fuel oil. Yet at least a third of this oil could be saved by a single new feature design.

... such lights were proved in Boston in the 1920s and again on Connecticut highways in the 1950s, only to be squashed by the manufacturing elite, to preserve their investment in the status quo.

It is estimated that any loss of the precarious Arabian oil production could be partially compensated by correcting such needless squandering of desperately needed fuel, while street lighting would be improved”

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“About 20% of electricity is used for lighting. The most widely used sources of artificial illumination are incandescent and fluorescent lamps, but this is about to change: Solid-state lighting (SSL) devices promise to replace conventional light sources, with impressive economic and environmental savings. In the US, expenditures for lighting may be reduced by $100 billion over the period 2000-2020. By the year 2020, electricity used for lighting may be cut by 50%, sparing the atmosphere 28 million metric tons of carbon emission annually.”

--Physics Today, Bergh, 2000

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The New York Times

Solar Flashlight Lets Africa's Sun Deliver the Luxury of Light to the Poorest Villages
May 20, 2007
http://bogolight.com/

A shurta, or guard, who called himself just John, said, “I used the light to scare away wild animals.” Others said lights were hung above school desks for children and adults to study after the day’s work.

With a little research, he discovered that close to two billion people around the world go without affordable access to light.

“L.E.D.s used to be very expensive,” Mr. Bent said. “But in the last 18 months they’ve become cheaper, so distributing them on a widespread scale is possible.”

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