Strategies for Degrowth Computing

Brian Sutherland
Faculty of Information
University of Toronto
Toronto, Ontario, Canada
b.sutherland@utoronto.ca

ABSTRACT

More energy is typically expended on a computer's manufacture than during its working life. This paper looks at 1) the concept of resource reduction and scarcity in the economy, degrowth, applied to the rendering of computing and information services, “degrowth computing” and identifies some strategies. It 2) explores some degrowth concepts around energy autarky with a Raspberry Pi, with some further thoughts about consumption within the research frames of the Limits community. When is the most sustainable computer not a new one? When might people not need consume this most useful of tools?

CCS CONCEPTS

Social and professional topics→Sustainability;

KEYWORDS

Materiality, sustainability, e-waste, history of information services, energy harvesting, consumerism, growth and post-growth; emerging architectures

Reference Format:

Brian Sutherland. 2022. Strategies for Degrowth Computing In LIMITS ’22: Workshop on Computing within Limits, June 21–22, 2022.

1 Degrowth

Degrowth is the economic idea of systematically making do with less, avoiding unnecessary consumption, promoting conservation over development and prioritizing repair and upcycling over waste. It is: “a planned reduction of excess energy and resource use to bring the economy back into balance with the living world in a safe, just and equitable way” [1]. Degrowth is considered by some economic environmentalists to be a way to address the rebound effect, or Jevon’s paradox, where increases in efficiency of energy aimed at conservation lower the price to the degree that “it’s the very economy of its use that leads to its extensive consumption” [2]. One example is industrial logging – heavy equipment produced more efficient logging but did not lead to shorter workdays and higher pay, just quicker deforestation, cheaper lumber, growth in construction and general consumption. Other rebound effects research suggests there may be a natural limit this phenomenon and some sector dependence. In space-heating for example, “this process eventually saturates, when more heat *even at lower costs* means discomfort” [3]. I propose with degrowth computing there is a natural limit or saturation of computing devices. This is aligned with the idea of LIMITS, the "design and development of computing systems in the abundant present for use in a future of limits or scarcity" [4].

2 Manufacture and Disposal

William Jevons was writing about the conservation of coal when he suggested the paradox of more efficient steam engines increasing coal consumption rather than reducing it, in 1865. In 2010, artists Harwood and Yokokoji suggested a link between coal and computers at their exhibition “Coal-Fired Computers” in Newcastle, UK. They proposed that the manufacture of computers occurs primarily in countries with high levels of coal consumption and that this energy of extraction and manufacture, known as embodied energy or “emergy” represented 81% of the total energy a computer would use in its lifetime [5]. Raghavan and Ma (2011) similarly estimated each laptop manufacture would consume 4.5 GJ, and on a three year replacement regime, this translates to 47W of energy consumption 24/7, even before the electricity used to operate the computer [6]. Aside from the embodied energy, Harwood and Yokokoji also estimated 318 000 worker-deaths per year due to exposure to coal dust.

While there is a cost to computing in energy and lives, the materials used to construct electronics *also* have a lot of dependencies [7] and carry a significant environmental burden. Notes Crawford (2021) in *The Atlas of AI*, “if we visit the primary sites of mineral extraction for computational systems, we find the repressed stories of acid-bleached rivers and deracinated landscapes and the extinction of plant and animal species that were once vital to the local ecology” [8]. This environmental burden appears again on the disposal side of computing as heavy metals and chemical contaminants leach into the environment [9] while large numbers of persistent “molded plastic epics” [10], machines of utopian imaginaries past, are relocated “in the Global South” [11].

LIMITS ’22, June 21–22, 2022.

3 Degrowth Computing at Scale

Degrowth computing in this frame would seek to slow down the cycle of obsolescence, to reduce the manufacture and discarding of computers by extending their lifetime, reducing the 47W per laptop continuous consumption figure. eReuse.org for example, has done this very effectively. They noted 80% of computing devices destined for recycling were in working order, and could be re-used by social entities in their extended lives [12], resulting in the repurposing of 30,000 devices per year.

Another conception of degrowth computing is, perhaps, "information batteries" [13] where networked server installations that are starting to obsolesce are used as a peak-shaving energy strategy. This means for example, as solar energy approaches its peak on a sunny day and starts to overload the electrical grid, large numbers of computers are brought online to render the excess energy into useful information products. Unlike energy, information can be stored easily! As Switzer and Raghavan point out, generated energy above demand is effectively surplus and carbon-free, so high efficiency in a computing platform is not a significant consideration: less efficient computers, such as from old data centres, can be utilized for research computation work to ensure their investment in embodied energy provides an additional return, before the hardware is retired and recycled. Aside from the information products generated, this infrastructure performs the useful secondary function of safeguarding the electrical grid.

We might further conceive of degrowth computing as energy autarkic information islands, where each unit of computing activity is powered by its own dedicated renewable energy supply [14]. Watts (2019) notes in *Energy at the End of the World: An Orkney Islands Saga*, while there is abundant wind energy, "the islands cannot sell unlimited green Orkney electrons to the world, no matter how much the market economics change. The rust-encased cable (to the shore) is the visible and material limit on their market" [15]. Were the Orkney Islands to render wind energy directly into information products locally, the market limit imposed by an aging cable to the grid might not be a problem. Shipping containers of second-hand servers could be delivered to make information products out of electricity rather than sending the electricity to the grid. No material restriction exists on green Orkney *information,* stored or conveyed over a fibre optic cable. The variability of wind energy might be utilized for scheduled second tier computing tasks, i.e. a computing facility could operate in sync with the ebb and flow of renewable energy.

Up to now the degrowth computing strategies discussed have involved *extending* the time computers are used before being recycled. A further strategy involves using them more *intensively* during their early period when they are the most power efficient. Time-sharing and collaboration strategies for computing hardware, of course, have a rich history from the earliest days of computing, when mainframes were limited or scarce and demand was high [16], as well as through the early days of online communities and the internet. One of the largest experiments of this time-sharing variety is the distributed computing system known as Folding@Home or FaH, in which constellations of users donate their unused computer time to researchers to bring petaflops worth of computing power to bear on research simulation problems [17], comparable to dedicated research facilities of thousands, even millions of computers. During SARS-CoV-2 or Covid-19, the FaH network was used to simulate the Covid protein structure and its potential interaction with antiviral drugs [18]. FaH became the world's first exaflop computer with about one million connected devices, 4.8 million CPU cores, 280,000 GPU cores, faster than the world's top 100 supercomputers combined. Unlike dedicated facilities, shared distributed computing systems have a whole army of volunteer maintainers, and no additional manufacturing of physical devices needs to occur. This gets at the degrowth concept that communities might have more resources without additional units of production simply by sharing privately-owned assets more effectively. Kallis speaks of degrowth as "a set of collectively agreed social minima and environmental maxima" [19]. Computer access is somewhat essential to a well-informed public, a social minimum, but unused computing time might be better employed to address other computing needs and the embodied energy problem, where as a society we are facing environmental and ethical limits.

Expanding the definition of what we mean by a shared computer would also help us utilize private computing resources more intensively. Some in the Global North possess many computing devices by virtue of smart thermostats, smart appliances, smart entertainment systems and mobile devices. New smart devices are also emerging: self-driving cars will soon be common on the roadways. Self-driving cars have significant computing capability, on the order of about 200 laptops worth, which might be used for computation tasks estimates a Wired article [20]. The Daymak Spiritus, a self-driving car launching in 2023, is set up to mine cryptocurrency while not being used on the road [21]. Why not instead of cryptocurrency, strike an agreement for more collective intensification: provide the owners of self-driving cars free parking in exchange for research computing resources, the same way Norway incentivized electric cars? Or rather than incentives, *only* license self-driving cars like these on public roadways *if* their computers are made available for research while they are parked? Degrowth doesn't specifically seek to reduce innovation, but a planned reduction of resource-consumption requires more efficient collective use of resources –in a way that doesn't simply accelerate consumption.

Aside from new strategies manufactured-in for sharing private computing assets more effectively, future smart cities of internet things may contain millions of connected computing devices which are publicly-owned and may have underutilized capability, that might be brought to bear on common computing problems as part of a distributed network. Prioritization of computing on the basis of importance, energy and device availability might determine how computing jobs are scheduled. One such availability computing network is http://solarprotocol.net/, where each computer in the network is energy independent or autarkic and networking information renders power information with the routing, with the result that web hosting shifts computer on the basis of available solar power [22].

Aside from using physical devices for a longer period, in shared configurations, or in symbiotic ways with energy, degrowth computing can also be supported by *software engineering*. One such web project, Low Tech Magazine, suggests "principles derived from degrowth are a useful heuristic for guiding the design of web environments that want to limit energy footprint", specifically: "designs which don't obsolete old machines or slower networks" [23]. These kinds of design strategies include avoiding animation effects, downsizing image and video resolution or frame rates, enabling offline reading, and auditing designs with analytical tools like the Safari web inspector energy impact meter. In the realm of operating systems, Linux is particularly useful for reviving older computer hardware that refuses to run the latest operating system from Apple or Microsoft.

Further to degrowth computing *applications*, some have advocated disincentivizing or even banning certain computing practices as needlessly consumptive, socially destructive, or not representative of the common good. Is in-silico modelling a valuable enough research strategy to justify the expenditure of environmental capital? Cryptocurrencies get around taxes, regulations and international borders, how can they reflect a common good? Streaming entertainment and working remotely reduce energy in transportation but aren't they socially distancing? Aside from the health burden of extraction, do people using computers damage their physical health? The crossover between computer use, free choice and expression suggest that future degrowth limits on application of computers would be difficult to *impose*. However, users might be persuaded by taxes or by social pressure to reduce consumptive applications in favour of more worthwhile practices.

4 Degrowth Transitional Devices

Thus far we have looked at systems of multiple computers. How do individuals stay within limits and degrowth appropriately in their individual computing technology habits? Knowing that embodied energy is a significant part of the ecological value of computing objects means that learning to repair them is a good skill to pursue actively. Keeping computers repaired means their use will value the social investment of their manufacture. Recycling old or unwanted technology to other users promptly is important, as an idle device obsolesces and benefits no one. The fact that many people are accumulating old devices should indicate that we are starting to reach the natural limit, or level of saturation I spoke of. In choosing a computer, consider systems in the market that have extended modularity, repairability or upgrade potential, or a used higher end model. Also consider how you might be able to use your computer less.

What might a transitional, lesser computer consist of? Increasingly very small, cheap computers have workstation capabilities, such as a 5W Raspberry Pi. At the time of writing the latest Pi model works with Microsoft Teams, although the video feed is a bit halting. If you have a good smartphone, it will often pair with a bluetooth keyboard or a smart TV to allow you to use it as a word processor, either with software on the phone or a cloud-based system. For notetaking it might be sufficient. Or use paper and simply reduce your computing time.

Upcycling is also an option. An SSD drive upgrade and some added RAM can make an old laptop fly in comparison to its previous performance. You can also choose to share a computer with a sibling, or use a shared computer at a library, instead of buying one. Just as writing instruments used to be personalized but now tend to be shared, computers are becoming less expensive to the degree they can be shared more easily, like a common pencil.

5 Energy Autarkic Degrowth

While computing hardware and software represent aspects of energy consumption which can be optimized for degrowth, a further optimization involves making computing hardware use only sustainable energy. In this respect the Samsung NC215S from 2011 is pretty inspiring, it remains the first and only mass-produced consumer portable computer with a built in solar panel, as well as an extra large battery. The Samsung NC215S has the ability to continuously monitor the solar energy it is receiving from the panel while in operation.

Figure 1: Samsung NC215S Netbook, 2011.

Energy autarky occurs when a system is energy independent. The Samsung NC215S is marginally so. If you are building a degrowth system which is energy autarkic, it is important to have a sense of the power profile of the system so you can scale the energy system appropriately. Bluetooth and WiFi can significantly alter the energy profile; likewise, adjusting the display’s brightness up or down. I used a Kuman KW47-US electricity usage monitor to develop a power profile correlating user activity and machine, to identify usage spikes (Figure 2). A 2013 27” iMac for example, uses a surprisingly large amount of power, towards 100W compared to a 2021 MacBook Pro with an ARM processor which averaged around 20W.

In exploring this space of a transitional energy system, the consumption data was very useful in creating a prototype workstation that was solar powered, and did not use batteries (no heavy metals). Instead, it used supercapacitors, which recharge 1M times and last decades.

Figure 2: Power Usage Profiling – Monitoring the Wattage

A sensitive electric device like a computer typically would not work plugged directly into a solar panel, even if the voltage was correctly adjusted, due to the variable current. The buffer design I used consisted of 24 x Maxwell D-Type 350F supercapacitors, each rated for 2.7V, balanced with a protection board in four groups of six. Theoretically, this series could support a combined voltage of 64.8V. The solar panel I used was a Canadian Solar 280W, rated at 36V open circuit. Military specifications for capacitor designs recommend running them with a 50% margin over the operating voltage, so 64.8V provided a good safety margin. Due to minor differences in capacitor manufacture, a protection board is important to balance the supercapacitors. This ensures that each one bears an equal part of the combined voltage; no one supercapacitor exceeds its 2.7 voltage limit. As a further safety measure there were 2A fuses between each of the four groups of six, in the event a short circuit occurred.

One unusual thing I discovered was that when supercapacitors charge from solar panels, they charge to the open circuit voltage due to the lack of resistance. This was unexpected. For example, a 12V solar panel designed to charge a car battery will typically charge supercapacitors to 21.5V as that is the open circuit voltage. It is important to monitor the voltage!

Figure 3: Rooftop Solar Panel 280W

The workstation I tested this energy harvesting system on was a Raspberry Pi 4, with 4 GB memory and an eInk screen. As part of the power profiling process I determined from the electricity usage monitor that the Pi consumed more electricity reading and writing to a USB-3 SSD than with a conventional SD card. The display I used was a 27” HP 27er flat panel that was rated at DC 19.5V, delivered via an AC transformer with a maximum draw of 28W. Two DC to DC converters were used to step down the voltage from the 30-39V solar charge of the supercapacitors. A DROK DC-DC buck converter constant current and voltage regulator 5-36V stepped the voltage to the 5V required by the Raspberry Pi. It had a USB plug (red LED display in Figure 5), while a Yeeco DC Buck Converter 8-60V to 3-32V 7A Adjustable DC-DC step down converter voltage regulator stepped the 36V down to the 19.5 V required by the HP 27er monitor (LCD display backlit in blue in Figure 5). I later added some filtering capacitors in parallel with the 19.5V DC output as the monitor worked well under steady sun, but not so well in partially cloudy weather or near the end of the day’s charge. The Yeeco had pushbutton adjustment rather than requiring a screwdriver, which was a great feature, no need to worry about it slipping.

Figure 4: Raspberry Pi 4 with eInk screen

A useful feature of the DC to DC converters was that both of them had fine adjustable outputs, so I could set the voltage to slightly exceed the 5V USB spec and give the Pi more stability or to accommodate the monitor startup power spike.

Figure 5: HP monitor, two DC-DC converters, Raspberry Pi

The outcome was a solar powered batteryless workstation that worked quite well, although the supercapacitor array was on the small side to buffer the system and on cloudy days the Pi would occasionally show a low power warning. Dependency on limited energy storage forced me to stop working around 6pm while the sun was going down, which perhaps is another aspect of degrowth – keeping a healthy work-life balance!

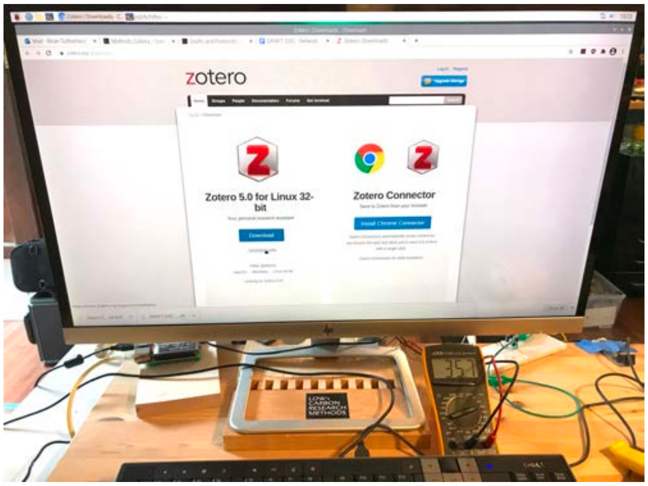

Figure 6: Solar Powered Batteryless Workstation

In a second iteration to this system, I used an Epever maximum power point tracker (MPPT), a 50 Ah 12V lithium iron phosphate battery, and a Renogy 1000W pure sine inverter to render regular alternating current. The benefit to this alternative setup was that the battery had a relatively benign chemistry, and considerably more storage compared with the supercapacitor array, so I could plug in a conventional laptop and work in the evening if I wanted. Adding an additional panel will likely generate create enough power to support an external monitor or an older laptop with a higher power draw.

Figure 7: Revised Power System -

6 Conclusion

Degrowth computing, both as a theory and a practice aligns with designing in the abundant present for a computing future of limits or scarcity. In studying the transitional Samsung NC215S solar charging laptop and constructing a solar powered batteryless workstation, I experienced a number of degrowth challenges around hardware repurposing and sharing, software design and power requirements, as well as the energy requirements for specific computing behaviours. The resulting transitional energy autarkic computer workstation prototyped a design for a future where computing could theoretically be sustained locally and indefinitely without regard to the network. One intriguing idea which arises from this, bearing further research, is that -- with suitable degrowth strategies like the ones described in this article for extending the life of computers, increasing their intensity of use, and for sharing them – if those were applied to ubiquitous computing, we might reach a point of saturation, like with heating, where increases in computing power produce negligible gains in human comfort -- to the degree that future increases in efficiency no longer produce significant consumption of the world's resources. Wouldn't that be degrowth!

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