Solar-Powered Server: Designing For A More Energy Positive Internet

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Abstract
User Experience designers, software engineers and computer scientists alike are rarely tasked with thinking about the environmental impact and resource consumption of their design decisions, both when creating online platforms and experiences and when publishing multimedia content. Furthermore, free or low-cost web and hosting services encourage designers and users alike to overlook the substantial energy footprint of their online behaviors and interactions. The Solar-Powered Server is as a system designed to more deeply investigate the power consumption of our online actions and compare different design elements and choices, while experimenting with the intrinsic qualities of renewable energy sources in order to create more resource-efficient content, to make information storage more accessible under low resource conditions and foster more energy positive behaviors.

Author Keywords
Renewable energy sources, solar; multimedia server; design; sustainability; climate; green computing

CCS Concepts
•Human-centered computing → Human computer interaction (HCI);

Introduction

We are living through a climate crisis and as engineers, designers, and consumers, we can no longer ignore the environmental impact of our daily decisions and choices on the future of this planet. A changing climate has a wide range of potential ecological, physical and health outcomes, which include extreme weather events (such as storms, floods, and heatwaves) and disruptions in infrastructure, food and water systems [6].

What we perceive as habitual innocuous actions, such as browsing the Internet, posting updates on social media, sending emails and hosting online content, actually rest on the shoulders of an incredibly vast and complicated infrastructure that does indeed consume large amounts of human and natural resources which go unnoticed by most users. In 2008, the Internet was already responsible for 2% of global CO2 emissions, exceeding those of the entire aviation industry [2]. The amount of users and network connections has increased exponentially ever since. Global IP traffic is expected to increase threefold over the next 5 years and the annual global IP traffic will reach 4.8 ZB per year by 2022, or 396 exabytes (EB) per month while the number of devices connected to IP networks will be more than three times the global population by 2022 [5].

According to an article published in 2013, 40% of the Internet's total carbon footprint may be attributed to the design of a web site [3]. In March 2017, the average weight of a site was 2.5MB, almost 3.5 times bigger than the average size of a website in 2010 [1]. This rapid increase is mostly attributed to images and videos displayed on websites. For mobile websites, the average "page weight" rose tenfold from 0.15 MB in 2011 to 1.6 MB in 2018. Using different measurement methods, other sources report average page sizes of up to 2.9 MB in 2018 [4].

It is time to investigate how we can embed concepts of sustainability, low-energy futures, possible intermittence of infrastructure and resiliency within the way we approach not only the design of our online experiences but also our relationship and behavior towards our consumption of such resources. Therefore, we are proposing an interactive demo that features our solar server, hosting a range of resources which can provide CHI attendees with information on the energy production of the solar power system as well as the energy consumption of server and networking activities to further discuss how together we can design more sustainable interactions.

Solar-Powered Server

Our project draws inspiration from projects exploring the energy footprint of the Internet like the work of artist Joana Moll [1] and design research projects like Low-tech Magazine solar-powered website [2], designed to drastically reduce the energy required for users to access the Magazine content. The Low-tech site brilliantly exposes some of the design options available for reducing energy consumption of a website such as opting for a static website instead of a dynamic one, choosing default fonts, dithering images as a way to lower the resolution and size as well as providing off-line reading capabilities to make sure the website is accessible to visitors with less reliable Internet connections or older devices.

The website runs off of a low-energy microprocessor and publicly visualizes and displays the status of the off-grid solar system that powers it to provide awareness to users of the environmental conditions around where the server is located. Due to it being powered by solar energy, the website occasionally goes offline.

[1] http://www.janavirgin.com/
[2] https://solar.lowtechmagazine.com/

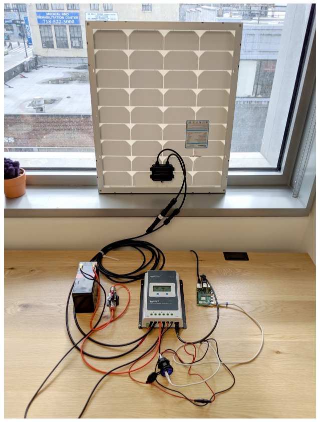

Figure 2: The off-grid system includes a solar panel, a battery, a charge controller and a single-board computer to host the server and serve the web content.

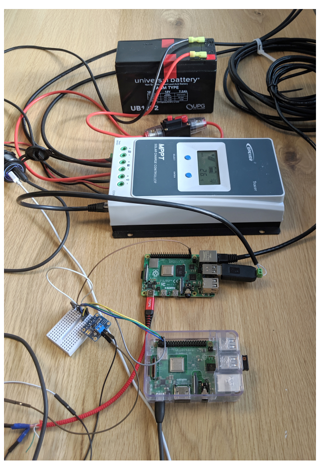

Figure 3: Solar-Powered Server hardware and testing circuit.

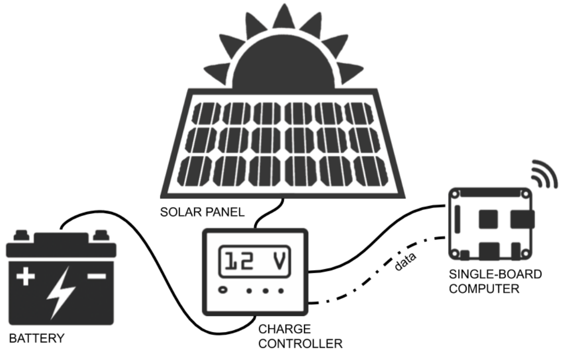

Figure 1: Solar-Powered Server Architecture.

Following in the footsteps of Low-tech Magazine, our team has been experimenting further with powering servers using renewable energy sources. We have iterated on the design of the hardware and PV system and designed a testing environment to measure the energetic impact of the most common UX/UI design elements. With this project we aim to address the current disconnect between design best practices and environmentally sustainable, low energy design. A primary goal of the project is to make the typically invisible energy consumption of Internet systems visible and understandable to both designers and end-users.

The Solar-Powered Server System relies on a low-cost, small, energy-efficient single-board computer (Raspberry Pi4) connected to a small scale off-grid photovoltaic (PV) system comprised of an MPPT charge controller, a solar panel and a lead-acid battery (Figure 1). As with the Low-tech Magazine PV system, the system is sized appropriately but it will go offline occasionally during long periods of overcast days as the charge controller will shut off the processor in order to maintain battery storage at an acceptable charge for the system to come back online during clearer days. The system was designed to try and adhere to the following design criteria:

Intermittence and Resilience

Intermittence is typically viewed as a constraint or failure in the contexts of both the Internet and energy systems. However, within this project, we are interested in exploring the concept of intermittence as a design quality. Could designed intermittence produce more resilient infrastructure and services by reducing energy loads? How could intermittent systems also reconfigure our relationship with online media in a positive way? There is already a growing slew of productivity tools that can be used to improve one's productivity by limiting access to social media platforms and websites. The very existence of these products demonstrates a growing interest in intermittence as a way of addressing the growing demands for our attention online.

Low-energy and Open-source

Both hardware and software systems were conceived to be as energy-efficient as possible, low-cost and non-proprietary in nature in order to improve the long term sustainability of the system while allowing for reproducibility and scalability (Figure 2).

Social and Educational Applications

We have identified a number of practical opportunities where small scale solar-powered servers are either currently in use or could be beneficial. The educational opportunities for this work are extensive. In particular, there are many opportunities for integrating this work into the photovoltaic STEM curriculum, the current Computer Science curriculum as well as the UX/UI design curriculum in the context of both data visualization as well as as testing platform (Figure 3). Personal websites designed and run by individuals concerned with the large carbon footprint of the Internet are another important application for this work. Resilient community portals of local information are growing increasingly important in the face of the current climate emergency and already make extensive use of solar-powered servers. These communities include regions directly impacted by climate events, community based organizations like community gardens and indigenous territories that have historically been under served by the traditional telecommunications infrastructure.

Conclusions

It is indeed possible to design sustainably and the technical ability required is within reach. Our experience suggests that the most significant challenges involve changing the behaviors and expectations of designers, engineers, and end-users through making the invisible visible. Because of the large carbon footprint of Information and Communication Technology (ICT) systems and their centrality in modern life, the opportunities for more sustainable web development are vast and the time has come to build literacy around design decisions and to think more critically about designing for lower consumption and a more intermittent society.

We are proposing to demonstrate the Solar-Powered Server at CHI 2020 because of its relevance to the ongoing efforts of the CHI community to benchmark the overall carbon footprint of the conference. More specifically, this project hopes to participate in the current conversation on everyday opportunities to reduce energy demand, promote more sustainable choices and more resilient last-mile logistics. We are excited to discuss with CHI attendees and with the incredibly energized sustainability group about design decisions that are possible today, ranging from UX/UI element selection all the way to larger decisions involving streaming habits and background analytics.

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