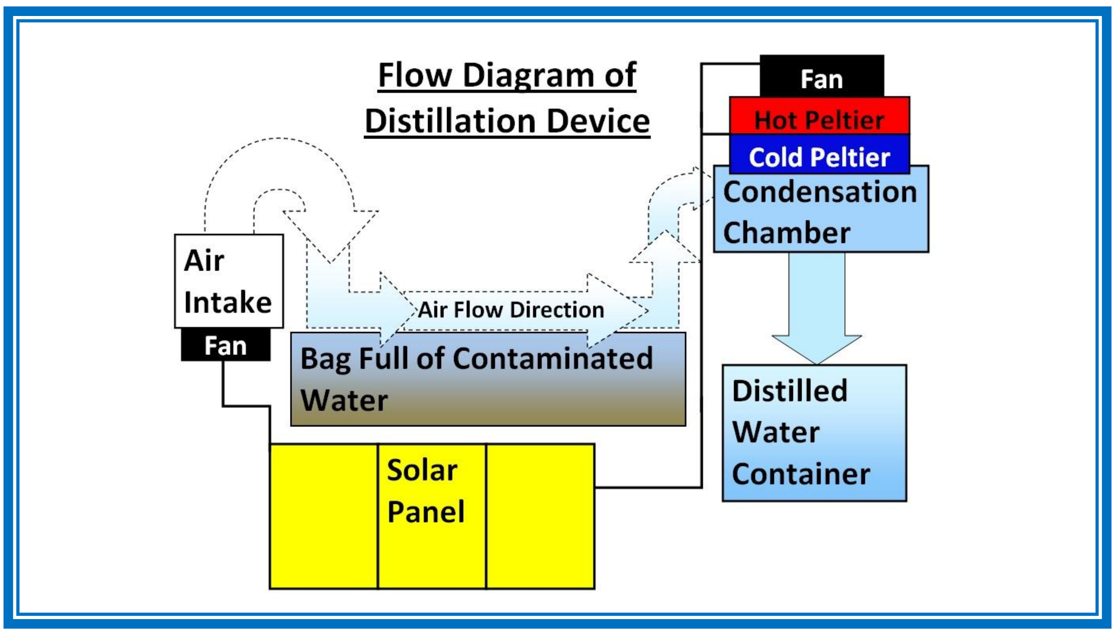
<u>1 Sun + 8 Bits = H_20 ABSTRACT</u>:

Digitally Optimizing "Smart" Photovoltaics for a Water Distillation Application, 2010

Nicholas M. Christensen worked with electrical engineer **John H. Jacobs** of **JouleNet LLC** to design a customized circuit board and program a real-time microprocessor in assembly to **optimize the power of a solar panel by tracking the maximum power point** and using switches to control the peak performance. Additionally, the board has a **radio link to transmit real-time data** on light and temperature fluctuations as well as power levels.

The specific application is a solar-powered Peltier device in a **water distillation system** that distills clean, potable water from contaminated water. While the basic distillation device worked occasionally, yielding over a liter several times and up to 2.2 liters in one day, the results were inconsistent. The unoptimized solar energy has proven to be unreliable, with minimal voltage readings, even in midday, and no voltage readings over 7.2 even though it is rated 12 volts. The circuit board is apparently working, but comparative studies with the optimized system are still in progress. If results prove promising, the immediate application would be the production of inexpensive point-of-use devices that could be used in developing countries or emergency scenarios. More importantly, the **microprocessor-enhanced solar panels have 1000s of applications and are now networked for solar farms by JouleNet LLC.**



This technology could be also be **<u>applied to covered irrigation canals in order to reclaim evaporation and distill potable water while also providing energy</u>** that might be added the electric grid or used to power water pumps.

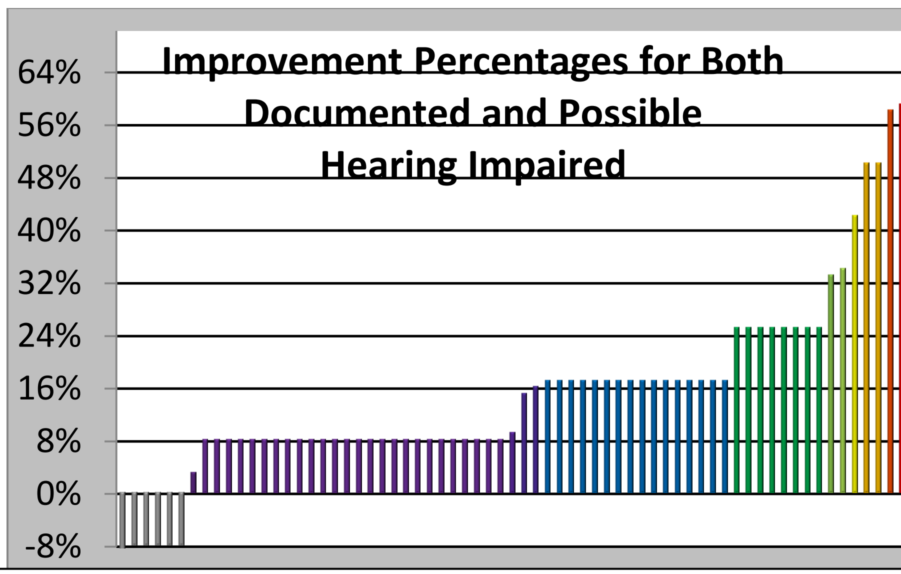
*(This project received an **international award by the US Air Force** at the Intel International Science and Engineering Fair 2010. It also placed **3rd in Engineering in the national Junior Science and Humanities Symposium, 2010,** and **3rd in the International Armed Forces Communications and Electronic Association** high school science competition, 2010. In Alabama it won **1st place in the JSHS competition** as well as a **1st place in the Alabama State Science and Engineering Fair**.)*

<u>Do You 'ear Wha' I 'ear?: Lowering Voice Frequencies in REAL Time to Revolutionize Hearing Assistance Technology ABSTRACT</u>—Nicholas M. Christensen, 2009

After researching hearing, voice production and digitization of sound waves, I wrote a **computer program that redigitizes .wav files of voices into lower frequencies that can be better understood by hearing-impaired people.** The program analyzes the .wav samples to determine the beginnings and ends of wave cycles, then counts the cycles, omitting one cycle intermittently as directed. It then interpolates numbers to resample the .wav at a lower frequency for the 44.1 kHz standard audio sampling within a set time frame.

I recorded low and high male and female voices, speaking similar-sounding words with many voiceless phonemes and processed them at five frequencies, from 12.5% to 25% lower than the originals. For a test, I mixed forty-eight of the recorded words randomly from different frequencies and asked normal and hearing-impaired people to circle which of three similar-sounding words they heard. I also recorded a male and female speaking sentences with many voiceless phonemes, which I processed in two different frequencies. In that test I asked which was easier to understand.

The test results from 130 people show that most prefer the normal voice range; however, those with **documented or even *possible* hearing loss better understood the words processed into lower frequencies**. On average, both groups missed 6% fewer words, with individual improvement up to 65%, at the lower frequency than at the original. This program shows promise for hearing assistance and may also have **application in radio and telephonic communication** where sound quality may be lost for anyone.



Individual tests show that at least two subjects improved nearly 60% from lowering the frequency of voices in real time (see **red** columns). Even though many subjects had **no** documented hearing loss, they still improved around 8% (see **purple** columns), whereas those **with** documented hearing loss generally improved 25% or more in word recognition (see **blue**, **green**, and **orange** columns).

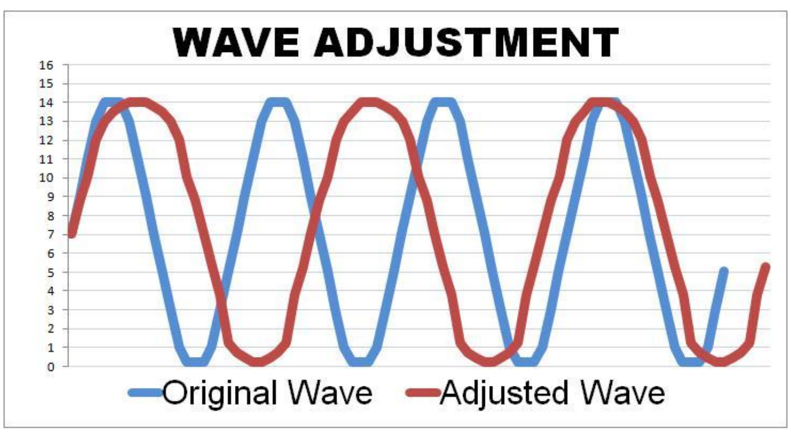
*(This project was the basis of Christensen's selection as an INTEL Science Talent Search FINALIST 2010 (1 of 40 in the US). It won **2nd place, worldwide, in Computer Science, Intel International Science and Engineering Fair, 2009.** Christensen was **1 of 8 students, worldwide, to receive the United Technologies Corporation Award.** The project also received an **international award from the Acoustical Society of America.** In Alabama, this project earned Christensen the **Gorgas award for the top senior science project** of the state as well as a **1st place in the Alabama Science and Engineering Fair**.)*

<u>Do You 'ear Wha' I 'ear: Redigitizing Voice Signals in Lower Frequencies to Revolutionize Hearing Assistance Technology ABSTRACT</u>—Nicholas M. Christensen, 2008

After researching hearing, voice production and digitization of sound waves, I wrote a **computer program that redigitizes .wav files of voices into lower frequencies** that can be better understood by hearing-impaired people. The program first reads the .wav header, then analyzes the .wav samples to determine the beginnings and ends of wave cycles. It can then count the cycles, omitting one cycle intermittently as directed, and do calculations to interpolate numbers to **resample the .wav at a lower frequency for the 44.1 kHz standard audio** sampling within a set time frame.

I recorded low and high male and female voices, speaking similar-sounding words with many voiceless phonemes and **processed them at five frequencies, from 12.5% to 25% lower** than the originals. To make a test, I mixed forty-eight of the recorded words randomly from different frequencies and asked normal and hearing-impaired people to circle which of three similar-sounding words they heard. I also recorded a male and female speaking sentences with many voiceless phonemes, which I processed in two different frequencies. In that test I asked which was easier to understand.

The test results from over 100 people show that most prefer the normal voice range; however, **those with documented or possible hearing loss better understood the words processed into lower frequencies.** They missed fewer words at the lower frequency than at the original. This technology **shows promise for hearing assistance and may also have application in radio communication** where sound quality may be lost.



The blue wave represents a sound wave with four cycles per unit of time, whereas the red wave has been stretched to include only three cycles in the same time period, which results in a **lowering of frequency, perceived as a lower pitch that's easier to hear** by most people who are hearing impaired.

*(This project won **4th place, worldwide, in Computer Science, Intel International Science and Engineering Fair, 2008.** The project also received an **international award from the Acoustical Society of America.** In Alabama, this project earned Christensen a **3rd place in the Alabama Science and Engineering Fair**.)*