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Solar Powered Sound Devices

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***Abstract*---- This paper describes recent developments in the construction of photovoltaic (PV)-powered sound producing instruments and equipment. The possibilities for making solar-powered musical instruments, sound systems, and loudspeakers are becoming increasingly realizable with the emergence of more powerful PV devices in diverse bundles. This paper reviews past and recent developments in this field, including several of the author's initiatives, and illustrates how the use of PV technology impacts the creative process in a unique manner. In addition, this paper explores how solar sound arts will improve the esthetic path taken in soundscape studies and acoustic ecology from recent work. Finally, this paper will point to future directions and possibilities, as performance-related PV technologies continue to evolve and improve, and become more affordable.**

***Keywords*--- Acoustic Ecology, Circuit Bending, Hardware Hacking, Human-Computer Interface Design, Laptop Orchestra, PV Technology, Sound Art, Electroacoustic, Solar Sound Arts**

I. INTRODUCTION

A photovoltaic power generation system consists of multiple components such as cells, mechanical and electrical connections and mounts as well as means to regulate and/or modify the electrical output. Such devices are measured in peak kilowatts (kWp) which is a volume of electrical power provided by a device when the sun is directly overhead on a sunny day. Hybrid power generation system blends a renewable energy source (in this case PV) with other sources of generation, typically a traditional diesel-powered generator or even another type of renewable energy such as wind.

Photovoltaics (PV) is based on principle of conversion of light energy into direct current. Photovoltaic work evolved gradually over the next hundred years. The last ten years have also seen a rapid increase in the use of PV technologies in art, especially art installations installed in remote locations, such as the Black Rock Desert in Nevada. It also seems that the different ecological threads of sustainability, including the phenomenon of music's own acoustic ecology, have created an environment in which the practice of outdoor, site-specific arts has grown into a real force of interest among many artists and curators. With an ever-emerging population of DIY electronics and digital art forms, it is not unexpected that PV would provide desirable options for remote power requirements, but it also provides an interesting new dimension in environmental engagement possibilities. This paper would present several ideas to bring PV to use in creative sound plays and devices, with an emphasis on environmental engagement by PV heterogeneity.

Solar Objects and Instruments:

The author's own investigation into this research comes from a long-standing tradition in soundscape composition and site-specific performance, as well as academic preferences and insights in digital instrument design and laptop production through technology. Several general principles of these projects are as follows:

- Autonomous networks. The artifacts and equipment are designed as all-in - one machines, with their own circuits, loudspeakers and energy collectors (PV arrays) for sound production.
- Bearable. The items are highly portable, and are small hand-held tools in the case of instruments.
- Sensitive context. The artifacts respond to the light directly and immediately in terms of both strength and sound modulation.
- Components Recycled. The artifacts are made from cheap parts and recycled materials.

Solar Noise Discs:

It's a small handheld devices also arisen from some earlier experiments, and all have the same basic characteristics. They are packed in recycled film canisters, especially small ones which are intended to hold 16 mm film 3.5-inch reels. To one hand they have speaker openings, from which the signal emits. On the other hand, they show three photocells and five points of body contact from Canadian dimes that use body capacitance when touched to cause circuit changes (see Figure 1). In these devices the sound-producing circuits are based on Schmitt control logic chips such as the 74C14[1] and the 4093. Through adding a RC

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circuit between the input and output pins on the board, these bi-stable multi vibrators used to create a square wave oscillator. Many oscillators are created with a single chip, and circuit-bending techniques are utilized to generate circuit modulations and instability. The resultant sounds are distorted to the player by way of an LM386 amplification and a tiny mic. The instrument includes a 2.1 mm coaxial DC power jack which connects to a PV array[2] or to any DC power source.

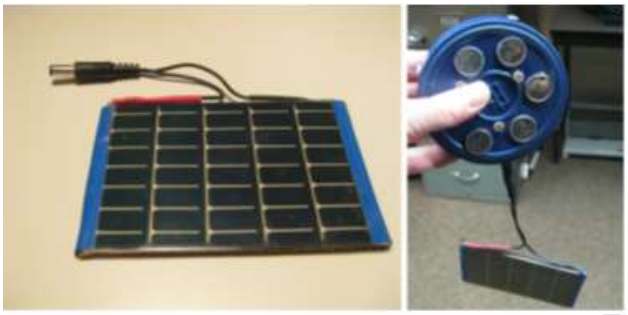

Fig.1: Solar Noise Disc

The instrument is played by gripping it, like a miniature accordion, between the legs. One hand becomes a kind of mute, which is essentially volume: you just cover the holes to stop the sound, you open your hands as you need more sound, which also changes the timbre. The other side, of course, surrounds the three photocells and connects the connections of the body in different ways, based on how the fingers are positioned. How you do that, and how it influences the tone, is something you need to learn and practice. It seems unpredictable at first, but one soon learns that if the conditions are right, events are regulated, and replicated. Two of these devices are currently in existence, as well as a few odd-ball variants.

While they also sound different due to circuitry differences, there is a similar quality about all of them due to the simple circuit design and the physical resonance properties of the device. There are two separate "levels" of electricity to control the devices, which compensate for a few different kinds of lighting level requirements and volume rates. In sunny days, these games are performed with "solar flaps," which are essentially small solar arrays placed on either side of a cardboard cover, flapping in the wind when it occurs. This will provide a maximum power of about 600 mW, more than enough to drive the device very well if it is bright, and it enables the prospect of fast character shifts as one can push it in and out of the shadows easily. Through attaching the device to a wider solar panel that is mounted on a pack-back or simply placed on the field, the next power stage is reached. The Go Power DURAlite series of photovoltaic panels, produced by Carmanah Technologies1, have proven to be the most efficient solution in the field. Such lightweight panels are built for RV and maritime use, and are quite durable due to the fact that the solar film is wrapped in a fiberglass laminate, rendering it practically unbreakable, as well as waterproof and cloud-resistant due to over-exposure to intense sunlight. Such products come in three varieties: 5, 10, and 20 watt plates, each with a 16 volt operating voltage. The 5 watt panel has proved to work very well even in gloomy environments.

Bird:

This installation project was an attempt to create something entirely self-contained, with the object being "built-in" to the PV technologies. A ring of several of these was linked in series using tiny 500 mV cells producing around 17 mA of current to form a PV array that was glued to a small disk. Of example, this series did not generate sufficiently wattage to drive the amp-speaker circuits used in the devices above, but only good driving piezo components would operate. The production of sound was generated utilizing Schmitt trigger circuits identical to the instruments above, linked to piezo speakers. The effects are a collection of fully self-contained beeping, twittering, and ringing apps, each using about 40 mW of electricity.

An author provides the designs of a "solar sound module" research were quite inspiring. The main focus in this work was not so much in the human concept itself, but in the notion of several of those working in a single system as a collection of voices. Picture walls lined with these items, in clusters or scattered throughout a room, or perhaps hanging from the ceiling in mobiles, became fascinating.

The resulting component is indeed a smartphone, called Bird, consisting of four circular items centered on the 4093 chip, a piezo speaker, a bottle-cap resonator, and a sequence ring of seven tiny 500 mV solar cells, all housed in bottle caps of plastic juice (see figure 2). The four machines hang in a column, attached by ball bearing fishing swivels to each other, allowing each to move freely. Those hang inside a column of streamers consisting of 1⁄4 "red leader plastic film.

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Fig.2: The Figure Portrays the Bird Device

It helps the wind to influence the noises from the devices due to rippling shadows casted by the streamers, as well as helping to create the energy needed to cause the devices to change in reaction to the breeze, producing an ever-changing sound depending on the sun and the weather. Bird was shown separately, and as part of larger installations.

Domeintonators:

Such machines are hybrid assembly items and tools, and have been constructed utilizing circuits identical to those of "Bird" above: a 4093 NAND gate chip [3]with two distinct patterns of modulating square wave oscillators, each of which is echoed by one of two piezo speakers. The circuitry is mounted in recycled security camera domes and provides an audio jack, if needed, to enhance the domes signal (in stereo). The systems also include two photocells at the bottom of the body, which are mounted in the dark battery compartment. When the door to the battery compartment is closed, the artist will control the instrument's sound by playing the photocells below the instrument, allowing the two modulated square waves to adjust their intensity. These are operated by a Power Film, Inc. 150 mW flexible solar strip [4]that generates a variety of small to medium-sized flexible strips.2. The solar strip is placed inside the transparent dome top of the instruments in an arch above the circuitry. This makes the instrument completely self-contained but it can be expanded in the sense that, if desired, it can be amplified using external equipment.

Such instruments have been used in both production and construction environments, but these could potentially be best suited for an immersive system in which audiences may "sing" the actual six players, while being further augmented by an external solar-powered amplifier and loudspeaker, allowing the six instruments work as a bigger, organ-like unit.

Arcade Bells:

The Arcade Bells were the result of a desire to move beyond these analog-ish ways of sound creation by using a tiny microprocessor. Additionally, this piece utilizes piezo disks to test ways to "rock out" or pulse larger objects, such as sheets of metal, cups, and other tools that could make nice resonators. This particular piece utilizes four tiny copper-plated footless goblets as transducers by gluing to the bottom of each large piezo disks and routing the leads through a hole drilled through the middle. To the left is connected a storage unit made of recycled proof tubes, in which the circuitry sits. The circuitry consists of an ATMEL ATmega328 chip and its life support (voltage regulator and power condensers, crystal clock, etc.), an LM386 amplifier, a small transformer, and a photocell which sticks out of the cup like a small flower. The chip is programmed to generate square waves in patterns at audio rates; specifically, ascending spectral arpeggios, similar to the sound effects of the 1980s arcade game. The chip also tracks the photocell status, which means the spectral arpeggios get better when light, and open up to more than one field.

The chip's tone is intensified by the LM386, then impedance-matched to the piezo-disk, which then resonates through the brass cup. Using the ATMEL chip needs more power than the simple logic chips used in previous experiments but they are still very capable of operating under low-power conditions. The whole circuit consumes less than 500 mW and is able to operate with much less. The amplifier is powered outside the loop of the 5 volt regulator, allowing the full voltage coming in from the solar panel to be more directly effectuated in volume.

Sol butter Instruments:

The final set of devices mentioned here are a new series of microprocessor-based devices, partially based on the work performed on the above Arcade Bells. Such devices also use the ATMEL ATmega328 processor[5] for sound production, as well as for interpreting sensor data from different control sources. As of this date, two prototypes have been completed, both using timer interrupts from the ATMEL to generate waveforms other than square wave forms, including sine waves and granular synthesis algorithms based on FOFs. These are round, handheld instruments with a built-in speaker amplified by an LM386

chip[6], mounted on the bottom of the container, like the noise disc instruments above. The instrument shown (Figure 6) features two pushbuttons (taken from a recycled toy), a potentiometer with 50 K ohm, and four photocells. Code-wise, the sound generating technique, written in the Arduino, uses the chip's PWM (pulse-width modulation) software output capability to mimic analog waveforms, and also uses a timer-interrupt procedure to insure that the sound-producing portion of the code gets priority. This device uses technology based in part on the open-source "Arduino"[7], which utilizes a simplified FOF synthesis model to construct a low-fidelity granular synthesis architecture. Charging this device is achieved in the same manner as charging the noise disks: either by plugging into a "solar flap" or a wider solar panel (or a generator or any other DC power source). This machine requires a minimum of 250 mW, which contains a voltage regulator and chip filter. The amplifier utilizes the solar panel's raw voltage, which ensures the total volume level is proportional to the amount of electricity obtained from the PV source.

II. LITERATURE REVIEW

This paper reviews the photovoltaic technology, its power-generating capacity, the various existing light-absorbing materials used, its environmental aspect coupled with a range of applications. Also discussed were the various existing performance and reliability assessment models, sizing and control, grid connection, and distribution[8]. The proposed method allows for the classification of the PV array status into three possible scenarios, namely normal operating condition, partial shading, and fault. The proposed treatment is experimentally tested to validate its effectiveness under different irradiation conditions[9]. The proposed method produces a diagnostic signal showing potential faults that may exist at the GCPV facility. The ratio between the DC and AC strength is tracked to determine the location of the fault. The developed software tool identifies various types of faults such as: fault in a photovoltaic module, photovoltaic string fault, inverter fault, and a general fault that may include partial shading, PV ageing, or MPPT error[10].

III. CONCLUSION

The work seems to have tremendous potential. It has already led to a number of intriguing events and projects, and hope that a kind of "solar sound art" will develop through a synthesis of these obsessions and experiments, and the obsessions and experiments of others, which could open up a whole new field of site-specific and spatial design ideas. Besides the apparent benefit of making electronic music performances outdoors utilizing ecological technology, the concept of real-time energy output as a sonic parameter is strong and will undoubtedly lead to a variety of interesting sound research with clear ties to environmental factors.

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