

Zero Emissions Network; A Pilot Program for Carbon Emissions Reduction

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Abstract

Public awareness of the disastrous consequences of continued rise in global carbon emissions reached a peak in 2019 with masses of people participating in Climate Strikes in more than 4,500 locations spanning 150 countries across the United States and the globe. The stage is therefore set for taking the matter to the people at a local level. In this paper, we report a pilot program: the Zero Emissions Network (ZEN), the newest program addition to the American Solar Energy Society (ASES), through which emissions reducing technologies such as solar electricity generation, green roofs, electric bicycles, geo-thermal HVAC, and re-planting of native flora using flight offset dollars are made more readily available and affordable, especially to lower income clients and communities. Student interns from the University of Colorado (CU), are the driving work force of the project, and we are working towards a sister chapter at the University of the Pacific (PACIFIC) in Stockton, CA.

The program solicits funding from both local and national sources for:

- a) providing micro-grants to low-income individuals and small businesses to help them afford solar electricity and other emissions-reducing technologies,
- b) building an information kiosk and web-based data center where all ZEN and ASES participants can get information on emissions reduction strategies and technologies, as well as track their overall greenhouse gas emissions to see how their investments in progressive technologies and lifestyle changes are reducing their greenhouse gas (GHG) emissions and those of their community.

Keywords: Zero Emissions Network, Monitoring and reducing GHG Emissions, Distributed Local Solar Generation

1. Introduction

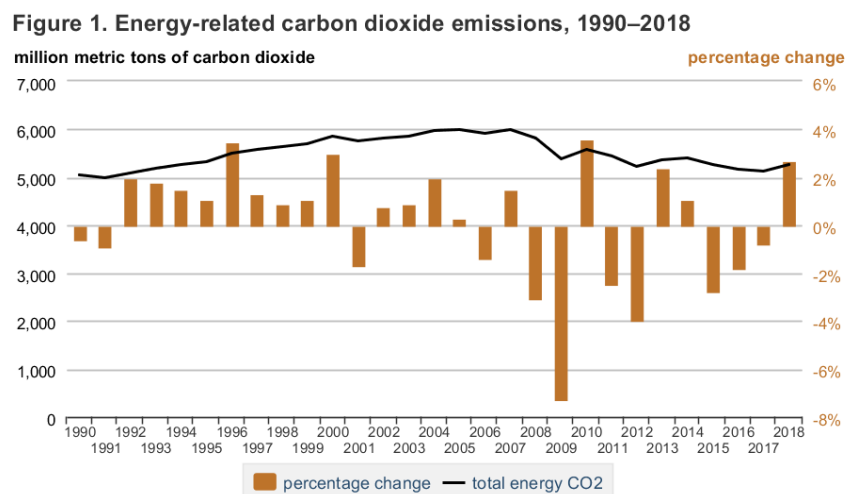
The Zero Emissions Network is a pilot project initiated by ASES and has attracted a strong core team determined to help the public take steps toward lowering their carbon emissions in many areas of life. In summary our 3-fold goals are:

- 1) Through micro-grants help elevate lower income communities to realize their place as leaders in GHG reduction within the environmental movement.
- 2) Help each location town by town, city by city, county by county, to track and see progress reducing their community's GHG emissions.
- 3) Educate and empower ourselves as ZEN team members, ASES members and ZEN participants, to track and take actions day by day which reduce our own GHG emissions so that we can serve as mentors and be examples for others who are ready to change their habits and help heal our precious atmosphere.

The project seeks funding from local and national sources and distributes the funds to local customers for installation of small to medium size distributed solar electricity generation and other GHG reducing technologies. The rapid and initial success of the ZEN program in securing its first two grants indicates the readiness of funding sources to help with this project. The project has very low overhead and is scalable to the availability of the local funding sources and the local needs of its customers. We hope that our presentation to the SOLAR 2020 audience will result in significant interest in replicating the project in other locales, especially by participating students, faculty, and solar industry representatives. Finally, Zero Emissions must be a global goal, and as important as it is to reduce local emissions, it is only through a massive global effort that we will achieve Zero Emissions, and hence the need for implementation of the ZEN program and similarly action-oriented models across the U.S. and the globe.

2. The need for ZEN project

The total U.S. carbon emissions was on a declining trend between 2007 and 2016 as shown in Fig. 1 (U.S. EIA, 2020).



 Source: U.S. Energy Information Administration, *Monthly Energy Review*, October 2019, Table 11.1, Carbon Dioxide

Fig. 1. Total and percentage of change in the U.S. energy-related carbon dioxide emissions. (U.S. EIA, 2020)

After peaking at 5983 Million Metric Tons (MMT) in 2007, the total U.S. carbon emissions reached a trough of 5171 MMT in 2016. In fact compared to 2005-levels, the total U.S. emissions dropped by 7% and 13% in 2010 and 2016, respectively. The drop continued in 2017 at 14% below 2005 levels. This is a significant decline by any measure. Various researchers have cited reasons for this decline, including:

- decline in the U.S. economy output in the years following the financial crisis of 2008-2009 (Peters, et. al. 2012) (Guardian, 2010), and (Murray and Maniloff, 2015).

- increase in use of natural gas (Feng, et. al., 2015) and (De Gouw, et. al., 2014)
- federal regulations imposed by the Obama Administration (Adler, 2011) (McCarthy and Copeland, 2016),
- and state-mandated regulations, and in particular, the Renewable Portfolio Standards (LBL, 2016).

However, as shown in Fig. 1, there was an up-tick (about 3% rise) in U.S. emissions in 2018. In that same year, the National Oceanic and Atmospheric Administration in its 2018 Report on “Climate Change: Current and Projected Impacts on the U.S.” called for the need for removal of existing carbon from the atmosphere to prevent the projected climate disasters by 2050 (NOAA, Fahey 2018). This call came at the time when a large number of deregulatory actions were being taken by the current administration in federal energy policies and especially in relation to electricity generation from coal. These actions include (Brookings Institution, 2019) and (National Geographic, 2020):

- Relaxing the rules on emission of greenhouse gases in new coal-fuel power plants.
- Relaxing the rules on producing mercury and other air-toxins by coal-burning power plants.
- Repealing Clean Power Plan, and
- Postponing enforcement of many Environmental Protection Agency (EPA) regulations.

In the absence of any federal mandate on reducing U.S. carbon emissions, and in light of recent federal energy deregulations by the present administration, and in particular, deregulation of the coal industry, the action of states in mandating emissions reduction has become the most important measure by state governments in reducing U.S. emissions. This action, referred to as the Renewable Portfolio Standard (RPS), requires utility companies to produce a certain percentage of their electricity from renewable resources. We previously reported the effects of enactment of RPS laws by the states in lowering emissions (Khoie, Calderon, 2018).

Considering the present circumstances, and in light of the warning by NOAA on the need for removal of carbon from the atmosphere, it is imperative that we get the public (the end users) involved in efforts to not only reduce their own emissions to zero, but also help remove carbon from the atmosphere. The Zero Emissions Network (ZEN) project aims to do just that: taking the cause to the public at micro-scale.

3. The ZEN history

In 2018, Sarah Townes was asked to moderate the Policy in Action session of the National Solar Conference (SOLAR 2018). The resounding message she received from many world renowned speakers was consistent and clear:

- The scientific urgency for the need to reduce greenhouse gas emissions and save our climate was thoroughly, credibly established.
- The technology necessary to reduce emissions was readily available.
- The economic modelling for how to make the transition to renewable energy sources was finally well established.
- What was missing were federal government initiatives and public engagement.

In other words, drastically reducing carbon emissions was both urgently necessary and completely doable, but missing two essential components: people and the federal government. This realization was further enhanced by her personal experience living in one of the most wealthy, educated, and theoretically progressive cities in the U.S. (Boulder, CO) where neither she nor any person she knew had made their lifestyle net zero emissions, or even tracked their carbon footprint enough to bring it close to that mark. In her experience most people made small efforts where convenient, but mostly bought what they wanted to buy, flew where they wanted to fly, ate what they wanted to eat, drove their cars, turned on the gas burning heater in winter and so on.

Further motivation for this project was the work presented by Rahim Khoie in SOLAR 2018 Conference (Khoie, Calderon, 2018) in which he conducted a study of the effects of RPS in several states which **proved that progress in emissions reduction was being made due to state mandates and local initiatives**. Though counter-productive policies by the federal government were moving us away from reducing green-house-gases (GHG) as a nation, still the city and state programs showed decisive progress.

This caused Sarah Townes to propose to her organization, the American Solar Energy Society (ASES), that a new program be created to help ASES members nationwide and in the headquarter city of Boulder, CO take decisive action to reduce their GHG emissions. This proposal was passed by the board in January of 2019.

4. Accomplishments

The following is a partial list of what has been accomplished so far:

1. We created a fantastic team of interns from the University of Colorado, Boulder (CU, Boulder) Environmental Studies Program, and together they created an online guide specific to Boulder for how to track and reduce carbon emissions. Months of dedicated research went into this very practical and doable set of suggestions. Areas of focus include home energy use, transportation, diet, and Natural Solutions carbon offsets.
2. We created a team of students from the University of the Pacific (Stockton, California) to conceptualize, design, and build a CO₂ monitoring kiosk that provides information on local, national, and global concentration of CO₂ in the atmosphere.
3. We met with city sustainability leaders and told them of our program and our goals, and received suggestions from them on how best to implement our ideas. In turn we promised to drum up support for their ambitious Climate Mobilization Action Plan which the City of Boulder recently rolled out.
4. We applied for and received a grant from the Left Coast Fund with which we purchased \$20,000 worth of subscriptions to Jack's Solar Garden, a wonderful energy CSA and regenerative agriculture farm. These subscriptions we will allocate to 10 lower income individuals & families in Boulder who will receive a monthly discount on their electric bill, and simultaneously reduce their carbon footprint with solar.
5. We have been awarded a second \$25,000 allocation with which we plan to purchase a solar array and trailer for El Costeño Oaxacan food truck. The owner Moises Santos has already outfitted his business with a full complement of resource saving devices to track and reduce consumption of water, food waste, and electricity. We are proud to be able to add solar panels to this wonderfully sustainable enterprise.
6. One of our team members helped submit two grant applications to fund an electric vehicle charging station in North Boulder that will serve a lower income community where most people do not have a garage to plug an electric vehicle into.
7. We are in the process of creating a Natural Solutions carbon offset fund, where local citizens can offset their GHG emissions by investing in local plants. This can include building green roofs, investing in local sustainable agricultural projects such as Dharma's Garden, and local reforestation projects.
8. We ourselves as a team have begun tracking our individual consumption habits and GHG emissions. This is incredibly humbling and eye opening. We wish everyone were as aware of their consumption and its effect on their life as we are, for example, aware of how much money we make, what we wear, and how we vote.

We currently have an application in with Boulder County asking the county to host a CO₂ kiosk which will educate citizens about the city's greenhouse gas emissions. The design specifications of a prototype of this kiosk is provided in this paper. When fully assembled, this kiosk will be placed in the heart of the downtown Pearl Street pedestrian mall. We would be delighted if SOLAR 2020 attendees to used our design to replicate and build this kiosk to be installed in their locale.

5. The CO₂ Kiosk

A team of students from the University of the Pacific has designed the necessary electronic components of the CO₂ kiosk as part of their senior project capstone course. The assigned project description provided to the student was: “Design and build a Carbon Dioxide Kiosk that displays the local, national, and global levels of carbon dioxide in the atmosphere. The requirements of the system are: solar powered, updating data once every 24 hours, measure and display carbon dioxide content of the local atmosphere in parts per million, be visible from 100 yards, and acquire and display the national and global CO₂ data from reliable sources, and particularly from the U.S. Energy Information Agency websites (U.S. EIA): <https://www.eia.gov/environment/emissions/carbon/>.”

A behavioral description of the electronic system of the CO₂ kiosk is shown in Fig. 2. The system requires no input, as it is designed to operate somewhat autonomously and in perpetuity. The output of the system are the three CO₂ levels; local, national, and global, which are displayed on a panel which is readable from a distance of up to 100 yards. The system consists of 6 subsystems: CO₂ sensor, solar panels, microcontroller, power storage and power conditioning, data storage, and software.

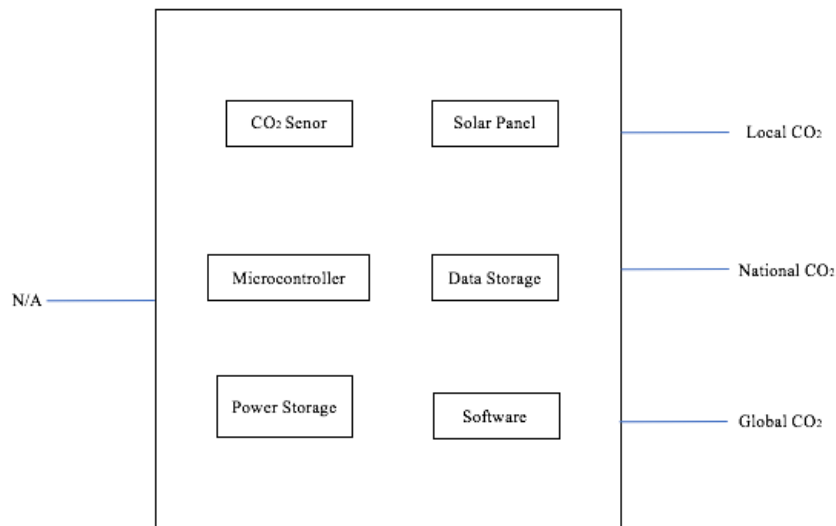


Figure 2: Behavioral design of the CO₂ Kiosk showing its input/output behavior.

A functional description of the electronic system of the CO₂ kiosk at various levels is shown in Fig. 3. The main components of the system are:

- 1) The CO₂ sensor module which uses a light tube consisting of an infrared source and an infrared sensor used for detection of the CO₂ content in the air at the locale. A low pass filter is used to reduce the interference noise. The signal from the sensor is further amplified and is received by the microcontroller for processing and storage.
- 2) The microcontroller module which receives, processes, and displays the data.
- 3) The display module that is powered from a DC source and is controlled by the microcontroller. This module consists of three display panels for local, national, and global CO₂ data.
- 4) The power module which consists of a solar panel, a rechargeable battery, and voltage regulator at various DC levels for the microcontroller module and the display module.

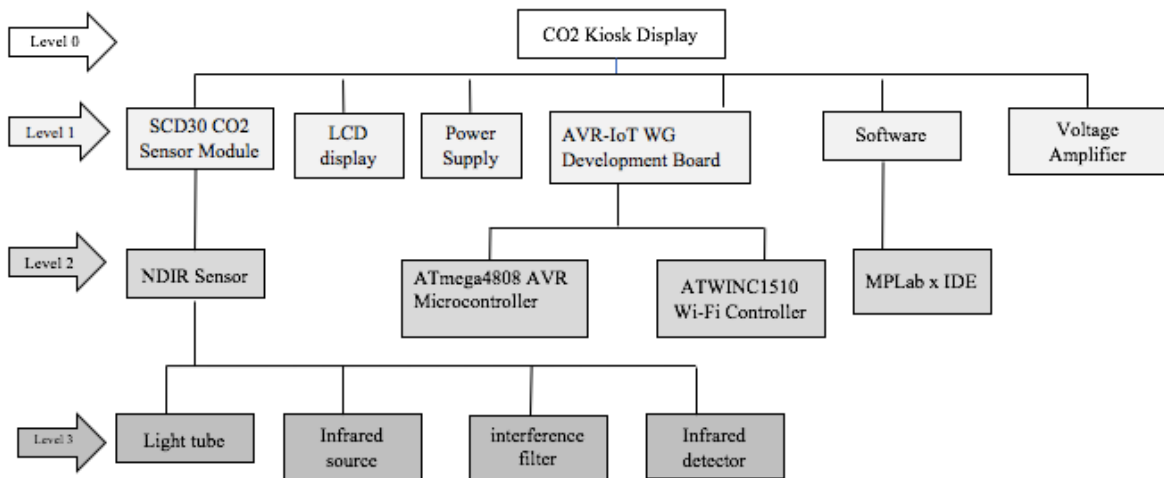


Figure 3: Functional description of the electronic system of the CO2 kiosk at 4 abstraction levels.

- 5) The Wi-Fi module which is used to access websites for data on national and global CO2 data.
- 6) The software module which consists of required programs to run the microcontroller and the Wi-Fi modules.

The modules listed above have been partially tested and or simulated to ensure that the design is viable. Each component of the modules has been thoroughly researched in order to identify the optimal parts in terms of the required cost and power usage. Additional information about the hardware and software components of the system will be provided upon request: email Rahim Khoie at rkhoie@pacific.edu.

6. The ZEN Website

The ZEN project is based on the idea that if people could comprehend the size of their carbon footprint they might be more inclined to reduce it. Then if someone reaches out a personal hand with mentorship and money to encourage their efforts, they cannot help but make progress. These principles have guided the programs within the Zero Emissions Network. A carbon tracker was built to estimate an individual's carbon footprint. Research was conducted in order to understand ways to reduce that footprint. A micro-grant program was created to support investment in green technology. A carbon offset program is underway, making it possible for people to reach net-zero in a non-intrusive way.

At ZEN we believe that knowledge and action are necessary tools to combat climate change. The ZEN website (<https://www.ases.org/zen-program/>) summarizes multifaceted topics that are related to environmental degradation and community involvement. We recognize solutions, leaving the decision to act to the people. The ZEN team plans to reach people digitally, through a solid space at the kiosk, through the ASES network, and via personal relationships. The following is a brief bullet point description of information the public will be able to gather by visiting the ZEN website.

- The “What We Offer” page outlines current and future services provided by the ZEN team (<https://www.ases.org/what-we-offer/>). This page outlines the ZEN micro grant program, the carbon offset program, and soon a carbon tracker.

- The ZEN micro grant program subsidizes subscriptions to Jack's Solar Garden, a holistic solar garden with integrated agriculture. These grants are reserved for low-income individuals who want to be a part of the renewable energy solution. Subscribing to Jack's Solar Garden reduces your carbon footprint and lowers your energy bill!
- The ZEN carbon offset program is a work in progress. When this program is fully realized it will direct funds to carbon sequestration projects. Individuals can buy into this program to offset their carbon emissions. This tool will be vital in helping people reach net zero emissions.
- The ZEN carbon tracker is a tool which is necessary to track an individual's carbon emissions. With this tool people can track their progress in reducing their emissions. We are currently refining it as our own team members track our individual carbon footprint, and plan to publicize the finished version this year.
- At the heart of our work is a section of the website titled "How to Reduce Emissions" (<https://www.ases.org/reduce-emissions/>). This section seeks to answer two basic questions: What are common carbon emitting activities, and what are carbon reducing activities. These questions are answered with respect to transportation, home energy, and diet.
- Another important section is related to local government and local utilities (<https://www.ases.org/zen-local-government/>). This section breaks down what local governments climate related goals are and their plans to achieve them. Also, information related to the local utilities is presented in this section. Both government and utilities play a large role in carbon planning and emissions. It is vital to be aware of these institutions and the means by which citizens have power to change them.
- One very useful and progressive section of the website is titled "Solutions" (<https://www.ases.org/zen-solutions/>). This section is entirely dedicated to local organizations that lower carbon emissions through natural solutions and innovations. These organizations help people to lower their carbon footprint.

7. Conclusions

One of the most inspiring discoveries of our work is the ever-growing list of how each effort to reduce GHG emissions improves the quality of life for the participant. To give just a few examples:

- bicycling over driving improves health and happiness,
- electric vehicles reduce noise pollution and cost less to maintain,
- air drying clothes lengthens their usable lifespan,
- eating local and sustainably grown food builds community and personal health,
- Connecting with others around reducing emissions builds strong relationships on a super positive foundation.

We find that each and every climate action taken brings direct positive results in our lifestyle.

Perhaps the greatest aspect of this project has been the sense of joy and comradeship with which our teams have carried out our mission to help reduce GHG emissions. We have a great time together when we meet, and we sleep better at night knowing that we are making progress in reducing our carbon footprint and helping others to do the same.

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Taylor Heisler, Major in Environmental Studies, CU Boulder

Local Utilities and Government:

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