

Net Zero Davis Project

Net Zero Goals and Strategies for Davis, California

Part 1: Project Perspective

December 2011

Project Sponsor:

Valley Climate Action Center

Project Principal Investigator:

**Gerald Braun
UC Davis Energy Institute
University of California, Davis**

Project Team:

**Alan Wecker (student team lead)
Jon Cook
Veronica Holland
Elise Brown
Suzanne Bates
Pradnya Khimsara
Alex Pineda
Monique Romero**



Project Perspective

The Davis City Council adopted climate action goals in 2008 and subsequently developed and approved the Davis Climate Action and Adaptation Plan. It calls for 15% reduction in greenhouse gas emissions relative to 1990 by 2015 and “carbon neutrality” by 2050, along with similar intermediate milestones.¹ Meanwhile, UC Davis adopted its own climate action plan as well as “net zero energy” goals for its new campus living space, referred to as West Village. The university’s success in achieving net zero targets so far in the initial West Village deployment phase, without sacrificing affordability or developer profits, pointed to the possibility of adopting net zero goals for Davis. However, a settled community faces different issues in implementing net zero strategies than are encountered by a home-builder or real estate developer.

To better understand these issues, the Valley Climate Action Center requested that UC Davis conduct a scoping study, the findings of which would be captured in a white paper. The white paper would present and evaluate net zero scenarios and document related data and assumptions. The California Integrated Renewable Energy Systems Program² organized a UC Davis student team to prepare the white paper under the guidance of the UC Davis energy experts. The white paper development process included literature surveys, energy analysis, and a series of seminars featuring speakers from other communities sharing their community’s work, perspectives and plans. It also included topical public workshops on building energy efficiency, transportation energy, and renewable energy, plus a public workshop at Davis City Council Chambers to summarize and take public input on study results.

The process of identifying the best portfolio of solutions for Davis resulted in a body of information and insight that will be valuable in more detailed integrated resource planning that will be needed. The expert workshops organized by the project team were essential to determining the issues in need of further study. The network of utility and local industry representatives and consultants, community activists, university faculty and researchers, private industry, and others who attended shared a wealth of knowledge that will inform the development of a net zero roadmap for Davis.

The body of the white paper identifies numerous initiatives or measures Davis could take over time, the collective effect of which could be achievement of net zero goals. Some could deliver

¹ http://cityofdavis.org/cdd/sustainability/pdfs/2010_Davis_Climate_Action_Adaptation_Plan.pdf

² Cal-IRES is a program of the California Renewable Energy Center, which is administered by the UC Davis Energy Institute. It is the Energy Institute program most actively involved in research related to community level renewable energy integration. The white paper was prepared by UC Davis graduate students working under the auspices of the UC Davis Energy Efficiency Center.

significant results in the next decade. The initiatives best positioned for implementation would involve building on UC Davis' net zero experience.

Other initiatives would require more time, even decades, to complete targeted market and infrastructure transformation. A scenario for using sequential net zero goals to frame an overall net zero roadmap is outlined in the figure below. For this or any comparable scenario, specific contributions to meeting the sequential goals can be identified. It is important that these contributions be realistic and subject to downward adjustment if no timely and concrete steps are taken to realize them. Each solution can be part of the overall solution, and together they offer the risk-mitigating benefits of diversity, plus the ability to emphasize alternate pathways when one or more is unexpectedly blocked. The white paper prepared by UC Davis students lists 17 steps Davis could take that would support the achievement of net zero goals.

This project perspective provides an introduction to emerging conceptual frameworks for the implementation of community scale net zero energy. It also outlines a strategy that attempts to translate the conceptual frameworks into realistic actionable steps for Davis.

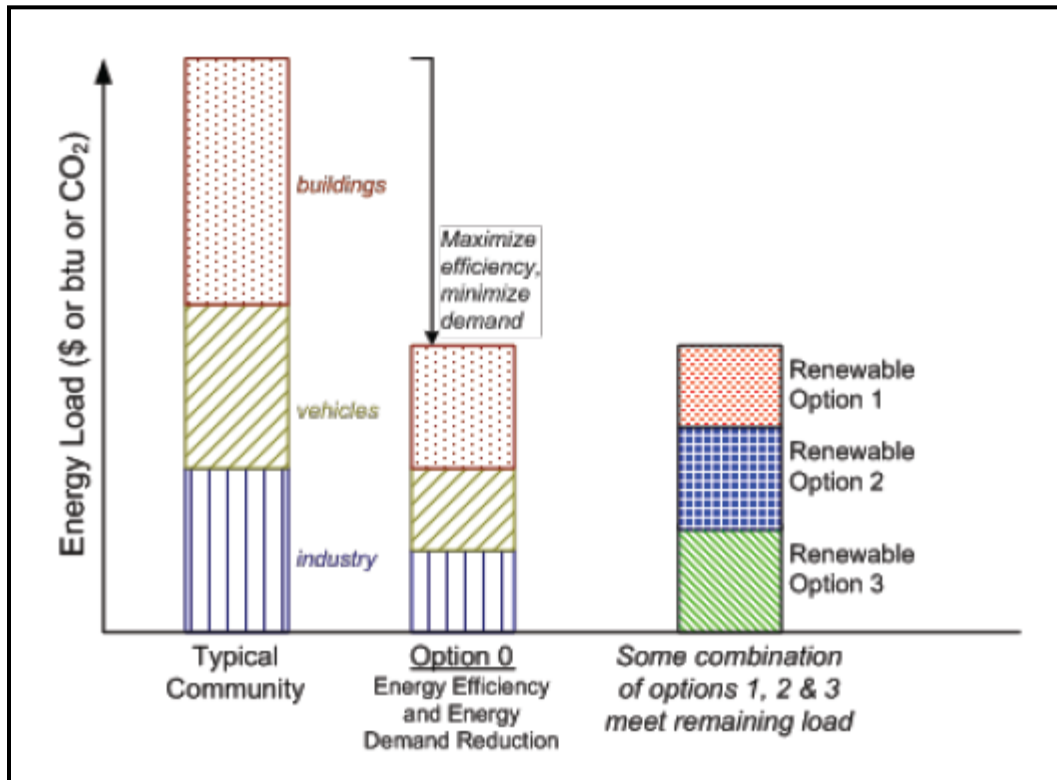
Electricity, natural gas and transportation fuel demand reduction measures Davis should investigate are included in the White Paper. Renewable energy supply measures that Davis should investigate are also included.

Introduction to Emerging Net Zero Frameworks

Three alternate net zero definitions were considered, i.e. net zero electricity, net zero carbon, and net zero source energy.³ Net zero carbon is well aligned with the city's climate action plan. These definitions imply different levels of infrastructure and supply transformation. Applied to communities like Davis, each has its own degree of difficulty and timeline. Success in applying one definition can provide a foundation for applying more challenging definitions. For example, it may be possible to achieve net zero electricity first, then net zero carbon, and finally net zero source energy. Achieving any of these net zero goals will require a combination of solutions from across the energy spectrum, including building energy efficiency, local renewable energy, and low carbon transportation strategies.

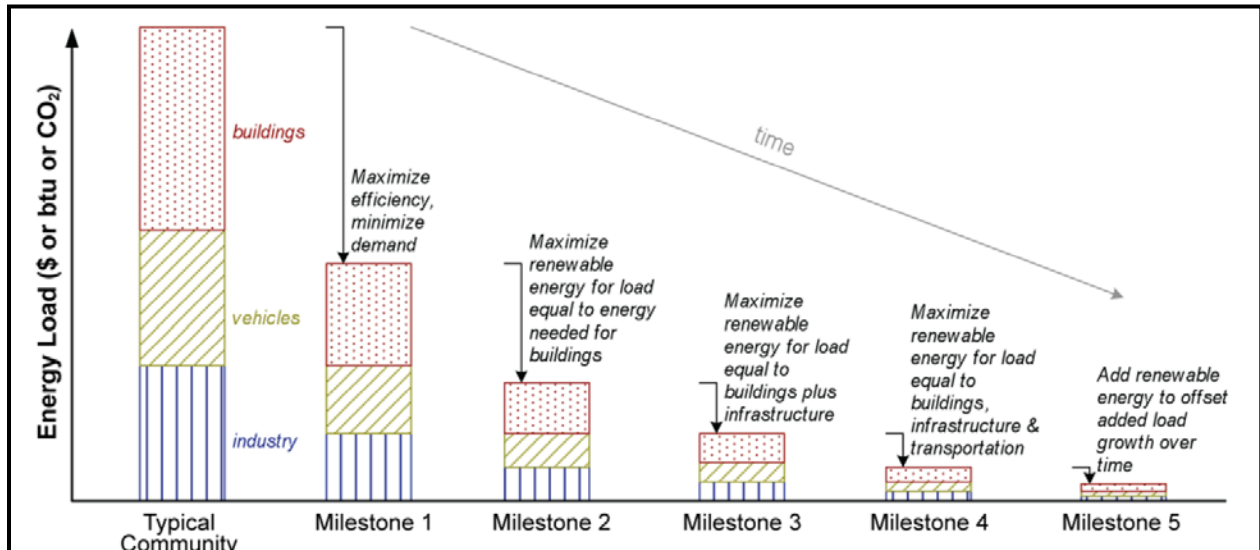
³ For present purposes, **net zero electricity** is defined as meeting the annual demand for electricity with an amount generated from renewable sources. For example, the UC Davis West Village campus designed to meet this standard. **Net zero carbon** is defined as balancing carbon dioxide released into the atmosphere from burning fossil fuels with renewable energy from sources that produce an equivalent amount of useful energy. Source energy refers to the primary energy used to generate and deliver the energy to the site. Applied to Davis, a **net zero source energy** standard would balance the energy content of natural gas and transportation fuels consumed in Davis plus the energy used to generate electricity to Davis, plus the energy is consumed in the production and delivery of fuel and electricity to Davis with renewable energy from sources that produce an equivalent amount of useful energy.

The basic “net zero (community) energy” concept, illustrated in the figure below, from an NREL report⁴, is to drive energy demand down as far and as fast as economically possible, and then use renewable sources to serve reduced demand. This strategy appears to be the best choice to spur progress toward goals set forth in the Davis Climate Action and Adaptation Plan.



Net zero strategies can be applied to communities as well as buildings and to settled communities as well as new communities, but implementation steps and related timing differ significantly. Therefore, Davis will need to develop a net zero implementation roadmap that accounts for its unique circumstances and opportunities, using the information developed by the Net Zero Davis project team and included in the body of the white paper. The figure below, from the same NREL report, suggests the need for milestones on the path to net zero.

⁴ Definition of a Net Zero Community: <http://www.nrel.gov/docs/fy10osti/46065.pdf>



The milestones in the figure are conceptual, not practical. For example, it is more likely in a settled community that significant renewable energy capacity will be deployed while energy conservation measures and incremental energy efficiency improvements proceed. This process is already underway with the installation of rooftop solar energy systems on an ever increasing number of Davis buildings and structures. A key frame of reference for development of Davis net zero milestones is the Davis Climate Action and Adaptation Plan.

A Complete Net Zero Strategy

Conceptual milestones and over-arching targets need to be supported by concrete milestones tested for achievability and backed up by the specific measures a specific community can employ. This will require further study. Further study should support a basic strategy, and the strategy should be within the city's capacity to implement.

The basic points of a complete strategy include:

1. **Exploiting Current Strengths** that have led to recognition of Davis as community committed to environmental stewardship
2. **Exploiting New Opportunities** to implement cost-effective measures supporting the basic net zero concept, e.g. new incentives for commercial and multi-family solar water heating
3. **Securing Funding** for:
 - a. **Net Zero Implementation Plan** identifying timing and metrics of future milestones and the most effective additional measures to achieve them
 - b. **Pilot projects and demonstrations** to build local deployment capacity and adapt technical solutions to local conditions.
4. **Expanding Collaboration** with:
 - a. Energy Utilities
 - b. Clean Energy Industry Leaders

- c. Local Businesses, e.g. heating, cooling, lighting and solar equipment suppliers and installers, design and project consultants, and energy and transportation retailers like auto dealers and fueling station operators
 - d. UC Davis
 - e. The National Renewable Energy Laboratory (NREL)
 - f. Legislators
5. **Expanding Public Engagement** by:
- a. **Setting Net Zero Goals** and monitoring and reporting on progress to achieve them.
 - b. **Surveying the Community** to gauge and promote public support and interest.

Examples of measures implementing these strategies include:

1. **Exploit Current Strengths**
 - a. Net zero implementation strengths for the City of Davis include an energy aware and engaged community, an extensive bike lane infrastructure and access to the cutting edge energy demonstrations and centers operated by UC Davis.
 - b. Local solar PV industry capacity
 - c. Local home improvement contractor capacity to do efficiency retrofits
 - d. Safe bike travel infrastructure
 - e. Legislative initiatives enabling investment in development of opportune local renewable energy resources
2. **Exploit Current Opportunities**
 - a. **Solar and Wind Electricity:** The city should consider regional wind resources in connection with “solar garden” implementation and related legislation. An evolving mix of solar and wind resources will provide a more balanced and better match to city demand profiles that either solar or wind alone, and therefore can minimize future utility charges related to supply and demand mismatch. Further, wind energy will have a role in an economically optimum resource mix as solar incentives expire or are reduced.
 - b. **Solar Water Heating:** In order to achieve its climate goal, Davis must address energy use for water heating. Heating and cooling energy uses account for 27% of California’s carbon emissions, while water heating alone typically accounts for about 15% of residential energy use. The city could create a program to encourage consideration of solar water heating at the time conventional water heater tanks are being replaced. An increasing number of cities and states and countries mandate the use of solar energy for water heating, and their experience would be instructive in designing a program for Davis. The program could disseminate information about state solar water heating incentives, especially those for commercial and multi-family buildings, because they are exceptionally attractive in the context of solar tax credits and other tax code provisions. It could also aim to expand Davis’ energy service infrastructure to include service

providers trained and experienced in the installation and maintenance of solar equipment.

3. **Securing Funding** for:

a. **Net Zero Implementation Plan** identifying timing and metrics of future milestones and the most effective additional measures to achieve them.

i. The white paper identifies and discusses a number of potential measures that would reduce the greenhouse impacts of transportation and building energy use or increase renewable energy supply. It will be helpful to have targets for the highest impact measures consistent with milestones on the path to net zero. It is recommended that targets be identified for the broad categories of community renewable energy supply, building energy use, transportation energy use and net zero energy. Segmentation of these categories could be according to energy users and energy supply projects as suggested in the table below. The table includes examples of the questions that could be addressed in a planning process that engages primary stakeholders for each segment. A unifying assumption in answering the questions is that specific targets will be achieved with assistance and leadership from the city but relying on a combination of public outreach and information programs and private sector investment to the maximum extent. It will be particularly important to account for current opportunities to exploit state and Federal incentives for renewable energy.

Categories	Segments	Example Questions
Community Renewable Energy	Building integrated	Pilot innovative solar industry programs?
	Brownfield sites	What is the solar gardens implementation plan?
	Greenfield sites	Expand solar gardens plan to include wind?
	Imports and RECs	Access to CCA?
Buildings	General	Access to properly segmented PG&E energy metering data?
	New residential	How to encourage building improvements at point of sale?
	Existing residential (owner occupied and leased)	Standards for water heater replacements?
	New commercial and public	Ultra efficient heating and cooling options?
Transportation	New personal vehicles	Pilot innovative auto and utility industry programs for accelerated plug in vehicle adoption
	Existing personal vehicles	VMT Challenge?
	Public transportation	Targeted subsidies?
	Other	Regional cooperation?
Net Zero	Homes	Guidelines for existing homes?
	Neighborhoods	Collaborate with PG&E or CCA to pilot virtual net metering?
	Vehicle charging	Solar charging mandate?

b. Pilot projects and demonstrations to build local deployment capacity and adapt technical solutions to local conditions.

i. **Net zero buildings** can be the cornerstone of strategies to achieve net zero goals at the community level. Net zero is a cost-effective strategy that combines efficient end use measures with locating solar at the point of use. Applying the strategy to existing buildings in Davis can be enabled by the unique and extensive experience with new net zero buildings at UC Davis' West Village. A program to demonstrate the benefits of net zero strategies in the city's existing building stock would provide necessary tools and benchmarks for the city's building owners.

ii. Net zero building enabling solutions:

1. **Solar Water Heating:** UC Davis has funding for two solar water heating demonstrations at West Village, but only limited data collection and evaluation will be possible during the one year design, construction, test and evaluation period.
2. **Renewable Space Heating and Cooling:** In residential communities in the Central Valley, space cooling accounts for a major share of electricity service costs as well as building carbon footprints. Davis could task steps to identify buildings having both high cooling demand and also the high cooling equipment utilization factors that would favor investment in low carbon but capital intensive energy solutions. Having done so, Davis could encourage building owners to investigate the feasibility of reducing electricity usage using solar heat collectors and/or ground or water source heat pumps.⁵

iii. **Solar Electric Vehicle Charging Stations:** UC Davis has funding for two solar and energy storage enabled plug in vehicle charging stations. As in the case of solar water heating, the city could seek funding to translate UC Davis demo experience into comparable retrofit demos in Davis and development of consumer guidelines enabling implementation of a program to de-carbonize Davis' water heating energy use.

4. Expanding Collaboration with:

a. Utilities

i. The biggest barrier to achieving net zero goals is the need for timely decisions backed up by credible analysis and reliable data. The need is for

⁵ Ground source or water source heat pumps, aka "geothermal" heat pumps, are compressor based heating and cooling systems that use the ground as well as the air as their heat sink or source. This leads to significantly less electricity usage but typically no actual use of the underground thermal gradients exploited to produce geothermal energy. Ground -source heat pumps and geothermal energy systems both rely on subsurface temperature information and subsurface heat pathways to exchange heat with the soil and ground water, but their purpose is essentially energy efficiency, and they are more properly compared with other energy efficiency options than with other "geothermal" options.

decision support for Davis governmental leaders and energy users. Electricity, natural gas and transportation fuel usage data are available, but there are costs and issues limiting its availability at the most useful levels of detail, especially in the case of data relating to energy usage for transportation. The city should take steps to secure all available energy metering data for use in its clean energy program planning and implementation.

- ii. The city also should Partner with PG&E to identify energy intensity “hot spots” in the City; building energy use and transportation energy use improvements should be aggressively pursued. There is a particular need to identify buildings having high cooling demand and high cooling equipment utilization factors and offer programs to shift related electricity usage to solar heating and cooling with natural gas or electricity assist, or ground or water source heat pumps.

b. Clean Energy Industry Leaders

- i. UC Davis could assist by organizing and conducting a series of workshops around the above recommendations in order to secure private sector and utility input for the development of requests for related qualifications and commercial offerings. (The California PV industry will certainly respond with some community level offerings, and some other renewable energy players may as well.)

- c. Local Businesses** have a critical role in net achieving net zero goals. The best thing the city can do to encourage their engagement is to ensure that its clean energy programs are designed with private sector capacity building in mind. Profitable projects are needed across the spectrum of heating, cooling, lighting and solar equipment supply and installation, project design and engineering, and retail sales of low carbon vehicles and related fuels and services.

d. UC Davis

- i. Partnering with UC Davis in other aspects of net zero community development where UC Davis is taking the lead is also recommended. For example, UC Davis has a wealth of experience in bio-energy conversion options and has a project to convert campus food waste to energy for West Village. Projects of this sort benefit from risk sharing and economies of scale. If the city would contribute its compatible waste streams, a joint project could be more economically attractive than multiple smaller projects serving only the city or the university.
- ii. In general, partnering efforts in clean energy would serve compatible goals and bring a greater diversity of solutions and capacities to the project planning table. For example, UC Davis hosts the California Lighting Technology Center and the Western Cooling Energy Center and has recently launched an center to address efficient water and related energy use.

A couple of highly relevant topics were given limited attention by the Net Zero Davis student team because of their emphasis on general framework considerations and energy measures. Fortunately, they were thoughtfully articulated by sponsor board members Dick Bourne and Eugene Wilson based on their review of the student white paper and this perspective. They are of special concern to Davis because of factors that drive its energy demand profile and because of Yolo County's on-going exploration of the Community Choice Aggregation option.

1. **Space cooling** is a major driver of energy demand in communities like Davis that experience extended periods of hot weather. Compressor based refrigeration equipment is typically used to meet cooling demand. As a measure of the importance of cooling energy demand, California's peak electricity use during hot summer periods exceeds its electricity use during peak winter periods by an average of 40%. This has serious implications for evaluating the best way of achieve net zero and carbon neutrality goals - in Central Valley communities summer to winter peak ratios are even higher than in high population density coastal areas. Failing to address cooling electricity demand impacts will reduce the economic advantage to the Davis community of achieving net zero goals. It is likely that as electricity demand increases due to new uses like electric vehicles and as demand on the grid becomes more uneven due to concentrations of variable renewable sources like rooftop solar, utility demand charges will be adjusted significantly upward to capture revenues from customers having low usage and high demand. Time of use energy charges would have the same effect.

The preceding discussion reinforces other recommendations here and in the white paper that Davis take steps to secure access to data necessary to determine daily and seasonal variations in electricity demand in Davis. With this data, it will be possible to identify strategies that minimize the cost of both electricity supply and delivery infrastructure and to better assess the benefits of renewable resources like solar energy. It is known that in California there is a strong correlation between peak demand periods driven by air conditioning demand and solar electricity production, because the air conditioning demand is driven by solar radiation incident on buildings and causing heating of internal spaces. The likely ideal strategy would be to strike a balance between investments in local solar energy deployment and space cooling efficiency upgrades, with particular emphasis on solutions developed for the generally semi-arid Western US. Tactics in support of this strategy could be developed with the help of both the Western Cooling Energy Center, and the California Solar Energy Collaborative – both are hosted and staffed by UC Davis.

2. **Community choice aggregation** is an option available to California communities and is especially pertinent to communities having climate action plans and/or economic reasons to influence the planning of energy supply for their communities. The community choice aggregation (CCA) option was established in state law in 2002. It allows California jurisdictions like Davis and Yolo County to take responsibility for sourcing their community's electricity supply, with incumbent electricity distribution utilities retaining responsibility for customer interconnection and billing, electricity delivery, and other

functions consistent with their monopoly franchises. The experience of Marin County and other communities in other parts of the United States suggests that CCA can deliver long term energy consumer cost savings after offering services at competitive prices in the near term as the local CCA gains experience and market power in negotiating with clean energy suppliers.

Currently PG&E is effectively Davis's primary resource and agent in effecting the kind of change envisioned in Davis' climate action plan. Many of the measures suggested in this project perspective and the companion white paper could be actively supported and/or initiated as programs by a local CCA. Importantly, they could be tailored to local conditions and needs, whereas statewide programs managed by investor owned utilities are typically "one size fits all" with limited efforts by the utility to encourage local government participation and sometimes very high transaction costs for the utility and program participants.

Another possible agent for Davis would be city or county government, but governmental units tend to limit program offerings to promotional efforts rather than more costly programs that require a dedicated revenue stream to implement. In the context of a municipal utility or a CCA, more costly and cost-effective programs can be funded out of electricity supply revenue streams, because they have the effect of reducing the cost of electricity service. Efforts the City of Davis might make in pursuit of net zero goals and climate action steps might also reduce costs of electricity service, but the savings would be shared with regional utility ratepayers and/or investor owned utility shareholders.

The Yolo County Climate Action Plan adopted by the Board of Supervisors in March, 2011, calls for a county-wide community choice aggregation program (CCA) and related projects, projecting that the combined effect could be to reduce GHG emissions 45% by 2020 while delivering improved air quality.⁶ In September, 2011, the county completed an extensive scoping report on implementing CCA.⁷

Recently enacted state legislation places an obligation on utilities that had been actively undermining CCA development in their service territories to now actively collaborate with communities interested in exploring CCA. While enforcement of the law is not assured, it does tend to mitigate political risks to elected officials who must vote on CCA measures, and it discourages misleading marketing to electricity customers seeking to encourage them to opt out of electricity supply service provided by the CCA.

In support of its net zero and climate neutrality goals, it is in Davis' interest to actively support and participate in Yolo County's efforts to evaluate the CCA option. Davis' goal

⁶ The county has since formed an Exploratory Committee consisting of an elected official from each jurisdiction, and the committee is now meeting to map out a process for identifying how to generate public support for CCA and a pathway for determining if a CCA is technically and financially feasible. (Source: Eugene Wilson)

⁷ http://yolo-agenda1.yolocounty.org/docs/2011/BOS/20111011_16/312_ccascopingreport5-0911.pdf

should be to determine to what extent and on what long term timeline its renewable energy and energy efficiency targets can be met in the event Yolo County opts not to implement CCA.

Summary

1. Net zero strategies can be applied to communities as well as buildings and to settled communities as well as new communities, but implementation steps and related timing differ significantly. Therefore, Davis will need to develop a net zero implementation roadmap that accounts for its unique circumstances and opportunities, using the information developed by the Net Zero Davis project team and included in the body of the white paper.
2. The basic points of a complete strategy include:
 - **Exploiting Current Strengths** that have led to recognition of Davis as community committed to environmental stewardship
 - **Exploiting New Opportunities** to implement cost-effective measures supporting the basic net zero concept, e.g. new incentives for commercial and multi-family solar water heating
 - **Securing Funding** for:
 - Development of a **Net Zero Implementation Plan** identifying timing and metrics of future milestones and the most effective additional measures to achieve them.
 - **Pilot projects and demonstrations** to build local deployment capacity and adapt technical solutions to local conditions.
 - **Expanding Collaboration** with utilities, project developers, clean energy industry leaders, local energy related businesses, UC Davis, legislators, etc.
 - **Expanding Public Engagement** by:
 - **Setting Net Zero Goals** and monitoring and reporting on progress to achieve them.
 - **Surveying the Community** to gauge and promote public support and interest
 - **Developing a better quantitative understanding** of the ways in which local **solar supply investment and space cooling equipment efficiency upgrades** could result in avoided electricity delivery and peaking generation costs.
 - **Actively supporting** and participating in Yolo County's efforts to establish a county-wide **community choice aggregation** program and in parallel determining the role and need for CCA as a lead enabler of a net zero implementation plan for Davis.