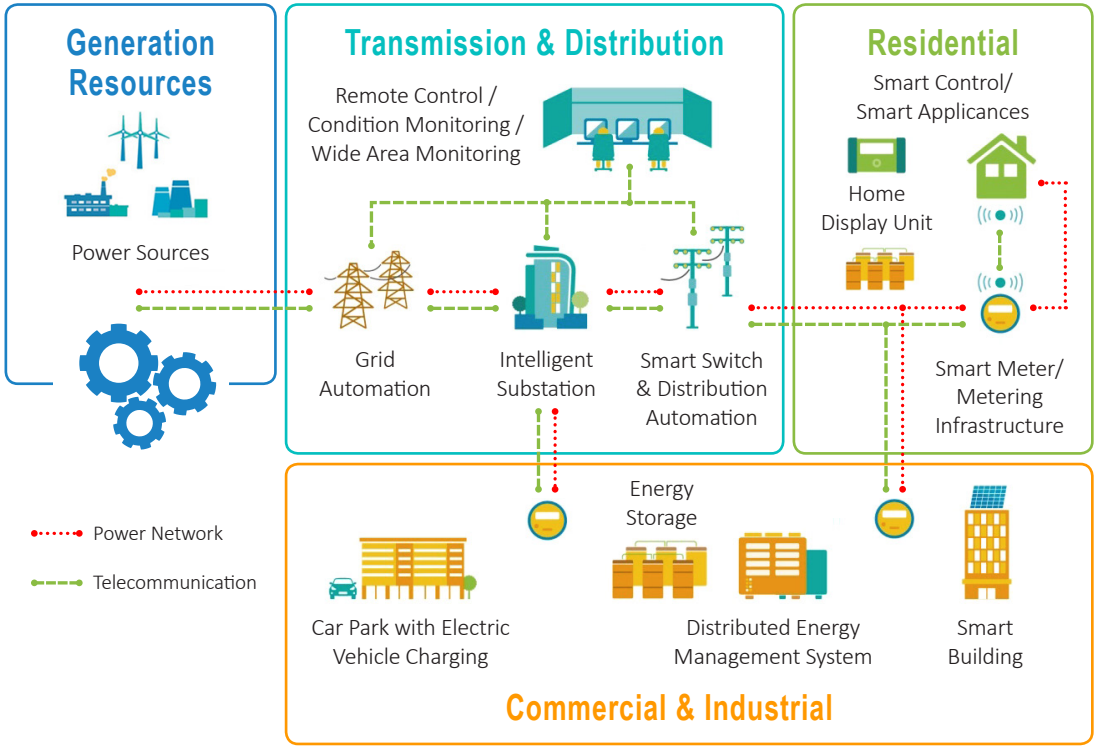
6 Future Trends & Creative Approaches

Solar photovoltaics (PVs) and other forms of renewable energy are a rapidly evolving field. New technologies and ideas for applying these technologies allow for renewable energy to be deployed more extensively and effectively. This chapter provides an overview of some of these new technologies and concepts, and how they might support more solar facilities in Butte County.

The Smart Grid

Since 2009, California has made a concerted effort to deploy "smart grid" technologies, led by the utilities that own most of California's electrical grid and a handful of State agencies. The smart grid is an update to the United States' current electric grid, which will better accommodate small-scale renewable energy systems, allowing surplus power from these systems to be used more effectively. The smart grid is more responsive at rerouting electricity as needed and managing changes in supply and demand using distributed generation, energy storage, demand response, and other demand side management tools, which can help avoid stress on the grid or power outages. This allows the smart grid to better handle renewable energy technologies such as solar and wind, which (unlike fossil fuels or hydroelectric power) do not provide a constant amount of electricity throughout the day. The smart grid will also allow for improved communication between utilities and customers, allowing people to better monitor and control their energy use to save money and resources. Looking forward, ongoing work to improve the reliability and flexibility of the grid will make it more responsive, while security projects (both physical and virtual) help protect the upgraded grid infrastructure from accidents or malicious attacks.



Energy Storage Systems

Under a conventional grid infrastructure, power plants and organizations known as balancing authorities are responsible for ensuring the amount of electricity supplied to the grid closely matches electrical demand. However, renewable energy systems are creating new challenges for grid balancing. Some renewable energy technologies only supply electricity intermittently (such as solar or wind power plants, which respectively only generate energy when the sun is out or the wind is blowing), and the most productive periods of electricity generation may not match with demand patterns or vice versa. Energy storage systems seek to smooth out these imbalances and keep electricity supply closely matched with demand, which can help make utility-scale renewable energy systems more viable.

Energy storage technologies come in multiple forms, from pumped hydro systems to battery systems, but all store surplus electricity generated when demand and cost are low, and feed it back into the grid during periods of high demand and cost. These systems can be small units that store electricity for individual homes or buildings, or they may be large utility-scale facilities capable of storing over a gigawatt (GW) of power.

In 2010, California adopted Assembly Bill (AB) 2514, which required State agencies to set targets for energy storage capacity. Utilities and partner companies are already installing energy storage systems in California, and property owners are increasingly purchasing small battery systems for use in their homes or businesses. When coupled with solar energy systems, such systems can allow buildings to operate entirely on self-generated power, even when the main grid suffers a power outage.

Pumped Hydro Systems

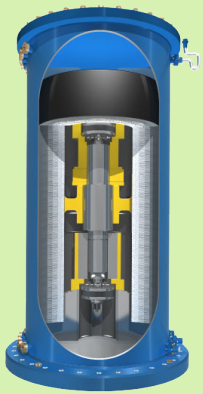
Pumped hydro systems, which pump water into reservoirs, currently make up most of California's energy storage. These systems can store very large amounts of electricity (over a GW), but require building a dam and reservoir, which can be difficult in the current economic and regulatory climate.

Battery Systems

Battery systems use various types of battery technologies to store excess power. They have a capacity ranging from a few kilowatts (kW) to tens of megawatts (MW). They can be used for individual buildings or for grid-connected utility-scale storage.

Other Storage Types

Other storage types involve compressed air and rapidly-spinning discs called flywheels to produce energy. Depending on the technology and the scale, such systems accommodate a few kW to hundreds of MW. They are less widespread than pumped hydro or battery systems, but have significant potential.



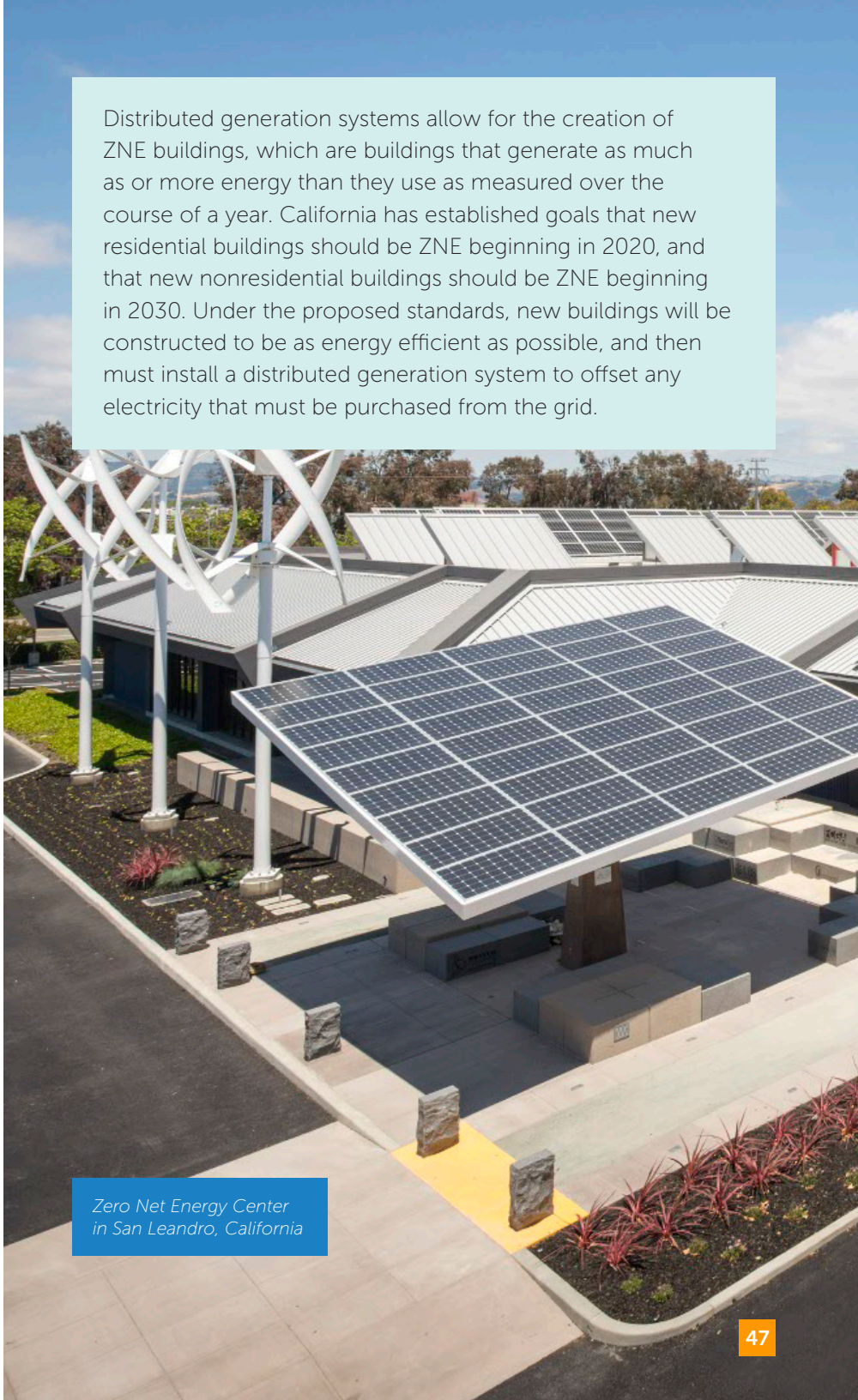
Distributed Generation, Microgrids, and Zero Net Energy

Renewable energy systems that generate and distribute energy to nearby local users are receiving increased attention as an important part of California's renewable energy future. These facilities are distinguished from utility-scale facilities that are intended to feed power onto the transmission grid for consumption throughout the region or state. These smaller systems may be referred to as distributed generation, community-scale or community-oriented systems and are typically defined as being connected at the distribution level (as opposed to the transmission level) of the grid and generating up to 10 MW.

Distributed generation involves a number of small systems producing electricity, in contrast to large centralized power plants. Distributed generation systems often, but not always, are used primarily to supply energy to buildings on the same property, known as self-generation. Microgrids are small-scale electrical networks (including generation, storage, and transmission) that can operate independently or can connect to a larger conventional grid. As discussed elsewhere in this Guide, distributed generation is becoming increasingly common in Butte County and elsewhere. Smart grid infrastructure, microgrids, and energy storage systems support more widespread adoption of distributed generation.

The increased availability of distributed generation systems and the pending adoption of zero net energy (ZNE) standards, in combination with other programs to improve energy efficiency, may decrease the need for new large-scale power plants. However, this may be partially or entirely offset by population growth, higher rates of electric vehicle use, statewide renewable energy mandates, efforts to replace natural gas appliances with electric ones, and other factors. Future State and regional energy forecasts will provide better estimates of the effects of distributed generation and ZNE buildings on statewide energy demand.

Distributed generation systems allow for the creation of ZNE buildings, which are buildings that generate as much as or more energy than they use as measured over the course of a year. California has established goals that new residential buildings should be ZNE beginning in 2020, and that new nonresidential buildings should be ZNE beginning in 2030. Under the proposed standards, new buildings will be constructed to be as energy efficient as possible, and then must install a distributed generation system to offset any electricity that must be purchased from the grid.



Zero Net Energy Center in San Leandro, California

Community-Shared Solar

Community-shared solar is a voluntary program that allows multiple community members to participate in solar energy projects, sharing the costs and benefits associated with the solar energy system. This allows community members who are unable to install solar energy on their own properties to be involved. In some models, participants can also have a say in how the power is used.

In California, participants in community-shared solar programs generally receive a share of the proceeds from the sale of electricity generated by the system. In order to receive a credit on their utility bill through a mechanism called "virtual net metering", all the participants must reside in a single building; thus, virtual net metering is commonly used in multifamily housing. Many utilities in California, including the Pacific Gas and Electric Company (PG&E), as well as all Community Choice Aggregators (CCAs), offer programs that allow community members to receive an increased share of electricity from renewable sources.

For example, PG&E has two related programs: Solar Choice and Regional Renewable Choice. In the Solar Choice program, PG&E procures energy from solar projects in Central and Northern California, and then sells the energy to participating customers. Participants can chose to either purchase 50 percent or 100 percent of their energy from these solar projects. In the Regional Renewable Choice program, PG&E customers can contract directly with individual renewable energy projects in PG&E's service territory to obtain between 25 percent and 100 percent. These programs are commonly labeled as community-shared solar, although strictly speaking they are not because participants do not receive any direct benefit from their involvement.

Solar arrays for community-shared solar programs can vary widely in size depending on the structure of the program and the number of participants. Utility-scale solar projects could be used for community-shared solar if there is sufficient demand. In Butte County, utility-scale solar projects could potentially be used to support PG&E's community-shared solar programs, as well as any others that may arise.

Community-shared solar can take a number of different forms, including the following:

1 Utility Model

Participating utility customers pay an up-front or recurring fee to construct and operate a solar energy system, which supplies power to the utility. In exchange, the customers receive a credit on their utility bill or are directly given a share of the proceeds from the sale.

2 Special Purpose Entity Model

A group of community members band together to create a dedicated organization that constructs and manages a solar energy system, using funds contributed by the participants. The energy can be sold to a utility or third-party, and the participants receive a share of the proceeds. Alternatively, the energy generated from the system can be directly credited to the participants as a reduction in their electricity bill if there is an agreement with the utility company.

3 Third-Party Model

A third-party organization organizes and administers a solar project on behalf of participating community members. The electricity is sold to a utility or third-party, and the participants either receive a share of the proceeds or a direct credit on their electricity bill if there is an arrangement with the utility. This approach is often used by housing developers as a feature of new residential communities and by non-profit organizations.

New and Emerging Solar Technologies

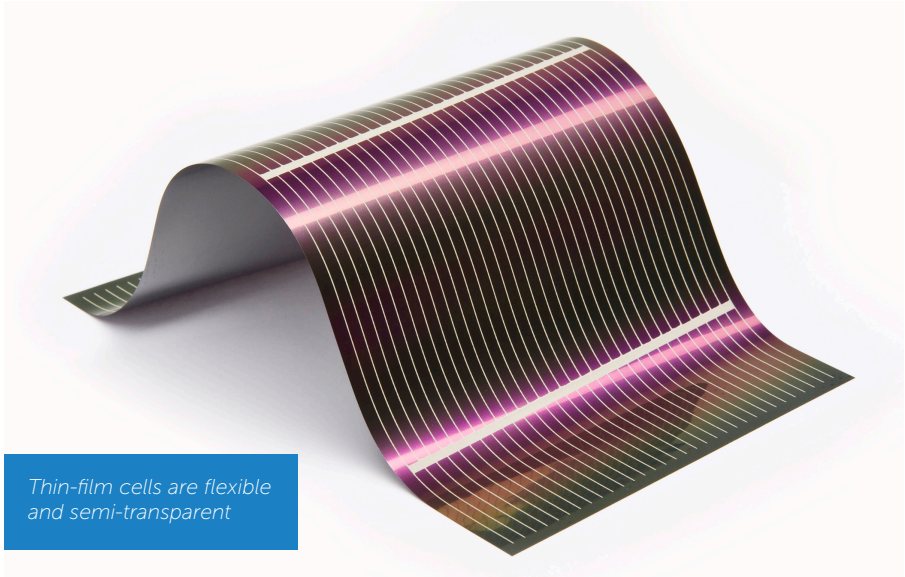
There have been a number of recent improvements in solar energy technologies, all of which make solar energy systems a more viable option and which could be integrated into future utility-scale solar energy systems in Butte County. Advances in the efficiencies of solar PV panels allow panels to remain the same size but produce more electricity. The most common types of solar PV panels, known as crystalline cells, typically are sold with an efficiency of 18 to 22 percent. However, crystalline cells being tested in laboratories can achieve efficiencies of approximately 25 to 27 percent. As these solar panels become commercially viable, solar energy systems can produce substantially more energy without taking up more space, potentially allowing for an increase in renewable energy installations or smaller solar energy systems.

Solar road in the Normandy region of France

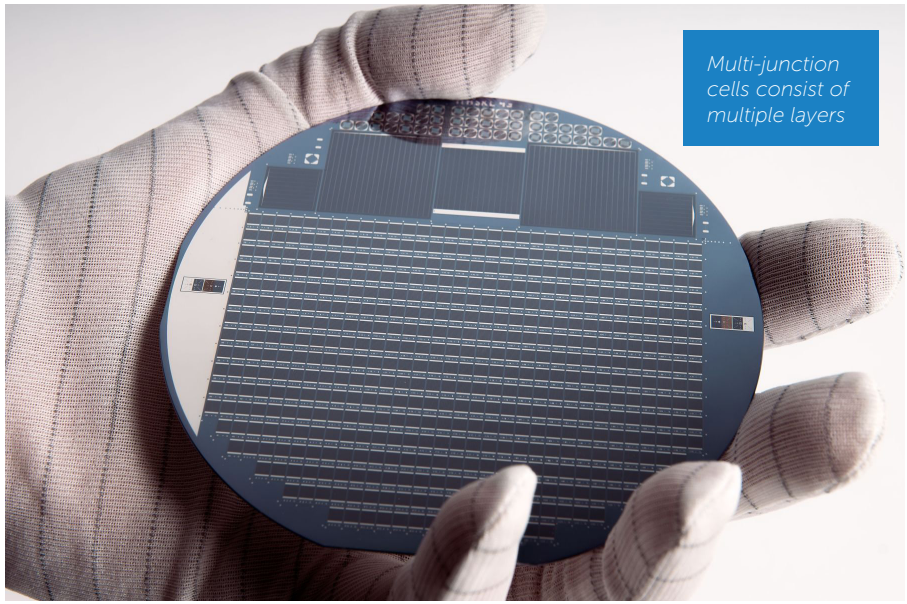
Floating solar panels at Far Niente Winery in Napa, California

A recent innovation in solar technology involves placing solar panels in new locations aside from rooftops or on special ground-mounted structures. Solar roads are one emerging option and involve using highly durable solar panels as road surface materials, allowing land dedicated for roads and highways to generate electricity. A solar bike path opened in the Netherlands in 2014, and the first solar road recently opened in France in late 2016. While they are currently very expensive, and have efficiency and maintenance concerns, it is possible that these installations could eventually be viable. Similar options are being explored with parking lots and sidewalks. Another opportunity is solar panels on floats, installed at reservoirs and holding ponds.

Researchers are also looking at different types of solar panels to increase access to renewable energy. Flexible solar cells, known as thin-film cells, can be integrated into building surfaces (such as roofing shingles and tiles) more easily than crystalline cells. Some thin-film cells are semi-transparent, allowing them to be used as glazing on windows. These technologies are often cheaper than crystalline cells but less efficient, although recent improvements have increased efficiencies, making them a more viable option. New types of solar cells, called third-generation cells, come in a variety of different technologies that offer benefits such as cheaper manufacturing processes, use of non-toxic materials, and ease of recyclability. These cells are still largely experimental but show significant potential.



Thin-film cells are flexible and semi-transparent



Multi-junction cells consist of multiple layers

Another type of solar cell, known as multi-junction cells, are constructed with more layers of material than the conventional two-layer solar cell, which allows them to achieve higher efficiencies than any other technology. These cells have traditionally been too expensive for most uses, although ongoing research can help drive the costs down. Solar cells can also be combined with lenses or mirrors that focus energy on the cell, generating a greater amount of electricity. This approach, known as concentrated solar photovoltaics, has been shown viable in limited cases and is currently being developed further. The world record for efficiency, 46 percent, was achieved with a multi-junction cell in a concentrated solar photovoltaic setup.