THE SCOPE OF SOLAR ENERGY

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Abstract

This study aims to inform and show different ways to utilize solar energy. Solar Energy is defined as energy obtained from sunlight and heat. Solar energy is widely abundant and has numerous uses and applications in addition to the conventional photovoltaic panel. In addition, other methods use solar energy in more passive and subtle ways that can promote sustainability and energy efficiency. This study will analyze the benefits of Solar Energy in the built environment in the Sunbelt States. This study answers the questions of what are ways that people can use solar energy, implement solar energy into architectural designs, what are effective materials to use in said design, how affordable are these methods, and what are possible ways to encourage the use of solar energy? Building orientation paired with smart building materials and other design choices provide an alternative method to utilize solar energy in the built environment. Solar panels enable homeowners to eliminate their electric bills. Adobe and rammed earth structures offer an alternative to conventional concrete that can reduce if not altogether remove, the need for utilities like air conditioning. Proper building orientations will save thousands of kilowatt-hours over the course of a year in large buildings.

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Chapter 1: Introduction

Background

Society has been slowly but steadily embracing sustainability over the past several decades. There is a market for green buildings. Solar panels are becoming both widespread and well-received (Frangoul, 2018). With the present threat of climate change becoming apparent, direct action needs to be taken. However, sustainable energy requires regional adaptation. Solar panels are perhaps the best-known sustainable energy source. Conventional solar panels require large amounts of sunlight to be fully effective. They work well in the Sunbelt states of the United States because of the abundant sunny days. However, this would not be the case in a place like New York City or the lateral extremes where there is less consistent sunlight on a day by day basis. Thus, those locations will need a more diverse source of both power and energy. This study identified four different techniques to use solar energy to demonstrate alternative solar energy strategies' effectiveness. These methods have applications globally but see the best results with more sunlight and heat energy.

Research Questions, Approach, Scope

In this study, the "Sunbelt States" that I am referring to are the states beneath 36 degrees and 30 minutes north latitude as according to the Kinder Institute (Kinder, 2020). These states are Alabama, Arizona, Arkansas, California, Florida, Georgia, Louisiana, Mississippi, Nevada, New Mexico, North Carolina, Oklahoma, South Carolina, Tennessee, and Texas (Kinder, 2020). I will use qualitative and quantitative measures to record the different solar energy methods to determine which ones are best suited for individual regions within the Sunbelt States.

Study Area

Figure 1 The sunbelt regions of the United States of America,

Questions Guiding the Study

1. What are the ways that people can make use of solar energy in and around their homes?
2. What building techniques can be implemented into the architectural design to improve the efficacy of solar energy?
3. What materials can be used to improve energy and heat efficiency?
4. How affordable are these techniques?
5. What are possible ways to encourage the use of these solar energy methods?

Chapter 2: Literature Review

This chapter is organized into categories based on the method of using solar energy. The four types are Solar Panels, Building Materials, Building Techniques, and Solar Thermal Energy.

Solar Panels

Israel, Kimbus, and Tavery (2020) claim that solar panels are a valuable method of using solar energy. Solar power is becoming more and more mainstream with each passing year. As of 2019, there were enough PhotoVoltaic (P.V.) solar panels to power 13.1 Million American homes (Israel et. al., 2020). Solar panels have the advantage of being usable in any part of the world, including the areas not covered in the study.

Matasci (2020) goes into further detail about the costs of solar panels. One of the most critical things people consider when using something is the cost. Solar panels have an average cost of about $15,000 for a 6-KW rated system (ConsumerAffairs, 2020). A new car can cost almost three times as much in the current year at about $40,000 (Jones, 2020). Electric bills are becoming more important with each passing year as more and more people start to work online or with technology. California is an example of the concept. California is one of the leading states in solar energy, which means that despite having a substantial 21.23 cents to the KilloWattHour, the state is only ranked 30th in energy bills (SaveOnEnergy, 2020).

Solar Panels are an investment that can quickly pay dividends. An array will save enough money to eventually pay for itself over an average of 7.5 years (Energysage, 2020). The exact savings depend on several factors, including the panel's lifespan, maintenance, replacement, and how many the homeowner purchased. This is also dependent on the energy company in the state and their stance on net metering. From there, the savings will add up over time as profit from switching to solar power.

The limitation behind conventional photovoltaic solar panels is that solar panels have a limited warranty before they eventually expire. Furthermore, the technology has yet to fully implement a way to recycle the panels (Xi et al., 2018). There are also concerns of rare earth materials used to facilitate electric current production (Chen, 2020). The current output of silicon has been falling amid the coronavirus pandemic, which will inevitably lead to a rise in solar panel prices as the material supply is used up (Chen, 2020).

Building Materials

Adobe

Michael Morningstar (2017) claims that adobe is a very effective and efficient building material when used in arid conditions. This is due to many different factors, ranging from how the building material can save on expenses from additional facilities such as Central Air Conditioning, heating, and integrated moisture barrier systems (Morningstar, 2017). The author also claims that the material can save on its own material cost because it can be naturally mixed and made locally. Morningstar (2017) also mentions the durability of adobe. The material has been in use for hundreds of years, and many adobe structures are still standing today.

Adobe is extremely effective in the dry climates of California, Nevada, Arizona, New Mexico, and Texas. New developments can make more effective use of their resources by converting the excess soil and clay into the adobe base. Adobe also costs significantly less energy to make compared to the traditional materials used in construction (Brently, 2012). At only 2,000 BTUs compared to the conventional materials 30,000, adobe takes only one-fifteenth of the heat necessary (Brently, 2012). This is one of the major reasons why adobe is more cost-efficient than using other building materials.

However, the challenge that adobe presents to construction is that it does not work for taller structures. Adobe is both quite heavy and load-bearing. It is recommended that the foundation be sufficiently compacted so that it can properly withstand the adobe structure. Furthermore, for larger buildings, steel and or concrete become a factor in supporting the structure, which defeats the purpose of using adobe instead of conventional materials in the first place.

Rammed Earth

Greenspec (2020) details a counterpart material to adobe known as rammed earth. Rammed earth is a material that is functionally similar to adobe- the difference between the two lies in the exact composition and the process of making the material. Rammed earth is created by moisturizing soil before heavily compacting it (Greenspec, 2020). The advantage that rammed earth provides over adobe is that the material is moisture resistant. This means that rammed earth would be the better option for the humid climates of the Sunbelt’s Southeast portions, including

South Carolina and Florida. Golebiowski (2009) gives a history of rammed earth in America, detailing how effective it was in South Carolina. A man had constructed several rammed earth structures on his home and a local church which had lasted up to the present day. The challenges that rammed earth faces are functionally the opposite of adobe. Rammed earth takes significant and high-quality construction work to properly implement (Greenspec, 2020). Furthermore, the base materials can not include too much clay, or else the moisture protection that the material is meant for will fail (Greenspec 2020).

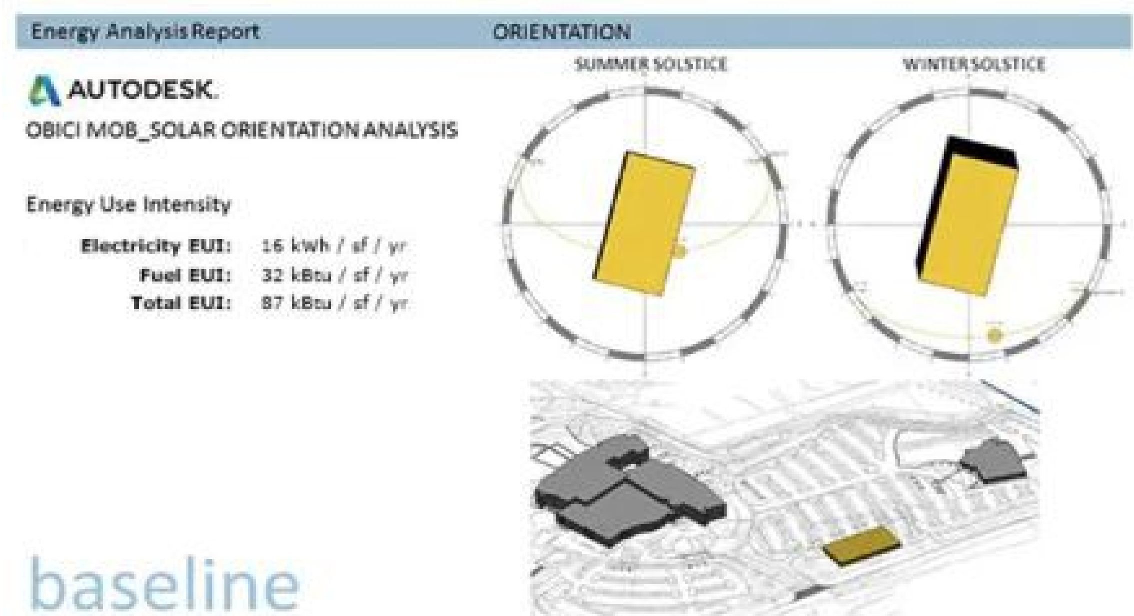
Building Techniques

Building Orientation

Gromiko, Gromiko, and CMI (n.d.) also have concluded that properly orienting a building to take full advantage of the sun's path will improve both its marketability and energy efficiency. This idea of orienting a building to face the sun is not new. Older homes were designed using a heliodon, and with modern technology, the process has become more refined.

The LEED 'Leadership in Energy and Environmental Design' accreditation and certifications acknowledge the concept of properly orienting a building to meet the sun's rays (2013). A building must have a south-facing glazing area that is at least 50% greater than the sum of the glaze on the east and west-facing walls to earn the accrediting system's maximum value. The east-west axis must also be within 15 degrees of being due east/west. The final condition is that at least 90% of the building's southern face must be shaded entirely (by an awning, overhang, planting, etc.) at solar noon on the summer solstice and also unshaded at noon on the winter solstice. (LEED, 2013). The first condition asks for a building to be much wider than it is long, and the second condition states that the wide side is angled almost entirely east to west. The third condition asks for a way to keep the sun from shining directly down onto the building by covering the wall with an awning or shade.

The example in this pair of images depicts the Sentara Medical Groupes Medical Office Building at Obici Hospital in Suffolk, Virginia. The image is a simulated plan of the building's footprint on the hospital campus. The data statistics on the images' left-hand side show how much energy is being consumed within the building. The energy savings reach roughly 20% because the building has been rotated by 30 degrees about its axis (Smith 2016). 3kWh is a lot of energy to save for every square foot of the building over a full year. A building with 7,000 square feet of space saves 21,000 kWh per year, or $2,520 per year (AVCalc, 2020). 1 kWh is about the amount of power that a laptop uses over a full day (ovoenergy, n.d).



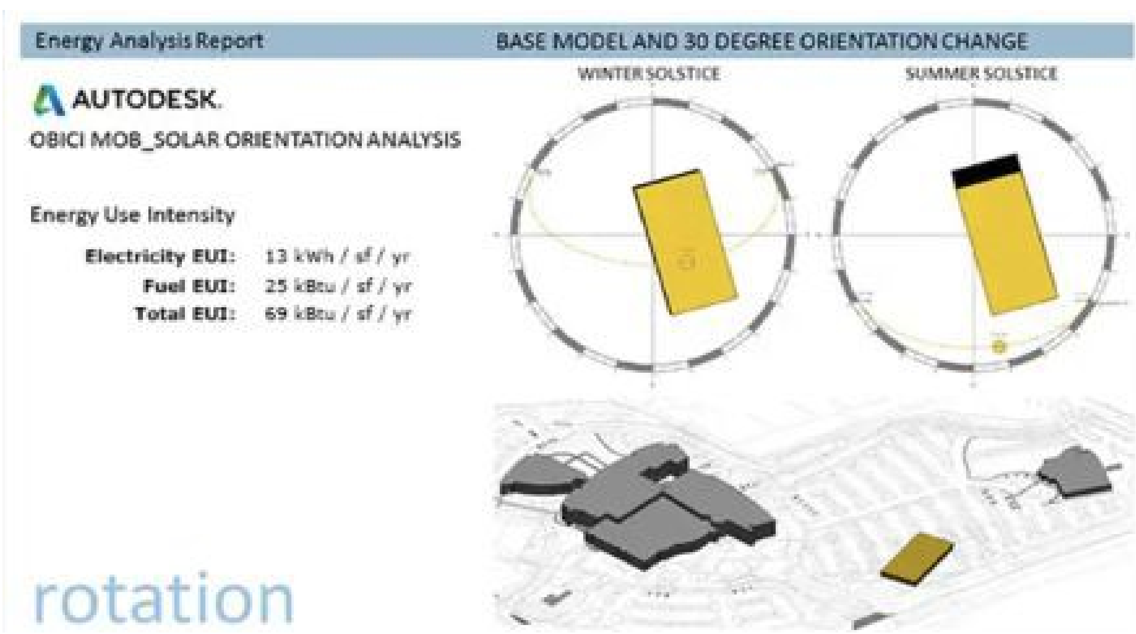


Figure 2 displays the effects of solar orientation when changing the angle of alignment.

The advantages of using these techniques cannot be understated. Properly orienting a building to handle the sunlight can save thousands of kWh worth of electricity and, by extension, money every year. Saving as many watts as possible will go a long way towards handling the energy crisis that will come with climate change if action is not taken

Orienting a building to take maximum advantage of natural sunlight is the single most challenging topic to implement in this study. This is because not every development will allow the technique to be implemented. Implementing the LEED credit occurs during the planning stages of development, rather than after the development process when people own the buildings on the land.

Trombe Wall

Keya Lea (2013) describes a building technique that serves as a heat buffer for a building. The concept is known as a Trombe Wall, which features a glass pane in front of the structure's actual load-bearing part. The wall is meant to be placed on the building's side that faces the sun, with an overhang included to block out the summer sun.

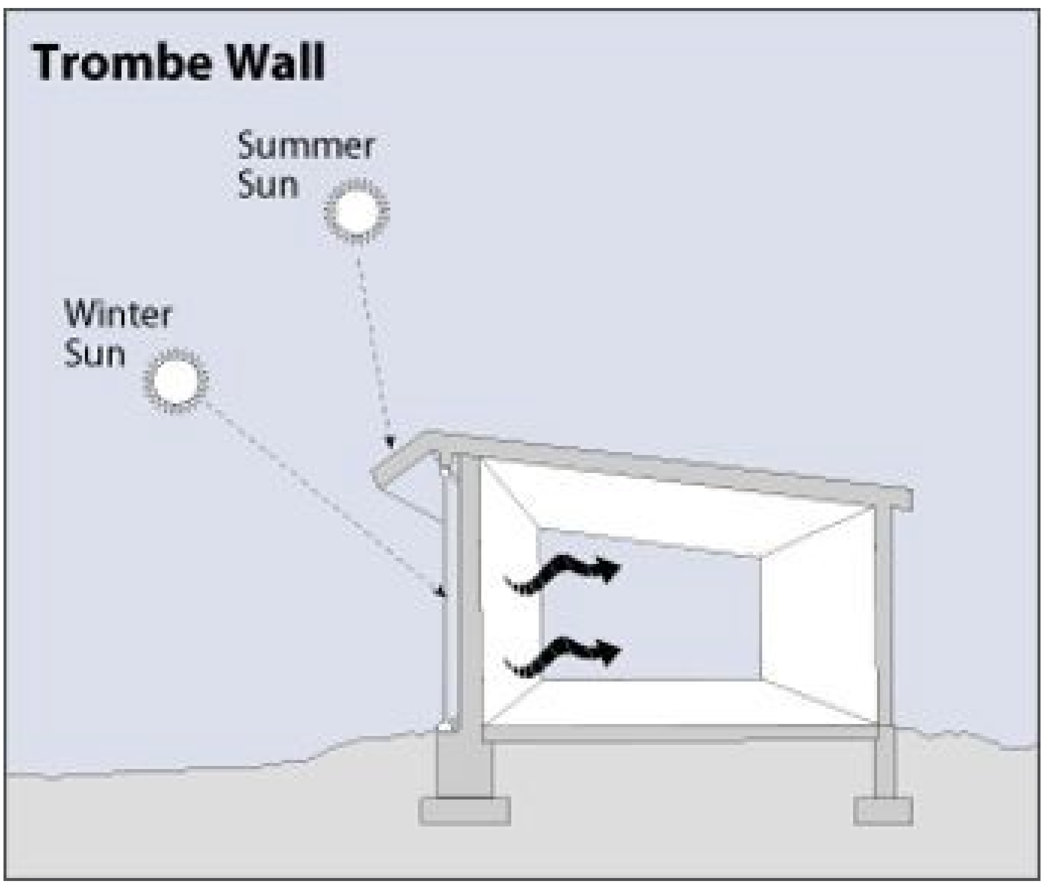


Figure 3 displays the conceptual design of the Trombe wall.

The Trombe Wall provides a useful source of heat energy during the winter season. The wall is similar to the building orientation credit. The wall's design must be built into the structure when the building is built for the wall to serve its purpose. The Lea article's house was able to use it in the building retrofit because the homeowner added an extension to the building that enabled a Trombe Wall.

Solar Thermal Energy

Solar thermal energy is used in multiple different areas and fields. Keya Lea (2013) also mentions the power of solar thermal energy in the building retrofit. It works very effectively as a heat battery. A heating tube filled with water takes significantly less maintenance than an Air Conditioning system. The Lea article's homeowner only has to pour bleach into the tubes once per year to clean them and prevent algae from growing inside the water. The owner claims to still have the same water in the tanks from their initial installation (Lea, 2013). The concept is based on the fact that water can store more than twice the amount of heat as concrete or stone (Lea, 2013). "For example, a cubic foot of water can store 62.4 British Thermal Units (BTUs) for each one degree Fahrenheit rise in temperature, while a similar volume of concrete can store only 28 BTUs for each one degree Fahrenheit rise. A British Thermal Unit is a unit of measurement that quantifies heat. One BTU is the approximate amount of heat required to raise one pound of water by one degree Fahrenheit" (Lea, 2013).

The advantage of this particular method is its low cost and low maintenance. The tubes are inexpensive, costing less than half of a solar panel array (Rockwest, n.d.). Water can be stored in heating tanks in the same way as a Trombe Wall is used and make for a very low maintenance thermal battery.

Three Home Examples

The Lea Home

Lea (2013) details an adobe home in New Mexico that underwent a retrofit that shows what is possible when multiple solar energy methods are applied together. The building retrofits added two portions to the home. The first was a sunroom on the south side of the house that is lined with glass. The second addition was a two-story segment with a Trombe Wall placed on the south-facing side to take advantage of the sunlight (Lea, 2013).

Lea (2013) explains that the house in the article spent $30,000 to install its solar panels and had fully paid for them from the energy savings in 8 years. The system was installed in 2005 and is comprised of three sets of 15 panels each and is rated at 5KW (Lea, 2013). The myth claiming that solar power does not pay for itself is effectively false (Lea, 2013).

The Balcomb Home

Mother Earth News (1979) reported how adobe can be used sustainably in the 1970s. The article about the Balcomb family details the reality behind the misconception about the desert environments of New Mexico. The building is located in Sante Fe, with an elevation of about 7,000 ft (Mother Earth News, 1979). The Balcomb Home, also referred to in the article as Unit One, is another instance of a building that takes advantage of several different energy forms. Unit One applies many of the same solar energy methods and ideas as the Lea home.

Both buildings utilize a glass sunroom with double-layer thermal glass as a heat source (Mother Earth News, 1979). Secondly, the building uses solar thermal energy batteries to store the excess heat during the winter day (Mother Earth News, 1979). However, the difference is that instead of water in tubes, Unit One stores its heat in 50 tons worth of stones beneath the floor (Mother Earth News, 1979). Unit One is different from the Lea home in that it demonstrates that this technology is not new and has applications in the built environment dating back over 40 years. Solar Energy methods have evolved in that time to make the technology easier to use and apply. Unit One is a greenhouse with adobe walls on three of its sides. The Lea home is not as intrusive with its solar energy methods.

La Mesa Residence

The idea of retrofitting an old adobe home has merit even outside of New Mexico. A very recent retrofitting project has shown that people are embracing the ideas of solar energy in their homes (Duttonarchitects, 2018). The project takes advantage primarily of the adobe structure originally built in the early 20th century. The home is in La Mesa, a city in San Diego County, California.

Unlike the other two homes, the La Mesa residence takes only peripheral advantage of solar energy. The adobe walls enabled Duttonarchitects to comply with the homeowner’s desire to not need or have an air conditioning system in their home (Duttonarchitechts, 2018). However, the other solar energy methods in this study are not actively applied.

Chapter 3: Methodology

Study Area

The area I have chosen is vast, encompassing fifteen separate states and multiple climates (Kiprop, 2017). I chose this area to show that the scope of solar energy can be applied to a large extent, that people can use these technologies and techniques without worrying about where they live. These different climates will impact the efficacy of solar energy technologies and how best to apply them

first and most prevalent areas are the desert and semi-desert conditions in the Southwest United States of America (Kiprop, 2017). The desert is arid and has both hot summers and cold winters. The second climate is a Mediterranean climate found in California (Kiprop, 2017). This climate has moderate temperatures with average rainfall. The climate has warm summers and cool winters. The third climate is a subtropical climate found in the states east of Texas and the northern part of Florida (Kiprop, 2017). This climate is humid, with warm summers and cool winters. The last climate in the Sunbelt is the tropical climate in southern Florida (Kiprop, 2017). South Florida is very humid with hot summers and cool winters. The tropical and subtropical climates also experience and expect large amounts of rainfall during hurricane season.

Methodology

This study will use two methods of study. The first is a descriptive analysis of the raw data collected from these techniques. This data was acquired through the observations and research portion of the study. The data will measure the cost-effectiveness of implementing possible energy technologies compared to utilizing the current methods.

The second method is an observational analysis of retrofitted homes in New Mexico and California. The buildings in question have undergone retrofits to take advantage of other solar energy uses while also saving the homeowner money in the process. The point of this data is to demonstrate that these techniques can and should be employed together to achieve the best results. These homes demonstrate how people are utilizing solar energy in the built environment, and show both how and how not to retrofit buildings to take advantage of solar energy. These observations, notes, and photographs will be used to identify the most useful and effective methods of using solar energy to be implemented in both current and new developments within the sunbelt states.

Chapter 4: Data and Analysis

Solar Costs and Savings

Cost of Solar Panels in the Sunbelt States

Sunbelt States	Starting Cost for a 6-KW system	September 2020 Energy rate (cents/kWh)
Alabama	$13,706	13.18
Arizona	$13,680	12.53
Arkansas	$14,713	10.8
California	$15,240	21.23
Florida	$13,920	11.97
Georgia	$15,840	12.11
Louisiana	$15,660	9.76
Mississippi	$14,763	10.84
Nevada	$14,760	11.97
New Mexico	$16,680	14.33
North Carolina	$14,040	12.15
Oklahoma	$14,667	10.87
South Carolina	$16,500	12.91
Tennessee	$13,909	10.6
Texas	$14,820	12.01

Table 1, Average costs of panels and electricity in the 15 sunbelt states. This data was retrieved from ConsumerAffairs and SaveOnEnergy

Cost of Solar Panel Systems Regarding Tax Incentives

System Size	Average Solar Panel System Cost (Before Tax Credit)	Average Solar Panel System Cost (After Tax Credit)	Total Savings
2 KW	$5,920	$4,381	$1,539
3 KW	$8,880	$6,571	$2,309
4 KW	$11,840	$8,762	$3,078
5 KW	$14,800	$10,952	$3,848
6 KW	$17,760	$13,142	$4,618
7 KW	$20,720	$15,333	$5,387
8 KW	$23,680	$17,523	$6,157
10 KW	$29,600	$21,904	$7,696
12 KW	$35,520	$26,285	$9,235
15 KW	$44,400	$32,856	$11,544
20 KW	$59,200	$43,808	$15,392
25 KW	$74,000	$54,760	$19,240

Table 2, Costs of solar panel systems before and after applying the ITC tax credit, plus the raw value of the money saved with the tax credit

Analysis

The data in the tables details the costs for solar panels in each of the 15 states. While the average costs of the solar panels are relatively close to each other and thus consistent between the sunbelt states, the cost of electricity in each of the states will vary quite noticeably. This means that the individual rates of return for using solar panels will inevitably vary as well. When a consistent amount of energy is used across all 15 states,

Tax Credit savings

This tax credit does not have a cap, enabling someone who has sufficient money on hand to drastically increase their solar panel supply while also reducing their income taxes. The tax credit savings are high enough that using the tax credit will allow the owner to afford additional solar panels and better electricity. A 25 K.W. rated system costs $74,000 without the credit. Employing the tax credit facilitates the same amount of money to purchase up to 32 K.W. worth of solar panels without the credit. That equates to roughly a 30% increase in solar panels and a drastic increase in return rate. Purchasing more solar panels than needed to reduce the monthly electric bill to zero increases the rate at which the homeowner will pay off their solar panels under a standard net metering agreement.

However, the problem with all of this value is that it depends on the homeowner actually owning their own home. Renters and multi-family buildings such as high rise areas have a limited amount of roof space per family, thus limiting their potential savings from solar panels. They will benefit but at a decreased linear rate for each family living under the same roof. This also assumes the people actually own the building.

New Mexico Home Observations

Image 2 displays the interior of the house with No lights on

image 4 displays the interior of the top of the Trombe Wall

Image 6 displays an overview of the building with the the solar panels and Trombe Wall in the background

California Home Observations

Image 7 displays the second adobe house in La Mesa

Image 8 displays the interior of the La Mesa house hallway

Image 9 displays the interior of the La Mesa home with the lights on

Image 10 displays the interior of the La mesa home but with with the lights now off.

Image 11 displays the floorplan of the La Mesa home. The plan has been rotated such that the left side faces North and the top side faces East.

Solar Panels

The New Mexico home has solar panels installed. These 5-KW rated arrays have already been paid for at the time of this observation. They provide a modest income of $80 per month to the homeowner instead of having to pay an electric bill (Lea, 2013). The La Mesa home does not have solar panels installed. The building can easily rectify this simply because the building is unobstructed and possesses a large roof space.

Building Materials

Both buildings have adobe walls. The buildings were inherently designed with adobe and retrofitted to continue to take advantage of the walls. The New Mexico home took advantage of the adobe to make for a very energy-efficient home. Meanwhile, the La Mesa home used the adobe from the original structure because it was cost efficient and within the homeowner's criteria.

Building Techniques

The New Mexico home makes use of both the solar orientation concept and Trombe Wall building techniques. It should be noted that the Lea house takes advantage of what can be done when the building is properly aligned. The building's ratio is in the wrong direction, but the building uses what it still can.

The La Mesa building uses part of the building orientation technique. The south-facing side of the building is open, allowing light to enter the building during the day in the winter. However, the building itself does not take full advantage of the technique. There are plenty of windows for natural light, but they are in secondary positions. The light will run closer to parallel with the windows in the central courtyard. The structure, despite its flaws, enables other possibilities. There is still sufficient natural lighting from the skylight windows, as seen in image 10. Image 9 also shows that the home is still receiving natural light but could have had more.

Solar Thermal Heating

Only the New Mexico home makes use of solar thermal heating technology at this time. The solar thermal tubes in image five have provided an efficient way to store heat during the day. The tubes cost less than the solar panels did and still have the same water from when they were originally installed.

The La Mesa home has a pool behind the house, away from the central courtyard. This enables the home's backyard area to take some advantage of solar thermal heating to cool the backyard due to the water's high heat capacity.

Chapter 5: Discussion

The data regarding solar panels and other ways to use solar energy shows that many of these techniques can be applied throughout the sunbelt with ease. Buildings within the sunbelt should try to take advantage of as many of these technologies and techniques as possible to be more energy-efficient and to save money over time.

Retrofitting

The Lea home is a good example of a building retrofit. Retrofitting enables the use of technologies because they can be feasibly added to current buildings. The front section with the solar panel arrays and the back portion with the two-floor Trombe Wall was developed after the building was completed (Lea, 2013). The solar panels generate both electricity and an average of $80 per month in income for the homeowner. The Trombe Wall provides passive heat energy for the home with no maintenance.

The La Mesa home is not a great example of a building retrofit but still important to this study. The building does take advantage of the original adobe walls but does not take advantage of the other solar energy methods. The easiest technology that can be applied is solar, seeing plenty of open roof space on the property.

The La Mesa home is not a good example of a retrofit because it demonstrates that the Lea home is not just an isolated incident in New Mexico. The house owner wanted to live life simply, as though they were living when the house was originally built in the early 20th century (Duttonarchitechts, 2018). People are embracing solar energy, even if it is only a beginning step in the right direction. This is a major aspect of using solar energy in general. The home demonstrates the marketability of solar energy methods, even if it was not the homeowner's original intention.

Most, if not all, buildings can be retrofitted to include solar panels. As long as there is sufficient space on the roof, (or property grounds if it complies with neighborhood regulations). they can function. Additionally, solar thermal heating tubes can be added to a home or building without difficulty (Rockwest, n.d.). The exact price of a fiberglass tube to replicate the ones in the New Mexico home will vary based on the tube's exact dimensions. It should be noted that the most expensive tube offered costs about $6,000, which is less than half of the price of a solar panel array.

Unfortunately, not all of the technologies presented in this study can be applied to the already constructed homes and buildings throughout the Sunbelt. Any building not already made out of adobe is not in a position to have the walls remade with adobe. Similarly, buildings with a poor alignment angle for natural sunlight cannot be retrofitted to take advantage of their orientation. Ultimately, tearing down and rebuilding the entire structure is not an example of retrofitting because it is a new structure. The main benefit of retrofitting a building is that it preserves the already spent resources used to originally make the building.

Building Codes

The largest challenge for implementing several solar energy methods is that they interfere with already built structures. It is not viable to demolish and then reconstruct the numerous households in the sunbelt states for the minor boost in solar energy efficacy. The solution instead is to move forward and put effort into future projects and developments. The best way to accomplish this would be to amend building codes.

Altering the building codes of new developments means that architects and developers will be forced to add on these techniques and technologies. California has demonstrated that this is directly possible with a vote in 2018 to mandate that all new homes have solar panels pre-installed (Chappel, 2018). This can be replicated with solar orientation or adobe walls to facilitate integrated building technologies to achieve solar energy efficiency.

Tax Credits and Incentives

Homeowners are eligible for a federal tax credit for installing sufficient solar panels on their property. “The federal solar energy credit is a tax credit that can be claimed on federal income taxes for a percentage of the cost of the solar photovoltaic system” (U.S. Department of Energy, 2020). Tax credits are desirable because they enable the taxpayer to purchase solar technology while decreasing their tax burden. The more dollar panels that are installed, the greater the amount can be deducted from their federal income tax. Incentives serve as a method of influencing people to do things. A solar panel array will already pay for itself after an average of eight years.

However, at this time, the tax incentive for installing solar panels is beginning to end.

The amount that someone could deduct from their taxes will decrease after December 2021 (U.S. Department of Energy, 2020). The United States Congress will have to renew the tax credit in order for the credit to remain in effect for the foreseeable future. Thus, this issue is relatively minor. The solution is to contact representatives and senators and convince them to renew the tax credit before it starts to expire in the coming years.

The other challenge this incentive faces is that it is not easily achieved by the general public. Many Americans have the income necessary to pay for solar panels. However, if they invest in solar panels, they will not have sufficient funds to pay for necessities and cannot pay their bills on time. Most people do not have sufficient savings to pay for solar panels upfront. Seventy-eight percent of U.S. workers live paycheck to paycheck (Martin, 2019). There are some ways to finance the sale of solar panels; however, the process is based on the homeowner's equity (Ygrene energy fund, 2020). The current incentives are not enough to encourage people to install solar panels on their homes, and the lack of funds for the downpayment is a significant barrier to using solar energy.

A potential solution to this issue is a government loan. This loan would work because the government would pay the upfront cost of the solar panels and have them installed on the roof of the homeowner's property. From there, the government would take a portion of the energy produced from the solar panels while the homeowner takes the other portion. After about 15 years, or twice the period of time it takes to pay off a solar panel array, the homeowner would take full ownership of the solar panel array.

Another major roadblock that solar panels must face is that electric companies have begun to change how they calculated energy savings. The electric grid's initial concept assumed a one-directional flow of electricity from the central power plants to the consumer (Cardwell, 2016). However, solar panels do not follow this system, as power is generated locally and can be transferred abroad when it is not needed. Under a basic conversion rate, the homeowner's electric bill would equal the net energy spent compared to how much energy they produced. Changing this rate to make the homeowner pay extra for electricity used in the evening prevents the homeowner from actually gaining value from the investment they made. The rate was changed to prevent them from taking advantage of the best part of the year, the summer months (Cardwell, 2016).

The solution to ensure that solar panels actually enable people to save money on their electric bills is straightforward. The government can amend the regulations, forcing electric companies to comply with net metering.

Chapter 6: Conclusion

The purpose of this study was to examine several different methods of using solar energy in and around the home. This study supports the possibility of widespread use of solar energy throughout the Sunbelt states in the United States. Technologies like solar panels are universally useful in neighborhoods. Adobe enables buildings to save on resource and utility costs without compromising the effectiveness of those utilities. The New Mexico and La Mesa retrofitted homes demonstrate that it is both possible and effective to implement these solar energy methods. La Mesa shows that solar energy techniques are becoming marketable. The New Mexico home was able to pay off the costs of its retrofits within the decade. Solar energy is affordable. Solar panels cost less than the price of a new car and can produce hundreds of dollars in passive income every year just for having them. Tax credits and deductions can save money on the initial purchase, reducing the time until solar panels have completely paid for themselves. Proper orientation of a building will save thousands of dollars and kilowatt hours over the course of a year. Solar Energy is becoming more of an essential part of the modern world with each passing day. Developers should look to take advantage of every technology and technique mentioned in this study to improve the overall efficiency of the homes of the future

Limitations

Important Limitations impacting this study are listed below

- Coronavirus pandemic limited the amount and type of observations possible as well as meetings with campus staff

Future Research

Based on the recommendations and locations regarding solar energy, I have listed the possible avenues of further research to expand upon the scope of solar energy.

- Exploring the use of batteries to store energy in areas outside of the Sunbelt.
- Partial or fully underground buildings has some potential regarding sustainability
- Applications for solar thermal energy heating tubes to serve as a source of hot water
- An additional form of solar power in that of Solar Powered Steam Boilers instead of relying on PhotoVoltaics

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