

# Investigation into Feasibility of Off-grid Small Dwelling in SLO County

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The trend towards green, sustainable living has grown more and more in the housing industry each year since before the turn of the century; solar in the last decade alone has grown by 60% (<http://www.seia.org/research-resources/solar-industry-data>). Living on a grid that runs on unclean sources of energy already has led us into an environmental disaster some call irreversible. This paper takes a detailed look into the feasibility of a small, off-grid, dwelling that utilizes modern technology in order to live more modestly. In conjunction with great advancements in solar technology along with energy storage such as deep cycle lead-acid batteries, on-site well systems with filtration can bring us to a fully self-sustaining small home.

**Key Words:** Green Building, Sustainability, Off-Grid, Small Dwelling

## Introduction

the benefit of a small, off-grid, dwelling that utilizes modern technology in order to live more modestly would be bringing down the average citizens' monthly bills, in addition to utilizing green technologies that will lead to a cleaner state. The challenge is whether such a home could be feasible legally, environmentally, economically, and in building expertise. Through research and interviews with experts in well-water, filtration, solar panel, and storage systems, I hope to determine a cost-range for equipment from the most efficient to the most affordable. Measuring feasibility for possible builders will be determined through online surveys taken via social media. Questions relating to price, length of time, and self-installation vs. contracting will be posed to the intended benefactors of the project, young adults to middle-aged citizens with an interest in living sustainably. The small home used as a model will be a building design previously obtained from Tumbleweed Tiny Houses called The Popomo with a self-built-contracted cost of approximately \$20,000-45,000 (<http://tinyhousetalk.com/tiny-house-costs>). All additional costs for equipment will be added to this range.

The benefits of an off-grid small dwelling are significant when applied to a cluster approach with sub-grids running throughout a development of pocket neighborhoods. Should a larger residential developer take the project idea and apply it to large developments, they could create the first net-zero energy and water community. Having no electricity or water bills would free citizens up to pursue their personal interests, in addition to reducing the general feeling of worry regarding monthly payments. With the American lifestyle shifting away from cable for television shows, from newspapers for news, and towards the internet/wireless connectivity for nearly all entertainment and information gathering, the number of people ready to pay only one monthly, all-inclusive bill is significant.

Beyond benefitting the wallet of home-owners who decide to purchase these homes, a further gain would come from lower pollution. Having personal grids would reduce the necessity of inefficient, pollution producing large grids like the ones we utilize currently. In fact, Elon Musk was recently quoted as saying he could supply power to the entire globe with a project wherein he develops just 100 Gigafactories, dedicated to the creation and distribution of solar and storage opportunities (<http://peaceenergy.ca/wp-content/uploads/2017/02/Watts100-The-Tesla-Gigafactory.pdf>). This is essentially the same idea for this senior project, only on a much larger scale and without water included. If Musk took steps towards efficient energy renewal that would bring self-sustainability into the public eye, it could lead to some very important changes in the way society lives and makes decisions.

## Methodology

The objectives of the study are as follows:

- To report what is feasible, by intended market audience;
- To highlight the financial, economic, and experience based challenges of construction;
- To highlight the beneficial effects an off-grid home has on an individual;
- To highlight the equipment options and the pros/cons of each;
- To highlight if the project is feasible based on market-definition;
- To report lessons learned from the project.

The prime methodology used for this paper is a case study. With the project idea being primarily qualitative, the knowledge was attained through surveys with the market audience, secondary research into the equipment requirements, and interviews with professionals about said equipment. The initial surveys with the market audience were to determine the definition of what is feasible in order to better frame later research. It was critical to have a price range and an idea of how much labor the possible builders would subcontract. The secondary research involved both consulting peer-reviewed articles, and analyzing the benefits/pitfalls of various companies' products for use in the project. Analysis of the products took place through online research, as well as scheduled interviews with company representatives to discuss the products in more detail. Finally, the information gathered was compiled and analyzed to determine feasibility with three options, primarily considering efficiency and cost.

## Feasibility Case Study

The survey was designed to receive the least biased answers possible, and give participants every opportunity to show disapproval or disinterest in the idea. It began with a simple question of interest in the dwelling, explaining the term off-grid in order to have a broader audience truly understand what is being asked. Gauging the interest in an idea considered fringe was key; in order to sell an idea the demand must be present. The next few questions were meant to find an average price buyers were willing to spend, what they wanted to build, and over what period of time. Determining the rate at which the consumer can afford to spend their money was an obvious need for the estimate. Certain off-grid systems are much more basic than others, and the price difference can be expansive. The lifestyle choice between these systems can be incredibly different: having an electric pump can be seen as a necessity to some, while others may be satisfied with having manual systems that require much more effort and time.

Another lifestyle change that can raise issues for homebuyers is the difference between electric and gas appliances. These options were offered in two separate questions, one referring to pumping manually or electronically, the other getting a general opinion on electric appliances. In order to get a better understanding of the potential customization demands of consumers, the next question asked respondents to give one utility which they would like to remain on grid. Finally, an understanding of the general building knowledge of millennial consumers was necessary as knowledge alone can lead to a very different final price on a project.

Question						
How interested are you in an off-grid small dwelling?	Very	Some what	Not	Unsure	-	-
%	54%	35%	8%	4%	-	-
How would you prefer to go about acquiring this home?	Build Self	Contract	Buy Built	Not	-	-
%	38%	31%	23%	8%	-	-
How long would you spread out payment?	<1 Year	1-2 Years	3-4 Years	4+	Built	-

Question						
%	12%	46%	0%	38%	4%	-
Would you prefer an electric pump or manual for water?	Electric	Manual	Other	-	-	-
%	77%	12%	12%	-	-	-
+/- \$15k, how much would be feasible for the build?	<40k	40k	75k	100k	130k	>150k
%	23%	15%	27%	19%	8%	8%
What is your opinion of electric appliances?	None	Dislike	Like	-	-	-
	23%	12%	65%	-	-	-
If required, which utility would remain on grid?	Water	Gas	Electric	-	-	-
%	42%	15%	42%	-	-	-
What is your level of building knowledge?	None	Some	Good	Large	-	-
%	46%	23%	27%	4%	-	-

While the number of respondents is suboptimal at 26 participants, I believe it is adequate to utilize in this project. From the results, it is unclear whether or not respondents answered with honesty, but the spread of answers seems to reflect what millennials might be expected to feel. The survey was left open for a four-week period, posted to numerous social media pages targeted for millennials, and reposted twice to each page. After collecting all responses, the mode and median were determined for all applicable questions as the data the survey gathered was qualitative.

Over half of the respondents placed themselves into the “very interested” category, and under 15% responded “not interested” or “unsure.” There is a very positive level of interest in a home with no monthly utility bills. Millennials are looking to save money in new and modern ways, while also not being afraid of paying the up front costs, which might explain the responses. Green building has become very popular in the eyes of the public, and especially so in the younger generations. The appeal is likely due to the potential for cost-savings from monthly bills, as well as a simpler lifestyle overall with less stresses of typical modern homeownership. This could, however, be due to non-response bias, with interested parties being more likely to respond. In terms of how the owner would want to build the home there were two major groups of responses: most would either build the majority of the project and contract out the specialty construction, and some would contract out most of the project while building limited amounts.

The amount of those looking to self-build/partially self build is likely due to this generation’s ability to find quick building information from the internet. Do-It-Yourself communities have inspired many to take the challenge of building into their own hands. There are also workshops the tiny house community holds to show the average citizen how to go about constructing a tiny home. Respondents were willing to pay up to \$100k +/- \$15k after averaging for the project design to be completed, with just 14% expecting to pay upwards of \$130k. Thus, \$100k +/- \$15k became the price point for ultimate feasibility. Respondents on average expected to spend 2-3 years paying off/building the project, however, a few expected to spend 4 or more years. With almost no respondents expressing demand for manual equipment for water acquisition, the build became clearly more modern-world than simple-living. Luckily, there seemed to be little to no issue with electric appliances and so the idea could continue without gas. Quality electric stovetops have become very popular, and are efficient as well as aesthetically pleasing, which is likely the main area of concern from consumers. Finally, the majority wanted to contract-out work and have explanations given to them, which could drastically drive up prices. I opted to keep a majority of the build self-worked, in the interest of final build price.

Overall, it seems like a consumer would consider the plan feasible if the price is equal to or under \$100k, can be completed in 2-3 years, utilizes electrical equipment for pumping, and actually gathers the amount of required power and water for a 1-2 person household. Paying off a \$100k home improvement project in two years may be too large a task for most young adults in professional careers, but financial plans could be altered to make it feasible. Contracting out the work will also drive price up, but with the rise of Do It Yourself (DIY), tiny house, and off-grid communities, more and more citizens are learning about the construction process online. Vast resources are available to the average consumer, and if fully taken advantage of, the need for contracted labor decreases appreciably.

### *Economic Feasibility*

The estimate for economic feasibility was done from the point of view of an average consumer utilizing the Tiny House and Do-It-Yourself communities for building knowledge and assistance. The estimate itself is in the Notes/Other portion of the binder. Information regarding pricing and equipment efficiency/lifetime was gathered from online distributors. The major portions of cost in the estimate were the local well system at just under \$10k, the nine 300 watt solar panels at about \$3k/panel, and the inverter for the solar system that ran just under \$2k. In total, the build itself ended up being just about \$75k depending on a few personal choices regarding material quality or solar and water storage size it could be brought up or down. Economically, the target market would consider the project feasible.

### *Environmental Feasibility*

In order to determine environmental feasibility, I needed to determine if the San Luis Obispo biome could support an off-grid small dwelling. San Luis Obispo gets close to 5 peak daylight hours a year, which with nine 300 watt panels and 8 deep cycle lead acid batteries could easily produce and store the necessary amount of energy two individuals would use in a small home (<http://www.solardirect.com/pv/systems/gts/gts-sizing-sun-hours.html>). In terms of rainwater collection, the San Luis Obispo biome does not on average produce enough water for it to be the sole water collection system. Rainwater in the past year is not the typical for the biome, and global warming makes it difficult to determine the amounts of future years. Well water produces enough to give 4 family homes on demand water ([http://www.water.ca.gov/groundwater/well\\_info\\_and\\_other/california\\_well\\_standards/b74-81chap1f.html](http://www.water.ca.gov/groundwater/well_info_and_other/california_well_standards/b74-81chap1f.html)). Utilizing a local well system with a water storage tank and a potable water filtration system will easily produce enough water for a two person small home, and so environmental feasibility has been determined.

### *Legal Feasibility*

Dealing with local government is a major portion of any project, and so it was presumed to be the most difficult to work around to achieve feasibility, if it was possible at all. The city zoning, permitting, restrictions and building guidelines can all be found on the San Luis Obispo county websites. San Luis Obispo does not have a minimum home footprint, but does however enforce a minimum of one 120 square foot room per house, which prevents the Popomo house plan because its largest room is only about 50 square feet (<https://law.resource.org/pub/us/code/bsc.ca.gov/gov.ca.bsc.2010.02.5.pdf>). The requirement could be achieved by redesigning the home to be more of a studio layout with attached bathroom. In terms of off-grid capability San Luis Obispo requires homes to be connected to the septic system, but the build could take place outside of city limits. In addition to research, interviews with city officials at the Utility and Building/Planning offices revealed that local government is quite friendly to off-grid building aside from the septic system. Aside from typical building permits and regulations, there is nothing stopping a citizen from building an almost entirely off-grid small dwelling. Thus, there is no reason that the build would not be considered legally feasible.

### *Lessons Learned*

Well-water is the most efficient form of water collection available to the average consumer. Despite having the highest up-front cost, and decently sized upkeep costs, wells can generate enough water to facilitate large, more standard American homes on demand. Used in a small house setting that could be applied to pocket neighborhoods of many individual households. A landlord could provide all utilities required by his tenants.

Solar collection and storage systems are relatively inexpensive and simple to install. Systems generating much more power than the one used in this project can be built for under \$5,000. Utilizing a series of deep cycle lead acid batteries allows for easy storage of unused energy. California gives a 30% federal tax credit on approved solar projects, highly incentivizing its citizens to go solar. Solar technology is also constantly improving, each year advancements are made in efficiency and storage.

Governing bodies are actively keeping people in larger, on-grid, homes primarily for a larger tax-base. Change will be incredibly slow-going to the point that it is questionable if local laws will indeed change to allow for a greener approach to home-building. The project in its entirety would be more feasible in an area whose local government does not restrict building as massively as most California counties do.

Interest in an off-grid small home is high among millennials, and has been determined to be economically and environmentally feasible. Despite a large potential market for homes like this, legally there are not a lot of options for consumers. The only way to create feasibility is to change the local building laws themselves or redesign the small home based around having a 120 square foot room.

## **Future/Conclusion**

The main takeaway from the investigation into the build idea is that an off-grid small home is attractive and feasible in almost every respect. It would help keep the environment clean while reducing monthly utility costs. In addition to a local well system, California is home to several climate zones that produce enough rainwater for collection/storage, as well as enough light for solar collection/storage. Environmentally it would not be difficult to find a feasible building site. Rainwater, however, proved to be the least dependable source in California, so most state residents would likely opt for a local well and pump system. Financially, most people would be able to undertake this project in 3-4 years, while the more prudent would be able to complete it more quickly. The project can also be made cheaper depending on the lifestyle cutbacks a person is willing to make such as composting toilet instead of septic system.

Generally people showed a great interest in living in a small, off-grid home. Popularity of small homes has been rising in the last decade and the added benefits of going off-grid could be enough to bring about a major change in the way millennial Americans buy homes.

Nevertheless, the major problem with this project is that local governing bodies have little reason to support small homes. With property tax percentages being so low, and the off-grid build being estimated at just over \$70,000, a home like the one outlined in this project would bring in less than 15% of the money a typical San Luis Obispo home does. This could change over time, but it would take an entirely new property tax format, based upon something other than property value, like lot-size or using a flat-rate. Laws governing certain size-requirements and subsidies for green buildings have contradictory goals and results. Going completely off-grid means even less money supporting utilities which means even less tax revenue. Having a small home ultimately means less space to fill, so less material goods to purchase and to tax. Until local government changes the building laws and how it views its citizens, this green home is unfeasible.

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