University of North Carolina at Charlotte
Department of Electrical and Computer Engineering

Solar Powered House Design

Report 3-2

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Section 1: Introduction

Rooftop solar power has been gaining momentum in Charlotte, North Carolina, as residents and businesses embrace the benefits of harnessing the abundant sunshine in this region. The Queen City, known for its warm and sunny climate, is an ideal location for solar energy generation. Homeowners are increasingly turning to solar panels to reduce their electricity bills and carbon footprint. Incentives and rebates provided by both state and federal governments have further encouraged this green shift. Charlotte's skyline is now adorned with solar panels, which not only reduce energy costs but also contribute to a cleaner environment.

The adoption of rooftop solar in Charlotte has not been limited to residential properties. Many commercial and industrial facilities have also recognized the potential of solar power. Businesses in the city have installed solar panels on their rooftops, which not only provide an alternative energy source but also showcase their commitment to sustainability. This move towards solar energy aligns with the city's efforts to reduce greenhouse gas emissions and promote a more eco-friendly way of life.

Charlotte's rooftop solar revolution has also created job opportunities and spurred economic growth in the region. Solar installation companies have proliferated, creating employment opportunities for local residents and supporting the growth of the renewable energy sector. With the city's commitment to clean energy and its favorable climate, rooftop solar is poised to play an increasingly prominent role in shaping Charlotte's future, reducing its carbon footprint, and contributing to a more sustainable and energy-efficient community.

Section 2: Storage Battery

Ultimately, for the metro Charlotte area, battery storage does not make financial sense on its own, due to the fact that the significant costs can range from 25-60% of the total system cost. Considering that the number of hours in a year that power delivery to the home is not consistent,

which is less than two on average for the state as a whole, the added cost is not justified. For areas with frequent power outages, this would be of more consideration, or a backup power generator may be more appropriate with areas of lower temperature and or snow (ie mountains)

Solar battery storage has emerged as a crucial component in maximizing the efficiency and reliability of solar energy systems. These batteries allow surplus electricity generated by solar panels during the day to be stored for later use, ensuring a constant and dependable power supply even when the sun is not shining. This technology has gained widespread popularity for both residential and commercial applications. One of the primary advantages of solar battery storage is its ability to significantly reduce reliance on the grid, offering energy independence and cost savings.

In addition to providing a continuous power source, solar battery storage systems play a vital role in reducing peak demand on the electrical grid. During periods of high energy consumption, such as hot summer afternoons when air conditioning usage peaks, stored solar energy can be tapped into, relieving stress on the grid and preventing brownouts or blackouts. This not only benefits individual users but also helps enhance overall grid stability and resilience, promoting a more sustainable and efficient energy ecosystem.

As technology advances and economies of scale drive down costs, solar battery storage is becoming increasingly accessible to a broader range of consumers. With improved energy storage solutions, the future of renewable energy is looking brighter than ever. Solar battery storage is a game-changer that not only ensures energy availability during cloudy days or nighttime but also contributes to reducing greenhouse gas emissions and accelerating the transition to a cleaner, more sustainable energy landscape.

Section 3: Inverter

The inverter in a residential solar system serves as a critical component that converts the DC electricity generated by solar panels into usable AC electricity for homes and manages the

interaction with the electrical grid. Its ability to maximize energy production through MPPT technology, enable grid connection, and ensure safety and monitoring make it an essential part of any effective solar power system.

Many modern inverters come with built-in monitoring systems, allowing homeowners to track the performance of their solar PV system. They can view real-time and historical data, including energy production and system health. Inverters also play a safety role by disconnecting the system from the grid in case of grid failures or electrical issues, ensuring that the PV system doesn't feed electricity back into the grid during maintenance or outages. It is for that reason that electricity grid operators require “Installed PV systems must comply with the IEEE 1547 requirements while the inverter must be certified to meet the requirements of UL 1741 or its successor.”

The inverter we selected to use was the ABB PVI-10.0-OUTD-US. This inverter is designed to use two circuits of DC power supplied by the Solar Panels. This inverter was chosen due to its reviews and popularity in the solar industry. Furthermore, this inverter with a proven track record, will need to be the most reliable piece of equipment as it is a single point of failure.

Section 4: Location

The suggested location: 1902 Lavon Ct, Charlotte, NC 28213 has a roof size that is estimated at 2,167 square meters. It will require about 846 square feet of solar panels for a yearly usable amount of sunlight of 1,642 hours. With a south-facing 30-degree angle roof and an average power consumption of 10kw/day, the yearly consumption is about 14,864kw. For the property solar installations are sized in kilowatts with a recommendation of 10.3kw for this house.

Section 5: Solar Cells

There are several highly efficient solar panels available on the market, and it's important to note that the efficiency of solar panels can vary depending on factors like technology, brand, and design. Some of the most efficient solar panels at that time included those based on monocrystalline and bifacial technologies, which tend to offer higher efficiency compared to traditional polycrystalline panels. It's worth checking for updates beyond this date, as solar technology is rapidly evolving, and new products may have been introduced since then.

-SunPower X-Series: SunPower was well-known for its high-efficiency monocrystalline solar panels. Their X-Series panels had an efficiency rating of around 22-23% and were a premium model, making them some of the most efficient panels available at the time. These panels were popular for residential and commercial installations due to their compact size and high power output. Estimated price: $40170.

-LG NeON 2: LG's NeON 2 series featured monocrystalline solar panels with an efficiency rating of around 20-21%.With LG an efficiency of 21%, those panels would be a premium model as the others would be standard models, LG is a reputable brand known for its high-quality

panels, and the NeON 2 panels were appreciated for their aesthetics and performance. Estimated price: $24515 with a system power of 12.3kw.

-Panasonic HIT: Panasonic's HIT (Heterojunction with Intrinsic Thin-layer) series was another high-efficiency option with an efficiency rating of around 20% which are thin films. These panels were known for their durability and consistent performance. Estimated price: $24329 with a system power of 10.89kw.

-REC Alpha Series: REC's Alpha series featured HJT (Heterojunction) technology, offering efficiency ratings of around 20%which are standard models. These panels were recognized for their reliability and performance in various environmental conditions. Estimated price: $18083.00 with a system power of 11.20 kW.

-Trina Solar Vertex Series: Trina Solar introduced its Vertex series with an efficiency rating of around 21% and a premium model. These panels used larger wafers and innovative cell technologies to maximize efficiency. Estimated price: $6619 for 390 watts

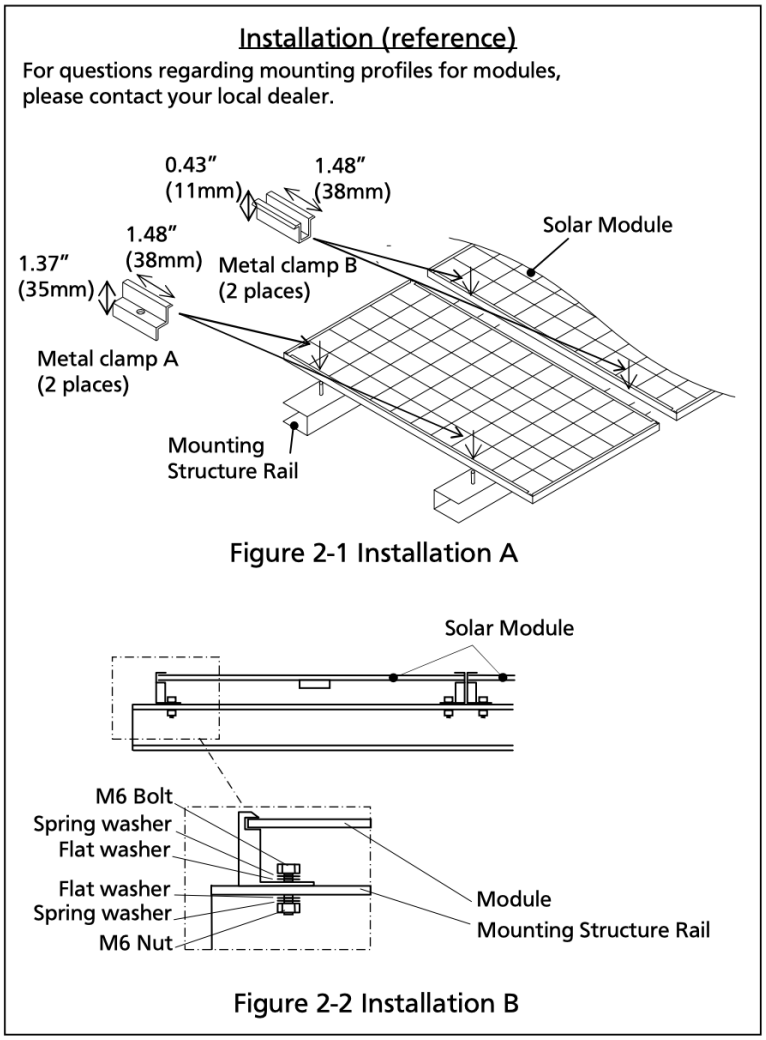
Efficiency is just one factor to consider when choosing solar panels. Other factors such as cost, warranty, durability, and brand reputation also play a crucial role in the decision-making process. Additionally, new products and technologies may have emerged since my last update, so I recommend checking the latest solar panel reviews and consulting with solar professionals to determine the best option for your specific needs.

Section 6: Installation

Notes for installations

- A clearance of “10 cm” between the roof surface and the module frame is required to allow cooling air to circulate around the back of the module. This also allows any condensation or moisture to dissipate. Install modules so that air can circulate between the roof and the module.

- We recommend installation methods shown in Figure 2. In some areas, local electrical codes may govern the installation and use of modules.
- To avoid the hazard of electric shock and fire, do not contact and damage the back sheet of the module with mounting bolts.



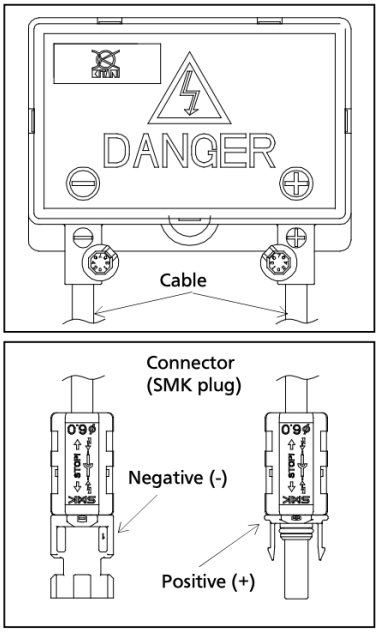


Figure 3: Configuration of Junction Box

Wiring

The maximum number of VBHNxxxSJ series that can be wired in series is seventeen (17). 4 Modules shall not be wired in parallel without maximum overcurrent protection. When installing a PV array, the system design must be completed with reference to the module electrical specifications for proper selection of inverters, fuses, breakers, charging controllers, batteries, and other storage devices. These modules contain factory-installed bypass diodes. If

these modules are connected to each other incorrectly, the bypass diodes, cable, or junction box may be damaged. Use copper wire that is sunlight resistant and insulated to withstand the maximum possible system open circuit voltage. Grounding should be carried out by the attachment to the module or array frame, to avoid the hazards of electric shock or fire. A junction box as a terminal enclosure is equipped for electrical connections on modules. Modules are equipped with SMK plugs as a terminal enclosure. Use these SMK plugs for electrical connections. Suppose two or more separable connectors are provided. In that case, they shall be configured or arranged so that the other and vice-versa will not accept the mating connector for one, if it will result in an improper connection. Modules equipped with one junction box contain terminals for both positive and negative polarity and bypass diodes. One terminal is dedicated to each polarity (with the polarity symbols engraved onto the body of the junction box) (see Figure 3).

Section 7: Incentives

Federal Investment Tax Credit (ITC): The Federal ITC, also known as the Solar Investment Tax Credit, allows homeowners to deduct a percentage of the cost of their solar panel system from their federal taxes. As of 2022, the ITC provided a 26% credit for residential solar installations. However, this percentage was set to decrease in subsequent years, so it's important to verify the current rate.

Residential Renewable Energy Tax Credit: This is an additional tax credit that covers a portion of the costs associated with solar installations. It can be used in conjunction with the ITC to further reduce the financial burden of going solar.

Net Metering: While not a federal incentive per se, net metering is a policy that many states have implemented, allowing homeowners to earn credits for excess energy their solar panels produce. These credits can be used to offset electricity bills during periods when the solar system isn't generating as much power, such as at night. Unfortunately, Duke energy has recently placed limits on net metering in North Carolina, these limits reduce the amount of energy saving that can be realized from depositing your excess energy to the grid for use later.

Federal grants and loans: Some federal programs, such as the U.S. Department of Agriculture's Rural Energy for America Program (REAP), offer grants and loans to support solar installations in rural areas. These programs can benefit homeowners and businesses in qualifying locations.

Property Assessed Clean Energy (PACE) Financing: PACE programs, which are supported by various states and local governments, enable homeowners to finance solar installations through property taxes. PACE financing often offers attractive terms, making it easier for homeowners to afford solar projects.

Energy-Efficient Mortgages (EEMs): EEMs are special types of mortgage loans that can include the cost of energy-efficient upgrades, such as solar installations. This allows homeowners to finance solar systems over the life of their mortgage.

Section 8: Total Budget

Based on the specifications required from the house to have solar panels installed it would be best to go with Panasonic HIT because of its durability consistent performance, as well because the system power is 10.89 which is closest to the house requirements of 10.3kw making our budget for installation about $35000 and taking into account the inverter, mounting, panels, wiring, and labor as well as mounting the panel so that the panel can remain at a constant angle of 35 degrees.

Item	Size/Quantity	Price
Solar cells	various	$24329
Metal clamp A (2)	1.37 x 1.48 in	$6.47
Metal clamp B (2)	.43 x 1.48 in	$4.50
Mounting Structure rail	26 in	$12.75
M6 Bolt	various	$2.75
Spring washer (2)	various	$4.75
Flat Washer (2)	various	$6.54
M6 Nut	various	1.25
Copper wire	25 ft	$6.23
Junction box connector	various	$9.97
Inverter	ABB PVI-10.0-OUTD-US	$1675.00
TOTAL ITEM: 15	**TOTAL $:**	$26,059.21

Section 9: Conclusion

The adoption of rooftop solar power in Charlotte, North Carolina, presents an exciting opportunity for both residents and businesses to transition towards a more sustainable and energy-efficient future. As this report has demonstrated, the city's favorable climate conditions, coupled with state and federal incentives, make solar energy an increasingly viable option. However, it's crucial to approach this transition with a comprehensive understanding of the various components and costs involved.

Our analysis revealed that while solar battery storage offers numerous advantages, it may not be a cost-effective solution for the metro Charlotte area due to the region's already reliable power supply. In terms of inverters, adhering to IEEE 1547 and UL 1741 standards is non-negotiable for ensuring system reliability and safety.

For the specific location examined, a 10.3 kW system using Panasonic HIT solar panels was found to be the most suitable, both in terms of performance and cost. These panels offer a good balance of efficiency and durability, aligning closely with the property's energy needs. The total budget for installing such a system, including all components and labor, is estimated at around $35,000. While this is a significant investment, federal tax incentives can offset some of these initial costs.

In conclusion, rooftop solar power is more than just an alternative energy source; it's a long-term investment in a cleaner, more sustainable future. By making informed choices about system components and installation, homeowners and businesses in Charlotte can not only reduce their carbon footprint but also enjoy significant long-term savings.

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