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Intelligent Zero Net Energy Construction for Disaster Relief

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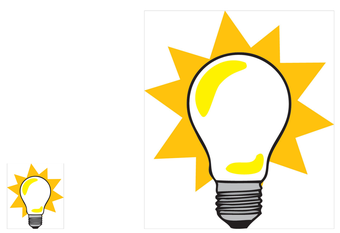
Abstract

The goal of our creative inquiry project is to create a home that can be placed on-site following a disaster without the need for accessing a potentially damaged or stressed utility grid. This home will rely solely on Photovoltaic (PV) solar panels, batteries, and high efficiency 'smart' devices. This prototype will embody the concept of Intelligent Zero Net Energy (IZNE) construction.

Materials and Methods

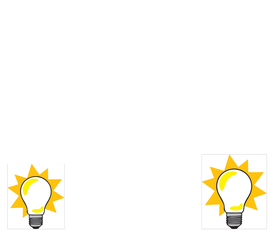
As much as 70% of the energy generated by centralized plants is lost through transmission and distribution [1]. For a small home needing 1000 kilowatt hours a month, more than three times that amount must be generated. By generating energy locally, these wasteful (and expensive) losses can be minimized.

Conventional Energy Generation



Energy Needed Energy Generated

Local Energy Generation

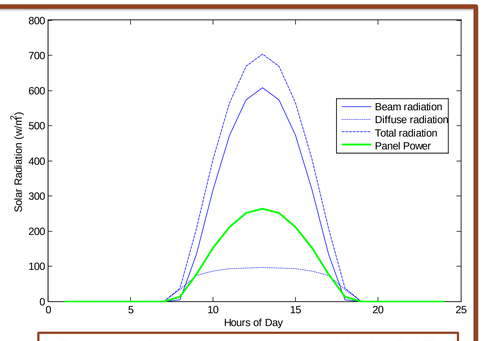


Energy Needed Energy Generated

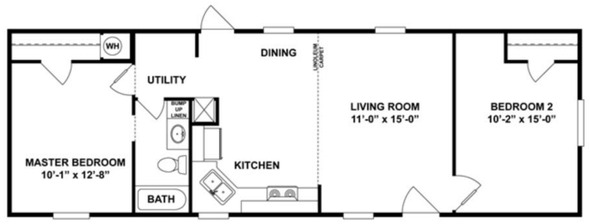
Centralized plants generate AC (Alternating Current) power. Our group took a standard mobile home and redesigned it to take advantage of localized DC (Direct Current) generation. This home could then generate its energy independently. One of the bedrooms was designated as the battery storage location to enable the home to be completely portable. Should several of these homes be linked to form a micro-grid, the storage could be moved to a central location.

Results

Using the datasheet for the SunPower X21-345 panel [3], a simulation was created in MATLAB to model the available solar energy for Clemson, South Carolina. This simulation was created to ensure that the roof of a small mobile home could provide enough space for the panels required to meet its energy needs. An AC comparison house was modeled and compared to the DC design. Both the AC comparison house and the DC design saw significant energy benefits from the implementation of devices such as smart thermostats and low energy LED lights.



Power Generated by a X21-345



Clayton Homes ASP16482A ASPIRATION
(with scale model)

- 752 sq. ft.
- 16' width, 48' depth
- 2 bedrooms, 1 bath
- Average monthly demand of 1000 kWh

Conclusions

When the benefits from local generation are combined with eliminating unnecessary energy transformations, energy savings of more than 50% are possible [2]. These energy savings are a key aspect of our design. Limiting wasted energy will maximize our available generation while lowering our cost. These economic benefits have myriad applications beyond the scope of our project, and it is our hope to demonstrate them through this small scale prototype.

References

[1] R. Singh, G. F. Alapatt, and G. Bedi, "Why and How PV Will Provide the Cheapest Electricity in the 21st Century", Facta Universitatis Series: Electronics and Energetics, vol. 27, no. 2., pp. 275-298, June 2014

[2] V. Vossos, K. Garbesi, H. Shen, " Energy savings from direct-DC in U.S. residential buildings", Energy and Buildings Vol. 68, pp. 223–231, 2014.

[3] SunPower, "X-Series Solar Panels", Document #504828 Rev D [Revised Dec 2014]