



November 20, 2023

## **RE: Comprehensive survey of residential photovoltaic systems in Puerto Rico**

Eduardo A. Lugo-Hernández, Marcel J. Castro-Sitiriche, Agustín A. Irizarry-Rivera, Lionel Orama-Exclusa

### **1. Key Insights**

- One of the main results from the study is that 92% of the participants with mental health diagnosis reported that their mental health symptoms worsen with electric blackouts. The majority of people reported experiencing feelings of anxiety, frustration, anger and desperation when experiencing blackouts.
- Customers report great dissatisfaction with various electric service indicators resulting in 79% being Unsatisfied or Very Unsatisfied with their electric bill. The majority of participants (66%) felt that the electric service has deteriorated since LUMA took over the administration of energy distribution. Also, 66% of those who have needed assistance from Luma's customer service felt Unsatisfied or Very Unsatisfied.
- Exploring power outages experienced in Puerto Rico it was found that 29% of participants reported having 3 or more weekly blackouts and 44% reported that it takes more than 4 hours on average to regain service.
- When asked about what appliances or equipment are essential for them to power during a blackout they indicated that Refrigerators (99%), Fans (77%), Stoves (35%), and respiratory therapy equipment or respirators (30%).
- Exploring PV adoption was found that 27% of the sample have a solar energy system of which 95% have batteries. The majority of study participants (66%) that do not have a solar system, indicate that cost is the main reason for not having one and 78% of those participants have no plan to purchase a solar system during the next year.
- Energy justice is a key element for people's health. Results revealed that 30% of the sample had some medical equipment that needed to be powered by electricity. The two most common needed equipment were respiratory therapy equipment or respirators, and refrigerators (for insulin or other medication).
- Energy burden is an area that needs more research as study results show that 60% of participants pay more than \$100 monthly in their electric bill and 26% pay on average more than \$200.

Results suggest a deep dissatisfaction with the quality of the electric service since the private company took over the distribution of the energy grid. This reality has moved people on this sample to purchase solar systems. However, there is still a large number of people who have not been able to transition to solar energy due to economic limitations. In Puerto Rico, this is a large sector of the population because of the high poverty rates.

The PR Census Bureau estimates that 39% of Puerto Rican families live under the poverty line, while 6 out of 10 children experience poverty according to the Youth Development Institute (Instituto de Desarrollo de la Juventud, 2023; Red State Data Center de Puerto Rico, 2022). This points to the need to create financial aid programs for impoverished families and communities to install solar panels and batteries. For communities this may mean having critical infrastructure such as communal centers powered by solar and equipped with appliances (refrigerators), computers (educational purposes for children) and outlets for people to use their medical equipment.

Energy inconsistency seems to have grave consequences for people’s mental health. There are also physical health concerns related to energy inconsistency. There is a high prevalence of physical health issues that require in-home treatment and equipment powered by electricity. Not being able to have a consistent source of energy can deteriorate people’s health and even become a life or death situation.

A key finding is that people who do not have a solar system, state that economic limitations are the main reason. This highlights the need for financial subsidies for people with low socioeconomic status (SES) to help them transition to solar energy.

A limitation of this stage of the study is that it appears that we have an overrepresentation of middle to high income families. Although we did not ask about SES, the fact that most people have private health insurance and that those who have solar systems bought them using their savings, points to an underrepresentation of low SES families. It is important for a follow up study to explore different sampling methods to enhance the SES diversity of the sample. This is key for establishing energy justice models.

**2. Raw results from the main questions.**

**Table 1. Satisfaction with the amount of household energy used.**

*Q18 - 9. ¿Cuán satisfecho te sientes con la cantidad de energía que utilizas en tu hogar?*

Respuestas	Número de respuestas	%
Muy satisfecho	88	12.84
Satisfecho	391	57.08
Insatisfecho	152	22.19
Muy insatisfecho	54	7.89
Total (N)	685	

Nota. Total 789 participantes. 685 respondieron el reactivo.

**Table 2. Quality of service since LUMA administers energy distribution.**

*Q21 - 12. ¿Desde que la compañía LUMA administra el sistema de distribución energética del país (1 de junio del 2021), cómo evalúa usted la calidad del servicio?*

Respuestas	Número de respuestas	%
Mejor que antes	64	9.27%
No he visto cambios en la calidad	172	24.93%
Peor calidad que antes	454	65.80%
Total (N)	690	

Nota. Total 789 participantes. 690 respondieron el reactivo.

**Table 3. Satisfaction with LUMA's customer service.**

*Q22 - 13. ¿Cuán satisfecho/a se siente con el servicio al cliente de LUMA Energy?*

Respuestas	Número de respuestas	%
Muy satisfecho	21	3.05%
Satisfecho	114	16.55%
Insatisfecho	193	28.01%
Muy insatisfecho	259	37.59%
no he requerido servicio al cliente	102	14.80%
Total(N)	689	

Nota. Total 789 participantes. 689 respondieron el reactivo.

**Table 4. Satisfaction with the type of financing used for solar energy systems.**

*Q26 - 23. ¿Cuán satisfecho se siente con el tipo de financiamiento que utilizó para obtener su sistema de placas solares?*

Respuestas	Número de respuestas	%
Muy satisfecho	90	60.81
Satisfecho	49	33.11
Insatisfecho	8	5.40
Muy insatisfecho	1	0.68
Total (N)	148	

Nota. Total 789 participantes. 148 respondieron el reactivo.

**Table 5. Amount of knowledge about residential renewable energy systems.**

*Q29 - 26. ¿Cuánto conocimiento diría usted que tiene sobre los sistemas residenciales de energía renovable (energía solar)?*

Respuestas	Número de respuestas	%
Mucho conocimiento	24	13.79
Bastante conocimiento	75	43.10
Regular	60	34.50
Poco conocimiento	13	7.47
Ningún conocimiento	2	1.14
Total(N)	174	

Nota. Total 789 participantes. 148 respondieron el reactivo.

**Table 6. Satisfaction with the solar energy system's purchase process.**

*Q30 - 27. ¿Cuán satisfecho se siente con el proceso de compra?*

Respuestas	Número de respuestas	%
Muy satisfecho	94	54.66
Satisfecho	72	41.86
Insatisfecho	4	2.32
Muy insatisfecho	2	1.16
Total (N)	172	

Nota. Total 789 participantes. 172 respondieron el reactivo.

**Table 7. Satisfaction with information provided before purchasing a solar energy system.**

*Q31 - 28. ¿Cuán satisfecho se siente con la información que se le ofreció durante el proceso de compras del sistema de energía solar?*

Respuestas	Número de respuestas	%
Muy satisfecho	76	44.70
Satisfecho	82	48.23
Insatisfecho	10	5.90
Muy insatisfecho	2	1.17
Total (N)	170	

Nota. Total 789 participantes. 170 respondieron el reactivo.

**Table 8. Evaluation of cost of solar systems purchased.**

*Q32 - 29. Siento que el costo del sistema de placas solares que compré fue...*

Respuestas	Número de respuestas	%
Muy alto	49	28.32
Apropiado	114	65.89
Más barato de lo que esperaba	10	5.79
Total (N)	173	

Nota. Total 789 participantes. 173 respondieron el reactivo.

**Table 9. Satisfaction with solar systems' performance after Hurricane Fiona.**

*Q33 - 30. ¿Cuán satisfecho se sintió con el funcionamiento de las placas solares luego del Huracán Fiona?*

Respuestas	Número de respuestas	%
Muy satisfecho	112	67.47
Satisfecho	46	27.72
Insatisfecho	6	3.61
Muy insatisfecho	2	1.20
Total (N)	166	

Nota. Total 789 participantes. 166 respondieron el reactivo.

**Table 10. Exacerbation of mental health symptoms associated with blackouts**

*Q43 ¿Siente que los apagones aumentan los síntomas asociados con su condición de salud mental?*

Respuestas	Número de respuestas	%
Si	122	91.73
No	11	8.27
Total (N)	133	

Nota. Total 789 participantes. 133 respondieron el reactivo.

### References

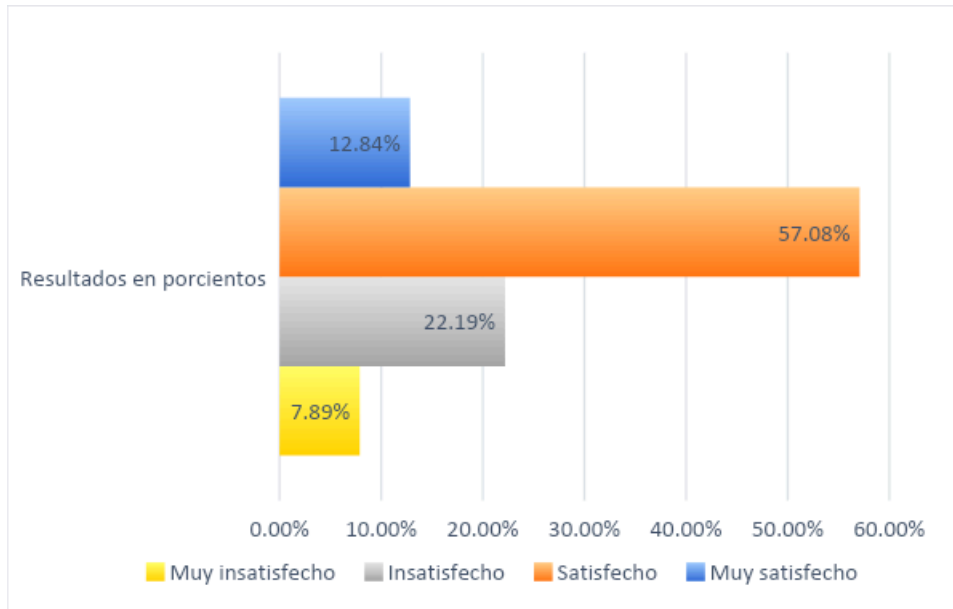
Child and Youth Well-Being Index & Municipal WellBeing Index 2023. San Juan: Instituto del Desarrollo de la Juventud, 2023.

Red State Data Center de Puerto Rico, 2022. Baja levemente el porcentaje de familias en pobreza en Puerto Rico. Retrieved from <https://censo.estadisticas.pr/Comunicado-de-prensa/2022-03-17t175803>

## Appendix

**Figure 1**

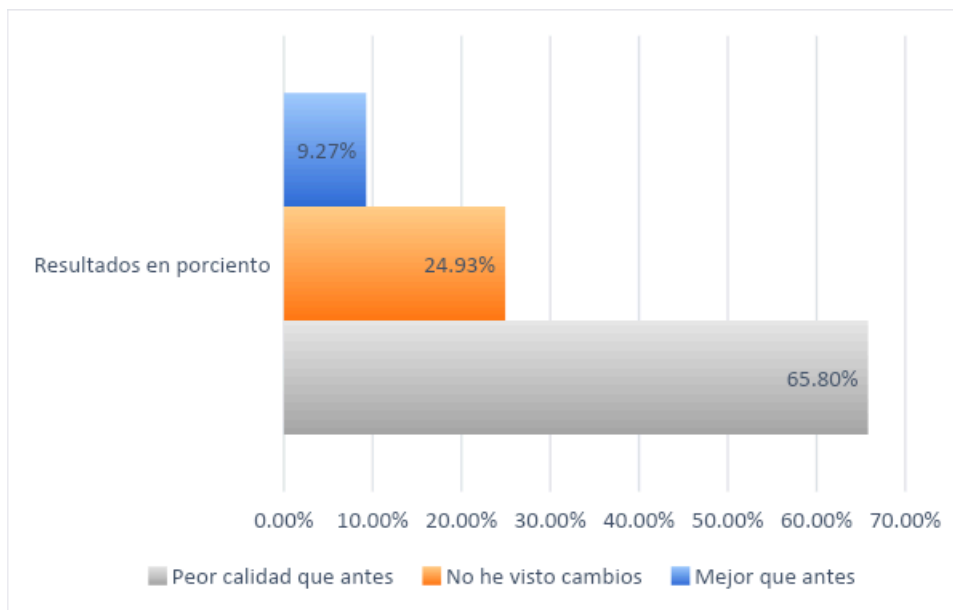
*Q18 - 9. ¿Cuán satisfecho te sientes con la cantidad de energía que utilizas en tu hogar?*





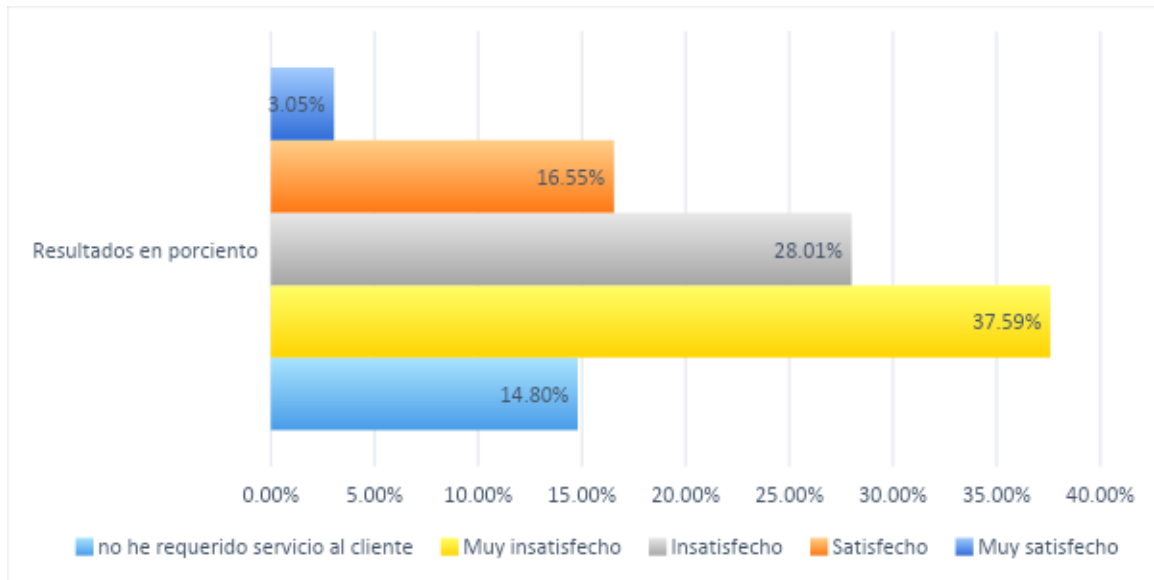
**Figure 2**

Q21 - 12. ¿Desde que la compañía LUMA administra el sistema de distribución energética del país (1 de junio del 2021), cómo evalúa usted la calidad del servicio?



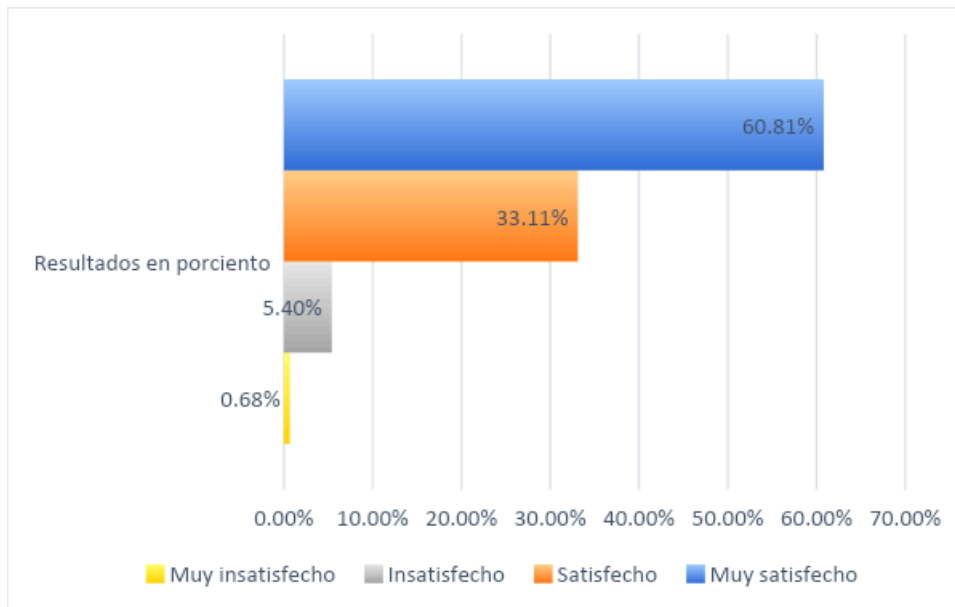
**Figure 3**

Q22 - 13. ¿Cuán satisfecho/a se siente con el servicio al cliente de LUMA Energy?



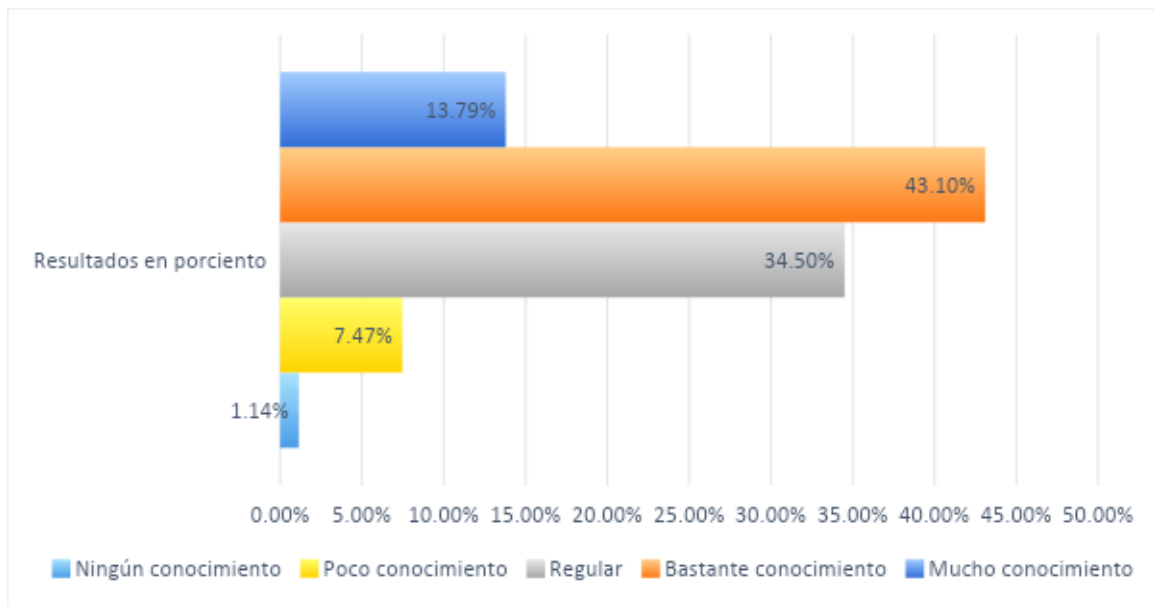
**Figure 4**

Q26 - 23. ¿Cuán satisfecho se siente con el tipo de financiamiento que utilizó para obtener su sistema de placas solares?



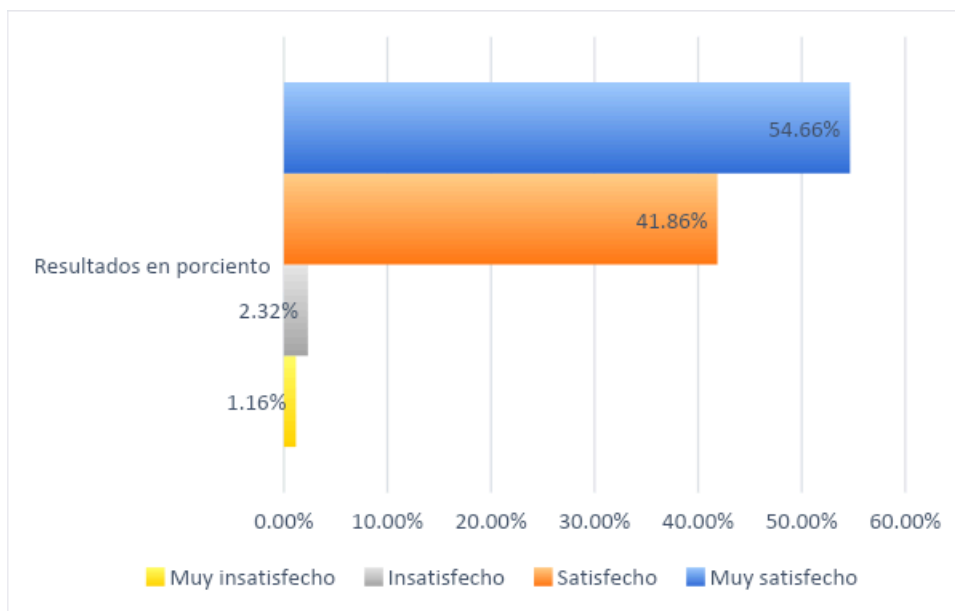
**Figure 5**

Q29 - 26. ¿Cuánto conocimiento diría usted que tiene sobre los sistemas residenciales de energía renovable (energía solar)?



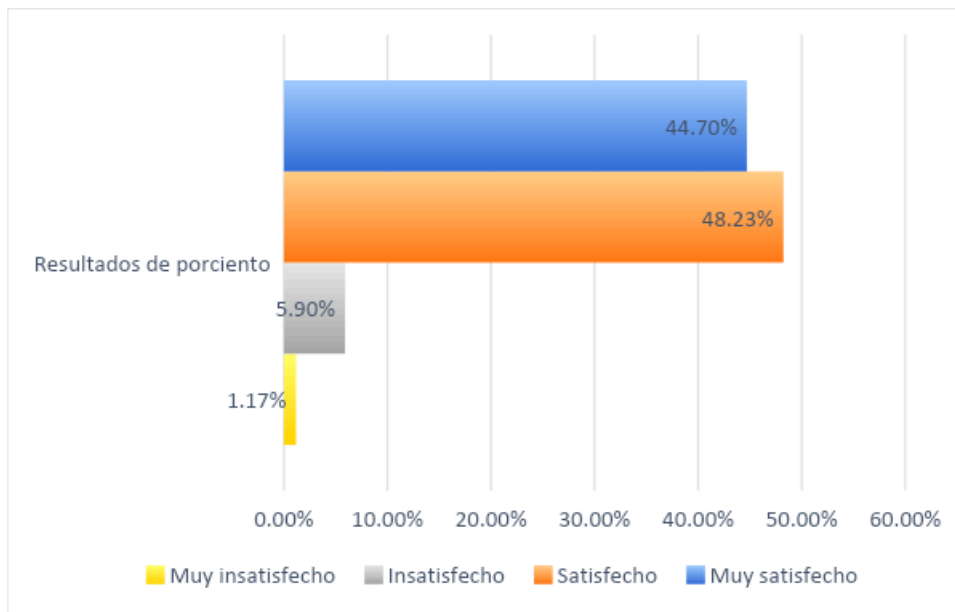
**Figure 6**

Q30 - 27. ¿Cuán satisfecho se siente con el proceso de compra?



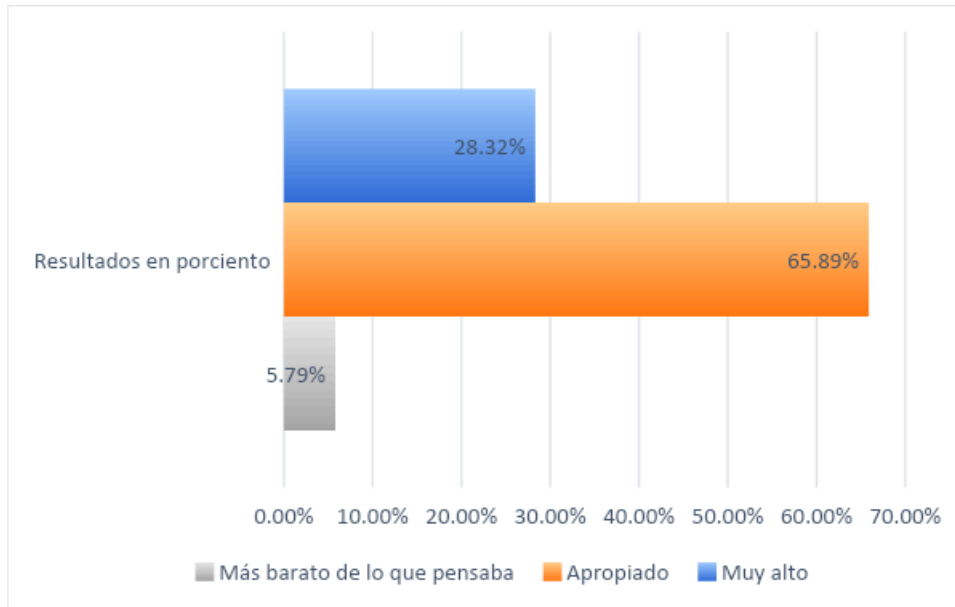
**Figure 7**

*Q31 - 28. ¿Cuán satisfecho se siente con la información que se le ofreció durante el proceso de compras del sistema de energía solar?*



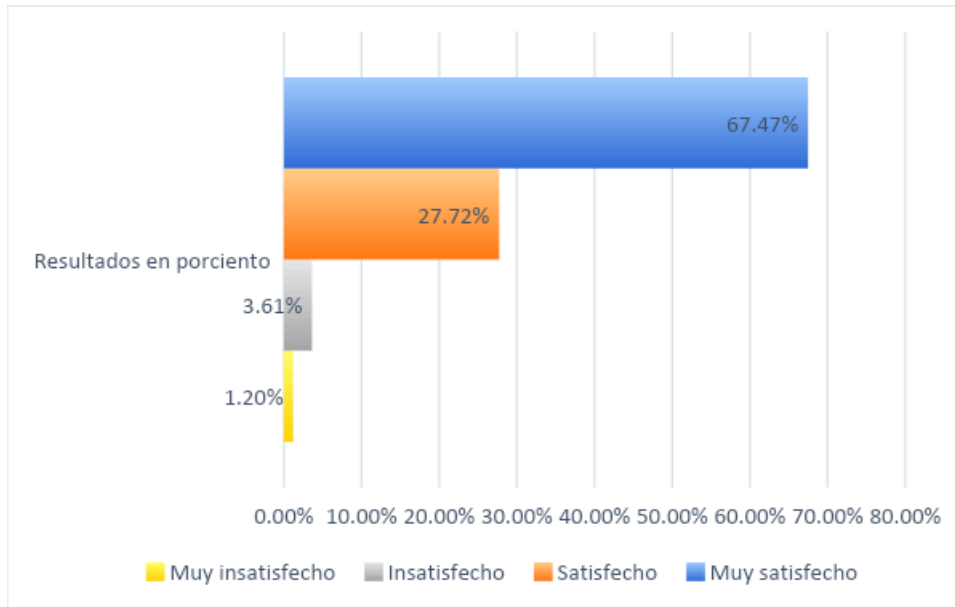
**Figure 8**

*Q32 - 29. Siento que el costo del sistema de placas solares que compré fue...*



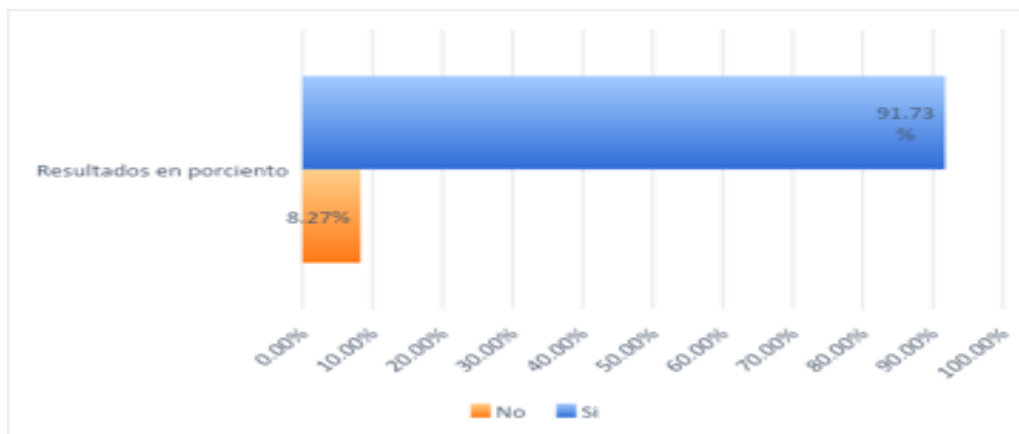
**Figure 9**

Q33 - 30. ¿Cuán satisfecho se sintió con el funcionamiento de las placas solares luego del Huracán Fiona?



**Figure 10**

Q43. ¿Siente que los apagones aumentan los síntomas asociados a su condición de salud mental?



### **3. Acknowledgements**

Funding was provided by the U.S. Federal Emergency Management Agency and performed under the technical management of the Department of Energy Grid Deployment Office. The views expressed in the article do not necessarily represent the views of the DOE, FEMA, or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.