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An opinion on minimizing the need for agricultural and public areas while renewable energy production capacity is increasing rapidly

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1 Introduction

The United States is making plans to meet a significant portion of its energy needs from renewable sources and aims to achieve this goal by 2030 (US. Department of Energy, 2021). In the process of achieving this goal, many agricultural and public areas will need to be converted into energy production sites. Starting from November 2021, the Bureau of Land Management (BLM) approved the use of some public areas for renewable energy production, signaling the start of this process (Bureau of Land Management, 2021). The Solar Projects shown in Figure 1, provided by SEIA, can give an idea in this regard.

Different perspectives can be considered regarding additional land requirements to achieve renewable energy production targets. For instance, while some studies state that renewable energy production areas may have negative effects on natural life (Gasparatos et al., 2017; Dhar et al., 2020; Rahman et al., 2022), another study argues that the land demand envisaged for renewable energy production will constitute approximately 1% of the country's land and that this should not be exaggerated (Union of Concerned Scientists, 2023). On the other hand, some studies provide data showing that there is already plenty of room for renewable energy production within the residential and industrial areas we currently use. For instance, a technical report by OSTI.gov states that roofs in the United States of America have the potential to meet 39% of the required electrical energy (Gagnon et al., 2016), similarly, another study mentions that the existing roofs of the United States can potentially meet all of the country's solar energy needs (Joshi et al., 2021).

While it's unrealistic to completely avoid using agricultural and public areas in renewable energy production, minimizing the impact on these areas and untouched nature is crucial. Although environmental impacts have been considered in the planning process so far, the primary goal seems to be achieving the required energy production capacity by 2030 (US. Department of Energy, 2021). To avoid criticisms about harming nature in the coming years, it needs to be more careful in renewable energy production planning. This, of course, requires addressing the technical and economic dimensions of the issue, determining priority methods to minimize the need for agricultural and public areas in renewable energy production, making legal regulations, and establishing necessary incentives.

This article presents an opinion on methods that can be used to minimize the need for agricultural and public areas in renewable energy production. It emphasizes the importance

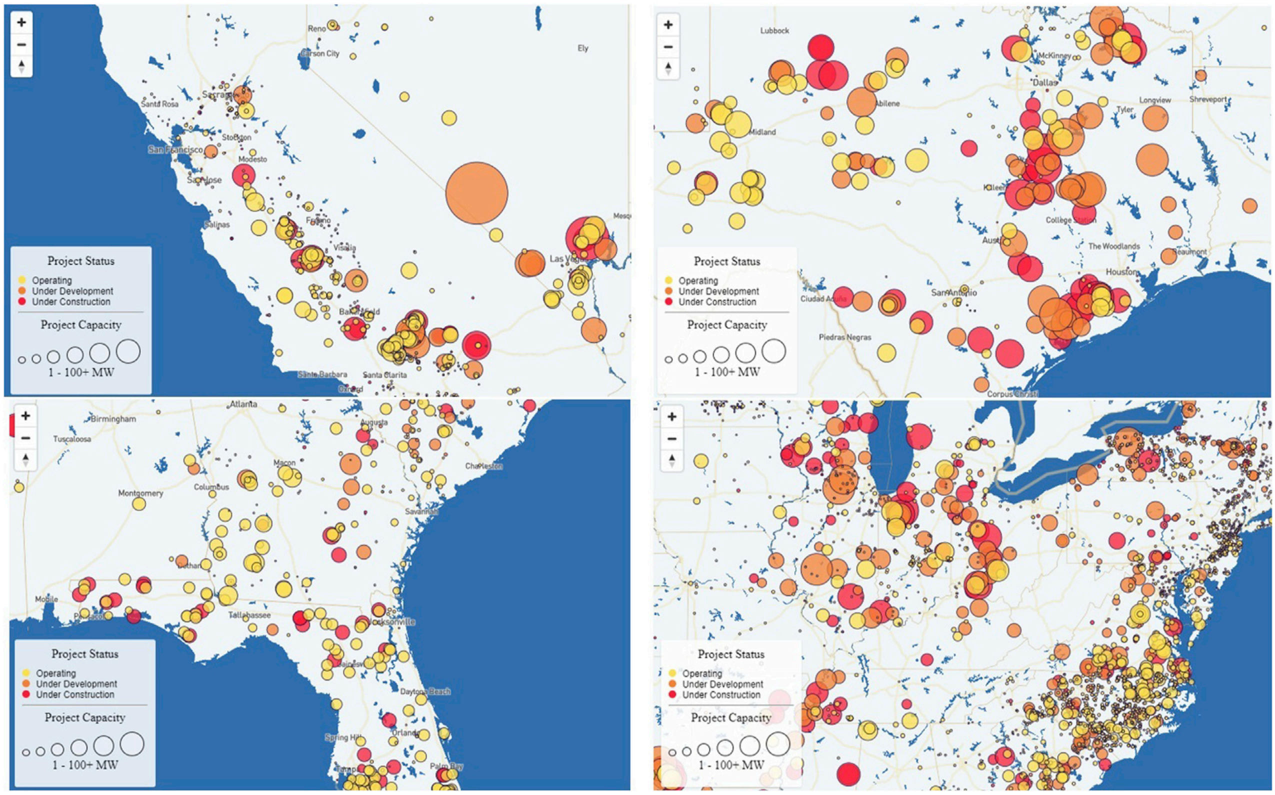

FIGURE 1
Major solar project started at the United States (SEIA, 2023).

of prioritizing methods, discusses potential obstacles in implementation, and offers solutions to overcome these obstacles. The most important method proposed is to focus on renewable energy production as much as possible within existing residential, and industrial areas. The article introduces two new concepts in its solution proposals: the leasing of roofs in residential areas for solar energy production and the installation of energy storage systems in residential areas, with their organization and commercial operation handed over to energy providers.

2 Renewable energy production in residential areas

A significant majority of electricity consumption in the United States of America takes place in residential areas (U.S. Energy Information Administration, 2022). Given that natural habitats are already fully or partially disrupted in residential and industrial areas, focusing on renewable energy production in these areas seems to be a viable solution to reduce the need for extra land. Additionally, producing electricity where it's predominantly consumed has long been known as an effective way to minimize losses. In this context, the first idea that comes to mind is to prioritize residential areas and ensure that Solar PV technology is extensively used in these areas for renewable energy production. However, in practice, there are barriers to using Solar PV technology in almost half of the residential areas (Sigrin and Mooney, 2018; Reames, 2020). Some of these barriers are listed below along with proposed solutions.

2.1 Barriers rising from physical conditions

Factors like roof orientation and inclination not being suitable for efficient solar harvest, roofs not being structurally strong enough to support solar panels, and shading from trees and neighboring buildings pose significant physical barriers (Li et al., 2020; Kiray, 2021). To overcome the obstacles arising from physical conditions, alternative solutions should be offered that allow Solar PV panels to be placed in suitable sun-exposed places other than the roofs of houses or garages. Projects and products that contribute to these solutions should be supported. For example, the RRSTS project combined a gazebo with a Sun tracking system to create an aesthetically pleasing solution (Kiray, 2021). Gazebos in such applications can be placed in various spots within gardens. Similarly, Smart Flower Sun tracking products, with their aesthetic design, are suitable for use in gardens and green spaces (Mulyana et al., 2018).

Another solution could be the dissemination of community applications that allow cooperation between neighbors in energy production and sharing and supporting them with incentives. Various models have been developed for such systems and are already in use (Michaud, 2020; Tabassum et al., 2021). The use of these systems can make significant contributions to overcoming barriers arising from physical conditions. Barriers Rising from Socio-economic Conditions.

2.2 Barriers rising from socio-economic conditions

It is stated in the supplementary report presented within the scope of Solar Future Studies that; There are different barriers according to whether people living in residential areas are homeowners and tenants, are middle and low-income individuals, and even have low credit scores (Heeter et al., 2021). Specific strategies must be developed to overcome such barriers, and this opinion article introduces a new concept to contribute to the solution. This concept: The roofs of houses in city centers can be rented in the same way as lands outside the city are rented for solar energy production. When a roof is rented for solar PV installation, the rental fee can be a reasonable amount that will offset the increase in insurance costs and contribute to the home's electricity bill. Data from solar calculator websites show that such applications are realistic and reasonable (Aurora Solar, 2023; NREL, 2023; SunPower, 2023). With such an application, the low income of the landlord or the low credit score can turn into an advantage. Similar practices can be extended to rental properties as well. By using Micro-inverter in Solar PV systems to be installed in such houses, it can be ensured that the entire electronic system is gathered on the roof and thus the tenants are less disturbed (Sivaraman and Sharmeela, 2020; Lagarde et al., 2021).

3 Renewable energy storage in residential areas

Another method to minimize the need for agricultural and public areas in renewable energy production can be to store surplus energy generated at night from renewable sources and use it during daylight hours. Thus, the need for new energy production systems can be reduced. However, it's important to clarify that if energy storage isn't pursued within residential and industrial areas, the same way extra land is needed for renewable energy production, extra land would be required for energy storage systems as well. An average of 1,000 square meters of space per MWh is needed for battery-based energy storage systems (Convergent, 2023; Convergent, 2023).

Due to concerns and barriers surrounding the concept of residential energy storage, these applications are not widely used today. Some of these concerns and barriers are discussed below and expanded upon with proposed solutions.

3.1 Concerns

As of today, the most suitable technology for storing electrical energy in residential areas seems to be battery technology. However, battery-based energy storage systems are both relatively expensive, short-lived, and mostly harmful to the environment. Therefore, residential energy storage systems, which aim to reduce the need for new energy production areas by transferring the surplus energy produced at night to daytime hours and thus protect agricultural and public areas, should prefer battery systems that cause the least harm to the environment. When battery technologies are compared, it is seen that suitable alternatives can be found (Wang et al., 2018; Hannan et al., 2021; Mrozik et al., 2021).

3.2 Barriers

The existence of many energy storage systems currently in use may lead to the belief that energy storage in residential areas is unnecessary. We can list two of these alternatives as follows. First, to identify special areas for energy storage and to store very high volumes of energy in these areas using technologies such as pumped hydro energy storage systems (Rehman et al., 2015; Blakers et al., 2021) or compressed air energy storage systems (Olabi et al., 2021; Bazdar et al., 2022). The second is that energy storage is also carried out in places where renewable energy is produced. The importance of such energy storage systems cannot be denied, but just like energy production, consuming and storing energy in the same place has a significant advantage in preventing energy losses. The fact that energy is consumed mostly in residential areas in the United States shows the necessity of energy storage in residential areas.

The other and most significant barrier to the adoption of residential energy storage is that profitability can't be generalized. Many factors influence the profitability of a residential energy storage system. NREC mentions these factors in a blog post (NREL blog, 2018). Factors like the presence of numerous energy providers in the United States of America, each with their pricing policies, make relying on end consumers for residential energy storage applications impractical.

This opinion article also introduces a new concept in this regard. This concept: The organization and commercial operation of energy storage systems in residential areas should be carried out by energy companies. Because the capabilities and flexibility required to make energy storage attractive in residential areas are characteristics of energy companies, not end consumers (RAP, 2016).

For instance, a model like this can be used. Energy companies place energy storage systems in residential areas, such a system can be called "Residential Area Energy Storage System," or RAESS. Thanks to the energy company RAESS, it sells very cheap night electricity at the highest electricity price during the day at convenient times. A part of the profit obtained is reflected as a suitable discount on the electricity bill of the house where the RAESS is placed, and a part is allocated to cover the investment cost of the RAESS system. Therefore, both producers, energy companies and end users can benefit from such applications.

If the residential energy storage concept is developed, further advantages can be achieved. For instance, roofs or gardens of all houses and apartments in residential areas may not be suitable for renewable energy generation, on the contrary, a suitable place can be reserved for energy storage systems in many houses and apartments. Therefore, a much higher potential for stored energy use than anticipated can be achieved and it can contribute to reducing the need for extra areas for energy production and storage. In addition, the expansion of energy storage in residential areas can be a factor that encourages renewable energy production. Because a person who installs an energy storage system in his house already has installed 70% of the system required for solar energy production.

Energy storage in industrial areas can be considered more advantageous than residential areas. Since larger areas can be found in these areas, it is possible to use less damaging, cheaper and longer-lasting energy storage systems (Dehghani-Sanij et al., 2019; Hossain et al., 2020). If these places can store more energy than they need, this can be considered an extra benefit.

4 Discussion

The opinion presented in this article argues that we need to develop some methods to minimize the need for agricultural and public areas by increasing the renewable energy production and storage capacity in Residential and Industrial areas and discusses the priority methods it has determined. These methods are summarized in the following items. At the same time, these articles are both a conclusion, a recommendation for the institutions organizing the legal regulations and incentives, and an invitation to some scientific studies that need to be done.

To minimize the need for agricultural and public areas while expanding renewable energy production:

It should support the production of energy where it is consumed. In other words, residential areas where energy is consumed the most should be considered as the priority areas for renewable energy production.

Incentives should be provided to support products and projects that hinder renewable energy production in residential areas and aim to overcome obstacles arising from physical conditions.

Energy storage in industrial and residential areas should be supported and this issue should be considered as a priority issue.

For energy storage in residential areas, battery systems that are less harmful to nature should be given priority and incentives should be arranged accordingly.

Energy storage applications in residential areas should be left to energy companies and legal regulations should be made for them to place energy storage systems and operate these systems commercially.

It should make legal regulations and give incentives that allow roofs or other suitable places in residential areas to be rented for renewable energy generation. Feasibility studies on this subject should also be supported.

This opinion article will be supported by some new articles containing simulation studies. In these simulations, the last two issues presented above, namely, two new concepts, will be addressed.

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References

Aurora Solar (2023). Solar PV calculator. https://www.aurorasolar.com (Accessed August 25, 2023).

Bazdar, E., Sameti, M., Nasiri, F., and Haghighat, F. (2022). Compressed air energy storage in integrated energy systems: a review. *Renew. Sustain. Energy Rev.* 167, 112701. doi:10.1016/j.rser.2022.112701

Blakers, A., Stocks, M., Lu, B., and Cheng, C. (2021). A review of pumped hydro energy storage. *Prog. Energy* 3 (2), 022003. doi:10.1088/2516-1083/abeb5b

Bureau of Land Management (2021). Bureau of land management. https://www.blm.gov/programs/energy-and-minerals/renewable-energy (Accessed August 25, 2023).

Convergent (2023). How much space will the system require?https://www.convergentep.com/landowners/ (Accessed August 25, 2023).

Dehghani-Sanij, A. R., Tharumalingam, E., Dusseault, M. B., and Fraser, R. (2019). Study of energy storage systems and environmental challenges of batteries. *Renew. Sustain. Energy Rev.* 104, 192–208. doi:10.1016/j.rser.2019.01.023

Dhar, A., Naeth, M. A., Jennings, P. D., and El-Din, M. G. (2020). Perspectives on environmental impacts and a land reclamation strategy for solar and wind energy systems. *Sci. total Environ.* 718, 134602. doi:10.1016/j.scitotenv.2019.134602

Gagnon, P., Margolis, R., Melius, J., Phillips, C., and Elmore, R. (2016). Rooftop solar photovoltaic technical potential in the United States. A detailed assessment *(No. NREL/TP-6A20-65298)*. Golden, CO (United States): National Renewable Energy Lab.

Gasparatos, A., Doll, C. N., Esteban, M., Ahmed, A., and Olang, T. A. (2017). Renewable energy and biodiversity: implications for transitioning to a green economy. *Renew. Sustain. Energy Rev.* 70, 161–184. doi:10.1016/j.rser.2016.08.030

Hannan, M. A., Wali, S. B., Ker, P. J., Abd Rahman, M. S., Mansor, M., Ramachandaramurthy, V. K., et al. (2021). Battery energy-storage system: a review of technologies, optimization objectives, constraints, approaches, and outstanding issues. *J. Energy Storage* 42, 103023. doi:10.1016/j.est.2021.103023

Heeter, J., Sekar, A., Fekete, E., Shah, M., and Cook, J. J. (2021). *Affordable and accessible solar for all: barriers, solutions, and on-site adoption potential (No. NREL/TP-6A20-80532)*. Golden, CO (United States): National Renewable Energy Lab.

Hossain, E., Faruque, H. M. R., Sunny, M. S. H., Mohammad, N., and Nawar, N. (2020). A comprehensive review on energy storage systems: types, comparison, current scenario, applications, barriers, and potential solutions, policies, and future prospects. *Energies* 13 (14), 3651. doi:10.3390/en13143651

Joshi, S., Mittal, S., Holloway, P., Shukla, P. R., Ó Gallachóir, B., and Glynn, J. (2021). High resolution global spatiotemporal assessment of rooftop solar photovoltaics potential for renewable electricity generation. *Nat. Commun.* 12 (1), 5738. doi:10.1038/s41467-021-25720-2

Kiray, V. (2021). A research study to increase usage of PVs in residential areas. *Front. Energy Res.* 9, 680304. doi:10.3389/fenrg.2021.680304

Lagarde, Q., Beillard, B., Mazen, S., Denis, M. S., and Leylavergne, J. (2021). Performance ratio of photovoltaic installations in France: comparison between inverters and micro-inverters. *J. King Saud University-Engineering Sci.* doi:10.1016/j.jksues.2021.11.007

Li, H. X., Zhang, Y., Edwards, D., and Hosseini, M. R. (2020). "Improving the energy production of roof-top solar PV systems through roof design," in *Building simulation* (Tsinghua University Press), 13, 475–487.

Michaud, G. (2020). Perspectives on community solar policy adoption across the United States. *Renew. Energy Focus* 33, 1–15. doi:10.1016/j.ref.2020.01.001

Mrozik, W., Rajaeifar, M. A., Heidrich, O., and Christensen, P. (2021). Environmental impacts, pollution sources and pathways of spent lithium-ion batteries. *Energy & Environ. Sci.* 14 (12), 6099–6121. doi:10.1039/d1ee00691f

Mulyana, T., Sebayang, D., Fajrina, F., and Faizal, M. (2018). "Design and analysis of solar smart flower simulation by solidwork program," in *IOP conference series: materials science and engineering* (IOP Publishing), 343, 012019.

NREL (2023). PVWatts calculator. https://pvwatts.nrel.gov (Accessed August 25, 2023).

NREL blog (2018). When does energy storage make sense?https://www.nrel.gov/state-local-tribal/blog/posts/when-does-energy-storage-make-sense-it-depends.html) [Accessed 8/25/2023].

Olabi, A. G., Wilberforce, T., Ramadan, M., Abdelkareem, M. A., and Alami, A. H. (2021). Compressed air energy storage systems: components and operating parameters–A review. *J. Energy Storage* 34, 102000. doi:10.1016/j.est.2020.102000

Rahman, A., Farrok, O., and Haque, M. M. (2022). Environmental impact of renewable energy source based electrical power plants: solar, wind, hydroelectric, biomass, geothermal, tidal, ocean, and osmotic. *Renew. Sustain. Energy Rev.* 161, 112279. doi:10.1016/j.rser.2022.112279

RAP (2016). Electricity regulation in the us: a guide (second edition). https://www.raponline.org/knowledge-center/electricity-regulation-in-the-us-a-guide-2/ (Accessed August 25, 2023).

Reames, T. G. (2020). Distributional disparities in residential rooftop solar potential and penetration in four cities in the United States. *Energy Res. Soc. Sci.* 69, 101612. doi:10.1016/j.erss.2020.101612

Rehman, S., Al-Hadhrami, L. M., and Alam, M. M. (2015). Pumped hydro energy storage system: a technological review. *Renew. Sustain. Energy Rev.* 44, 586–598. doi:10.1016/j.rser.2014.12.040

SEIA, (2023). SEIA. https://www.seia.org/research-resources/major-solar-projects-list) [Accessed 8/25/2023].

Sigrin, B. O., and Mooney, M. E. (2018). Rooftop solar technical potential for low-to-moderate income households in the United States *(No. NREL/TP-6A20-70901)*. Golden, CO (United States): National Renewable Energy Lab.

Sivaraman, P., and Sharmeela, C. (2020). "Solar micro-inverter," in *Handbook of research on recent developments in electrical and mechanical engineering* (IGI Global), 283–303.

SunPower (2023). Free solar cost calculator. http://go.sunpower.com (Accessed August 25, 2023).

Tabassum, S., Rahman, T., Islam, A. U., Rahman, S., Dipta, D. R., Roy, S., et al. (2021). Solar energy in the United States: development, challenges and future prospects. *Energies* 14 (23), 8142. doi:10.3390/en14238142

US. Department of Energy (2021). *Solar futures study report*. US. Department of Energy. https://www.energy.gov/sites/default/files/2021-09/Solar%20Futures%20Study.pdf (Accessed August 25, 2023).

U.S. Energy Information Administration (2022). Energy consumption ratios in the USA. https://www.eia.gov/energyexplained/electricity/use-of-electricity.php (Accessed August 25, 2023).

Wang, Q., Liu, W., Yuan, X., Tang, H., Tang, Y., Wang, M., et al. (2018). Environmental impact analysis and process optimization of batteries based on life cycle assessment. *J. Clean. Prod.* 174, 1262–1273. doi:10.1016/j.jclepro.2017.11.059