A New Approach to Developing Community Solar Projects for LMI Communities in ERCOT's Competitive Electricity Markets

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***Abstract*—The development of Community Solar (CS) projects across the United States has increased in the last decade because of benefits like the reduction in the cost of solar and the avoidance of upfront capital costs common for standalone solar home systems (SHS). Many communities, cities and states have turned to CS projects to meet their climate action plans, renewable energy portfolios, and sustainability goals. CS projects can also be used to reduce energy bills for low-to-moderate income (LMI) communities. This is not the case in Texas. Due to the unique characteristics of the Texas electricity market, deploying CS projects can prove difficult. In this paper we discuss some of these characteristics. We also introduce and discuss a new community solar (CS) model that focuses on increasing under resourced, underrepresented and LMI income communities' access to clean energy technologies while reducing their high energy burdens in the process in the competitive ERCOT electricity markets in Texas.**

Keywords—Community Solar, LMI, energy dividends, ERCOT

I. Introduction

Due to the deregulation of the Texas electricity markets in the early 2000s, which ensured that electricity is sold at a price close to the marginal cost of supplying it, Texas has some of the lowest electricity prices relative to the national average [1]. But many low and moderate income (LMI) Texan households still experience high energy burdens (EB). Many American researchers agree that an EB greater than 6% is high and greater than 10% is severe [2], [3]. In Texas there are 3.7 million households that live below 80% of the Area Median Income (AMI). Households within 30-60% AMI experience an energy burden of 7% and those 0-30% AMI experience extremely high energy burdens at 15% [4].

Traditionally LMI communities in Texas have been underserved by clean energy investment opportunities, like solar and storage installations. Studies have shown that community solar (CS) can be an effective alternative to centralized utilities [5]. And CS has been shown to expand clean energy access to single and multifamily homes who cannot afford the cost of the upfront cost of single home solar systems or where solar installation is physically inadequate [6], [7].

Due to the diverse nature of the Texas electricity market, the deployment of CS in the competitive ERCOT market has proven difficult from an economic standpoint, because of very low margins for retail electric providers (REPs) [8]. Most CS installations have been done in the non-competitive ERCOT and non ERCOT markets. According to a 2020 study there have been eighteen CS projects in Texas since 2015, and only four have been in the ERCOT competitive market [8].

In this paper we introduce the LMI Community Impact Solar (LMI CIS) program, a novel model that allows for the economical deployment of CS in ERCOT's competitive market, potentially addressing these two problems of high energy burdens and lack of access to clean energy investments in Texas.

Finally, while this model was being developed Texas experienced a statewide blackout which left over 4 million households without gas, electricity, or water, due to winter storm Uri [9]. This has led to an increased awareness of the Texas electricity grid and its operator the Electric Reliability Council of Texas (ERCOT) [10]. Considering this we also give a brief description of the Texas electricity market and ERCOT. It is important to note that this paper does not discuss the causes and effects of the 2021 blackouts. It just presents an overview of the Texas electricity market and shows how its unique characteristics make the development of traditional LMI community solar projects difficult. The authors direct the reader to the paper and report by Busby et al. 2021 and Jones et. al 2021, Harmon et. al (the latter two papers were written by the authors of this paper), which discusses the blackouts and its effects [9] [10], [29].

II. Brief overview of the Texas electricity market

The Texas electricity landscape is highly diverse, complex and- fairly unique. There are three interconnections that make up the U.S mainland electric grid – the Eastern, Western, and

Texas interconnections. Figure 1 shows the interconnection map for the mainland U.S. electric grid. The Texas electric grid is managed and operated by the entity called ERCOT. ERCOT is a "membership-based 501(c)(4) nonprofit corporation, governed by a board of directors and subject to oversight by the Public Utility Commission of Texas and the Texas Legislature" [11].

The story of the entity that is currently known ERCOT began in 1927, with the landmark Supreme Court ruling in *Rhode Island PUC v. Attleboro Steam and Electric Co.* where the court held that states were constitutionally prohibited from regulating or controlling the prices of electricity generated in the state and sold across state lines [12]. Due to the gap in any Federal legislation for the interstate commerce of electricity, congress passed the Federal Power Act in 1935, which gave the Federal power Commission (FPC) – now the Federal Energy Regulatory Commission (FERC) – the power to develop rates and conditions for the interstate sale and transmission of electricity [13]. The law denied the FPC (now FERC) jurisdiction "over facilities used for the generation of electric energy or over facilities used in local distribution or only for the transmission of electric energy in intrastate commerce, or over facilities for the transmission of electric energy consumed wholly by the transmitter" [14]. In response to this Texas utilities "elected to isolate their properties from interstate commerce", and thus were beyond the reach of federal regulation [15].

In 1970, ERCOT was created as a voluntary membership organization by Texas utilities to provide the services of a regional electric reliability council, whose members joined on the understanding that if any utility in Texas decided to make interstate interconnections other utility members would sever their connections to that utility – hence preserving the intrastate character of ERCOT [15].

In 1975, the Texas legislature passed the Public Utility Regulatory Act (PURA) to regulate the state's energy market [16]. And for the first time in almost a century after the first commercial central electric power plant came online on Pearl Street in Manhattan, New York city, Texas' electricity market came under the regulation of a government entity [15]. PURA led to the creation of the Public Utility Commission of Texas (PUCT) which had jurisdiction over ERCOT.

Today as authorized by state statutes ERCOT is the independent systems operator (ISO) responsible for overseeing the reliability of electric transmission to over 25 million customers (over 90% of electric load) in Texas and administering the retail and wholesale electricity markets.

A. Deregulation of the Texas electricity market

In 1995, the Texas legislature passed an amendment (Senate Bill 373) to the Public Utility Regulatory Act, which effectively deregulated the electricity market in Texas, allowing for competition in the wholesale market [1], [17]. By 1999, the Texas Senate passed Bill 7 which effectively unbundled utilities into generation companies, transmission and distribution entities, breaking the vertical integrated business model. It included a new entity called the retail electricity provider (REP). This was done to allow for competition in the retail market, in hopes that it would lead to lower electricity prices and give more options to customers [1], [17]. Utilities under the local political authorities like municipalities (munis) and cooperatives (coops) were given a choice to opt into the retail competitive market [1], [17]. While munis and coops do not have a competitive retail market, they generally buy electricity on the ERCOT wholesale market and then sell to their customers. ERCOT was given the responsibility of administering both the wholesale and the retail markets.

B. ERCOT and non-ERCOT electrcity markets

ERCOT covers about 90% of electric load in Texas [11]. While the other 10% of electric load in Texas is not under the ISO ERCOT, they are under the jurisdiction and have their retail rates regulated by the PUCT [18]. Refer to table 1 for the residential customer count of all utility types in Texas. The utilities in the non-ERCOT market are considered the – investor owned vertically integrated utilities (VIUs). Some of the non-ERCOT VIUs include El Paso Electric, Southwestern Electric Power Company (SWEPCo), Entergy Texas and Southwestern Public Service (Xcel Energy).

The ERCOT utilities are usually referred to as the transmission and distribution utilities (TDUs). The TDUs provide the transmission and distribution services for the wholesale and retail sale of electricity.

REPs buy electricity from generators on the wholesale market and then sell the electricity to customers. The TDU provides the transmission and distribution for the physical flow of electricity. For these services, the TDUs are paid a fee regulated by the PUCT. These fees are reviewed by the PUCT twice a year [1], [17], [19], [27]. The REPs usually pass these charges through to consumers directly [27]. Refer to figure 2 for the service territories of ERCOT and non ERCOT utility types.

C. ERCOT competitive and non-competitive markets

Within ERCOT there exist the competitive and non-competitive retail markets. In the competitive markets, the TDUs are responsible for the transmission and distribution service, and the REPs are responsible for marketing and selling electricity to customers. About 57% of a Texan residential electric customers shop for a provider in the state's competitive retail energy market where more than 80 REPs compete [1], [10], [11],[17], [19]. By law only REPs can sell electricity to retail customers in the competitive ERCOT market. In the competitive market, the utility (i.e., CenterPoint, Oncor, AEP (North and Central), or TNMP) is a geographically discrete entity that provides transmission and distribution services (TDUs). It is important to note is that the rates for energy REPs charge their customers are not regulated by the PUCT. And here lie in one unique feature of the Texas electricity market. Unlike in other parts of the country and the non-ERCOT and non-competitive ERCOT market, prices for the retail sale of electricity in the ERCOT competitive market are not regulated.

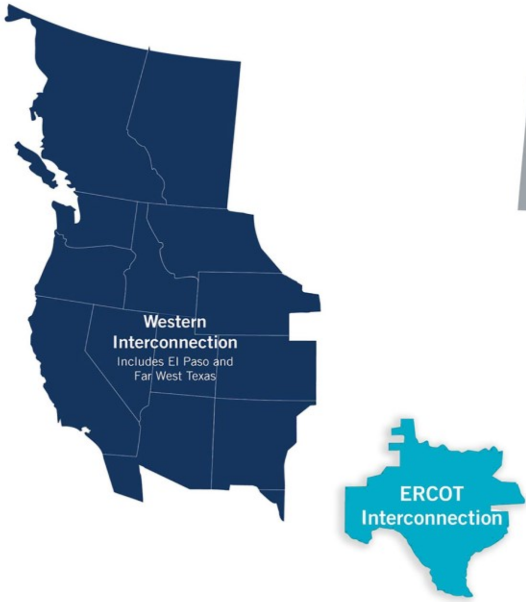

Fig. 1. U.S. mainland electricity interconnections [10]

The non-competitive ERCOT markets include customers served by cooperatives (coops) and municipalities (munis). For these customers their electricity provider is also their utility. Hence while ERCOT provide a wholesale market for munis and coops, these utilities are responsible for providing transmission, distribution, marketing and selling of electricity to their retail customers. Some of the coops and munis within the ERCOT market include Austin Energy, CPS Energy, Pedernales Electric Cooperative, South Texas Electric Cooperative, among others. Figure 3 shows the various entities in the ERCOT market.

Table 1. Residential customer count by utility ownership type according to the U.S. Energy Information Administration. Annual Electric Power Industry Report, Form EIA-861 detailed data files. Sales to Ultimate Customers: 2019.

Utility Type	**Residential Customers**	**Share of Market**
Cooperative	2,047,389	18%
Vertically-Integrated (VIU)	1,058,102	9%
Municipal	1,796,557	16%
Transmission-Distribution (TDU)	6,451,123	57%
Grand Total	**11,353,171**	100%

III. Community Solar Projects in Texas

Community solar (CS)can take the advantages of rooftop solar, clean and cheap energy, and mitigate the large capital costs and limited access [6], [7], [8]. By spreading out the costs among many different players, achieving economies of scale, and using large shared lands, people who normally could not participate because of costs or lack of roof space now can [5], [6], [7],8].

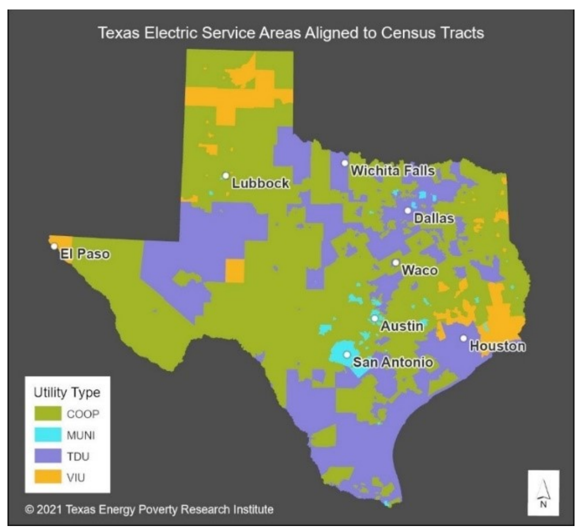

Fig. 2. The Texas electricity landscape is highly fragmented with 57% of all Texas residential electric customers shopping for a provider in the state's competitive retail energy market where more than 80 retail energy providers compete. In the competitive market, the utility is a geographically discrete entity that provides transmission and distribution services (TDUs).

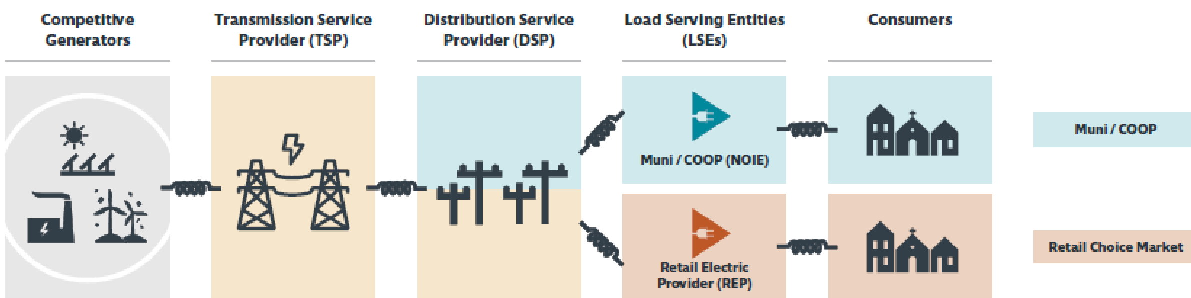

Fig. 3. Various entities of the Texas ERCOT electricity market.

As awareness around the issues of energy justice and just transition gain visibility CS projects are now being considered as an effective tool in increasing the access of under resourced communities to clean energy technologies and reducing energy bills for LMI communities that experience high energy burdens have become very common [8], [20].

CS installations are typically installed on unused or underused lots or on large areas of roof space and with innovative financing products low-income households can now participate in the clean energy economy [20].

Different models and programs for developing CS projects have been developed. Many of these programs include policy mechanisms like the "value of solar" and market mechanisms like net metering to increase the deployment of these assets [28]. For utilizing CS projects for LMI communities the mechanisms and programs for deployment for CS projects focused on LMI communities are a bit different [8], [20], [28]. In general, these mechanisms and programs can be broken down into incentives and mandated carve outs.

A mandated carveouts is a situation whereby a faction of the CS projects capacity or generation is reserved for LMI customers. This mechanism is common in Colorado, Connecticut, Hawaii, Maryland, and Oregon [20]. Incentives usually involve some financial benefit or subsidies to help defray the cost of development and LMI customer acquisition for the developers. For example, in Seattle customers pay \$6.25W/W monthly and they receive a credit of 0.7/kWh state incentive plus a \$0.09/kWh virtual net metering credit on their bills. This type of mechanism is common in California, Colorado, Illinois, Washington, and Rhode Island, among others [20].

In Texas, the non-ERCOT and non-competitive ERCOT utilities have also utilized incentives and carveouts to implement their community solar programs. These programs are usually initiated and administered by city governments [8]. For example, in the CPS Energy service territory in San Antonio, the 5MW Big Sun Community solar project has a carve out for LMI households [8].

As of 2019, only 18 CS project are operational in Texas compared to the 811 projects in a total of 39 states and Washington DC as at 2018 [8], [32]. Out of these only 3 of them are provided by REPs in the ERCOT competitive market, and none of these CS projects have an LMI component [8]. Due to tight margins in the competitive market, many REPs choose to buy cheap wind energy from West Texas or utility scale solar at wholesale prices to sell to their retail customers. They also avoid costs of the development and managing CS projects and then administrative costs of acquiring and managing CS participants [8]. As per PUCT rules a CS project would fall under on-site or DG generation. If the asset is less than 1MW, it would have to sign an interconnection agreement with the local TDU. If it is between 1 – 10MW, and capable of net exporting energy to the distribution system, in addition to an interconnection agreement with the TDU, a developer would have to register the asset as a Settlement Only Distribution Generator (SODG) with ERCOT and sign an agreement with a Qualified Scheduling Entity (QSE). Any CS project larger than 10MW would have to meet the requirements listed above and full ERCOT registration requirements for competitive generators [8]. Hence there is very little incentive for them to deploy CS project, and much less incentive for an LMI CS project [8].

The LMI CIS model described in this paper avoids all these issues for CS projects.

IV. LMI Community Impact Solar (CIS) Model

To increase the access of clean energy through CS projects to LMI communities and reduce their energy burdens, the Texas Energy Poverty Research Institute (TEPRI), a nonprofit organization committed to developing energy solutions for low-income communities, Big Sun Solar, a solar developer that operates the Big Sun Community solar program in San Antonio, Texas developed the LMI CIS model for LMI communities in the ERCOT competitive market. We also estimated the amount of potential reduction in energy burden for LMI communities in the city of Galveston, Texas.

In developing the model, the following objectives were considered:

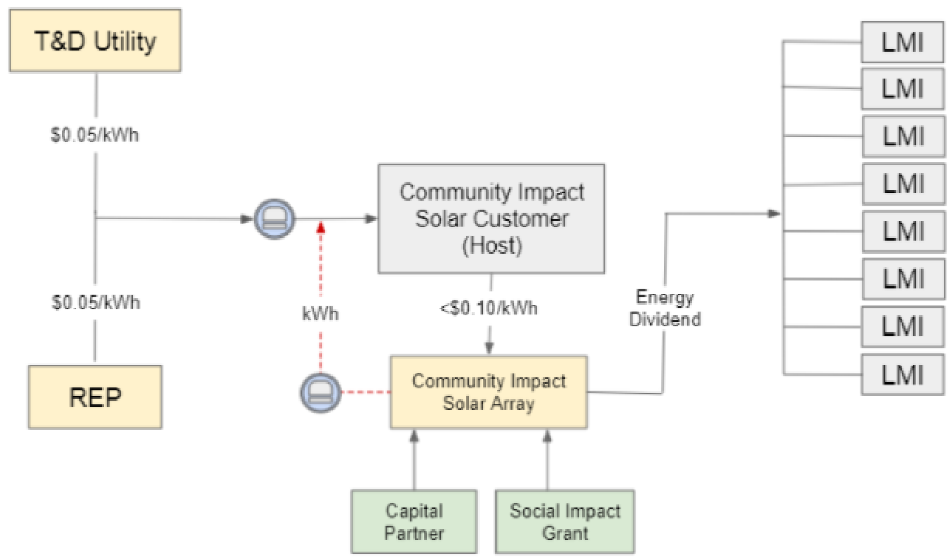

Fig. 4. TEPRI Low-to-Moderate Income (LMI) Community Impact Solar (CIS) Model.

1. The must be direct financial and environmental benefits of local solar investment to local underserved community members.
2. It must be a sustainable model that can scale in the ERCOT competitive markets, with little to no philanthropic investment.
3. For the model to work it should not require policy change (works in current environment).
4. It must maximize value at every opportunity for better economics.

A. Advancements: Unqiue features and benefits

Some of unique features and advance of the model over the traditional LMI CS programs include:

1) Generates energy dividend

An energy dividend, usually an X dollar amount is generated from the system and directed towards underserved households. This could be either in energy credits on electricity bill or cash. There is room for flexibility in the allocation of financial return.

2) Behind the meter (BTM)

The physical CS system resides behind the meter (BTM) of a medium to large power user (MLPU). This user will consume all the power from the CS system and the system would be incapable of exporting energy back into the distribution system. This is done to avoid specific ERCOT registrations requirements that would increase the cost of deploying the system.

3) Leverage potential T&D charge reduction by lowering 4CP peak demand

The model can substantially reduce demand charges for the MLPU through participation in the 4 Coincident Peak 4CP Curtailment program.

The 4CP program is a program where commercial and industrial customers can reduce their TDU charges by curtailing their energy consumption during each four 15-minute coincident peak events that occurs in ECORT during the summer months of June, July, August and September [21]. Using the CS system an MPLU can reduce their TDU/demand charges.

4) Competitive PPA for on-site generation

The MLPU can get a competitive PPA for on-site generation without having to own the asset. There is also the potential of benefitting from the systems tax credits.

5) Social and environmental benefits for host (MLPU)

MLPU can use the asset to meet their sustainability or renewable energy portfolio goals without having to make the necessary upfront capital investment. As the system potentially would result in no rate increase

6) Independent of retail electric provider

To sell electricity in the competitive ERCOT markets one needs to be registered as a retail electric provider. The system avoids that and the LMI CS program can be administered by mission driven non-profit entity. The system is able to serve customers of any REP and does not include REP administration.

7) Extensive Community Engagement

The LMI CIS model involves working with local community-based organizations (CBOs) to determine eligibility criteria, administer the LMI participants, among other things.

8) Sustainable, scalable model

Apart from the fact that the model can be replicated by anyone across Texas, it also generates enough cashflow that can be used as a growth fund to fund the next project.

The model comprises two important entities for its success. This includes a medium to large power user (MLPU) which would serve as the CIS host and a capital provider. The capital provider could either be a commercial or philanthropic entity, or a combination of both for any specific transaction. The social impact grant as referred to in figure 4 could come from a commercial or philanthropic partner.

Due to the fact that to sell electricity in the ERCOT competitive markets one needs to be a retail electric provider (REP) the LMI CIS model bypassing the need for a REP, by placing the CS system behind the meter (BTM) of a medium to large power user (MLPU). The MLPU consumes all the power at a rate determined in a PPA between the MLPU and the entity that manages the LMI CIS program.

This PPA rate should be less than what the MLPU currently pays for TDSP/demand and energy charges. The PPA rate should also be more than the rate the capital provider needs to justify the investment. The PPA rate less the capital provider rate gives a delta. For example, is “Acme Inc” was the CIS host or the MLPU, and their blended rate for electricity is about $.09/KWh. Then “Diversity Capital” is offered $0.06/KWh to finance the asset over 25 years. A PPA rate of $0.08 can be signed between the LMI CIS administrator and the MLPU. The MPLU is saving $0.01/KWh on electricity. After the capital provider is paid the energy dividend from the LMI CIS project is $0.02.

This delta (dollars) is used to manage the LMI CIS administration cost, and then the rest which is called the “energy dividend” is sent over to a pool of resources used to fund LMI participants to be applied to their energy bills or for utility assistance.

B. Reducing energy burdens for LMI households in Galveston, Texas.

We conducted this analysis as part of a “pre-development” process aimed to result in the launch of a community solar development on Galveston Island in Texas. Galveston is a historical island off on the Texas Coast near Houston. In the past it was the biggest port Texas until the Houston Ship Channel was created to move the port inland so it wouldn’t be affected by the frequent hurricanes. Now Galveston main economy is based off tourism both on the island and the cruise terminals it houses.

Galveston has a population of around 50,000 and most residents live on the East side of the island. Most households only house one to two people and the average household size is only 2.2. Around 40% of Galveston households make less than $35,000 and the median renter income is $31,327. Most residents in Galveston rent (57%); however, the public housing in Galveston public has shrunk from almost 1,000 units before Hurricane Ike (2005) to only around 500 now. Due to the limited number of affordable homes, at least 3,000 renters spend more than 30% of their income on rent. Furthermore, Galveston’s housing stock in general is older which can increase repair and energy costs.

Some of the biggest public employers and business in Galveston include UTMB, the Galveston Municipal Court, Texas A&M Galveston, Ball High School, and the Port of Galveston. They have all expressed interest in clean energy and have large amounts of land on the island.

1) Electricity and Solar Requirements of Low-Income Galveston Households

Based on the information from DOE’s LEAD tool, Galveston low-income households (80% of AMI or less) spend between $1,200 - $1,400 a year on energy costs [22]. Assuming $0.10 cents / kWh they use between 12,000 and 14,000 kWh / year. Furthermore, households who make 0-60% of the AMI are energy burdened (spend more than 6% of their income on energy expenses) and those who make between 60%-100% of the AMI are close.

For our purposes we will say low-income residents use 13,000 kWh / year. According to the Solar Energy Industry Associate, solar panels in Texas produce 1500 kWh per kW installed per year. Therefore, it takes about 8.67 kW of solar to power one low-income household. Around 40% of Galveston’s households make less than $35,000 representing about 9100 households. It would take almost 80 MW of solar to completely power all of Galveston’s low-income households with solar.

We used Project Sunroof to get a general idea of the solar potential [23]. We prioritized large rooftops and large parking lots owned by a single entity. The data from Project Sunroof suggests there are 22,000 roofs that have solar potential and a capacity of 440 MW that can produce up 588,000 MWh a year. Of those rooftops 1,028 of them have the potential for a system larger than 50 kW with 26 roofs having the capability of a 950-kW system or higher.

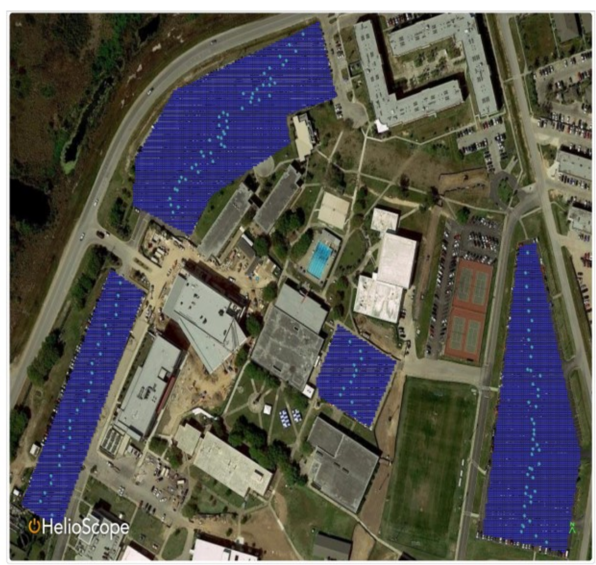

Fig. 5. Layout of CS system at Texas A&M Galveston.

2) Detailed Solar Assessment of Texas A&M Galveston

We used HelioScope to demonstrate how a community solar project could be placed on some of the land and structures of Texas A&M Galveston. Shown below is a potential 3.92 MW solar project. Most of the solar panels would be installed over the parking lot. The remaining solar panels would be installed on top of some of the larger buildings. Refer to figure 5 for the layout.

Therefore, the proposed 3.92 MW solar project could provide 5880 MWh / year which could power over 450 homes. Electricity in Texas is about $110 / MWh ($0.11 / kWh), so this project could produce up to $646,800, even selling electricity at a discounted rate of $80 / MWh ($0.08 / kWh) would produce $470,400. Utility scale solar is being installed at a cost of $1000 / kW and household rooftop solar in Texas at a cost of $2790 / kW. So, a community solar installation would between about $3.92 and $10.94 million which correlates to a payback period between 6 and 17 years.

At a PPA rate of $0.08/KWh and a capital provider rate of $0.06/KWh, the system can reduce energy burdens to about 110 households by 2.81%. This is based on an annual income of $25,783 (30-60% AMI) per household with an annual electricity cost of $1,534.

C. DOE NCSP TA – Model Validation

The LMI CIS model went through a validation process provided by the Department of Energy (DOE) National Community Solar Partnership (NCSP) Technical Assistance (TA) program [24]. The TA prices found the model to be scalable and viable, it was also discovered that the model, especially the solar/energy dividend portion share some similarities to: LLBO (Leech Lake Band of Ojibwe) energy assistance program and the RREAL (Rural Renewable Energy Alliance) Community Solar for Community Action.

1) LLBO (Leech Lake Band of Ojibwe) energy assistance program

Under this program, rather than energy assistance dollars flowing to community action agencies to be re-distributed to utilities on behalf of low-income families, the community action agency generates its own electricity on behalf of its low-income clients. The community solar array sells power to tribal government buildings and utilities and uses the revenue generated to fund energy payments for low-income community members [25].

2) Rural Renewable Energy Alliance (RREAL) Community Solar for Community Action

Rather than simply paying low-income families' energy bills year after year, Community Solar for Community Action (CS4CA) forges a new model of energy assistance through the use of community-owned photovoltaic (PV) solar arrays as Solar Assistance. These centrally located systems provide renewable electricity to participating low-income community subscribers [26].

V. Potential Applications in other Energy Markets and Jurisdiction

The LMI CIS model has unique characteristics that could be beneficial to the deployment of CS projects in other energy markets of jurisdictions. For example, interconnection costs, which sometimes could involve long extensive studies and upgrade of expensive coupling equipment and facilities could be prohibitive for many CS project developers [20]. The LMI CIS model avoids this by setting up the system behind the meter for the MLPU host. This could potentially reduce the cost of development for many CS projects in other parts of the world.

After the winter storm in Texas, discussions around the need for developing "community resilience hubs" in major cities like Austin, Houston, and Dallas [30]. These hubs would be located at centrally located facilities with the capacity to serve as staging areas for relief support in times of disasters like convention centers and larger school campuses, among others. The LMI CIS model with a storage component could be a great candidate for a community resilience hub.

With the growing prevalence of very large-scale weather events (VLSWE), discussions around adopting a more resilient grid have increased among policymakers, grid operators and other industry stakeholders. The resilience function, albeit unintended, provided by the Princeton University microgrid after superstorm Sandy in 2013 largely begun this movement towards a more resilient grid. The system was as a beacon of light in a sea of darkness and served as a staging area for relief efforts [31]. CS systems, that are behind the meter could provide this type of resilience function in any energy market in the world.

They could also be used to create multiple streams of income by providing demand response energy and ancillary services to the grid in other organized electricity markets like MISO and PJM.

VI. Conclusion

The LMI CIS model can increase the access of LMI communities to clean energy investment opportunities while reducing their high energy burdens in the process. It allows commercial and industrial customers – that is medium to large power users – reduce their TDU/demand charges by providing a powerful demand response resource (DRR) for summers months in the ERCOT market. It avoids the challenges and cost of meeting PUCT and ERCOT requirements for interconnecting DG systems, making the development of CS systems in Texas more economical. Above all it can be replicated in other electricity markets across the United States that do not necessarily have the unique features ERCOT. It our hope that this model catalyzes more frameworks and process that would facilitate the deployment CS systems which focus on LMI communities ensuring our next energy transition is just.

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