



Rallying the anti-crowd: Organized opposition, democratic deficit, and a potential social gap in large-scale solar energy

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ABSTRACT

Declining costs and high public support for solar energy in national surveys predict accelerated development of large-scale solar (LSS) systems across the United States. Both scholarly work and the popular press suggest LSS projects increasingly face local resistance at the project level. This gap between the number of LSS projects proposed and those completed can be thought of as a social gap, just as Bell, Gray and Haggett first described with respect to wind energy development in 2005. Here we use those scholars' framework to investigate a potential LSS social gap in four communities in Michigan. Using 34 qualitative semi-structured interviews with residents, local officials and LSS developers, we describe how a social gap may develop because of organized opposition groups generating a democratic deficit. The undue influence and organization of this vocal minority, along with a lack of meaningful engagement with residents by local officials and developers, led to distrust in relationships and the decision-making practices necessary to address residents' qualifications. Those qualifications centered on LSS's aesthetic impact, inadequate compensation, improper use of agricultural land, water safety, project size, and the transparency of decision-making processes and residents' ability to influence those processes. Our results suggest that addressing such a social gap requires increased communication and earlier engagement by local officials and developers with residents, and better alignment of agricultural values and production with LSS development. Finally, better organization of—and by—project supporters may increase opportunities to influence and take ownership of LSS projects.

1. Introduction

Solar photovoltaic (PV) power was expected to make up approximately 40% of new electricity-generating capacity in the United States (US) in 2021, more than either wind or natural gas [1]. Approximately 12 gigawatts (GW) of this new capacity was expected to derive from large-scale solar (LSS) systems, or ground-mounted PV systems producing at least 1 megawatt (MW) of power [1]. While a great deal of this development was slated for the western US [2], the US Midwest (e.g., Michigan, Indiana, Minnesota and Illinois) has also begun to experience rapid development. Michigan, the target of this study, ranks 18th out of the 50 states in projected growth of LSS over the next five years [3].

High public support for solar energy in national and state surveys appear to support such rapid increases in capacity, with studies reporting between 80 and 93% of the U.S. public supporting solar development [4,5] and 90% of Michigan residents supporting increased solar power in the state [6]. Additionally, Michigan's renewable

portfolio standard and recent legislation opening farmland preservation land to LSS development provides a favorable environment [7], as do federal tax credits that have been targeted for long-term extension by the Biden administration [8]. Not only is utility-scale solar PV less expensive than residential systems [9], but LSS slated to begin operation in 2026 is estimated to have a levelized cost of electricity lower than combined-cycle natural gas and onshore wind, even without subsidies [10]. Despite recent increases in the cost of steel, polysilicon, and PV modules due to disruptions in international supply chains caused by the Covid-19 pandemic [11], a long-term decline in both the cost of modules and the installed cost of LSS systems should facilitate accelerated development of LSS in both Michigan and the US [12], as well as the world more broadly [13].

Scholarly work in the US [14–18] and media accounts across the western US [19–21] and US Midwest [22–24] purport a different story, as does scholarly work from outside the US [25,26]. Despite the readily acknowledged benefits of LSS and renewable energy more generally (e.

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g., community economic development, tax payments, landowner and community compensation, the rejuvenation of some places, and reduced air pollution and carbon savings [27,28]), LSS projects have increasingly faced local resistance at the project level, both in the US and abroad [26,29]. Citizens criticize LSS's intermittency, aesthetics, noise, and negative impacts to rural and Tribal culture, values, and community energy sovereignty, along with LSS's risk to wildlife, productive farmland, biodiversity, and human health [14,17,25,27,28,30]. Perceived risks include lowered home and property values, increased electricity rates, impacts to tourism, and the toxicity of materials used in construction and operation [27,28,31]. Many of these concerns may be exacerbated in the US Midwest as the land sought by solar developers often lacks optimal resource potential, ample existing grid capacity, and sufficient distance from or natural buffers between communities [32].

How support for utility-scale wind energy changes as the distance between projects and residents decreases is a recurrent theme in social acceptance research [33–35]. Less research exists examining local support for LSS—though notable exceptions do exist in Europe [25,31], South Africa [26] and Australia [36], as well in the Western US [4,16]. Regarding the latter two studies, Larson and Krannich [16] find a significant gap between Utah residents' general support for proposed LSS and their support for projects built within 25 miles of, or within sight of, a respondent's home. Carlisle and others [4] found no discrepancy between levels of support nationally and support for projects built in a respondent's county in the US Southwest. However, residents did prefer that projects be sited at least one to 5 miles from residential, cultural, and recreational areas and up to 11 miles away from wildlife migration routes or breeding grounds [37]. Sharpton et al. [38] too found that 80% of US residents were accepting of LSS, as long as the projects were at least 5 miles away from their home.

The physical gap preferred by residents between LSS and their homes suggests there may also be a gap between what is consistently high general support for solar PV nationally and reduced community support for LSS at the project level. Such a gap has existed with respect to wind development for some time, identified first by Bell and colleagues [39,40], and by others since, though to differing degrees [41]. Some scholars even argue that a gap in the opposite direction might be possible [42–44], suggesting that in certain cases farmers in pursuit of the revenues associated with wind turbines have evinced a “please in my backyard,” or PIMBY approach, rather than a “not in my backyard” or NIMBY approach to wind development.

While a host of studies examine the wind social gap, few studies examine the impact and acceptance of LSS sites in the US [4,14,16,28,37] or abroad [25,26,29,31,36]. Even fewer focus on the social acceptance¹ of LSS in the US Midwest [46], or how a LSS social gap there may arise. The purpose of this study is to investigate social acceptance and the determinants of a potential LSS social gap in the US Midwest. In conducting our investigation, we rely on thematic analysis of 34 semi-structured interviews with residents, local officials, and developers across four different communities in Michigan, each experiencing LSS development differently. Successful development requires decision-makers to understand and address the values and concerns of residents regarding proposed or existing LSS [15,28]. Yet obtaining public input, especially in rural communities, is the most neglected part of the energy development process [15,47]. For these reasons, we also investigate how developers and local governments are, or are not, addressing public perceptions and values in their approach to LSS development.

¹ In this paper we use the term acceptance to bundle together distinct terms, namely: support, opposition, attitudes, and perceived impacts. Support and opposition often relate to proposed projects, while attitudes correspond with existing/pending projects [34,45]. Perceived impacts refer to a person's own understanding of the attributes or impacts of a proposed or existing project and can either align or conflict with technical reports or projections.

As such, the current study aims to answer three principal research questions:

RQ 1: What are the key values, perceived impacts and concerns driving residents' opposition to and support for LSS in Michigan and thus the US Midwest more broadly?

RQ 2: Using Bell and colleagues' [39] social gap theory, how might a LSS social gap arise in Michigan and what are its determinants?

RQ 3: What are the decision processes by which LSS siting currently occurs and how might they be improved?

The remainder of this paper is structured as follows: in the next two sections we describe Bell et al.'s [39] social gap theory and why communities in Michigan serve as unique and important case studies. In Section 2, we describe our methods of data collection and qualitative analysis as well as introduce our four case-study communities; in Section 3, we present our results across the three research aims described above, providing participants' own words where illustrative; and in Section 4, we discuss more broadly how residents' values, perceptions and concerns contribute to an LSS social gap and suggest decision processes that may improve development outcomes and community welfare.

1.1. Social gap theory

Bell and colleagues' [39,40] wind social gap theory attempted to explain why the high public support for wind energy in the UK (80% in 2002 per [48]) still only resulted in a quarter of contracted wind project capacity actually being commissioned. They explained this difference as resulting from either democratic deficit, qualified support, or self-interest. A democratic deficit occurs when a minority of residents exert control over a decision due to their increased willingness and likelihood to voice their opinions and become involved in the decision-making process. Residents opposed to a wind farm may believe the cost of their actions during decision-making are worth the potential benefit of impacting development, while residents with neutral or supporting opinions may be less inclined to act due to the belief that their actions will have a negligible effect and the developer's advocacy will sufficiently propel the project to approval [49]. This deficit may be exacerbated by a technocratic and top-down “decide-announce-defend” framework commonly deployed in energy siting processes, which intentionally seeks criticism rather than support [50].

Qualified support, or the lack of, occurs when an energy proposal does not sufficiently meet would-be supporters' criteria or demands [39]. In this case, residents are accepting of a renewable energy project so long as the negative impacts to landscape, wildlife, and humans, etc., are sufficiently addressed by developers or officials. The final explanation involves self-interest, or NIMBYism, in which people support wind energy generally but oppose those projects slated for their own community [39]. Bell et al. [39], as well as a growing list of other scholars [35,47,51–55] argue that NIMBY is not the only or even the most relevant contributor to a social gap. Those authors criticize NIMBY for its vague explanations, lack of appreciation for the root causes of opposition, inconsistent use in the literature, and reduction of residents opposed to utility-scale energy development to roadblocks needing to be overcome. Bell et al. [39] identify an additional complication in identifying self-interest, namely that it can impersonate qualified support in public settings (e.g., public hearings), or vice-versa. As a result they recommended private settings be used to determine residents' reasons for opposition. We use private settings here to investigate a LSS social gap in Michigan.

1.2. Michigan communities as case-studies

Communities in Michigan present a unique opportunity to

investigate a LSS social gap. First, the state remains in its infancy regarding LSS development. By the end of 2021, there was only one LSS site producing over 50 MW in MI and only six sites generating over 10 MW [56]. Despite MI having far less solar potential than the US Southwest,² all three of the state's largest investor-owned utilities have set strategic goals to increase renewable energy with LSS projects as a major contributor [58–60].

Second, Michigan recently approved a statewide policy that allows the construction of LSS arrays on land previously enrolled in the state's Farmland Preservation program, or PA 116 land [7]. Land that was once designated strictly for farming is now able to be leased to developers, as long as certain requirements are met.³ Such a policy increases the availability of continuous, flat land ideal for deploying LSS, but may generate backlash due to the removal of prime agricultural and ecologically valuable farmland from preservation [61].

Lastly and perhaps most importantly, Michigan's zoning law allows municipalities, e.g., townships, cities, and villages, to create their own land use regulations [62]. While many communities take advantage of this opportunity, others either choose to or, due to self-zoning requiring a considerable amount of planning, time, money, and legal consultation, must rely on county zoning ordinances [63]. Consequently, many communities that rely on county zoning also remain subject to the larger county's vision, a potential source of conflict. A LSS boom in Michigan and states with similar zoning laws like Illinois and Pennsylvania could result in a significant increase in the number of municipalities electing to self-zone. This would not only raise costs, but may also redefine community borders and the distinction between local and regional values.

2. Methods

2.1. Study context

This study examines LSS development and a potential social gap in four communities in Michigan, each at a unique point in the development process.⁴ Sites were selected based on a review of the popular press, media sources and discussions with subject-matter experts to intentionally include communities at multiple zoning levels (either township- or county-zoned), facing proposed LSS (>1 MW) development, and experiencing different levels of opposition to or support for that development. At the time of this writing, the four projects described here were the largest proposed LSS sites in Michigan.

2.2. Case study communities

Two communities, here referred to as Hyde and Essex, were county-zoned, and two communities, Maxfield and Raleigh, were township-zoned (See Fig. 1).⁵ Few media accounts or subject-matter experts

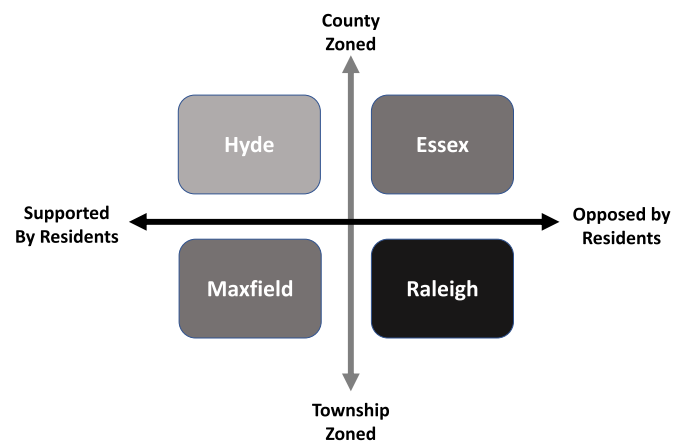


Fig. 1. Zoning for and opposition to LSS in four Michigan communities.

reported any significant opposition or controversy regarding the projects in Hyde and Maxfield, while Essex and Raleigh had already experienced notably contentious development processes.

Hyde consisted of two townships, both zoned at the county level (see Table 1). A special use permit had been unanimously approved by the county planning commission to permit construction of a solar farm that would span over 1000 acres and produce more than 200 MW of power. The developer in this community advised on their website that they had worked closely with township residents and facilitated discussion by hosting several community forums. Media accounts claimed the public had been receptive to the proposal, even when the project was first introduced to the area.

Essex, a single township, had been county-zoned until a proposal was introduced to build a solar array on roughly 1000 acres of rural land primarily within the township's borders. Essex residents reported being upset about the prospect of living next to an LSS project, and township officials argued the solar farm was not in accordance with their master plan. In response, Essex moved to self-zone and established an interim ordinance that would temporarily block LSS development, causing the county to postpone consideration of the LSS application. The developer subsequently sued the township, and litigation remains pending.

Maxfield, a self-zoned municipality, had unanimously passed a solar energy ordinance several years prior and have since approved multiple LSS project proposals collectively exceeding 1000 acres. Two developers engaged in this community claimed to have used a similar public engagement approach as that deployed in Hyde. Newspaper accounts had not identified residents raising concerns.

Raleigh, a single township, was locally zoned. The township board had initially approved a solar ordinance and a developer proposed a utility-scale project covering nearly 1000 acres. The original ordinance was deemed illegal however and was returned to the planning commission for modification. At this point, community members became increasingly involved and significant opposition was reported. The planning commission worked with the developer to tailor the logistics of the zoning amendment and subsequent project design to better balance community interests; for example, the original setback distance of 250 ft from residences was increased to 500 ft. Despite public resistance, the

² MI has a relatively low global horizontal irradiance of about 3.5–4 kW-hours/m²/day; areas in the US Southwest have a global horizontal irradiance twice as high [57].

³ Cover crops and pollinator habitats must be employed to sustain soil fertility during project operation; field tile must be maintained to ensure new wetlands are not created, and the developer must post a financial guarantee with the state to decommission the project at the end of its life.

⁴ Bell et al. [39] measured the social gap by comparing the installed capacity of wind farms to the number of wind farm planning applications. Doing so with regard to LSS is not yet possible as Michigan does not have a comprehensive database of solar project applications, nor was determining the exact size of such a gap the aim of this study. Instead we focused on characterizing community-level gaps, i.e., where an LSS project had been proposed, but failed to develop, and we did so qualitatively.

⁵ The name of each study site has been changed or redacted to protect the confidentiality of research participants, as are any site-specific references (e.g., media sources, public records, and project websites) that may betray participants' identities.

Table 1
Community characteristics.

Attribute	Hyde	Essex	Maxfield	Raleigh
Level of zoning	County	County	Township	Township
Level of opposition	Low	High	Low	High
Population	5000	2800	2100	3400
LSS project size (proposed)	1000 acres	1000 acres	1000 acres	1000 acres

planning commission made a motion to recommend the zoning amendment to the township board. The amendment was denied by the board and sent back to the planning commission for further revision. Numerous additional meetings occurred, and the ordinance had yet to be finalized at the time of this writing; the project remains on hold.

2.3. Interview guide and participant sample

To examine the LSS social gap as well as adequately capture the values, concerns and decision-making processes used in each community, we constructed an interview guide and participant sample targeting three groups: local government officials, LSS developers, and community residents. The interview guide was developed over the course of several meetings and was constructed to address themes from the social gap literature, research examining values and concerns associated with renewable development in MI, (e.g., [46,64]), and previous meetings with local developers and renewable energy grassroots organizers. To develop the participant sample, we attempted to contact all local government officials involved in LSS decision-making, e.g., township officials, zoning administrators, planning commissioners, and board members, and if both county and township authorities were involved, attempts were made to speak with representatives at each level. Developers were identified and contacted via email or phone, and efforts were made to speak with one individual per project, preferably the project manager. Residents were identified and subsequently contacted using multiple methods including: i) scanning the meeting minutes of public hearings to identify individuals that made comments, ii) searching Facebook groups linked with the solar project, iii) driving through accessible communities and noting addresses with oppositional or supportive yard-signs, iv) emailing government clerks to request contact information for potential land-leasers, v) overlaying LSS project site maps with parcel maps to identify project neighbors, and finally, vi) snowball sampling.

In total, 141 individuals were contacted and 33 interviewed (26 men and 7 women⁶), resulting in a response rate of 23% (one developer spoke about projects in two communities making the overall number of interviews 34) (see Table 2). Interviews were completed over the phone due to restrictions put in place as a result of the Covid-19 pandemic and typically had a duration of 40 min. The interview guide relied on open-ended questions that directed the interviews in each group (i.e., local officials, developers and residents), but also allowed for flexibility (see Supplemental Information). Participants' responses were recorded and subsequently transcribed. The University's Institutional Review Board approved this research, Study ID: STUDY00004254.

2.4. Data analysis

Data was analyzed by the first and second authors using recursive

Table 2
Interviews by community and category.

Participant	Hyde	Essex ^a	Maxfield	Raleigh
Resident - supporter	2	2	1	2
Resident - opponent	5	3	1	3
Resident - neutral	0	0	2	0
Government official	5	1	1	1
Developer	1	0	2	2
Total in community	13	6	7	8
TOTAL 34				

^a The developer in Essex was unable to participate due to pending litigation.

⁶ We chose not to collect data regarding our participants' age or race, but suspect all were White and between the ages of 30 and 80 years old.

thematic coding [65]. This type of thematic analysis allowed us to not only summarize our data and highlight key features, but also identify important insights that would help to answer our three research questions, regardless of how many times they arose in the dataset [66]. Each recorded interview was transcribed verbatim using Trint (London, UK) software and subsequently reviewed and corrected by the first author. Memos regarding tentative themes in the data were generated and discussed by the authors during regular meetings. The memos were used to construct a codebook (i.e., code names, definitions, rules, and examples) using MAXQDA (2021) software. The first and second author tested the codebook on several interviews, leading to a revised codebook (see Supplemental Information). Codes were categorized as "neutral," "positive," or "negative" to help organize the passages, and themes in community perceptions, values and decision-making processes were identified within and across all communities.

3. Results

3.1. Most common values, concerns and perceived impacts of LSS

Table 3 lists the most common concerns and perceived benefits associated with LSS development by residents, along with the number of interviewees that identified each across the four communities.

3.1.1. Aesthetic impacts

The most common concern identified regarding LSS was its negative aesthetic impact, which was amplified by those residents who reported

Table 3
Residents' most common concerns and perceived benefits of LSS^a.

Concerns	No. reporting ^b
Negative aesthetic impact	13
Decreased property values	10
Misuse of agricultural land	9
Exaggerated economic benefits (e.g., small tax base, few jobs)	7
Still inefficient and emergent technology	7
Large size and potential for expansion	7
Contamination of groundwater and soil	6
Impacts to human health and safety (e.g., natural disasters, EMF exposure)	6
Reliance on government assistance (e.g. tax credits, subsidies)	6
Electricity exported from community	6
Fear of failure to decommission project	5
Lack of accountability due to transfer of project ownership	5
Use of imported materials	4
Noise and disturbance due to construction	4
Barrier to wildlife	4
Drainage impacts	3

Benefits	No. reporting
Economic benefit to lease-holding landowners	8
Economic benefit to community	7
Clean source of energy	6
Less burdensome land use (i.e., compared to wind or housing)	5
Farmer succession	4
Serves as a land bank	4
Technology appropriate for Michigan	3
Net energy exporter	2
Minimal aesthetic impact	2
Solar energy as production agriculture ("farming the sun")	2
Reduced pesticide use	2
Native plants and pollinators	2
Safety	2

^aTable excludes government officials and developers. Table is intended to represent the number of people that spoke about each concern or benefit and is not a ranking of importance.

^bA concern or benefit was counted only once per individual regardless of how many times they identified it.

either moving to the area due to or long appreciating the community's existing rural aesthetic. Buffers, or measures taken to conceal LSS sites from view, often failed to ameliorate this concern. Residents identified that proposed vegetative buffers would be too short at the time of planting to sufficiently block their view and fencing constructed in lieu of vegetation was considered as unappealing as the solar array itself. A male opponent from Essex explained:

"I don't know how high of a fence they got to put up before I won't be seeing that stuff anymore. But even so, if they do put a fence up, I'm looking at a fence instead of a field."

The lack of a more broadly distributed and disrupted viewshed—often seen as a relative benefit of LSS over wind turbines—was identified by a few residents to actually have decreased their support.

3.1.2. Economic impacts

The perceived economic impacts of LSS development varied, but the most common concern regarded the potential devaluation of residential property. Other residents identified the benefit to schools, roads and taxes that LSS development provided, but some believed such benefits were exaggerated. Certain residents resented the way LSS projects were being financed, arguing that renewable energy subsidies and tax credits amounted to a government transfer. Others argued that generous tax abatements decreased the local property tax revenue generated, which was often used by developers in public meetings and marketing materials to generate support for LSS projects. A woman opposing the project in Raleigh argued this way:

"So you're throwing all these big figures out but whether or not you're going to pay it is, number one, very questionable. Probably you're going to be asking to not have to pay that. And even if the township or the state says 'well yeah you only have to pay 50 percent of it,' now, these big figures that you've thrown out to entice us as the carrot, all of a sudden half the carrot is gone."

Like their counterparts in wind communities [67], lease-holders and farmers on the other hand not only recognized the immediate short-term benefit of direct payments, but also the longer-term community-wide benefit of being able to invest in, improve, and supplement their farming operations.

3.1.3. Land use and environmental impacts

The land-use impacts of LSS were perceived both positively and negatively across the four communities, all of which had long-standing agricultural ties. Some farmers, lease-holders and residents argued that LSS farms could serve as a land bank. Conversely, non-farming residents often argued that their community's agricultural land was not appropriate for power production, fearing that LSS was not only a permanent land use, but also permanently impacted local culture. A woman from Essex explains:

"I just think that there's something to be said for preserving the agricultural land and the heritage of this area. Once they ruin that, it's never gonna come back. There's always going to be parts of it that's ruined."

Such land use was particularly distressing to some due to the sheer size of the projects and their potential for rapid expansion. Two of the four projects began with a footprint of only a few hundred acres, but by the end of the development process had nearly quadrupled in size. Other residents preferred LSS to building additional housing units and wind farms. Residents in Hyde had experienced a contentious wind farm proposal prior to the LSS project and almost universally preferred the latter.

Concerns regarding the toxicity of panels and fears that chemicals could leach into groundwater were also voiced. Such concerns were especially prominent in one community that had a history of

groundwater well contamination. Others worried that LSS would negatively impact local wildlife, forcing deer to avoid the area or get caught in fencing. Supporters argued that LSS sites would no longer need to be sprayed with heavy pesticides, resulting in less pollution runoff, and the native plants required by developers targeting PA 116 land might absorb excess water and increase biodiversity. Only two individuals specifically voiced "climate change" as a reason for supporting LSS.

3.1.4. Energy impacts

Each of the four communities' LSS projects would generate more electricity than was demanded locally, and most of the projects upon completion were slated to be sold to regional utilities, which would distribute the power more broadly. These arrangements were perceived differently by residents, with some viewing them as a distributive injustice; the community would bear the burden of energy production yet reap little of the benefit. Residents also voiced concerns about how LSS sites would be decommissioned or repowered, especially once the project's ownership was transferred after construction, a practice that is common in Michigan. A woman from Raleigh argued:

"We know very well that the developer doesn't usually end up being the end owner of the project. So they walk away from it, leave all the problems to somebody else eventually."

3.2. LSS social gap

3.2.1. Organized opposition and the democratic deficit

Across all four communities, government officials and developers, as well as some residents, identified that project opponents both were more inclined to participate in and exerted greater influence at public meetings than did project supporters. Interviewees from Hyde and Maxfield reported substantially less opponent involvement in public meetings than did those from Essex and Raleigh. Estimates of the number of opponents in the former two communities were in the single digits, while the number of opponents in the latter two communities were in the hundreds. This difference was linked specifically to the presence of organized opposition groups, which interviewees reported worked to suppress the voices of those supporters that did attend meetings. These organized opposition groups were reported to be comprised most often of nearby neighbors that had predominantly negative perceptions of LSS development. By contrast, interviewees argued lease-holders and self-proclaimed environmentalists, both more positively inclined to development, were far less organized. A government official from Essex described the environment at her meetings:

"There were a few people here and there that did come out and speak in favor of [the project]. But they felt so overwhelmed by the opposition sometimes that they didn't feel comfortable coming and speaking. You know, they didn't want to be the one person in the room with the ninety-nine that didn't want it."

Organized opposition groups had been initiated in Essex and Raleigh by several passionate, well-respected members of each community. Such groups did not exist in Hyde or Maxfield. When responding to a question about why the community project in Maxfield faced little to no fierce backlash, a developer responded:

"You know, I've certainly been in communities that weren't too dissimilar where there was more opposition. I think sometimes it's if you get that one or two influential people that are against it and they're going to kind of rally the anti-crowd. Big difference. You know, and it just cascades."

In addition to attending public meetings in larger numbers, organized opposition groups were able to disseminate information more rapidly and to a wider audience. A Raleigh man described his group this

way:

“We’re working with the 250 of us that are kind of working as a group. We’ve got group text and everything to remind everybody of you know, there’s a meeting tonight at seven thirty.”

A developer described the opposition group’s efforts to focus officials’ attention on concerns that were not only unsubstantiated, but also unlikely to be widespread amongst the community:

“They can trick the board members into thinking it is an actual issue, but it’s not. ... I’ve never seen [opposition] like this be as effective as they are in the board resisting facts. And the board not voting in the best interests of the broader community. It’s really shocking.”

Not only were these organized groups able to influence outcomes, but they also worked to remove local officials from office, quickly working to identify and promote their own approved candidates to fill the vacancies. An Essex man and member of an opposition group argued:

“No doubt the board is leaving in November. A couple of trustees, our supervisor’s leaving, and we need two extra trustees, so we [opposition] packed them all.”

3.2.2. Qualified support

Qualified supporters require solar projects to meet certain explicit criteria to support development; however, determining qualified support necessitates differentiating between a qualification, a concern, and self-interest. For example, an individual may be concerned that a solar project receives tax credits, but they would not necessarily support the development were the credit eliminated. Whereas another individual may be concerned about the visual impact of an LSS, but would support the project were a vegetative buffer employed. As such, interview responses were coded as qualifications if and only if they took some form of the if-then statement, “I don’t support this project because of *x*; however, if *x* was addressed, then I would support this project.”⁷

Interview responses indicate numerous instances of qualified support in each of the four study communities. Some were context-specific such as those regarding the need to protect water quality, while other criteria were relevant across the case study communities and LSS more generally. Not all criteria were realistic regarding project size, cost and technical constraints.

Several comments were made regarding the need to reduce the visual impact of projects. One man from Hyde identified his willingness to support the project were that impact reduced:

“Well, if it had been set way back from the road, so I didn’t have to look at it, not as much of it. I probably would not have been as opposed to it.”

Several individuals, particularly those concerned with their property values being negatively affected by LSS, stated that they would support the project were they to be directly compensated. Such concerns were common amongst organized opposition members. Many participants preferred solar projects not be constructed on prime agricultural land. To these qualified supporters, selecting a different land type, in particular targeting marginal farmland or redeveloping brownfields was preferable. Others demanded a more reasonably sized proposal. What constituted *reasonable* varied between qualified supporters, but one thousand acres was considered by many to be excessive. An Essex woman and qualified supporter commented on the size of her community’s proposal:

“I don’t think that I have talked to anyone that was against solar, but it was overkill. It wasn’t we’re going to bring some solar into your

area and it may affect two or three people, it was we’re going to bury you in a solar field and tough noogies on you.”

In addition to questioning the technical attributes of projects, many qualified supporters desired a more transparent decision-making process and increased influence in that process. A female resident from Raleigh reported how a developer could have improved their approach:

“So that’s the biggest thing, is quit trying to do this under the table. Be open and transparent. Transparent. Like I said, if solar is so amazing and wonderful, tell us how amazing and wonderful it is and we’ll buy into it. But at this point, nobody likes [the developer] and nobody likes these farmers [because they] have done this back-handed and underhanded so long.”

Another resident, a Hyde man, preferred a direct vote and in his explanation acknowledged that what was occurring at public meetings was not representative of the broader community.

“let the county vote on it as a whole. And I know we would have lost, but at least ... the democratic process took its wheels in motion and did what it was supposed to do, and that’s the way the vote turned out. But when you don’t get that and you just get it shoved down your throat, that leaves a bad taste in my mouth.”

Only two residents made explicit, unqualified, comments about how their community’s solar project would be more suitable in locations that did not affect them. Yet based on the remainder of these two interviewees’ comments, these were isolated instances of self-interest and not representative of the interviewees’ broader perspectives on LSS, which were identified as qualified support.

4. Discussion

The above responses provide evidence for the existence of a potential LSS social gap in Michigan, confirming media and subject-matter-expert accounts of generalized support for LSS in Hyde and Maxfield and opposition in Essex and Raleigh. In the latter two communities respondents spoke about organized opposition groups led by influential community-members contributing to a democratic deficit and slowing project development. Members of these organized groups and residents identified criteria that required adjustment of zoning ordinance rules or accommodations to be made by developers. Yet even when those changes or accommodations were made, residents often remained opposed to LSS, pursuing referendums, moratoriums, or the ousting of planning commission members or local officials, citing distrust of developers and officials or the process by which LSS were permitted. This cycle of individuals qualifying their support, only to put forward additional qualifications or question the veracity of officials and developers’ accommodations once made, has been observed previously by the authors in wind communities, along with similar forms of retrospective punishment. McRobert et al. [68] and Stokes [69] described analogous outcomes in Ontario following passage of that province’s Green Energy Act. The latter warned that this type of “spatially distorted signaling” could lead to even greater influence by vocal minorities, as well as encourage renewable development to eventually target communities with fewer financial resources and social capital. Recent work supports the latter claim [29,70].

The presence of vocal critics of projects at public meetings, even in large numbers, does not necessarily denote a democratic deficit; however, responses from government officials, developers, and residents in both Hyde and Maxfield suggest that these groups intentionally intimidated supporters, amplified concerns that were unlikely to be widespread throughout the community, and more effectively used communication channels to increase opponent representation at public meetings than did supporters. The extent to which these efforts relied on extra-local anti-renewable activist groups for support and information is unknown—no respondents in this study specifically identified activities

⁷ More generalized concerns are identified in Section 3.1. and Table 3.

by such groups. However, these groups are increasingly present online [71] and in-person across Michigan and the Midwest more broadly. At least one representative from such a group, the D.C. Energy Advocates [72], has provided support for and made presentations in numerous communities in Michigan.

The participation of organized opposition groups, particularly those from outside the community, makes determining the integrity of qualified supporters' specific demands difficult. In response to such demands, the majority of planning commissions here established stricter requirements for vegetative screening and setbacks, and developers either expanded screening beyond their original plans or secured additional land to expand setback distances. Yet these responses rarely had the desired effect of increasing support. Were these qualifications simply well-designed moving targets deployed by opposition groups to delay development and enrage residents? Or did these demands represent more important and difficult-to-articulate place-based values? As Wolsink [73] and Cowell et al. [74] describe, the visual impacts of LSS are much greater than just its aesthetic or visible impact. Instead, LSS's visual impact includes effects on residents' attachment to place, their perceived loss of amenity, and changes to the character of the landscape [25]. As seen with Tribal communities opposing oil and gas development, these concerns are often harder to specify and quantify, and thus are easier to ignore by local officials and developers [75]. In such cases, physical alterations like planting buffers and installing screening may not only fail to increase support but would instead increase LSS's visual impact—as perhaps occurred here.

Regarding requests by residents for direct payments to neighbors and non-lease-holders, officials and developers were less responsive. One likened such requests to having to compensate residents every time a department store was constructed in town. Another offered a community benefit package that could be used or distributed however the community saw fit (which could have included direct payments); however, local officials declined this offer, arguing such payments constituted a bribe. The lack of attention paid to these distributive justice concerns by both the developer and local officials is surprising, considering how important the distribution of benefits is to solar acceptance [25,29]. On the other hand, payments being interpreted as bribes is common in the wind literature [76], as is residents questioning the size of such payments, mistrust in developers' motives for providing payments (i.e., public relations schemes and marketing) [77], and rhetoric about bribes undermining the perceived positive benefit of payments [78]. Previous work suggests that institutionalized benefit packages may increase support [76]. Yet many of our interviewees identified developers' reliance on tax credits and government subsidies as a key concern, as were efforts by developers and government officials to reduce previously agreed upon tax burdens. This, along with LSS projects being sited in predominantly politically conservative areas, suggests that institutionalized benefit packages may not have the desired positive effect, especially if they lack significant influence over decision-making processes or increased community ownership of LSS [79]. The importance of community members being meaningfully consulted, i.e., being able to influence the design, distribution of impacts and outcomes of LSS, and even outright owning portions of the project, have all been identified as key to improving the procedural justice of LSS siting, and improving acceptance [25,31]. Here such consultation was largely absent.

Similar to recent work by Nilson and Stedman [17] in New York, many residents argued that prime agricultural land was inappropriate for LSS. However, local officials and developers identified significant constraints in siting LSS elsewhere. Officials argued that omitting farmland from a solar ordinance would amount to exclusionary zoning, which is illegal in Michigan, and developers argued that siting LSS on non-agricultural land was too costly and risky to pursue. One developer argued that siting on brownfields not only increased risk, but increased engineering and environmental compliance costs making such development unrealistic. Such constraints are likely to be exacerbated by

more aggressive decarbonization efforts. In order to meet New York's 70% GHG reduction by 2030 plan, Katkar et al. [80] demonstrated that 84% of the land suitable for LSS development would be agricultural. To mitigate the impact of that development those authors recommended limiting the local concentration of LSS and maximizing dual use of agricultural land via agrivoltaics.

The size and concentration of LSS sites was a key qualification here as well, supporting recent research showing that positive attitudes toward solar diminish as the size of projects increase [17,25,29,81]. The extent to which concerns about size are substituting for more entrenched opposition or place-based concerns is difficult to know. When one developer significantly reduced the size of their proposal to address residents' concerns, the public balked, citing distrust in the developer. That same developer in response to concerns about their project negatively affecting water quality agreed to relocate the project away from a groundwater source, set extra precautions for pier drilling procedures, and offered ground water testing throughout the project's operation. Yet support did not increase, with residents instead citing both fear that these measures would not safeguard their water and a lack of faith in the developer, who they accused, again, of using deceitful tactics to get the project approved. Accusations of deceitful behavior by developers have been identified by other solar acceptance researchers [25].

This cycle of qualifying support only to renew opposition once accommodations are made makes applying social gap theory difficult. Not only did it prove difficult to distinguish between qualified support and self-interest, even in private settings, which we argue supports previous work questioning whether the latter is an appropriate or even relevant explanation for opposition—we argue it is not. But our application of the theory, and perhaps our use of thematic analysis, struggled to distinguish between—though did help to identify—what amounted to four underlying causes of opposition, each unique in its ability to be addressed by decision-makers. These included: i) physical or technical aspects of project design, ii) concerns about LSS's impacts to place, amenity, and local character; iii) distrust and/or a lack of transparency between residents, officials and developers, and iv) bait-and-switch tactics employed by organized (often ex-local) opposition groups. In response, we identify measures below that can work to address all four of these causes.

4.1. Recommendations

Direct votes on LSS have been proposed [39], yet Michigan residents can only petition for a referendum on zoning laws or amendments and cannot directly approve of development applications [62]. Instead, we encourage less formalized methods such as surveys or polls, conducted online, distributed via social media or mailed to households, which as identified here can more accurately gauge support and gather representative data regarding preferences. Community members are unlikely to be familiar with specific LSS characteristics, so additional resources may be necessary, such as providing static images or virtual simulations of system attributes [82]. University researchers and Extension agents could be especially useful in developing and conducting such surveys due to their experience and third-party status.

As with wind energy, meaningfully involving community members in the LSS development process needs to begin as early as possible [54,83], if possible during the formation of the master plan and solar zoning ordinance. Ideally, this engagement should occur before a developer demonstrates interest in an area. No community here had a formal collaborative process whereby citizens could directly affect or see their criteria incorporated into decisions. Opportunities for public participation in the zoning and permitting process relied exclusively on public meetings, which focused on informing (i.e., one-way communication) or consulting (i.e., two-way communication). Neither of which necessitated decision-makers acting on the views shared with them [84]. Instead, local officials and state governments should expand opportunities for residents to participate by conducting participatory planning

exercises, such as “Solar Powering Sunnyside” [85]. Such efforts are not only key to improving acceptance of renewable energy development [83,86], but also its outcomes [87]. For developers, open houses, door knocking, project websites, and social media campaigns were all identified as effective means of building trust and increasing transparency.

Organized networks, a tactic deployed effectively by opponents, can also empower project supporters. Independent coalitions of advocates or landowners have demonstrated success in uniting supporters for renewable energy projects [88]. Interviewed here, a representative of one of these coalitions identified the value of targeting thought-leaders from communities, including representatives from the Chamber of Commerce and different church groups. Instead of increasing the number of supporters, these groups instead aim to amplify their voices in a manner similar to that used by opposition groups. It should be noted that such coalitions are not always effective [89], and here a large number of supporters were identified by a group attempting to organize in Raleigh; however, many of those residents remained unwilling to support the project publicly due to the hostility of those in opposition.

Compensation continues to be a controversial element in LSS development. Residents here preferred cash payments, e.g., good-neighbor payments, and reduced electricity rates. However, what residents consider fair may not align with what developers consider fair. Previous studies have shown that financial incentives used to address property value loss were not sufficient to offset burdens and were perceived to lack procedural fairness [90]. Recently, the state of New York adopted the provision of an annual utility-bill credit to all residential electricity customers in a town or city that hosts a solar or wind project with a capacity of 25 MW or more, funded by the owner of the project [91]. A more effective means of empowering residents may be through community ownership, either through decision-making processes that allow individuals to contribute to project design, or by providing options to own or lease a portion of the project with adjusted utility rates based on investment [25,30,31]. Such measures can positively affect support [49,92], and individuals who have a personal tie to a project are more likely to want to see it succeed [39,87].

Finally, continued LSS development, particularly at the speed necessary to decarbonize US energy systems, will require the use of agricultural land, and states should encourage the implementation of agrivoltaic systems, which have demonstrated success by improving the landscape fit of LSS [18,80]. Alternatively, states like Michigan could encourage solar projects on brownfields by enhancing existing financial incentives and streamlining processes for liability protection [93].

5. Conclusion

This study describes a potential LSS social gap in two communities in Michigan. Contributing factors to such a gap involve organized opposition groups maintaining a democratic deficit, and a lack of meaningful engagement with residents by local officials and developers leading to distrust in those relationships and the decision-making practices necessary to address residents' qualifications. Those qualifications centered on LSS's aesthetic impact, a lack of adequate compensation, the improper use of agricultural land, water safety, project size, and the transparency of decision-making processes and residents' ability to influence those processes. Means of addressing a gap involve increased communication and earlier engagement by local officials and developers with residents, better organization of—and by—project supporters, increasing opportunities to influence and take ownership of LSS projects, and better aligning LSS development with agricultural values and production.

Declaration of competing interest

All authors have participated in (a) conception and design, or analysis and interpretation of the data; (b) drafting the article or revising it critically for important intellectual content; and (c) approval of the final

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Appendix A. Supplementary data

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