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Understanding Barriers to Agrivoltaics: A Survey Approach

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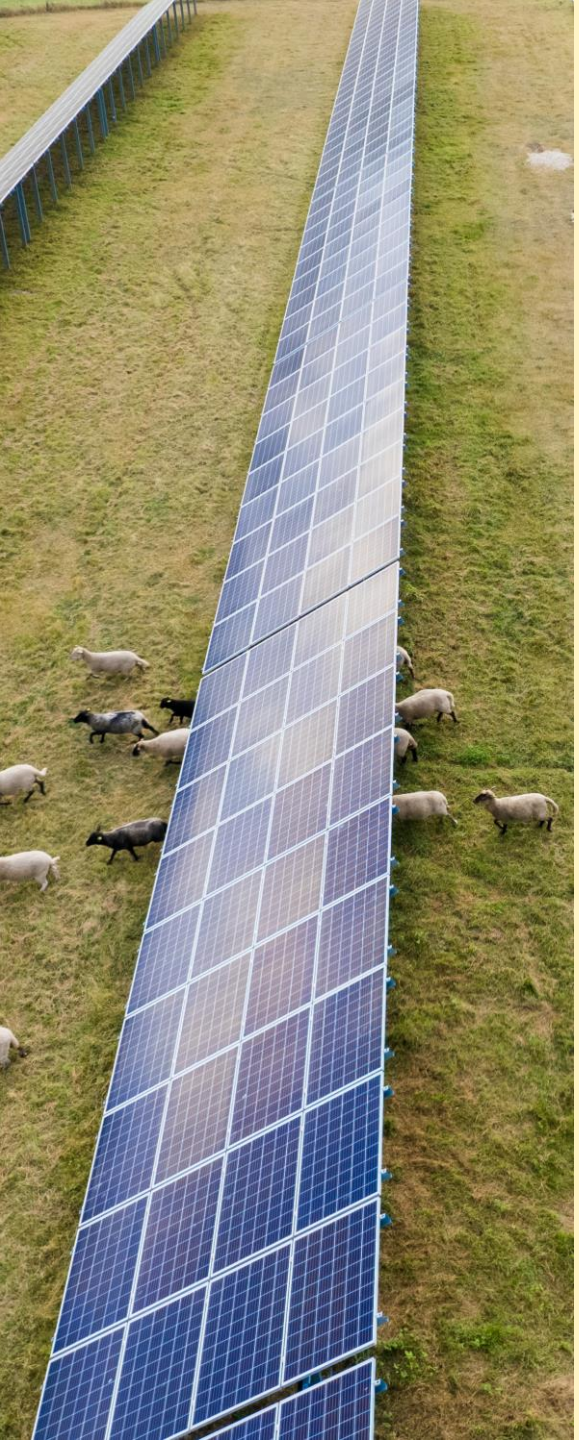

Key Findings

- **Up to 70% of farmers open to large-scale solar on farmland, under certain conditions**
  - Large majorities of farmers are open to the idea of large-scale solar on farmland, but support is primarily conditioned on the inclusion of dual-use or agrivoltaic strategies in system design
  - While 30% of farmer respondents consistently opposed large-scale solar under any condition, these respondents were less likely to be familiar with agrivoltaic design concepts
- **Farmland projects seen by developers as easier to develop in almost all respects, except permitting**
  - The frequently level and clear landscapes with good soil created by farmers often create more favorable conditions for developers. However, permitting is seen as significantly harder for farmland projects due to public opposition to development on farmland.
  - Developers expect that large portions of their future business will be on farmland. Many expect to use agrivoltaic design concepts in the future if they don’t already.

Key Findings

- **Farmers motivated by additional income streams; developers by reputational benefits**
  - Farmers are motivated to add large-scale solar installations to their farmland by the additional income streams presented by the systems, with most indicating that these income streams are intended to supplement and not replace the farm operation. Most farmer respondents were in favor of system designs that allowed continued use of land under the solar panels for agricultural purposes
  - While developers are interested in pursuing farmland solar projects because they can be easy to develop in many respects, they are interested in pursuing agrivoltaic system designs because it preserves farmland and enhances the reputation of their company within the community. Developers want to grow their business, but there is recognition that keeping farmland in operation where possible can help enable growth.

Key Findings

- **Farmers and Developers want to see agrivoltaic projects, but many dual-use strategies can be challenging to implement**
  - Farmers overwhelmingly point to agrivoltaic strategies as mitigants to their concerns around farmland solar development. Over 85% of developer respondents have tried or would try to implement agrivoltaic designs in developing projects. Where the parties diverge is around implementation difficulty, with developers pointing to challenges in deploying several agrivoltaics design strategies
  - However, developers with experience in developing agrivoltaics projects report less difficulty in implementing all agrivoltaics strategies and less concern around potential agrivoltaic roadblocks.
- **All stakeholders agree that incentives, financial/legal guidance, best practice guidelines can help address barriers**
  - Of the 17 strategies proposed, respondents across pathways coalesced around 8 strategies, with incentives for agrivoltaics projects heavily favored by most respondents. Legal and contract guidance, and per-reviewed research on system design, soil and water impacts and crop and livestock impacts also rose to the top.

Key Findings

- **Less support for farmland solar and lower levels of familiarity with agrivoltaics from non-white farmer respondents**
  - Though sample sizes were small, non-white farmer respondents were less likely than white respondents to be conditionally open to utility-scale solar on farmland (57% to 80%) and were less likely to express familiarity with agrivoltaics than white farmers (33% to 69%)
  - Non-white farmers also preferred to receive information on solar development on farmland from different sources than white farmers, with non-white farmers preferring extension services, farm and farmland member organizations and state agricultural agencies, while white farmers preferred solar developers and research centers/universities.

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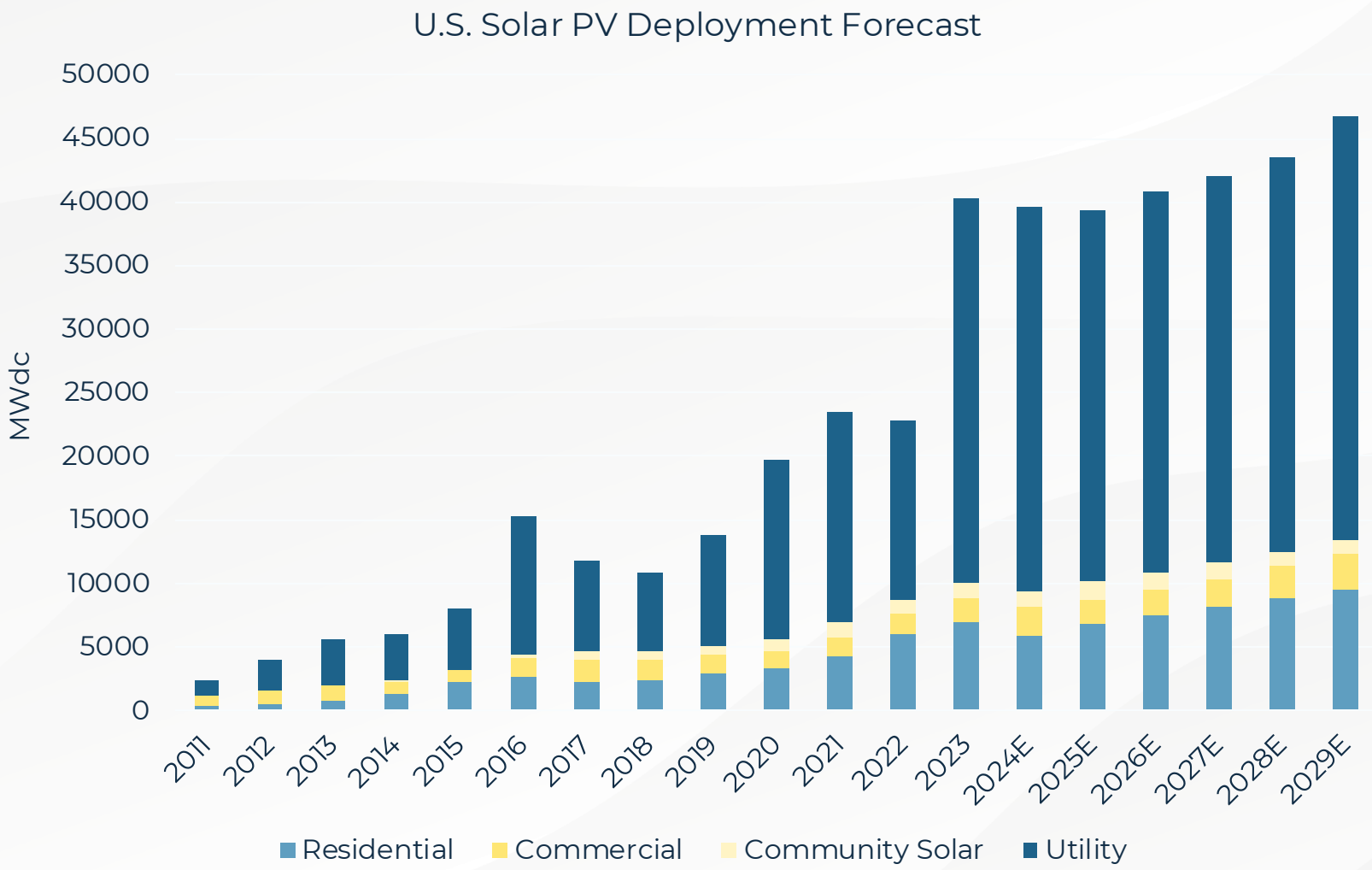
Introduction

A Growing Solar Industry

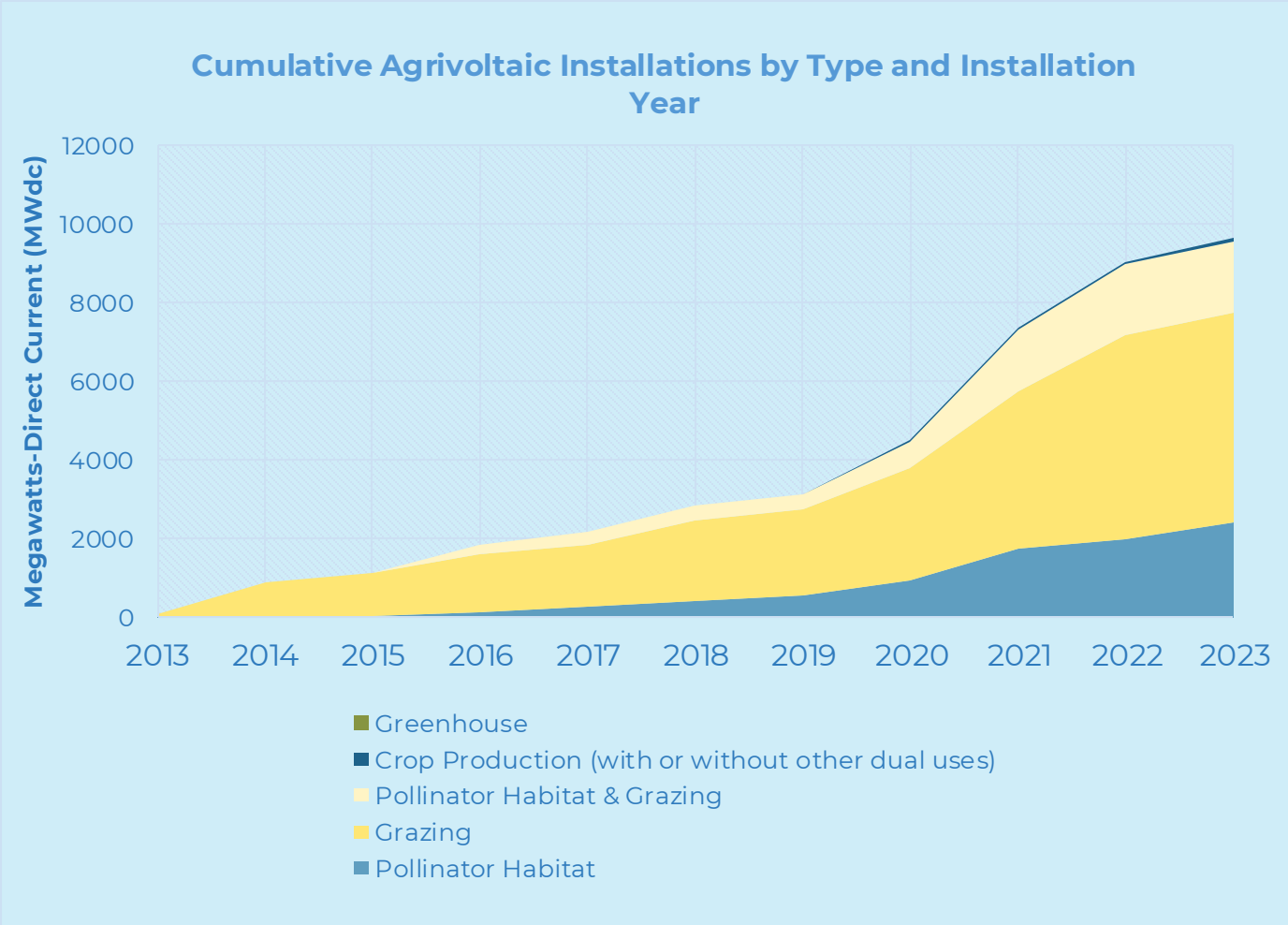


- 6% of U.S. electricity comes from solar energy, almost **6 times** its share a decade ago.[1]
- Solar PV prices have declined **43%** over the last 10 years.[2]
- The industry is continuing to grow, with **450 GW** of new solar capacity expected to be installed over the next ten years, more than tripling the amount of solar installed in the U.S. today.
- As solar energy is more rapidly deployed it is expanding into new markets, which has, in some instances, created tension between solar development and existing land uses.

Source: SEIA/Wood Mackenzie U.S. Solar Market Insight Q2 2024

Farmland Solar Development Increases

- Agricultural land is especially well-suited for solar development because it is frequently cleared and level with easily worked soil.
- According to American Farmland Trust (AFT) **83% of all utility-scale development between 2020 and 2040 is expected to occur on agricultural lands.**
- While estimates on farmland used for solar production range from 0.3%[3] to 0.7%[4] over the next 10 – 20 years, **development may be more acute in areas** with smaller shares of farmland[5] or in close proximity to transmission.
- Farmers too, have an interest in solar development as the lease payments generated to landowners can help diversify and stabilize income streams.
- As a result, interest in solar development on farmland has increased, leading to local and state-level public opposition, denial of building permits or zoning variances and in some cases, **broad-based moratoria** that restricts or bans future solar energy development in a community.



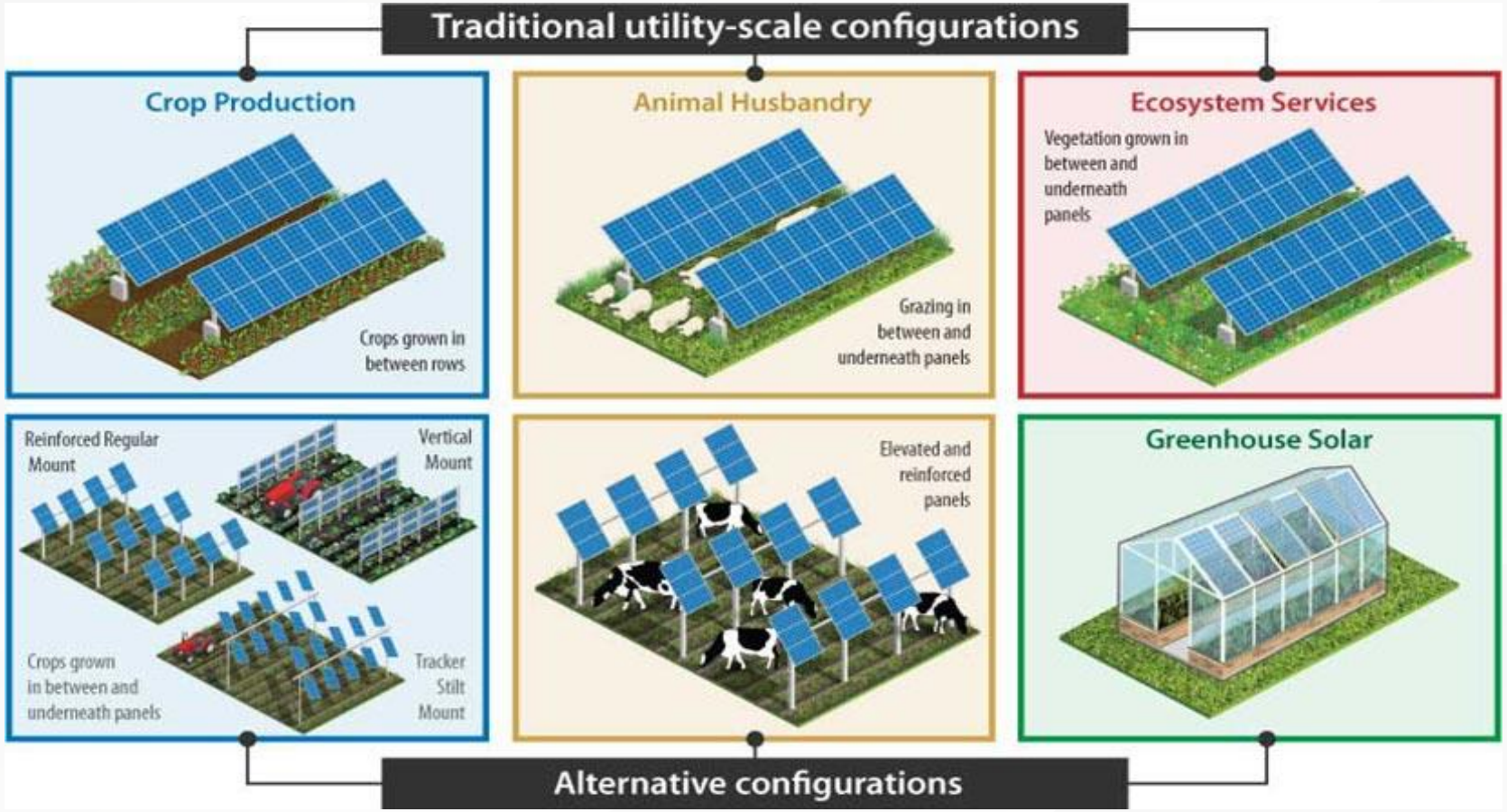
Source: InSPIRE Agrivoltaics Map: https://openei.org/wiki/InSPIRE/Agrivoltaics_Map

Opposition to Farmland Solar Development

Opponents to farmland solar development cite concerns around the preservation of farmland, rising land prices, loss of natural amenities, potential degradation of soil health, diminished farm support services, and lack of community-wide benefits.

This opposition has led developers and other renewable energy supporters to explore a variety of strategies to address local concerns with farmland solar development, including the payment of mitigation fees, negotiation of property tax agreement or broader community benefit agreements, compensation of adjacent landowners, and finally, the implementation of **dual-use or agrivoltaic elements** in project design. This final strategy is the core focus of this research effort.

Defining Agrivoltaics



Source: NREL, https://www.nrel.gov/news/program/2022/growing-plants-power-and-partnerships.html

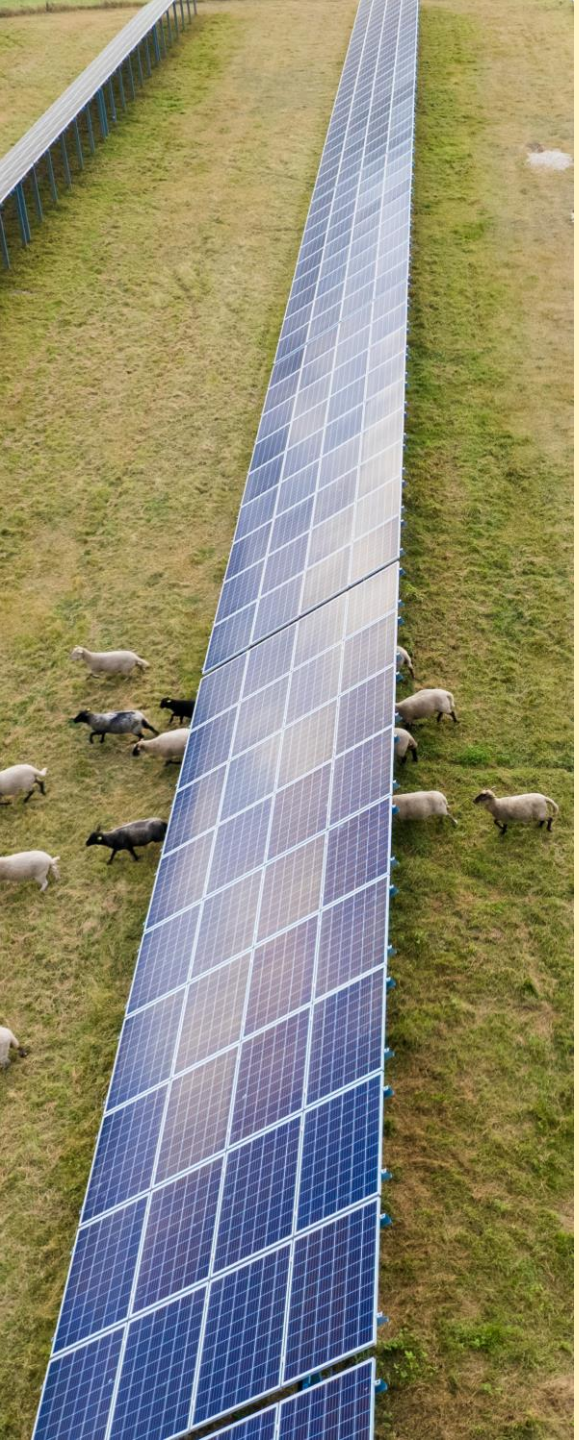
According to the U.S. Department of Energy, **agrivoltaics is defined as agriculture such as livestock grazing, crop production, or pollinator habitat that occurs under, between and around rows of solar panels**.

Because this is an emerging field the definition is often shifting. For example, industry and policy makers have moved away from including pollinator habitats in the definition because in many instances it does not have a direct agricultural output. However, **pollinator habitats would still fall under the broader definition of "dual-use solar"**, and because it has frequently been deployed as a strategy in farmland solar development, it was considered as part of this research effort.

Agrivoltaics Benefits

Agrivoltaics can benefit farmers by increasing and diversifying their income while still allowing for agricultural production. As **farmers have seen their input costs grow by 28% since 2020**[6] and have been beset by natural disasters and a changing climate, many farmers have struggled to maintain profitability. This is especially true for small farms and those located in disadvantaged communities, which face unique challenges, related to scale, market access, energy costs, pollution and other socioeconomic burdens.[7] For these farmers, the income from a solar project can help increase or stabilize finances and allow for an income stream outside of their traditional business, while allowing them to maintain or even enhance their existing agricultural operations.

Agrivoltaics have increasingly been shown to **provide benefits to the soil, crops and livestock** maintained under and around the panels.[8] The shade provided by the panels can be beneficial to grazing livestock and many types of crops and can reduce irrigation needs . Pollinator colocation can improve crop yield, and the native vegetation planted can improve soil health, increase water retention and reduce runoff.[9] Solar grazing, a specific type of agrivoltaics in which sheep are used to provide vegetation management for solar projects, **can significantly reduce developer operations and maintenance costs** while providing needed pastureland and additional income for sheep farmers.[10]



Community Agrivoltaics Benefits

- At the community level, the installation of agrivoltaics installations can **support the development of new short-term jobs** in solar installations, while maintaining and in some cases increasing agricultural employment.[11]
- Sites that include pollinator habitat can provide benefits to adjacent landowners.[12]
- Because the systems often allow for similar or expanded levels of agriculture at the site, **many agrivoltaics projects receive less public opposition** than traditional large-scale solar development, allowing for an easier permitting process and reducing cost to both developers and landowners.[13]

Agrivoltaics Challenges

Despite benefits to farmers, developers and communities, the **cost to install agrivoltaic systems is typically higher** than that of traditional large-scale solar development.[14] While some agrivoltaic strategies can be implemented without major changes to traditional system design, many designs require panels to be elevated beyond their traditional height, increasing materials costs, or for rows between panels to be widened, which reduces energy density and return on investment. There is also additional cost associated with the planting of native non-invasive grasses and flowers that are used in projects that implement pollinator habitat and/or solar grazing. Many developers lack experience in agrivoltaics system design and as a result have to spend more time and money designing the system or hiring specialized subcontractors.

On the agricultural side, **more research into impacts from varying agrivoltaics system designs on a wide-range of crops and livestock is needed** to address farmer uncertainty. Concerns around liability have presented challenges to both farmers and developers seeking appropriate insurance for their projects.[15] It can also be harder to finance agrivoltaic projects given the lack of energy and agricultural performance data from a relatively small number of systems installed in the U.S.

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Developing Resources for Deploying Agrivoltaics

Developing Resources for Deploying Agrivoltaics

- This research builds on the existing literature around opportunities and challenges in U.S. agrivoltaics development by providing comparative experience and sentiment analysis across multiple stakeholder groups, specifically, **farmers, solar developers and utilities**.
- While existing survey research has assessed farmer sentiment towards farmland solar and agrivoltaics, and community attitudes towards farmland solar, no known research effort has sought to compare sentiment across multiple stakeholder groups using the same survey instrument.
- In doing so, this research is able to **identify challenges that are shared by multiple stakeholder groups and unique to individual groups**.
- This approach also allows for the identification of challenge mitigation strategies that can work across stakeholder groups or can be targeted to a specific challenge or group.

Funder: U.S. Department of Energy Solar Energy Technologies Office

Funding Amount: $544,843

Project Partners:

- Solar and Storage Industries Institute (SI2)
- National Rural Electric Cooperative Association, Research (NRECA)
- National Farmers Union (NFU)
- Solar Energy Industries Association (SEIA)

Target Project Size:

>1 MW for crops

>10 MW for grazing & pollination

Deliverables and Timeline

Fall/Winter 2023	Literature review & survey design
February 2024	Survey release & promotion
Summer 2024	Survey analysis
September 2024	Survey report release
Fall 2024	Case study site selection
Winter 2025	Conduct case studies
Spring 2025	Analysis and writing
Fall 2025	Release of best practice guides, contract templates, and final project report

- This survey effort is part of a larger project, **“Developing Resources for Deploying Agrivoltaics”**, funded by the U.S. Department of Energy Solar Energy Technologies Office.
- In addition to this survey effort, the project team will **conduct case studies of 6-8 operating or under development agrivoltaics projects** to allow for more detailed qualitative research into specific challenges faced by a wide array of project stakeholders.
- The case studies and survey results will then be used to support the development of several agrivoltaics **best practice guides customized for each of our stakeholder groups**, plus an additional guide for policy makers.
- These guides will be accompanied by at least **three insurance or contract templates** for use by practitioners with the intention of addressing gaps around liability, risk management and financing.
- The effort will also yield a final project report designed to inform further research in the field.

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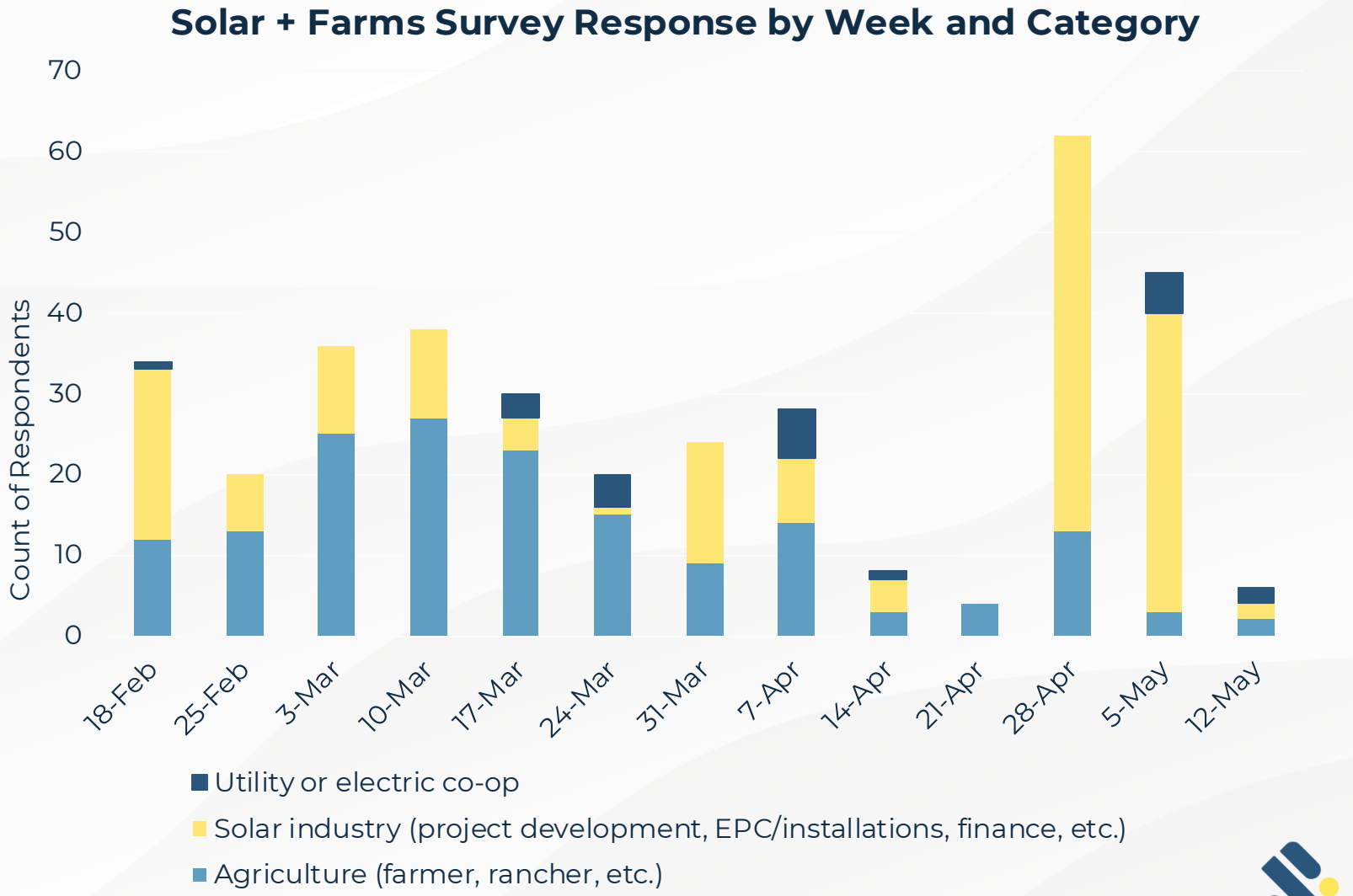
The Solar + Farms Survey

Survey Methodology and Design

- **Survey funnels respondents into agriculture, solar and utility pathways.**
  - Each pathway includes 30 – 40 questions with lines of questioning specific to each segment.
  - Where possible, similar questions are asked across pathways to compare sentiment by different stakeholder groups.
  - Question types include a mix of short and long form open-response, multiple choice, Likert scale and ranking.
- **Each pathway includes three sections:**
  - Respondent details (company type, size, location)
  - Experience with/sentiment towards solar on farmland
  - Experience with/sentiment towards agrivoltaics
- **Question design informed by literature review**
  - American Farmland Trust's *Smart Solar in Connecticut* report was directly referenced, with permission, to build consistency in analysis and test their results across a broader sample.
- **Survey incentive of $50 Gift Cards to 25 randomly selected respondents.**

Survey Outreach

- Survey open February 21st – May 10th
- Survey conducted in digital-only format
- Outreach conducted by partner organizations using social media, weekly newsletters, e-mail marketing and in-person and virtual presentations.
- Median Response time of 16 minutes.



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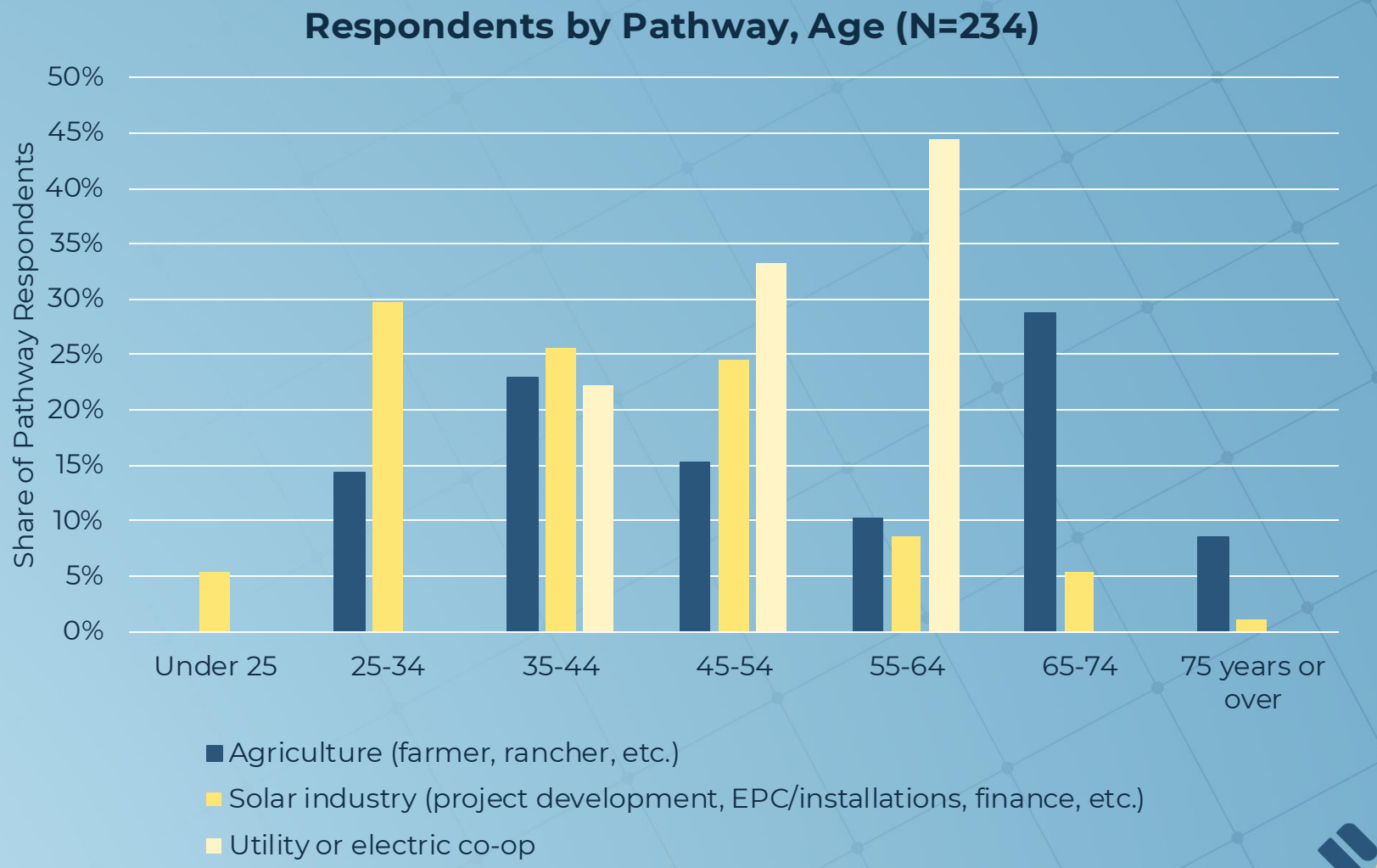
FARMS Survey Sample Details

Overall Sample Details

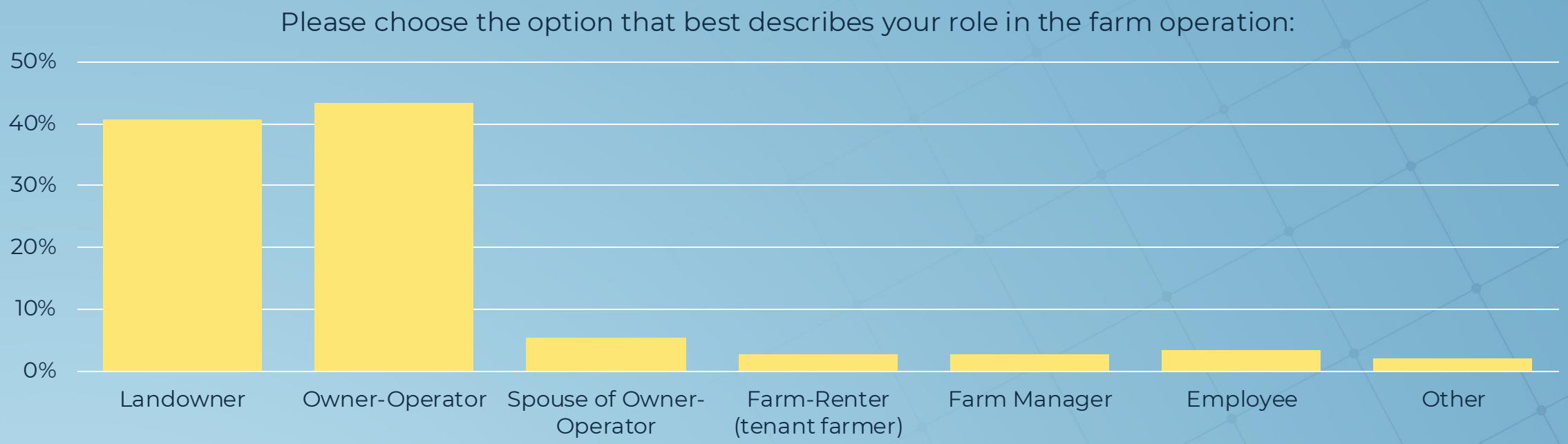
- **355 Full and Partial Respondents**
  - Agriculture: 163
  - Solar: 170
  - Utility: 22
- **Sample is not representative**
  - Respondents were not selected randomly and were largely pulled from the membership of three of the partner organizations involved. Respondents opted into the survey and many, especially within the solar industry, are presumed to have more knowledge and experience with agrivoltaics than the average industry member.
- **Low utility response rate**
  - Fewer than a dozen respondents answered some questions in the utility pathway, limiting the conclusions that can be drawn for that stakeholder group. Findings presented in this report will pull largely from the remaining stakeholder pathways.
- **Good response rate from other pathways**
  - The solar response rate in particular outperformed expectations based on previous survey efforts in the solar industry, suggesting heightened interest in the subject matter.

Overall Sample Details

- Overall and pathway samples are **2/3 male**.
- **Mode Age Range is 35 – 44**
  - Solar respondents skew somewhat younger than agriculture respondents.
  - The age category 55 – 64 was initially missing from the survey response options. While survey designers corrected this error upon awareness, roughly 1/3rd of respondents were not presented with this response option
- **White respondents make up ~75% of overall and pathway samples.**
  - Black/African American: 3.4%
  - Asian: 3.4%
  - Prefer not to answer: 9%

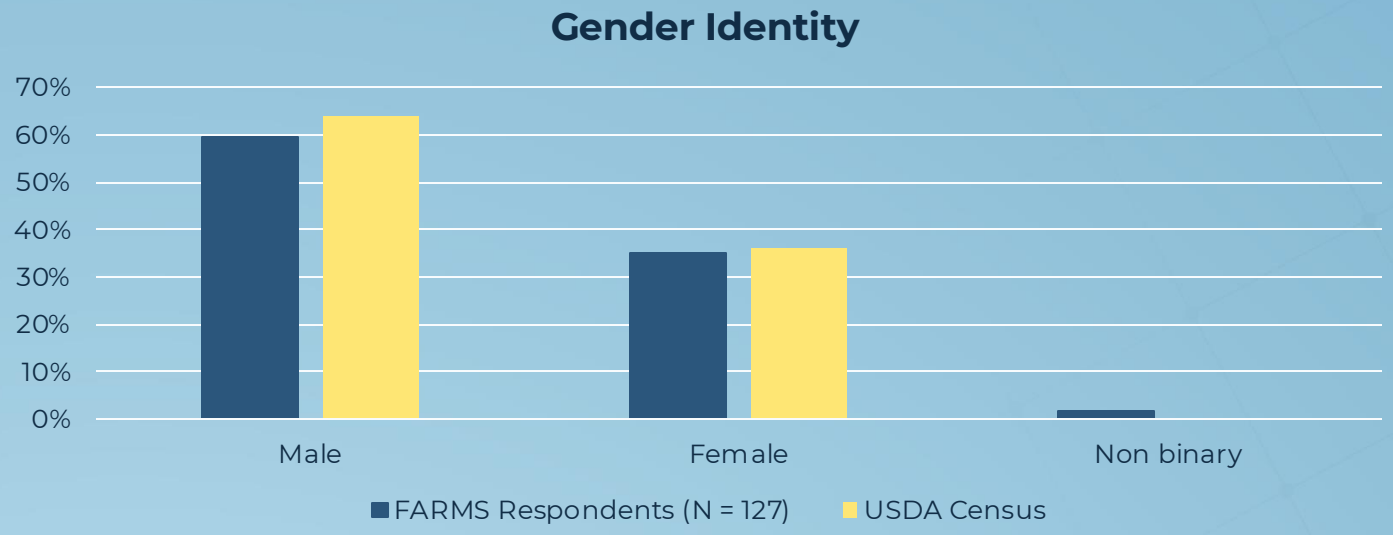


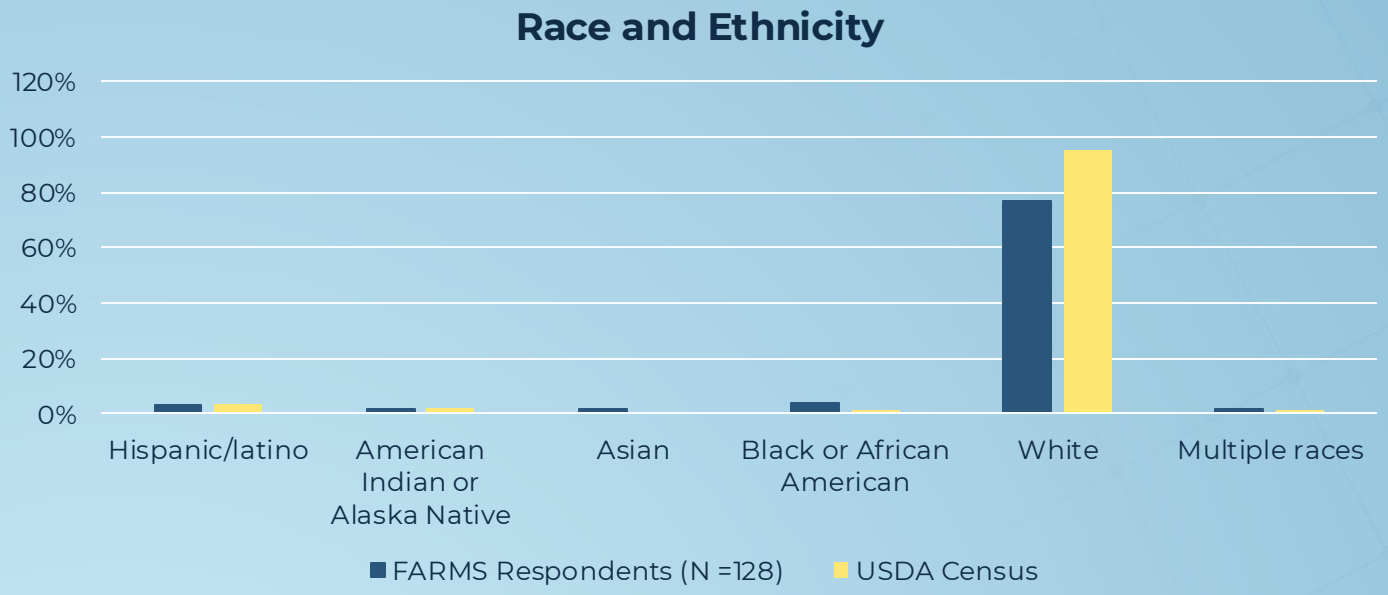
Sample Details: Agriculture



- **163 agriculture sector respondents** from 39 states
  - Midwest somewhat overrepresented relative to other regions
- 55% indicated their farm has a succession plan.
- Majority of respondents indicated that they are the landowner or owner-operator of the farm operation (41% and 43% respectively).
  - While we describe all agricultural respondents as “farmers” throughout the survey, it should be noted that a significant minority of respondents may not actively be involved in the farming operation
- 64% of respondents indicated that the **farm is a family-owned business**.

Sample Details: Agriculture



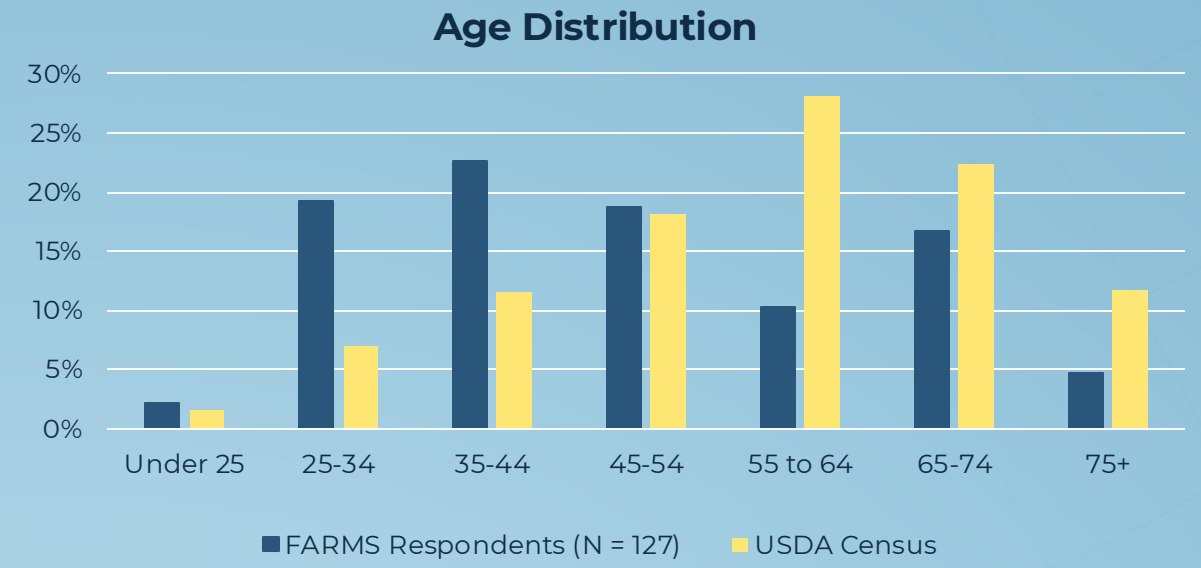


Demographics of farmer respondents are mostly in line with demographic data from the U.S. Department of Agriculture 2017 Census of Agriculture (USDA Census).[16]

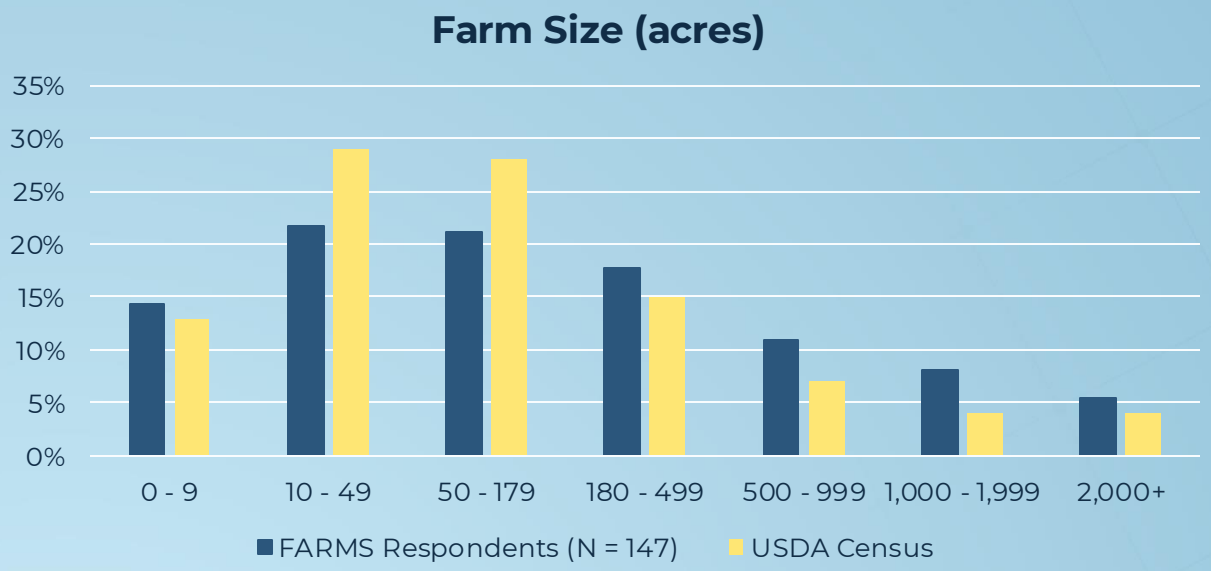
On gender identity, 60% of farmer respondents were male and 36% female, compared with 64% and 35%, respectively, in the USDA Census

76% of farmer respondents were white, less than the 95% reported in the USDA Census. This difference is explained, in part, by modestly higher levels of non-white farmer respondents to this survey. Additionally, 12% of farmer respondents chose not to provide race and ethnicity details.

Sample Details: Agriculture

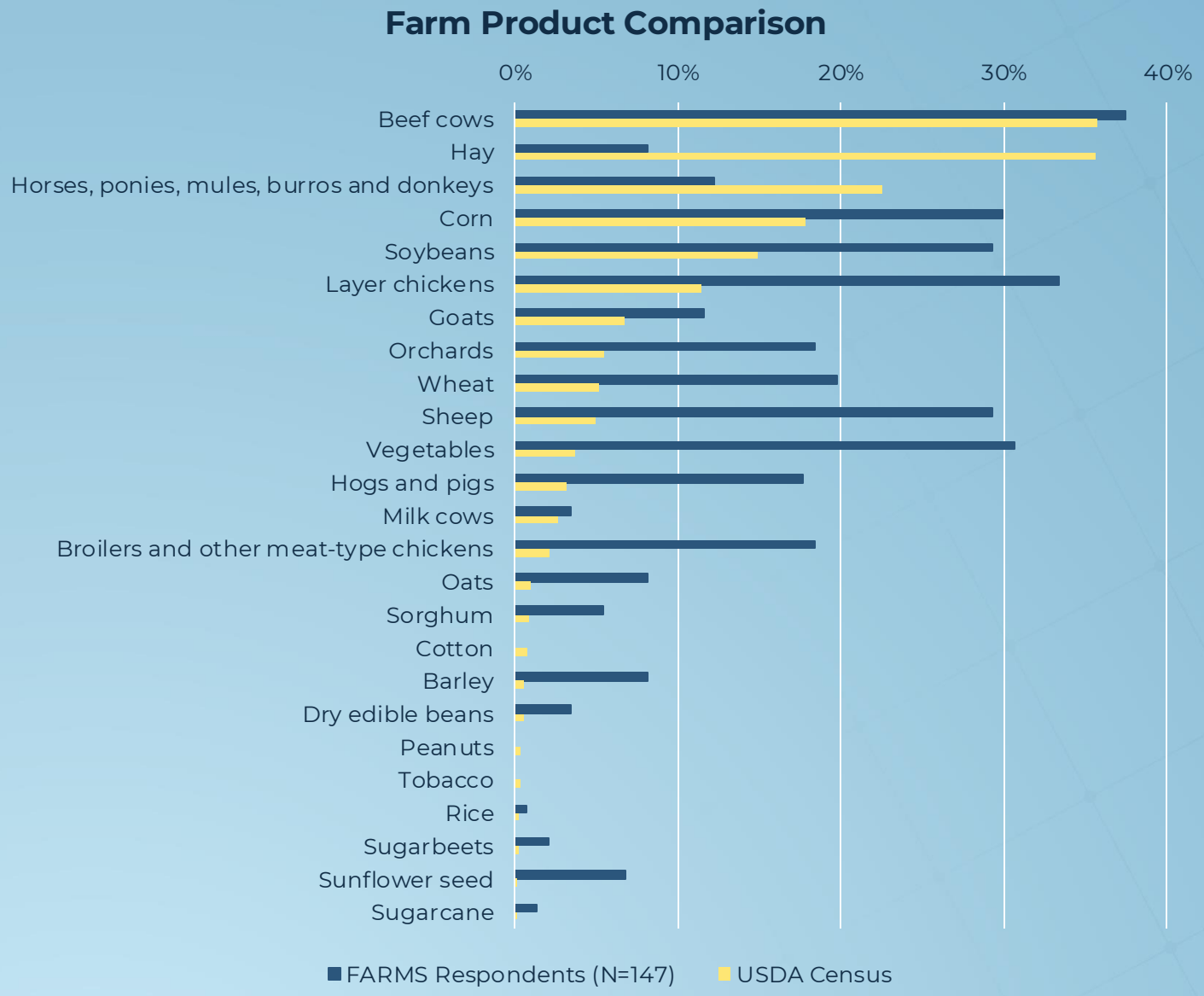


Farmer respondents skewed younger in age than in the USDA Census. This is likely due, in part, to the survey design error that left out the 55 to 64 response option for roughly 1/3rd of respondents. This could also be explained by internet and computer usage patterns of younger Americans compared with older Americans, or by more acute interest by younger farmers in agrivoltaics and solar on farmland.



Farmer respondents reported somewhat larger farm sizes (in terms of acreage) than what is reported in the USDA Census.[17] Still, more than half of respondents reported farm sizes under 180 acres, with 75% working at farms under 500 acres.

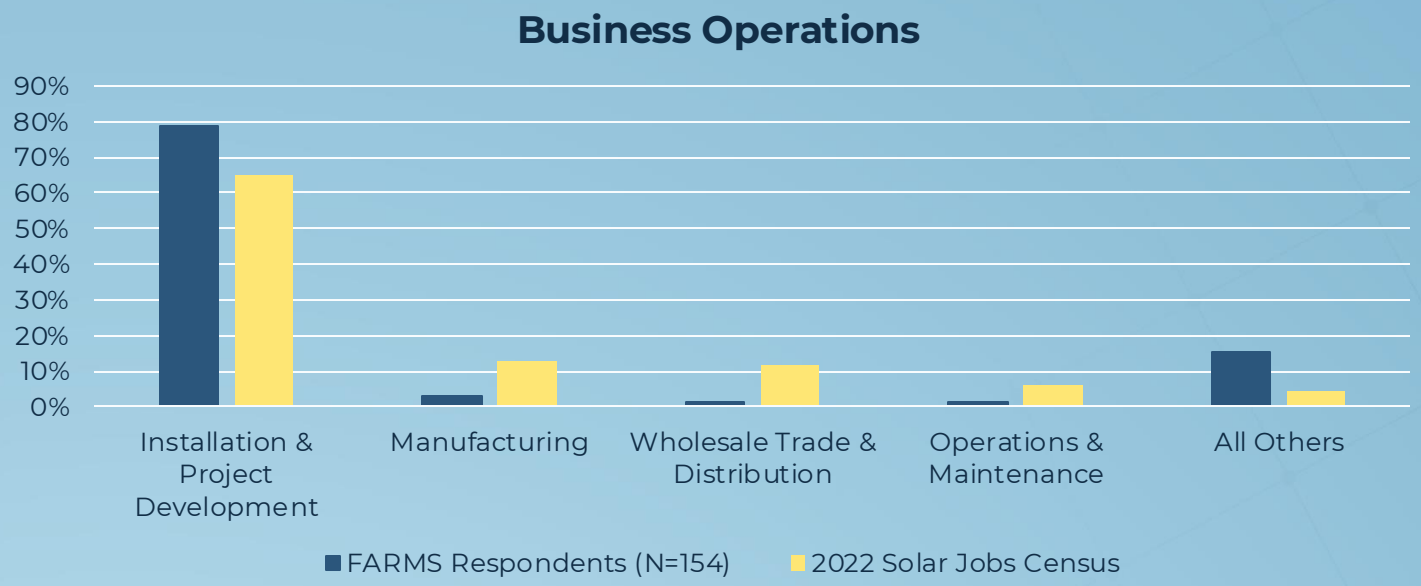
Sample Details: Agriculture

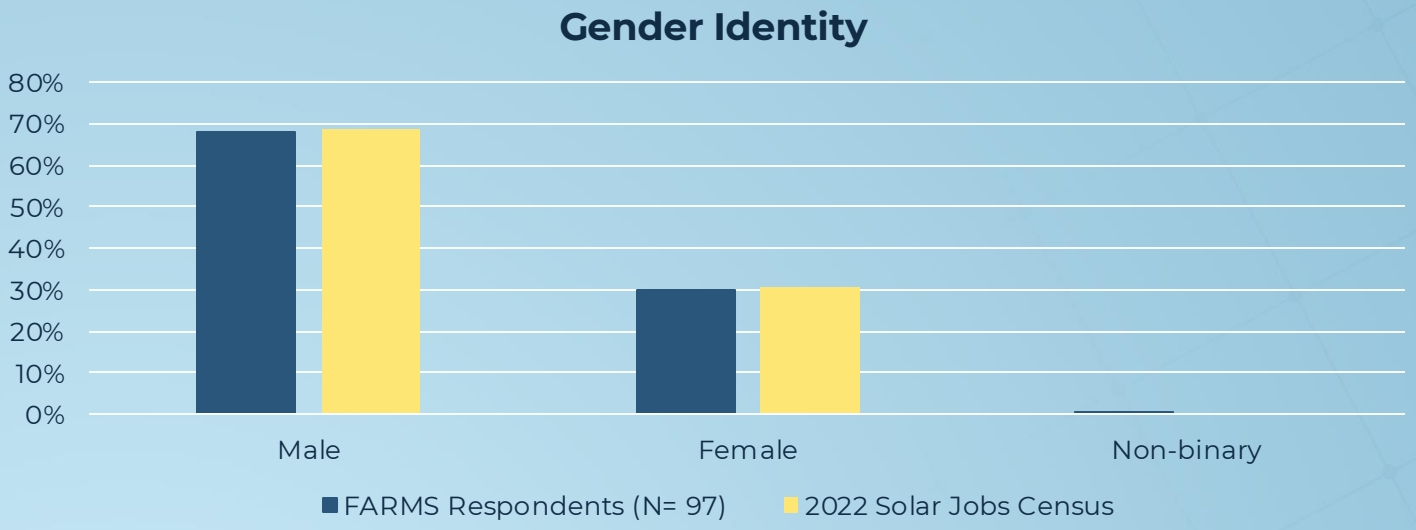


Though the questions are difficult to compare due to differences in the way each study collected data on farm products, these data coupled with responses to open-ended questions **indicate an overrepresentation of sheep farmers in this sample** relative to the population, along with vegetable farmers, to a lesser extent. Farmers producing hay crops also seem to be underrepresented in this survey.

The implications here are unclear, but **could lead to some bias in this survey towards solar grazing focused around sheep**. The relatively high prevalence of vegetable farmers might also lead to different perspectives on under panel farming than would be expected if the sample more closely resembled the population.

Sample Details: Solar Developer



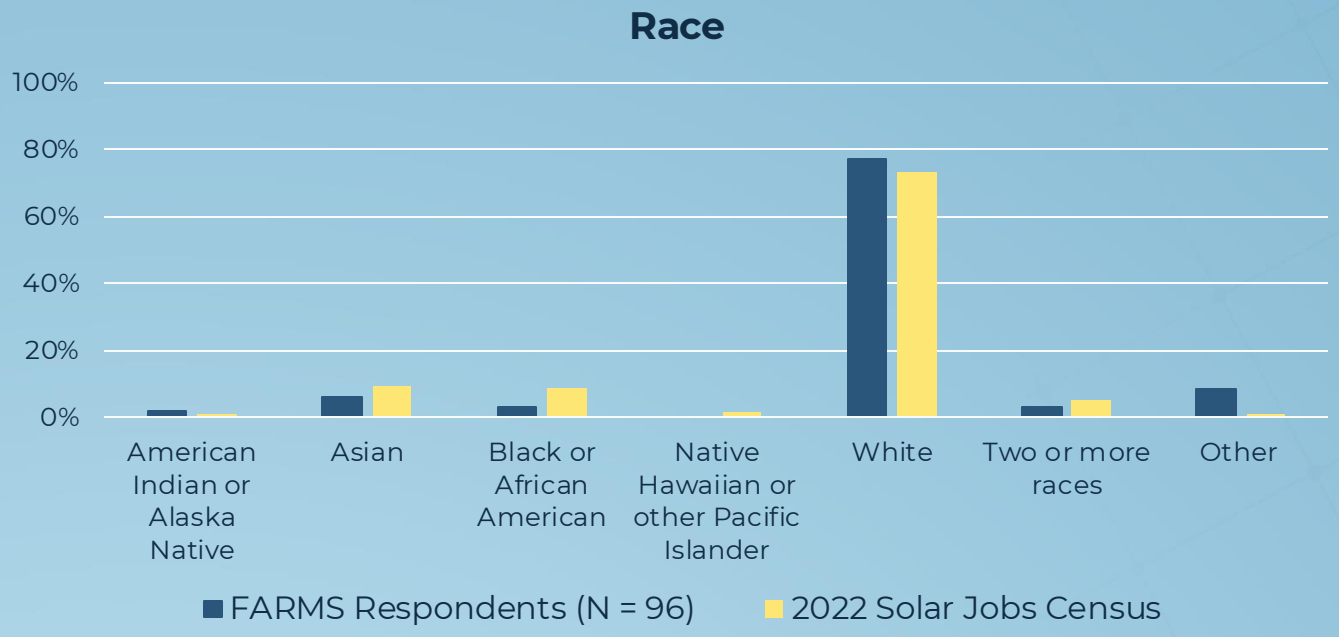


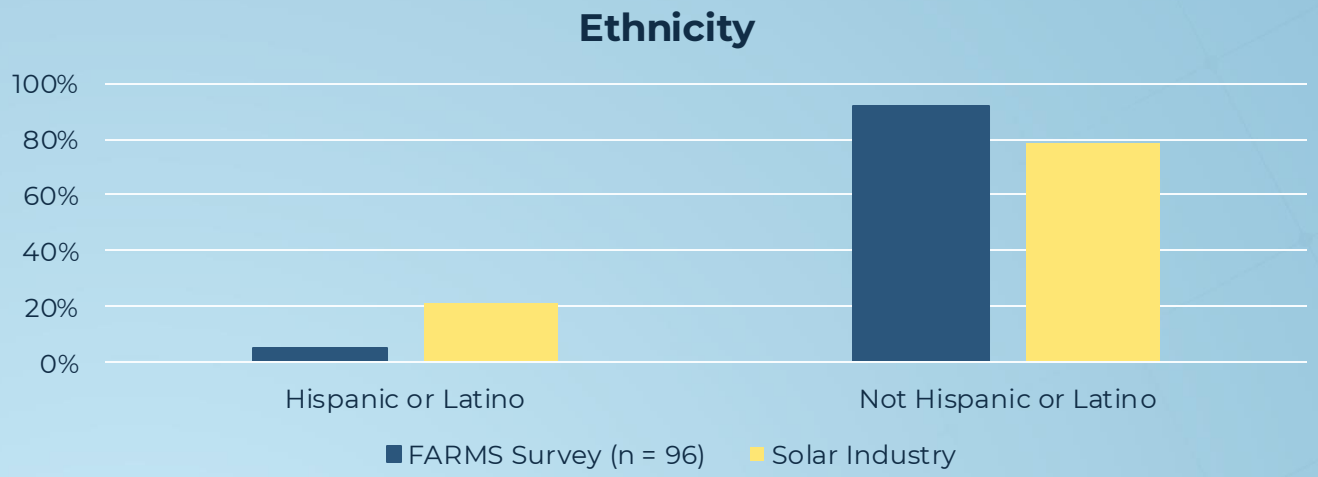
Solar respondent demographics were compared against the Interstate Renewable Energy Council's (IREC) 2022 Solar Jobs Census, which has tracked employment trends in the U.S. solar industry since 2010.[18]

Larger shares of solar respondents work in installations and development than in the solar industry at large. This is primarily because solar developers and solar engineering, procurement, and construction (EPC) companies were the targets of this survey outreach effort, given their familiarity with solar development on farmland.

The gender identity proportions of solar respondents matches closely with gender identity proportions of the overall industry.

Sample Details: Solar Developer





77% of solar respondents identified as white, compared to 73% of the industry overall. A smaller proportion of solar respondents identified as Asian, Black or African American, Native Hawaiian or Pacific Islander, or two or More Races as compared to the industry at large, while similar proportions identified as American Indian or Alaska Native. **Comparisons here are impacted by the presence of "prefer not to answer" and "other" response option in this survey instrument**, which collectively drew 8% of solar participant responses.

Hispanic representation among solar respondents was lower than in the industry at large. 5% of solar respondents identified as Hispanic or Latino as compared to 22% in the broader industry.

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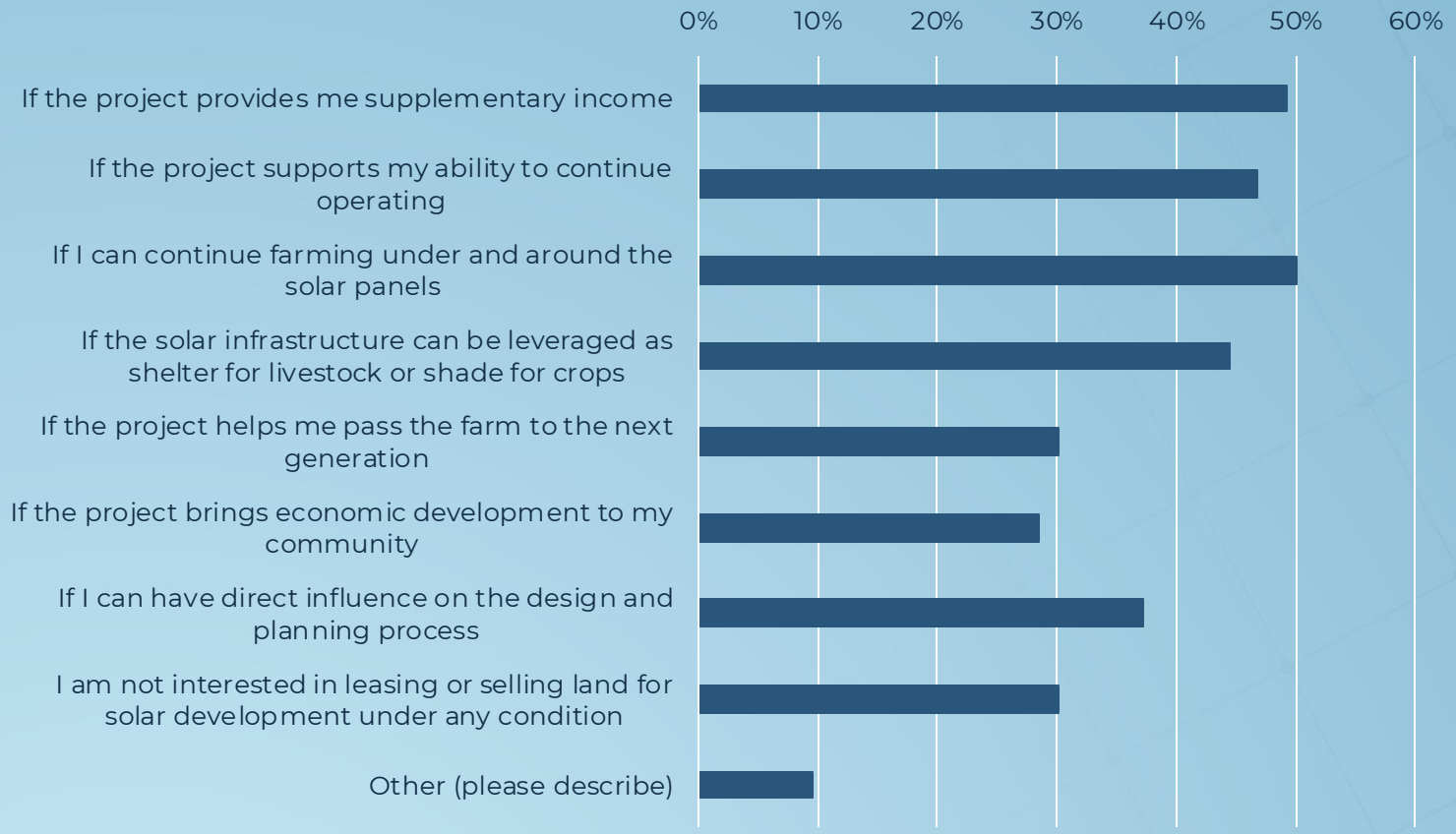
Farmer Perceptions of Farmland Solar Development

Over 70% of Farmers Open to Utility-Scale Solar on Farmland

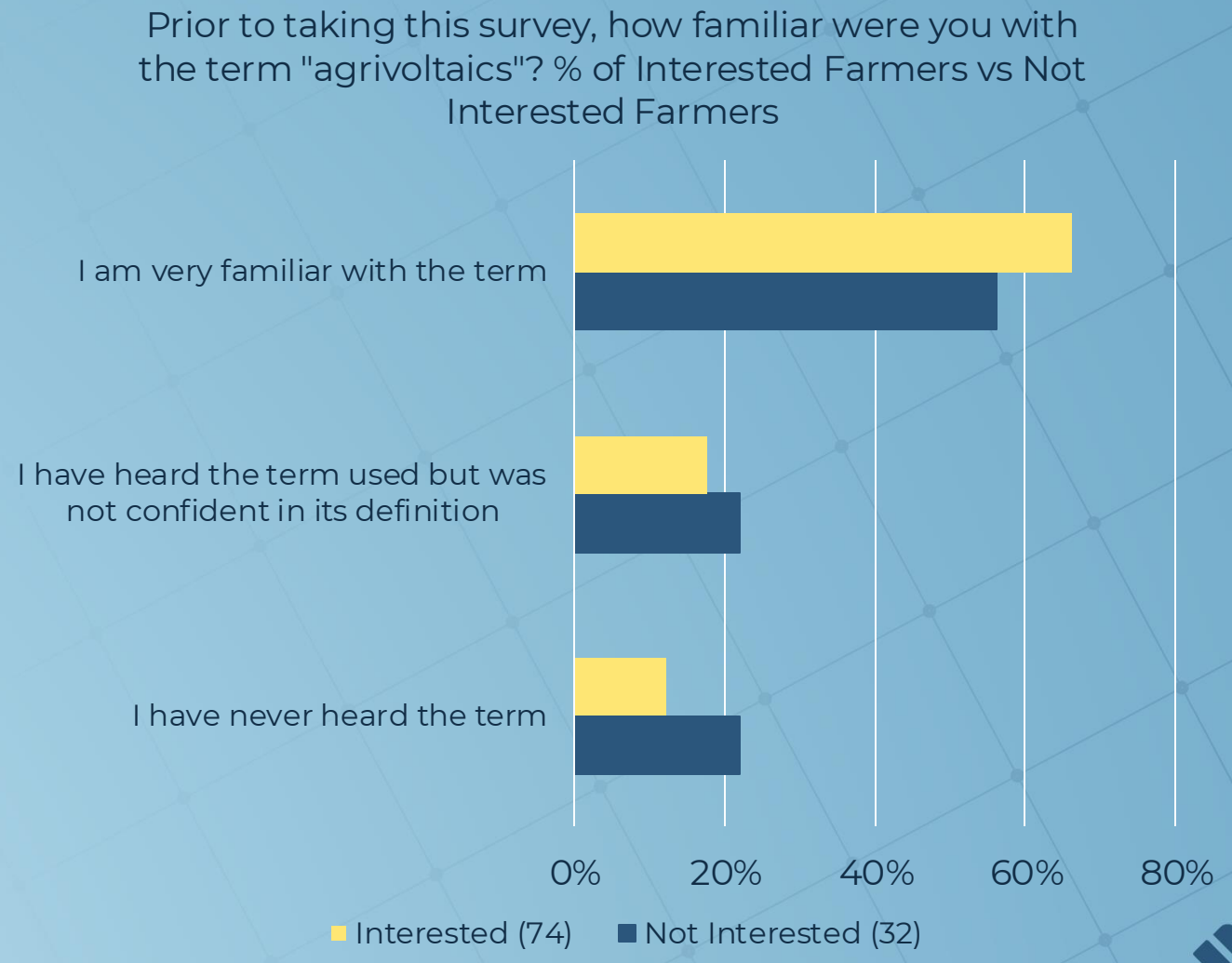
Under what conditions would you be willing to sell or lease farmland to a solar developer for the purposes of installing a utility-scale solar project in which electricity from the project is exported to the grid? (N=126)



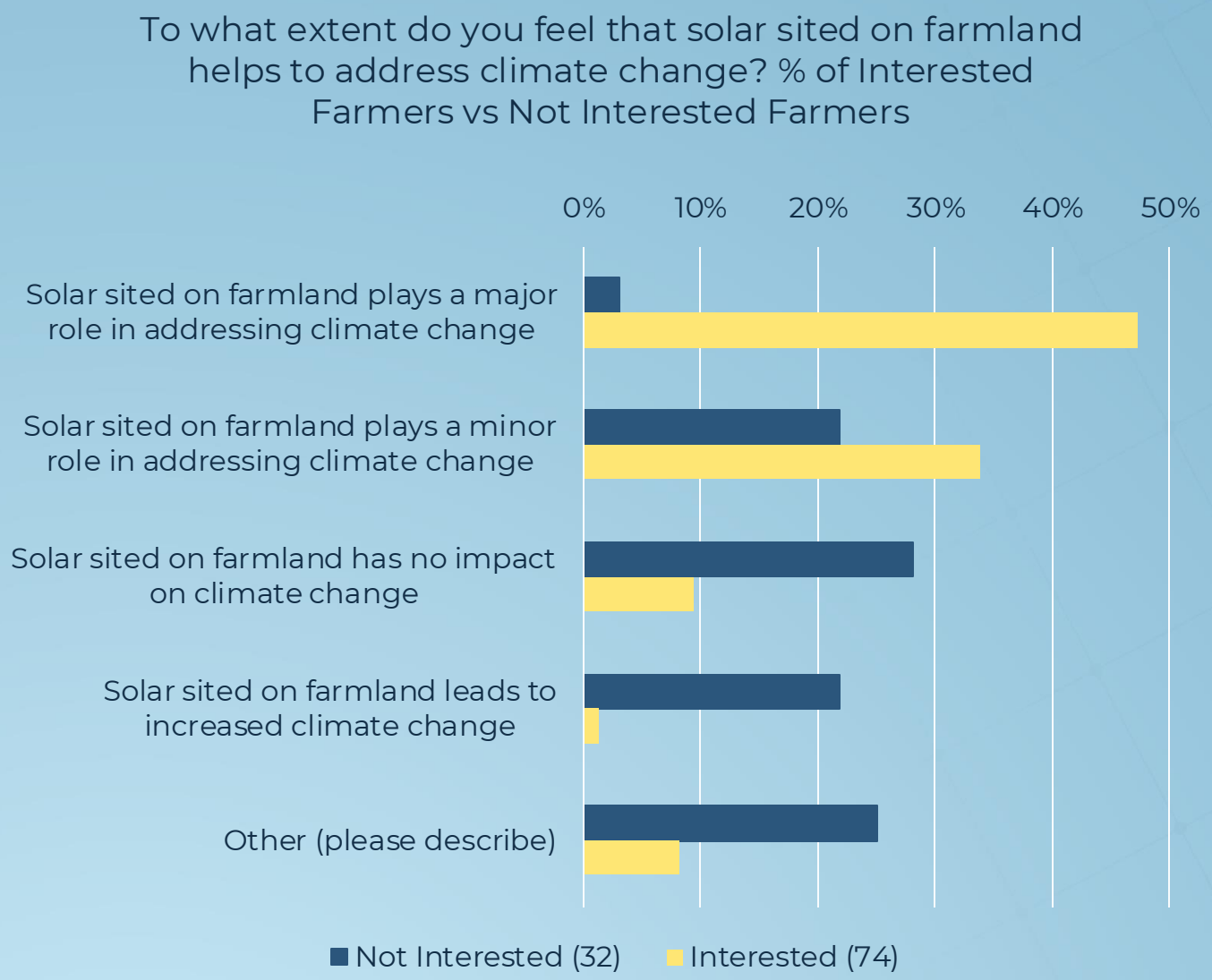
- Across multiple questions in this survey used to gauge interest in utility-scale solar on farmland, **roughly 70% of farmers consistently indicated some level of interest**. This is consistent with findings from previous studies on this topic.[19]
- However, this support is conditioned on a number factors, including, most notably, the ability of the utility-scale project to provide supplementary income and the ability of the farmer to continue farming operations under and around the panels.
- While the former can be achieved by non-agrivoltaic solar projects, the latter can only be realized **using agrivoltaic or dual-use strategies**.
- Two of the top four conditions selected would require dual-use strategies and three of the top four suggest a desire to continue some type of farming operations alongside the solar installation.

30% of Farmers Opposed to Farmland Solar

- **30% of farmer respondents opposed to utility-scale solar “under any conditions”**
  - Farmers that indicated “no interest” in solar development across multiple questions (n = 32) were grouped together and compared against a second group of farmers that showed some level of interest across the same questions (n = 74)
  - Responses to other questions from the “not interested” and “interested” groupings were then compared to assess any differences in response patterns
- **“Uninterested” Farmers less likely to be familiar with agrivoltaics**
  - “Uninterested” farmers were 10 percentage points less likely to be “Very familiar” with agrivoltaics and 10 percentage points more like to have never heard the term
  - Suggests that additional education on Agrivoltaics could lead to greater support for farmland solar development

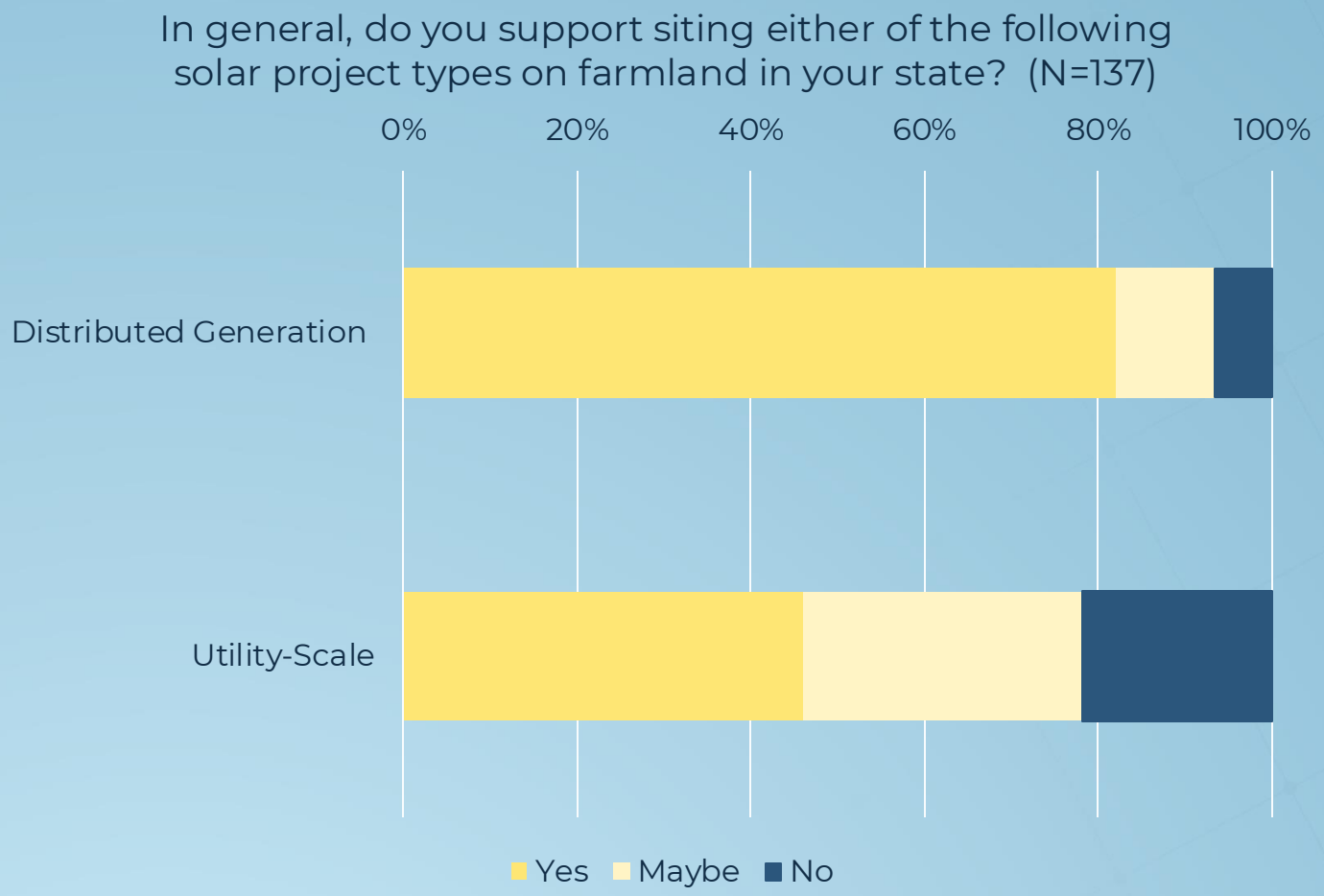


Analysis of Uninterested Farmers



- **"Uninterested" Farmers less likely to be concerned about climate change**
  - 44% of farmer respondents uninterested in utility-scale solar felt that climate change will have no impact or a positive impact on their farms in the future, compared with just 18% of farmers interested in utility-scale solar
  - Similarly, 50% of uninterested farmers felt that utility-scale solar development on farmland would have no impact on climate change or lead to increased climate change impacts
  - The finding suggests that messaging around climate change is unlikely to motivate significant portions of "uninterested" farmers towards solar development on farmland.
- **"Uninterested" farmers prefer non-solar industry messengers on solar issues**
  - While solar developers were a trusted messenger around solar on farmland for 62% of "interested" farmers, they ranked near the bottom of all information sources for "uninterested farmers, who preferred to get information from extension services, universities, and farmland organizations.
  - "Uninterested" farmers were also twice as likely to prefer to "do their own research" on solar issues

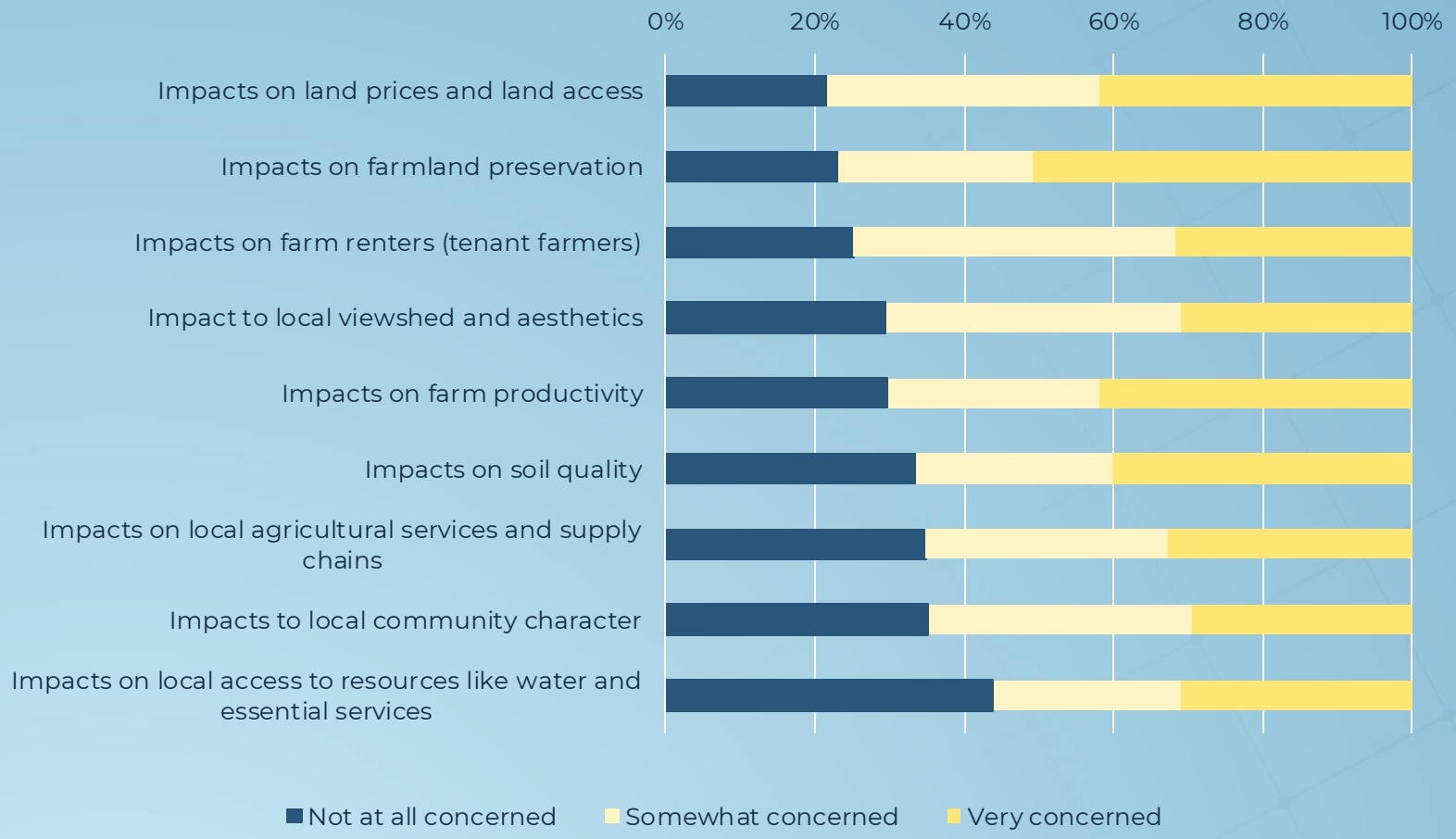
Farmers: Okay with DG Solar, Less so for Utility Scale



- Farmer respondents were **far more likely to support distributed solar projects on farm property**, defined as smaller-scale solar projects that are used to directly power the farm operations. 82% of farmers supported this type of solar project, while only 6% were opposed.
- Support for utility-scale for solar projects was far less resounding, with less than half of respondents generally supporting utility-scale solar on farmland. However, **only 22% of respondents indicated outright opposition to utility-scale farmland solar**, roughly in line with the 20 – 30% of respondents who consistently report opposition to this type of solar on farmland throughout the survey.
- **Roughly 1/3rd of respondents hold conditional views** on the question, with many pointing to agrivoltaics or dual use strategies as a necessary condition for their support. From one farmer respondent: “Definitely want to have solar to power my own farm and I support utility solar on farmland as long as they commit to Agrivoltaics.”

Farmers: Concerned about impacts to farmland price, preservation

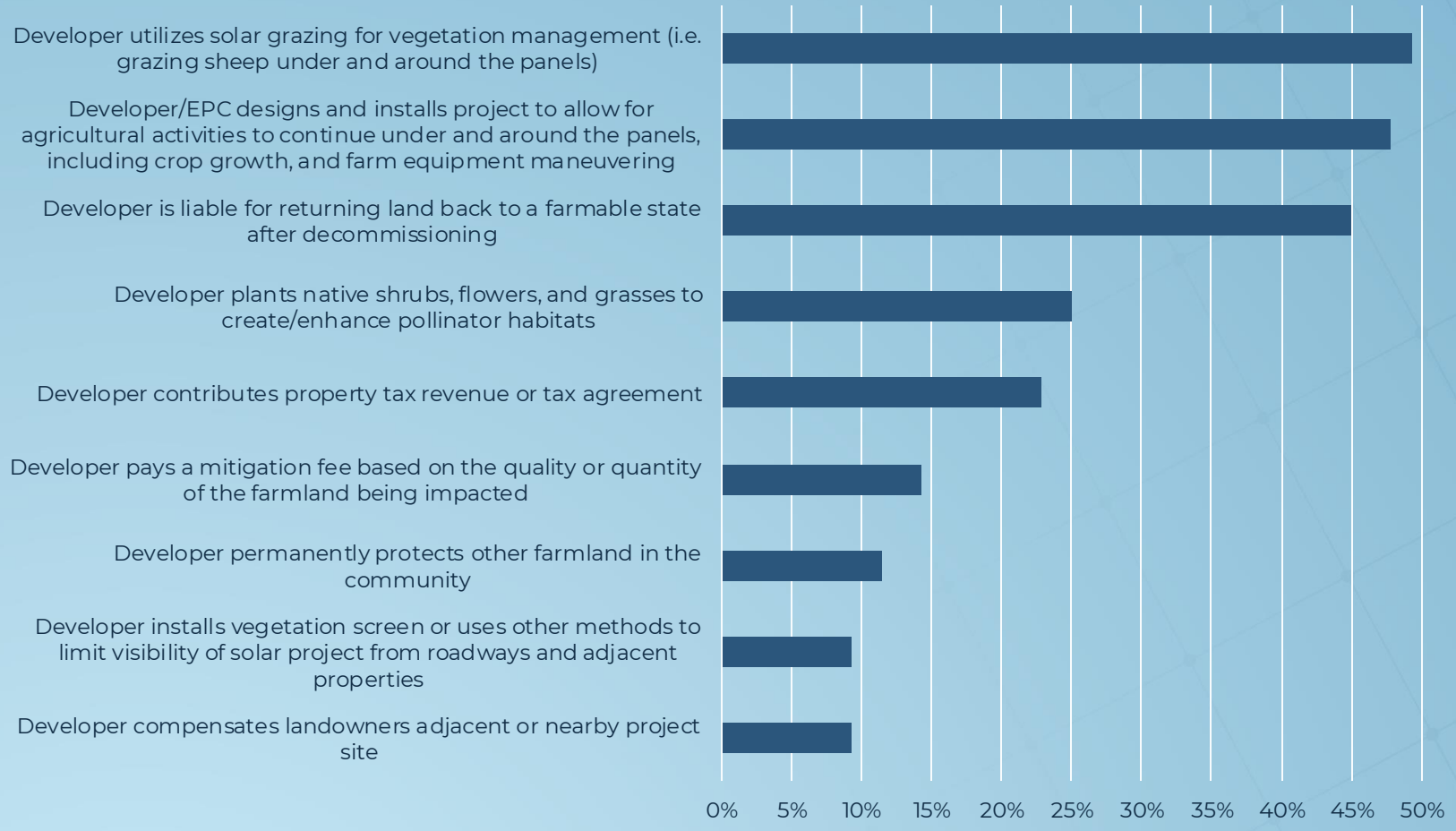
When it comes to utility-scale solar development on farmland in your state, please indicate your level of concern with the following potential impacts. (N=123)



- Farmer respondents' concerns with utility-scale solar on farmland primarily centered on impacts to the land itself, both its intangible and monetary value.
  - **Over 78% of respondents were "somewhat" or "very" concerned with utility-scale solar impacts on farmland price and access**, while 77% had some level of concern around utility-scale solar impacts on farmland preservation.
  - 75% of respondents also expressed concern around impacts to farm renters.
- While not rising to the same level of overall concern, more acute concern was raised around utility-scale solar impacts on farm productivity and soil quality, with 42% and 40% of respondents, "very concerned" around impacts in those areas, respectively.
- The least amount of concern was expressed on issues at the community level, such as impacts to local community character, local resources and agricultural supply chains.

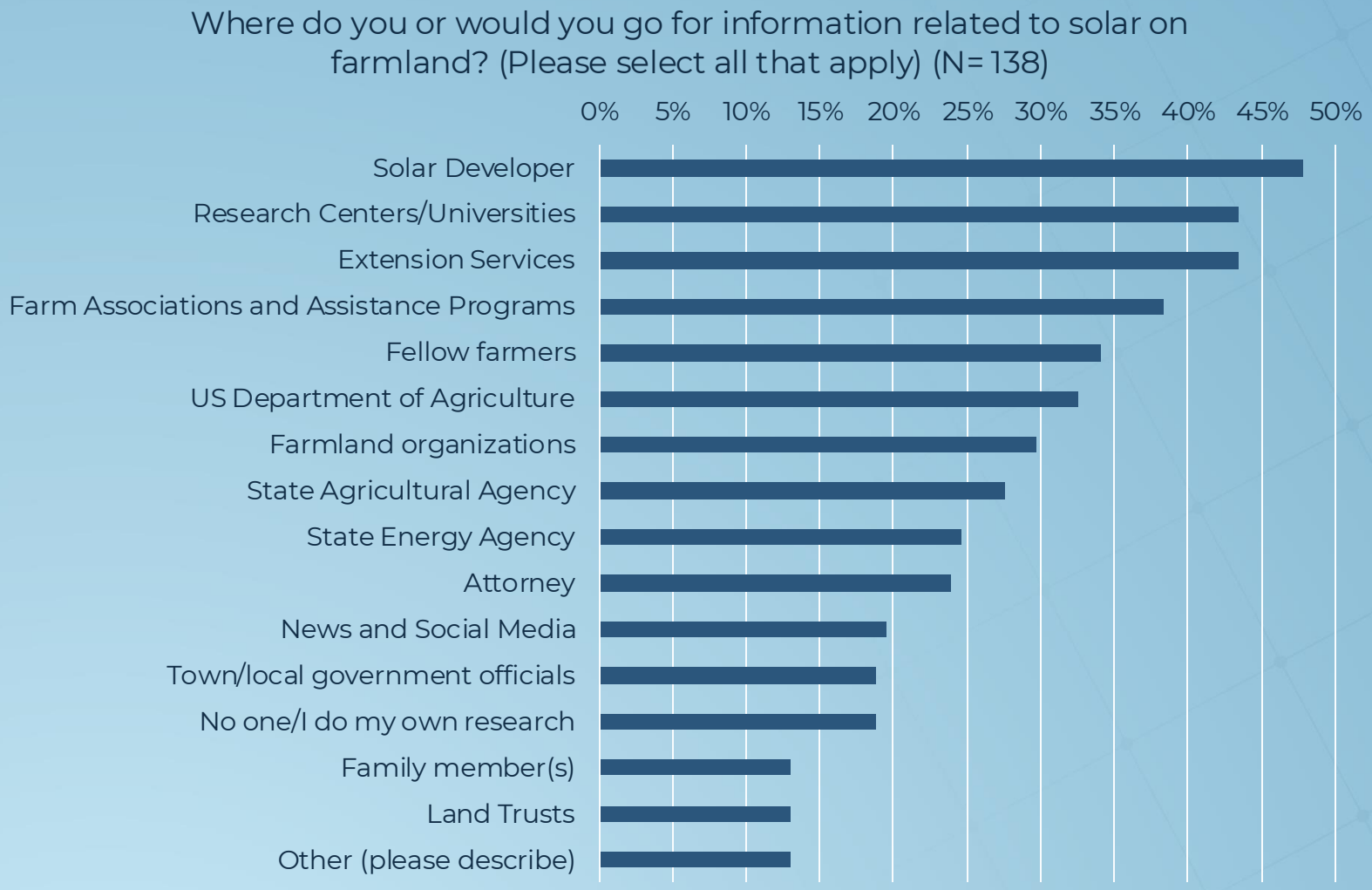
Farmers: Ways to mitigate concerns are mainly using dual-use techniques

Of the options below, please select the 3 most effective actions a solar developer or landowner could take to address your concerns with utility-scale solar sited on farmland. (N=140)



- When asked how their concerns with utility-scale farmland solar might be mitigated, **farmers primarily pointed towards dual-use agrivoltaics techniques that would allow for continued use of the project land for agricultural purposes**.
  - 49% of farmer respondents selected solar grazing, while 48% selected agricultural activities including crop growth and farm equipment access as potential ways to address their concerns with utility-scale solar.
  - 45% of farmer respondents also indicated that placing liability on the developer to ensure the land remains farmable after decommissioning could help mitigate their concerns.
- Mitigation fees, adjacent landowner compensation and developer commitments to preserve other farmland garnered significantly less interest from respondents.
  - This feedback could be informative as some states and localities have considered or adopted requirements like these to preserve farmland and disincentivize farmland solar development.[20]

Sources of Information for Solar on Farmland for Farmers



- Farmers look to developers, universities for information on farmland solar
  - **Nearly of 50% of farmers would look to solar developers as a trusted source of information** on farmland solar, while universities and extension services also ranked highly
- Responses here conflict somewhat with previous research on the topic
  - In other studies, solar developers have ranked closer to the bottom of the list of trusted sources
  - These results might reflect small but non-trivial differences in question wording (“solar on farmland” vs “agrivoltaics”), and the ability of respondents to select “all that apply”

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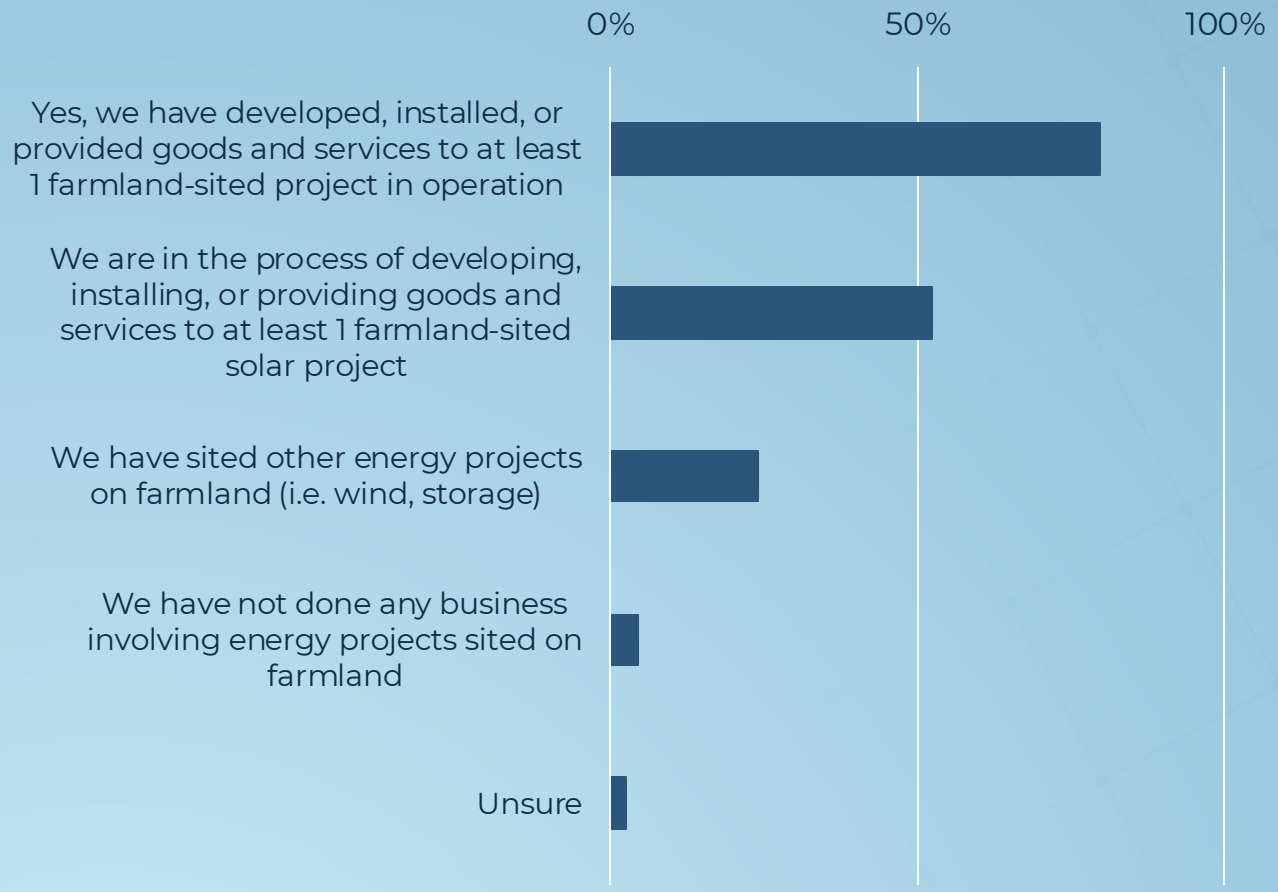
Solar Developer Perceptions of Farmland Solar Development

Nearly all Developer Respondents Experienced in Farmland Solar Development

Has your company developed, installed, or provided goods or services to solar projects sited on farmland (please select all that apply)? (N=153)



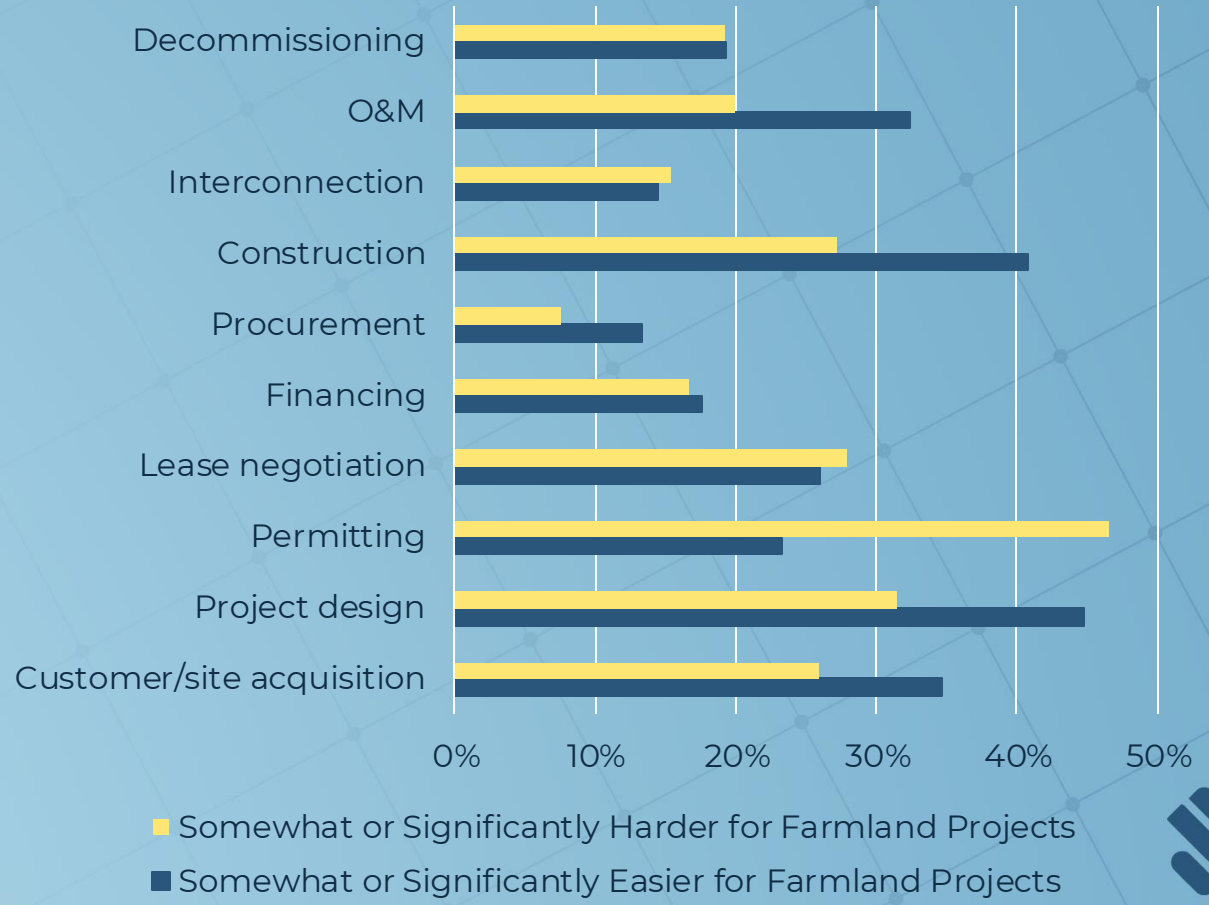
- **93% of developer respondents have some experience developing solar projects on farmland.**
  - Most of these projects are community solar or front-of-the-meter projects.
  - However, nearly one-third of developer respondents have experience working on projects with on-site use.
- The popularity of solar on farmland partially reflects the fact that **farmland is relatively flat and clear** which minimizes the need for grading or tree-clearing.
- Developer respondent on benefits of using farmland for solar development:

  "Often flatter and clear, reducing the amount of disturbance and additional civil costs for construction. Often easier to execute an Option to Lease/LOI compared to public sites, which allows the project to advance quicker and uses less resources. Farmers know the land better, providing background on the pros and cons of the site (flooding tendencies, etc.)"

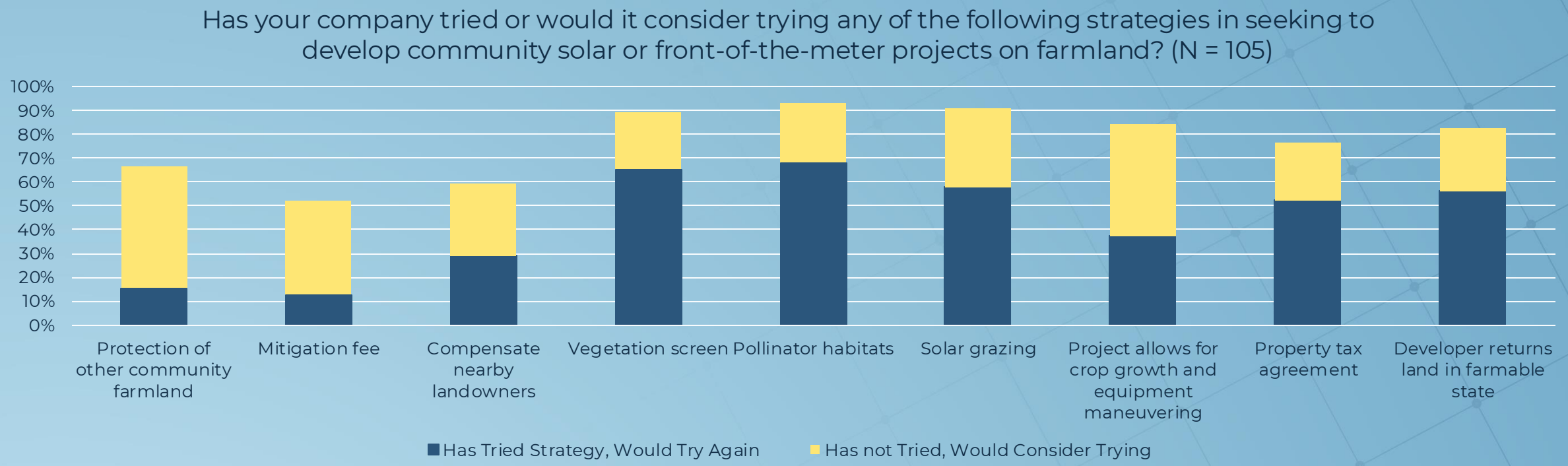
Farmland is easier to develop in almost all respects, except permitting

- Developers report that processes at nearly every stage of large-scale development are easier for farmland projects, with one exception: permitting.
- Many large-scale solar projects face local opposition from the communities they are proposed in, and developer responses suggest that **the problem is more acute for projects proposed on farmland**.
- Respondents stated that, “the community doesn’t want to see their farmland change”, and that opponents of farmland solar make their case both from an aesthetic and practical perspective.
- Both “opposition to altering rural character” and, “reservation around taking farms out of their typical use” were cited by respondents as common arguments against farmland solar development.
- As bottlenecks in the permitting stage of development have prevented thousands of megawatts of clean energy from being brought online, one respondent highlighted the importance of having the vocal support of the farmer or landowner of the project site. **“Their voice on these permitting meetings makes all the difference in a project being approved or rejected”**.

Considering only community solar and front-of-the-meter solar projects (i.e. in which electricity from the project is sold to a utility or other large off-taker for grid use), how much easier or harder are the following processes for farmland-sited solar?

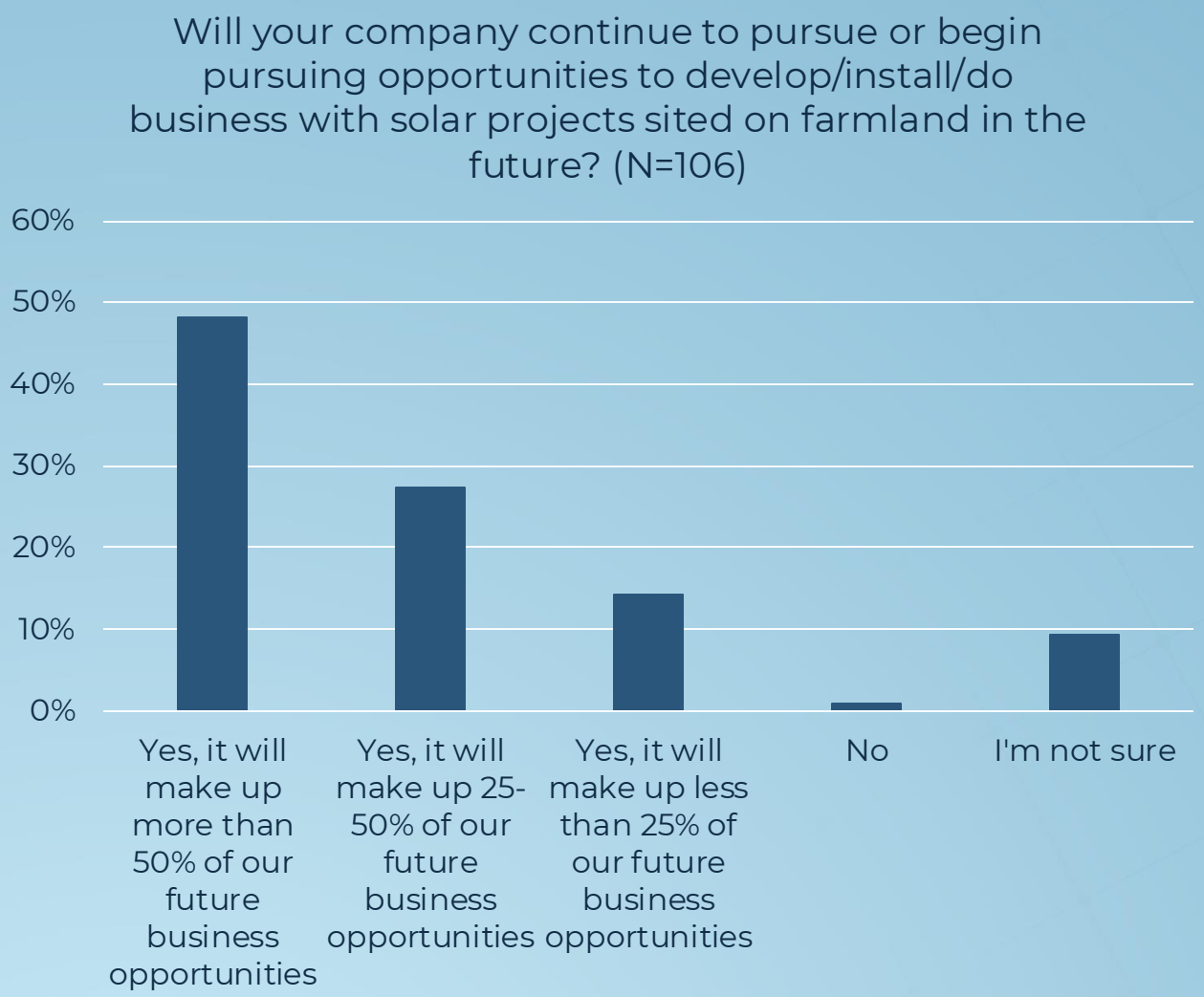


Developers open to many Agrivoltaic techniques



Seeking stronger support from local communities, farmers and landowners in the development of large scale solar on farmland, developers have reported varying degrees of investment in unique development strategies and system designs. 90% of respondents either have already or would consider implementation of vegetation screens to alleviate the viewshed-related concerns held by local communities. Developers also **reported significant interest in pursuing dual-use system designs** to keep land ecologically and agriculturally productive while hosting solar. While the implementation of pollinator habitats is the most common practice currently, there is still strong interest in collocating both grazing and crop production with solar facilities. Responses here suggest an openness to many of the top rated strategies of farmers, and though these strategies vary in current implementation, a majority of developer respondents would at least consider implementing each of the options listed.

Developers expect to pursue considerable amounts of farmland solar in coming years



- **Farmland is the most common siting type for utility scale solar today**[21] and respondents expect their companies to continue pursuing farmland projects going forward.
  - Over 75% of respondents said that farmland projects will make up ¼ or more of their future development plans.
- Despite the permitting challenges associated with farmland projects, **farmland solar will continue to be a priority of developers**.
  - Many respondents cited the natural synergy between farmland and solar development, as farmland is "generally flat, open and contiguous making it ideal for renewable energy development."
- In addition to the favorable geography of farmland, numerous **respondents highlighted proximity to transmission lines** as a reason their company expects to continue to pursue farmland development
  - "Access to economic transmission capacity is what drives utility scale siting more than any other factor"
- Finally, many respondents cited a more general, symbiotic relationship with farmers as a motivator.
  - "Agribusinesses continue to struggle economically, and solar land leasing is a way to help small, family run agribusiness be more viable".

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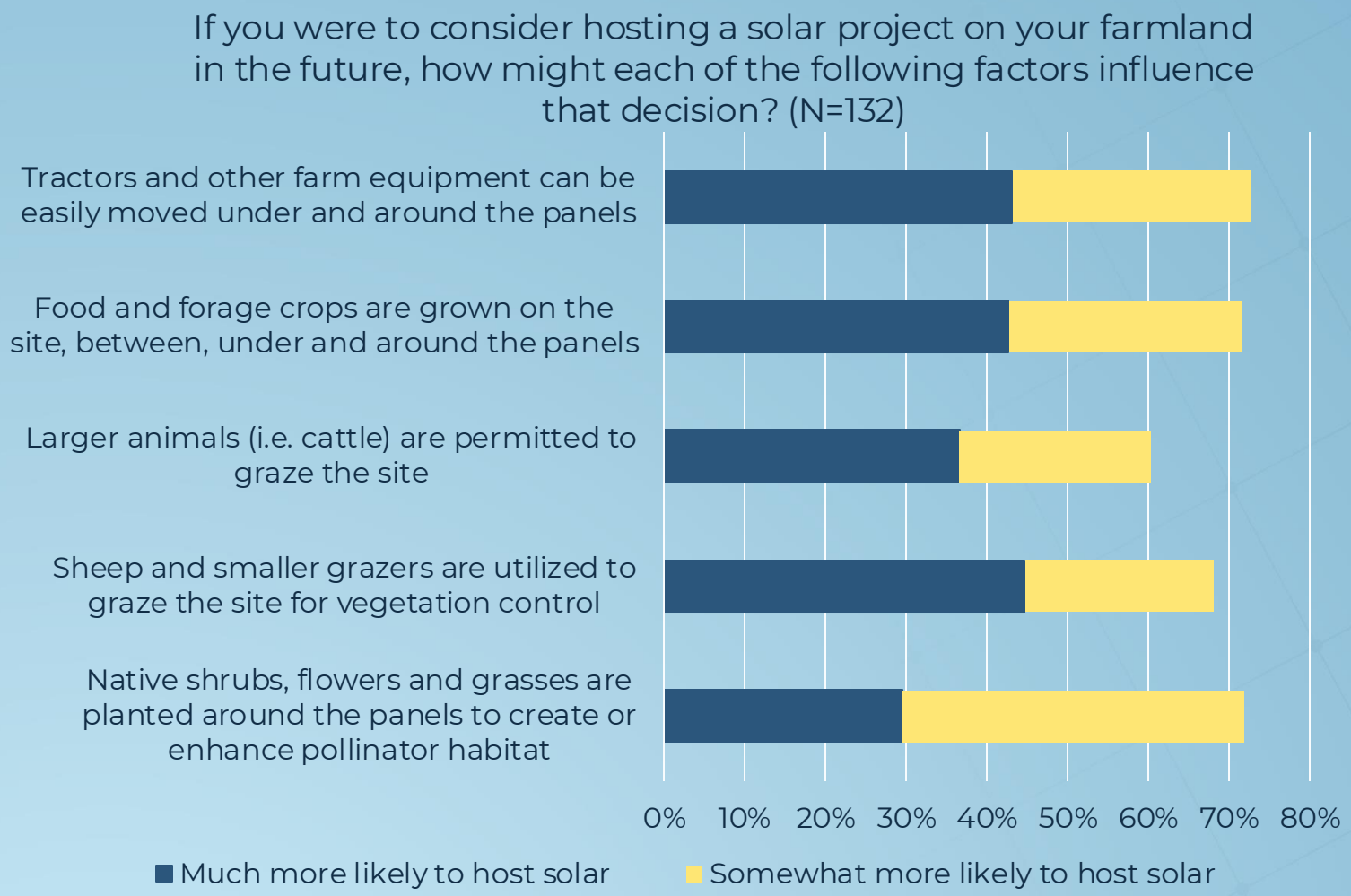
Overlapping Interest in Agrivoltaics

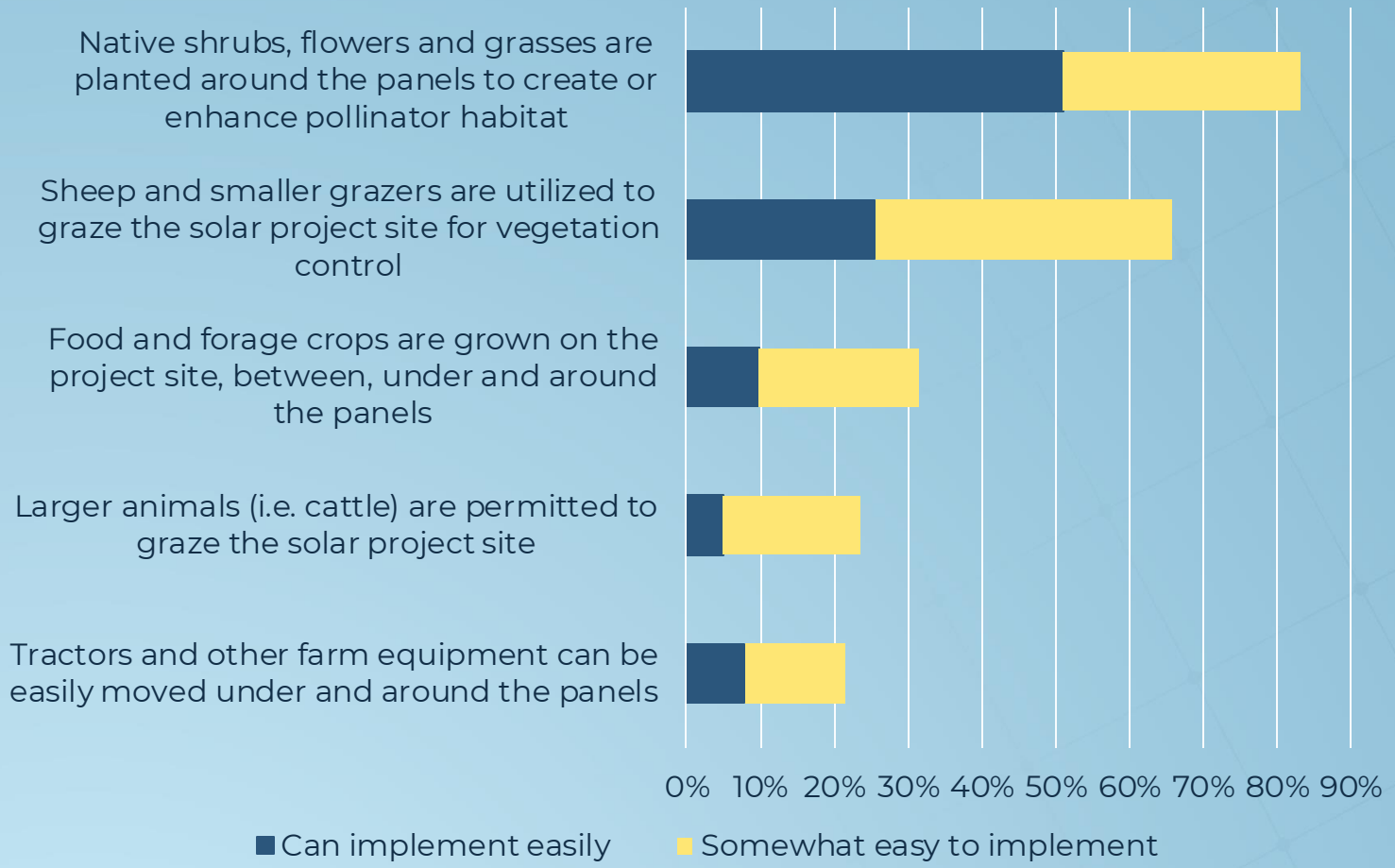
Farmers interested in most agrivoltaic system designs



- Given farmer's expressed interest in dual-use and agrivoltaic techniques as mitigants to their concerns around utility-scale solar on farmland, its no surprise that **they expressed considerable interest in more specific agrivoltaic techniques** when presented with more detail.
- While each of the options presented received considerable support, **support for grazing of larger animals was somewhat less pronounced**, perhaps due to under representation of large-sale cattle farmers in the sample.
- While total support for pollinator habitat was considerable, it was far less acute than support for solar grazing with sheep.
- Of note, for each category **roughly 1/3rd of respondents reported that these techniques would have no impact or an adverse impact on their decision to host a utility-scale solar project**, consistent with the size of the group of farmers "not interested" in large-scale solar on farmland under any conditions

Developers report difficulty in certain agrivoltaic system designs

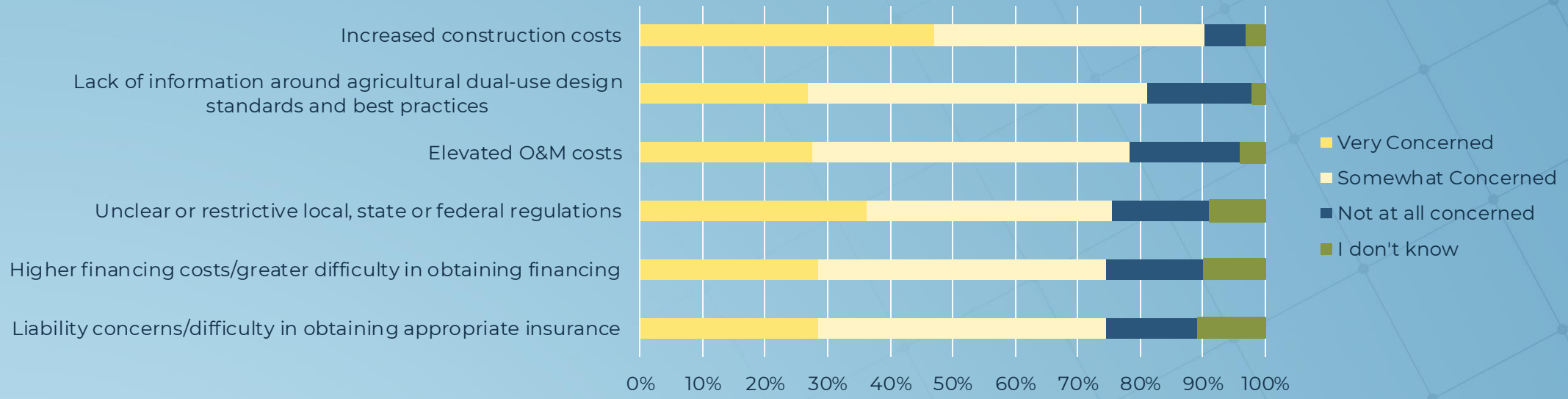
In your experience, how difficult would it be to implement any of the following agricultural dual-use or agrivoltaic strategies into your system design? (N=105)



- Solar respondents **report a wide gap in the ease of implementation** between various forms of dual-use projects.
- Pollinator habitat projects and small animal grazing projects are seen as relatively easy to execute.
- However, **system designs that typically require the elevation of solar panels beyond typical heights are seen as much harder**, with only 20-30% of respondents seeing these dual-use strategies as easy to implement.
- These responses from solar developers mirror the current state of play in the agrivoltaics space**, as pollinator habitat and solar grazing projects are more common** than dual-use PV and crop production.

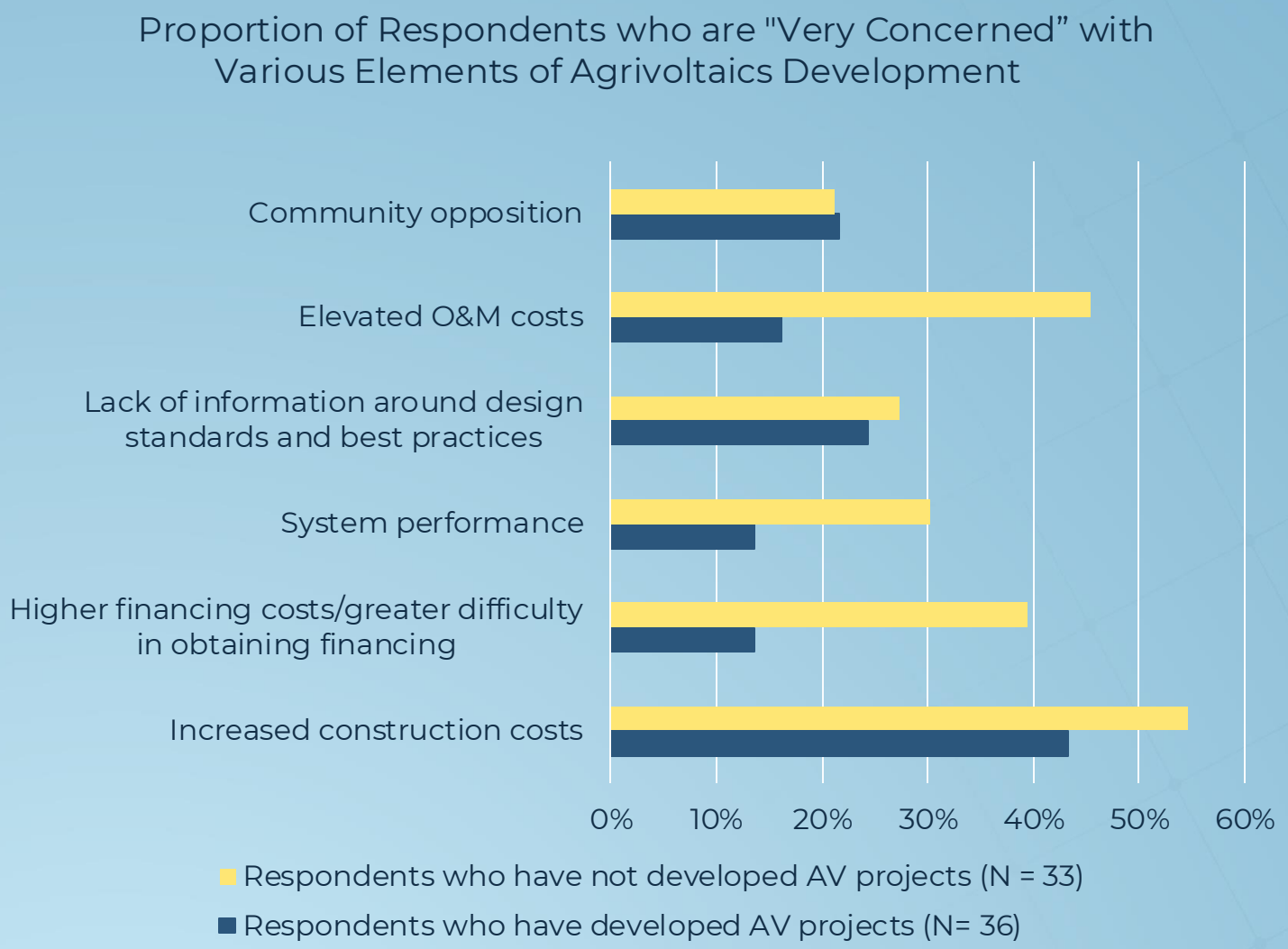
Developers concerned with additional cost of agrivoltaics

In considering incorporating agricultural dual-use, or agrivoltaic, components into your system design, specifically including grazing, crop production, and farm vehicle access under and around solar panels, how concerned are you about the following facto



Solar industry respondents, despite interest in agrivoltaics, see significant barriers to implementing crop production and grazing with solar PV. Cost is the most salient barrier among the survey's respondents. **90% of respondents have some degree of concern around elevated construction costs**, and around 75% have concerns around O&M and financing costs. Lack of regulatory transparency, as well as lack of information around system design also are of high concern to respondents. As agrivoltaics remains a relatively nascent space within the U.S. solar industry, participants in the market face uncertainty not only in their own development processes, but their construction and financing partners also may have less expertise in agrivoltaics development, **leading to higher contracting, finance and insurance costs.**

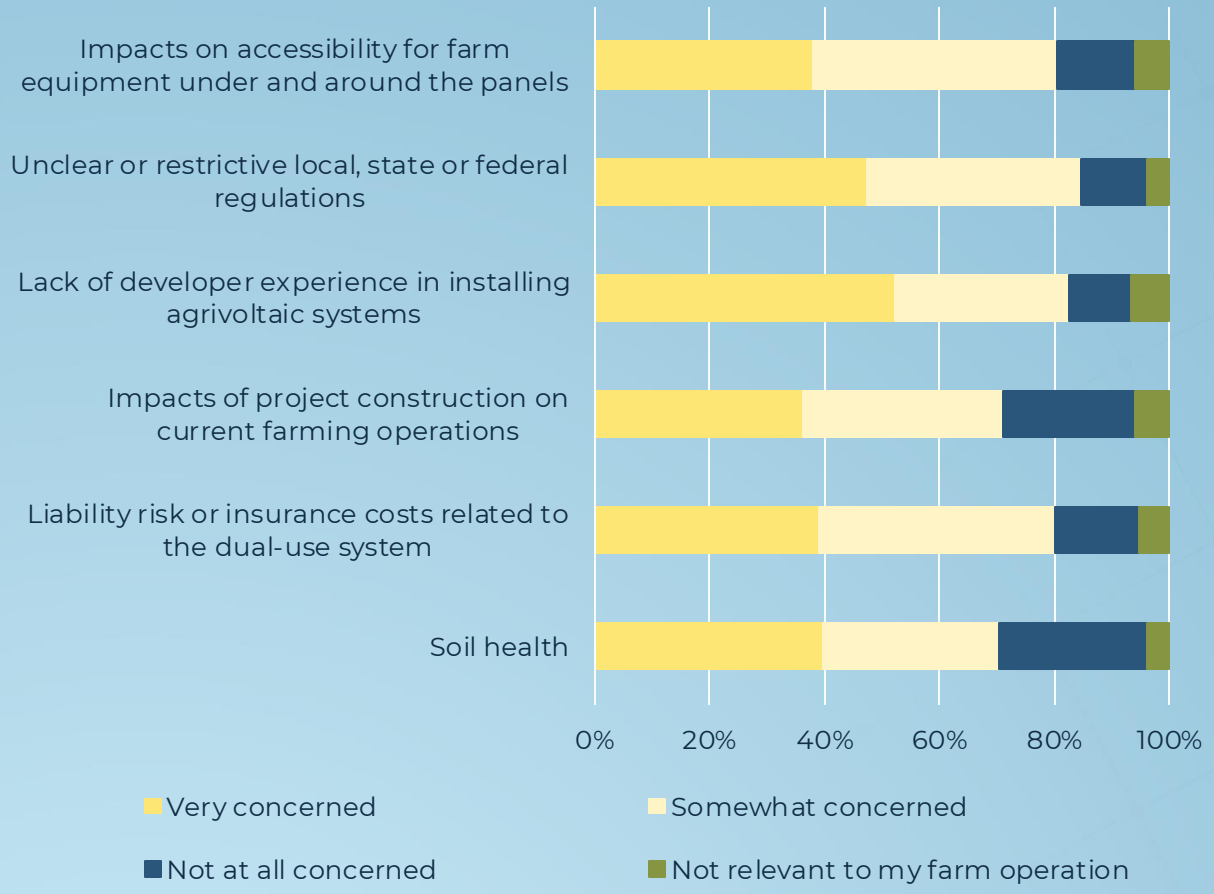
Experienced developers less concerned with agrivoltaics challenges



- Although there are real barriers to agrivoltaics development, **respondents who have developed agrivoltaics projects have a lower level of concern** across various development processes than respondents who are not experienced in the space.
- Though this analysis introduces some bias (developers who have pursued agrivoltaics projects are more likely to hold a favorable opinion of the space), it does suggest that **frequently cited agrivoltaics obstacles are somewhat mitigated by relevant development experience**
- Respondents reported less acute levels of concern across almost every category, with the exception of community opposition. This particular metric stayed largely flat, suggesting that **the gap in perceived vs experienced challenges is smaller with respect to engaging with the local community surrounding a proposed agrivoltaics project.**

(Developer) Experience matters for Farmers as well

In considering agricultural dual use or agrivoltaic approaches to siting solar on your farmland, please indicate your level of concern with each of the following factors. (N=132)



Note: chart only shows the 6 largest areas of concern. Full results available at ssii.org/farms-project

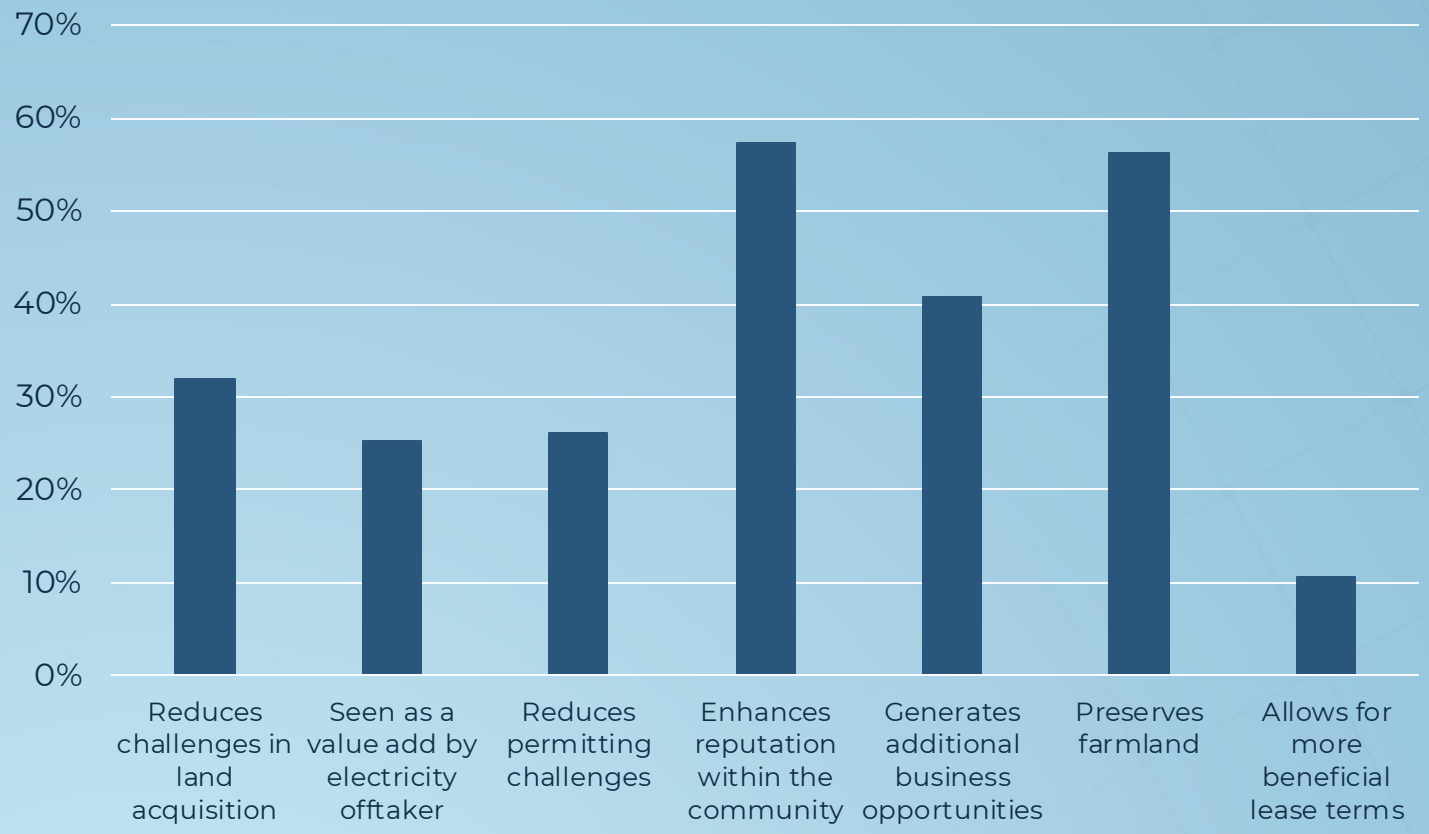
Developer experience is an important factor for farmer respondents as well, who cite a lack of developer experience as one of their biggest concerns with respect to siting utility-scale solar on farmland. **83% of respondents expressed some level of concern around lack of developer experience**, while over 50% of respondents were “very concerned”. The finding suggests a bit of a chicken vs egg problem in the industry as farmers seek developers with experience in agrivoltaics, and developers try to assemble clients who will allow them to gain experience.

The largest area of overall concern was around unclear or restrictive policy. When understood in the context of farmer’s response to open-ended questions, this can be interpreted to most likely **indicate concern around local and state ordinances that ban or limit utility-scale solar installations on farmland** or any land. As one farmer said, “The roadblocks are at the policy level. Our county, for example, makes up solar zoning rules for each project. Having static state-level definitions and guidance would be a huge help.”

While at least 48% of farmers expressed some level of concern with each of the 13 factors they were offered, **there was less concern expressed around crop irrigation (48%) and shading impacts (58%)**. While research is ongoing, evidence suggests that the shading provided by agrivoltaics installations can be beneficial to certain crops and livestock and can help reduce irrigation needs. The numbers here might indicate some level of understanding of that research by respondents.

Developers motivated towards agrivoltaics by reputational benefits

From your company's perspective, why would you consider developing an agricultural dual use solar project or agrivoltaic project, as opposed to a farmland solar project that doesn't include agricultural dual use? (Select 3) (N=103)

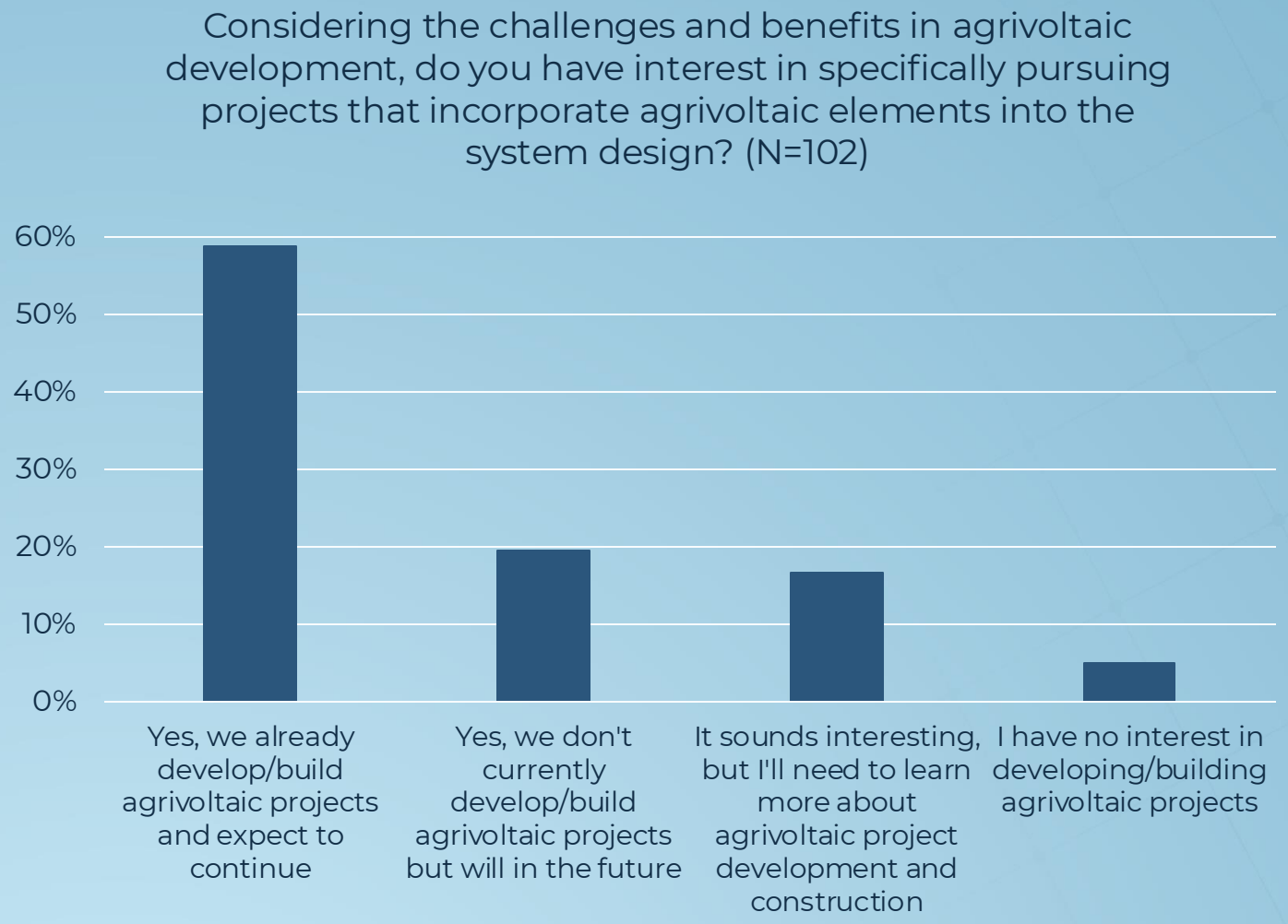


Solar developers reported reputational benefits and preservation of farmland, as being the primary motivators for agrivoltaics development. **The top three response options suggest that developers are taking a long-term view when considering agrivoltaics development.**

Developers see agrivoltaics as being beneficial for relationship-building with local communities, potentially engendering support for future development opportunities. **Preservation of farmland was also highly valued by developers**, presumably in response to frequently raised local concerns around farmland development.

The lack of salience for increased permitting ease as a motivator was somewhat surprising and could suggest that developers still see significant permitting barriers for these project types or that they **are more convinced on the long-term reputational and values benefits of agrivoltaics than they are on its effects on an individual project.** Restricting respondents to 3 options may also have artificially reduced responses in this category.

Most developers plan to utilize agrivoltaics going forward



Motivated by the potential long-term benefits of agrivoltaics development, **nearly 80% of solar industry respondents indicated that their company has plans for agrivoltaics development in the future.**

17% of developers say that they are interested in agrivoltaics but need to learn more before developing dual-use projects. Unexperienced developers tend to be significantly more concerned about cost and system performance than developers who are experienced with agrivoltaics.

This finding may not be representative of the solar industry at large. **There is potential for non-response bias in this survey, as respondents who favor, or are otherwise highly interested in agrivoltaics, may be more likely to respond and share their thoughts on the space** than other members of the solar industry, who may be less involved or less informed about agrivoltaics. This likely leads to underrepresentation of developers who have no immediate interest in developing agrivoltaic projects.

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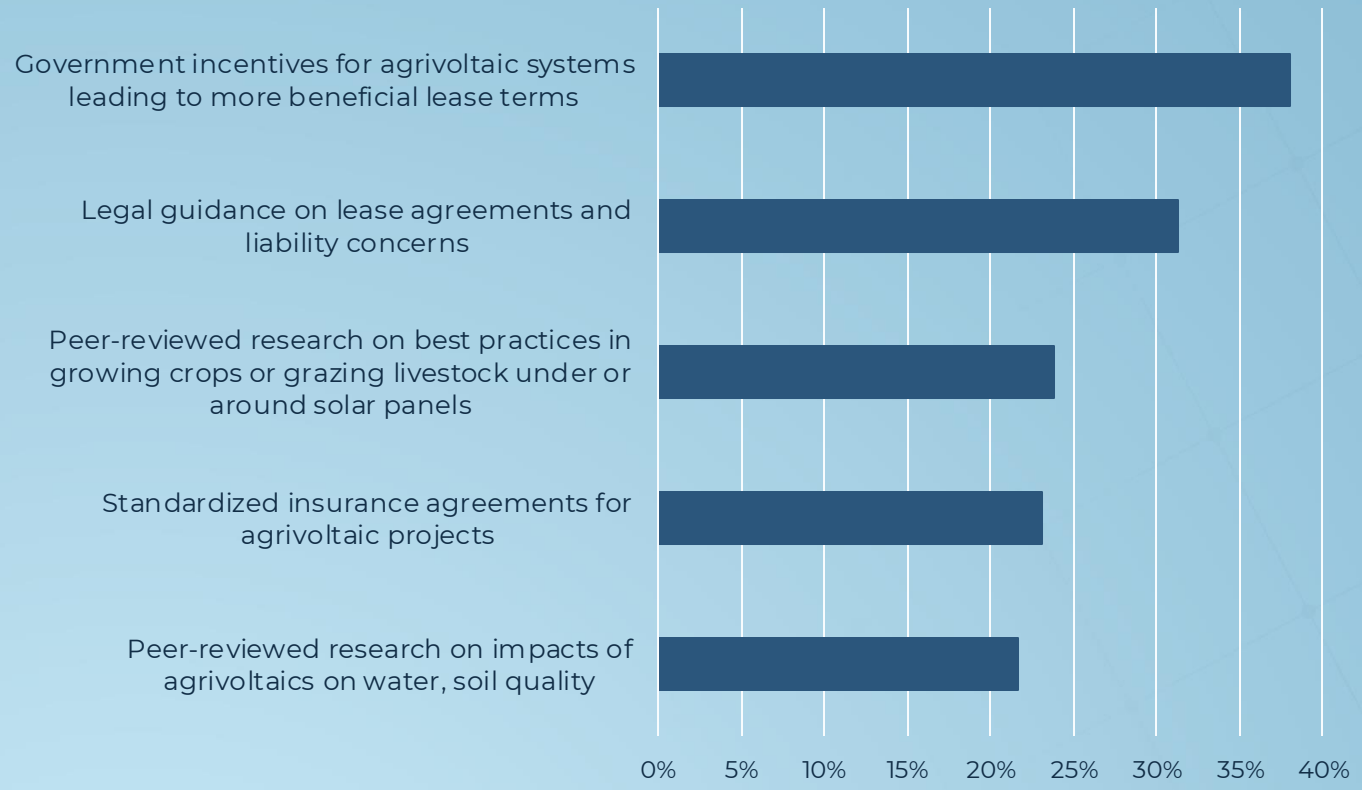
Strategies to Address Agrivoltaic Concerns

Strategies to address agrivoltaic concerns: farmer perspective

Of the options below, please select the top 3 most impactful things that could be done to alleviate your concerns with agricultural dual-use or agrivoltaic development on your farmland. (N=134)

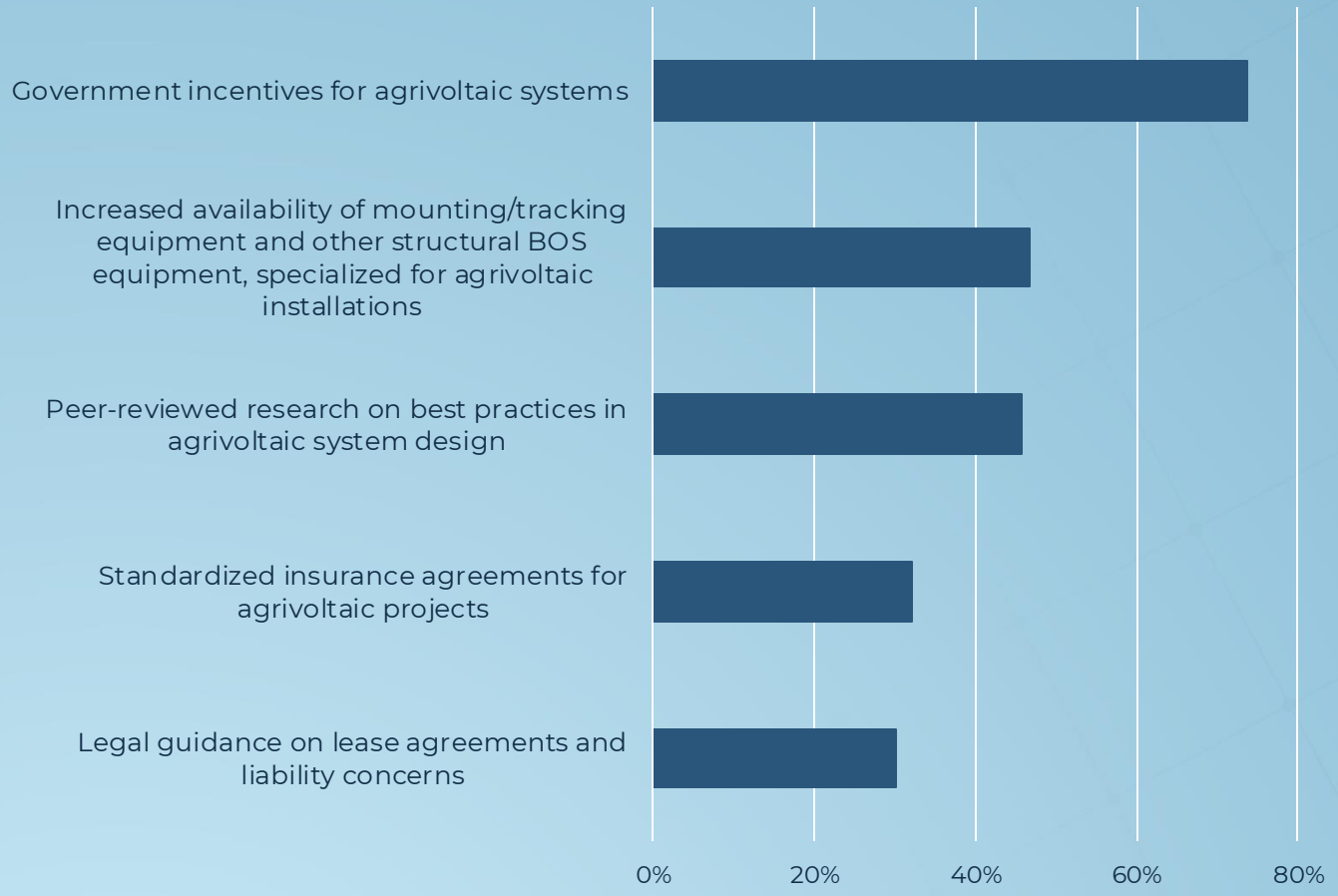


Note: chart only shows the 5 most popular responses. Full results available at ssii.org/farms-project

- To address concerns with agrivoltaic projects, **over 1/3rd of farmer respondents pointed to government incentives**. Farmers also were interested in legal and liability guidance, and peer reviewed research on agrivoltaics effects on farmland and crop yields.
- Developers had less interest in special credentialing of agricultural products grown in agrivoltaic settings, but **all other response options outside the top 5 garnered 14% - 19% support**.
- While incentives and legal guidance were clear preferences, the relatively even distribution of interest across other response options might indicate **some uncertainty within the farming community on what actions might best address concerns around agrivoltaics**. It could also suggest that many of these things are needed.

Strategies to address agrivoltaic concerns: developer perspective

Of the options below, please select the top 5 most impactful things that could be done to alleviate your concerns around agrivoltaics development? (N=103)



Note: chart only shows the 5 most popular responses. Full results available at ssii.org/farms-project

Of a list of strategies designed to address challenges with agrivoltaic development, **government incentives for agrivoltaics systems clearly attracted the most support from developers, with 74% of responses**. Incentives could help reduce the heightened development cost associated with agrivoltaics that developers indicated was their top concern and could also provide some level of legal and regulatory guidance, which would address another concern around unclear legal frameworks.

Developers also pointed to **greater availability of specialized hardware for agrivoltaics installations as a way to mitigate concerns around design, procurement and construction costs**. Because utility-scale project construction is highly specialized, the equipment needed to elevate panels can be more expensive, both on an absolute and per unit basis. Presumably, greater demand for agrivoltaic installations will lead to increased supply of agrvivoltaic-specific hardware solutions and ultimately, greater supplier competition and lower prices.

Similar to farmers, **developers also expressed interest in legal, liability and best-practice resources.**

Strategies to address agrivoltaic concerns: discussion across segments

Response Option	Developer (N=103)	Farmer (N=134)	Utility (N=11)
Government incentives for agrivoltaic systems	74%	38%	45%
Increased availability of mounting/tracking equipment and other structural BOS equipment, specialized for agrivoltaic installations	47%		55%
Peer-reviewed research on best practices in agrivoltaic system design	46%		45%
Standardized insurance agreements for agrivoltaic projects	32%	23%	18%
Legal guidance on lease agreements and liability concerns	30%	31%	55%
Platforms designed to connect farmers with solar developers	30%		27%
Peer-reviewed research on best practices in growing crops or grazing livestock under or around solar panels	28%	24%	36%
Standardized lease contract templates for agrivoltaic projects	27%	14%	0%
Peer-reviewed research on best practices on agrivoltaic system performance	26%		36%
Site visits to operating agrivoltaic installations	24%	16%	18%
Peer-reviewed research on impacts of agrivoltaics on water, soil quality	20%	22%	9%
Forums, seminars, courses on agrivoltaic system design and best practices	19%		9%
Free technical assistance from extension agent, farmer member association or government agency	17%	16%	45%
Licensing/credentialing of solar developers in agrivoltaic development	14%	19%	27%
Special credentialing of crops/livestock grown/raised in agrivoltaic settings	13%	7%	9%
Documented solar developer experience in installing agrivoltaic projects		16%	
Detailed information on project's impact on crop yield and farm economics		18%	

Despite differences in occupation, motivation and experience, the surveyed stakeholder groups coalesced around a shortlist of preferred strategies for overcoming barriers to agrivoltaic development. **Of the 17 strategies trialed in the survey, just 8 strategies showed up as a top 5 selection for each respondent group**. These strategies are highlighted in yellow at left.

Government incentives were a top two choice for all groups, addressing stakeholder concerns around expense, unclear or unsupportive policy and return on investment. Development of specialized hardware for agrivoltaics installations also garnered interest from both developers and utilities. Though it wasn't presented to them as an option, farmers would presumably support this development as well to the extent it enables the deployment of agrivoltaics systems, in which clear majorities of farmer respondents expressed interest.

Many of the other strategies preferred by respondents would provide **additional research and guidance around certain elements of agrivoltaic system design and implementation**. Many of these research efforts are underway but could benefit from broader dissemination of findings.

Note: due to fewer response options, farmer respondents selected their top 3 strategies, while developers and utilities selected their top 5

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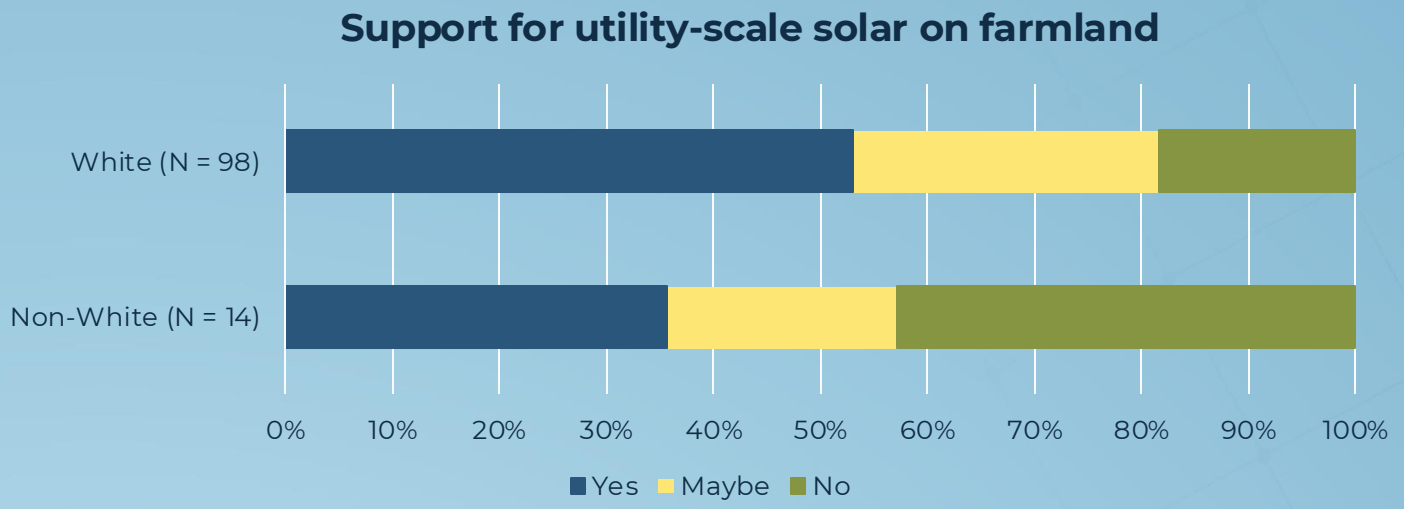
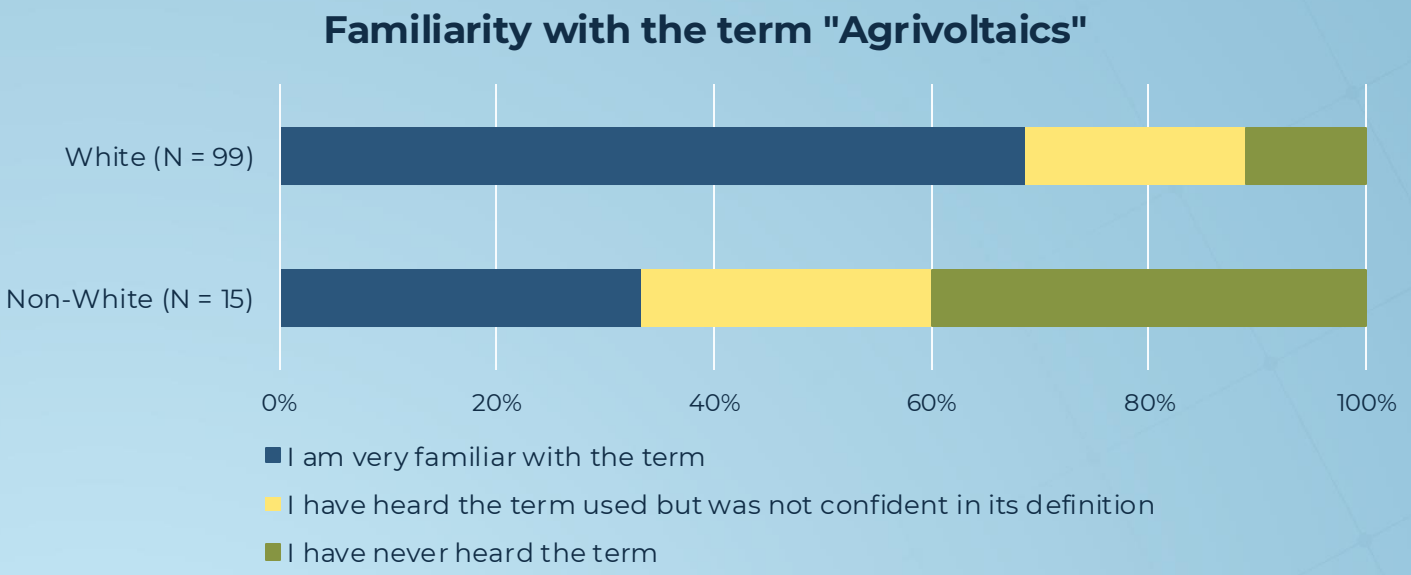
Demographic Crosstabs

Non-white farmers less interested in utility-scale solar on farmland





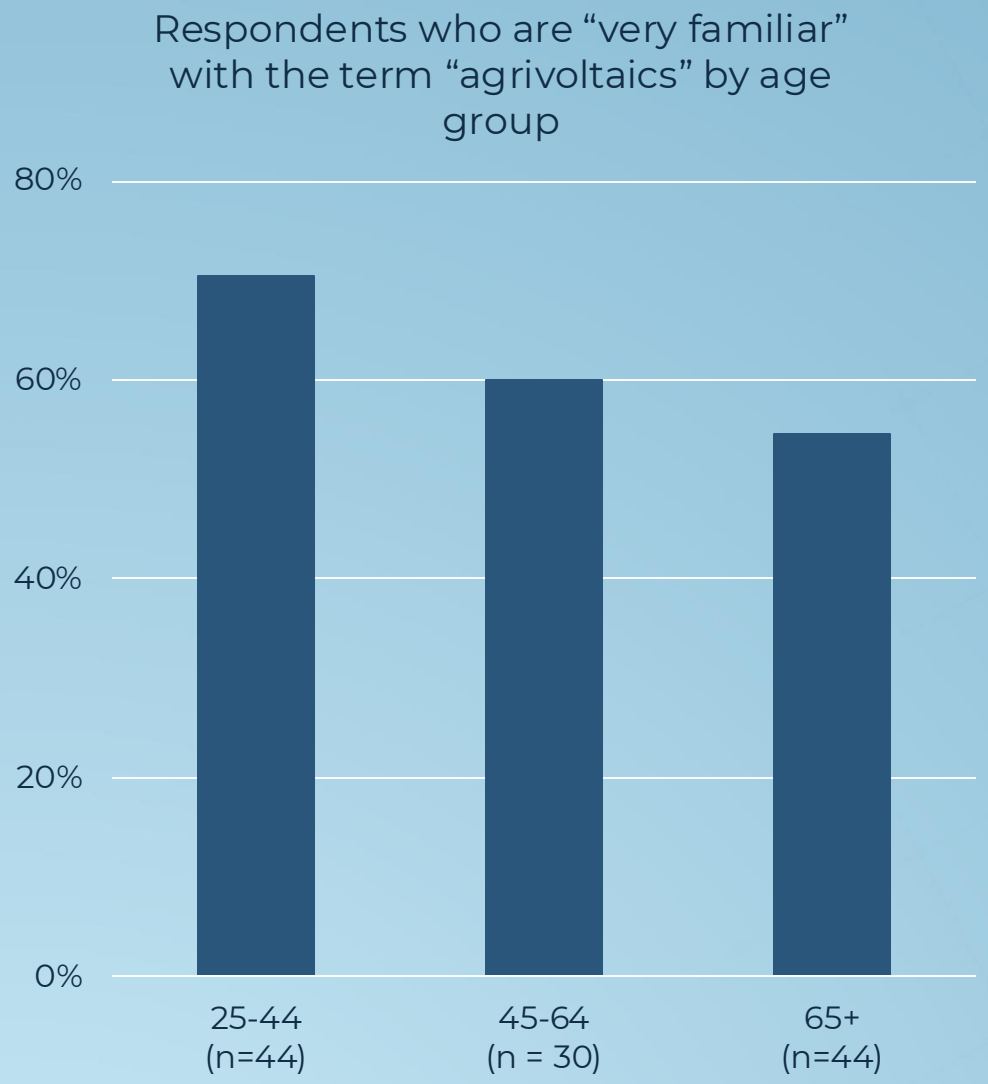
While sample sizes were small and are not generalizable to the broader respondent demographic groups, **non-white farmer respondents were less likely than white respondents to support utility-scale solar on farmland**. 42% of non-white farmer respondents were opposed to utility-scale solar, compared with 18% of white respondents.

Non-white farmer respondents were less likely to be familiar with agrivoltaics with 40% of respondents reporting that they never heard the term, compared with 11% of white farmer respondents.

Non-white farmers also preferred to receive information on solar development on farmland from different sources than white farmers, with non-white farmers preferring extension services, farm and farmland member organizations and state agricultural agencies, while white farmers preferred solar developers and research centers/universities.

It is important to note that non-white respondents represent multiple racial groups, both white and non-white groups contain respondents with varying ethnicities that may also inform response.

Selected Crosstabs by Age, Gender



- Perceptions of climate change impacts on farm operations were consistent across all age groups in the study (55% - 57% of participants in each age group were worried about the effects of climate change on farm operations). However, younger farmers (under 44 years of age) were more likely to see solar sited on farmland as a method to help address climate change.
- **Female farmer respondents were more concerned about the effects of climate change than male respondents**: 62% of female respondents worried about the effects of climate change on farm operations while only 49% of men had these concerns. However, female farmer respondents were 11 percentage points less likely than men to view solar on farmland as having any impact on climate change.
- **Younger farmer respondents tended to be more familiar with agrivoltaics than older participants**. 70% of young farmers answered they were “very familiar” with dual-use projects, as compared to 60% of farmers aged 45-65 and 55% of farmers over 65. These farmers were more likely to get their information about solar sited on farmland from extension services than older famers (who were most likely to get their information from developers).

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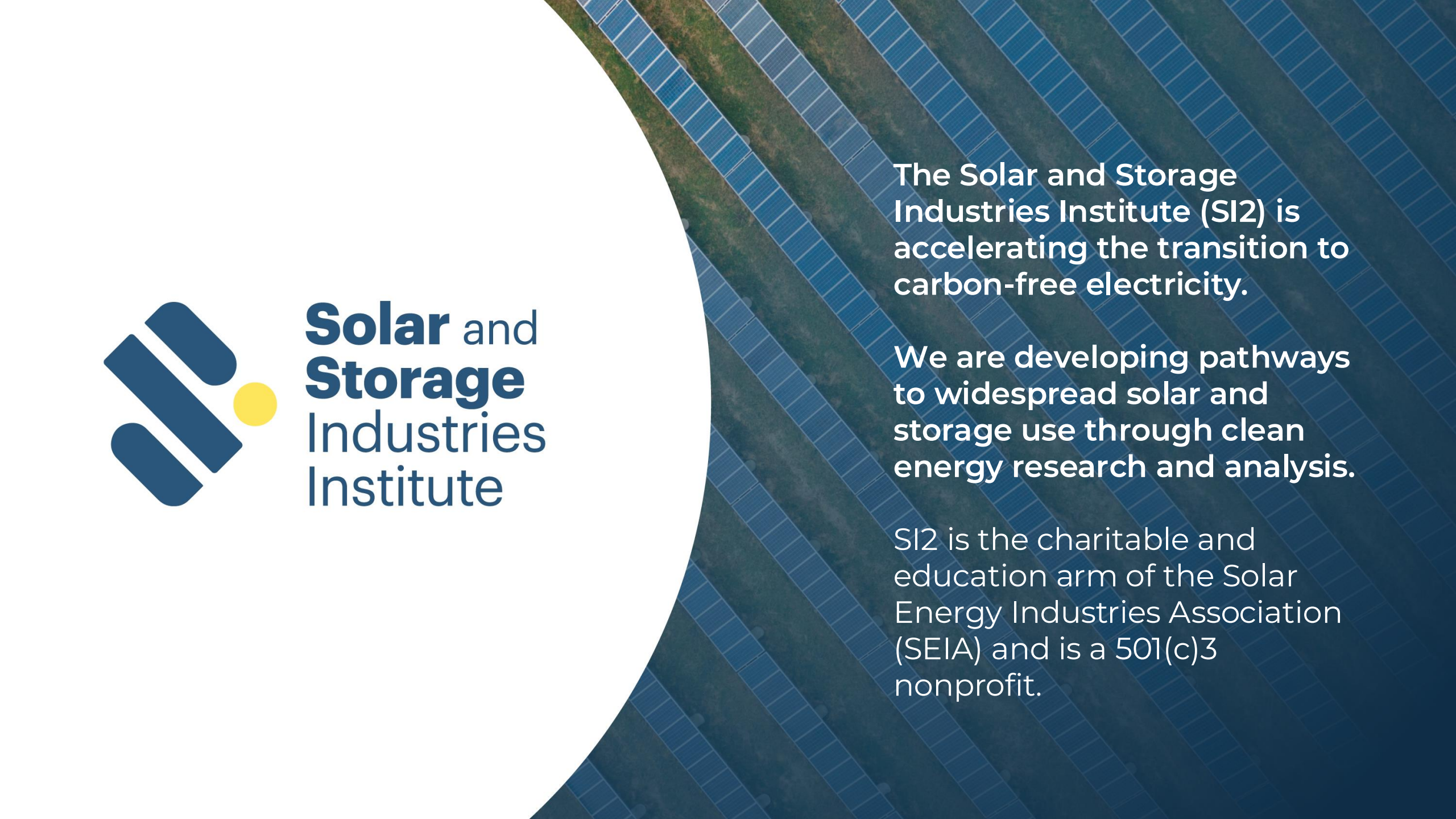

Solar and Storage Industries Institute

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We are developing pathways to widespread solar and storage use through clean energy research and analysis.

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