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Perceptions of Large-Scale Solar Project Neighbors: Results From a National Survey

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Perceptions of Large-Scale Solar Project Neighbors: Results From a National Survey

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Background & Research Questions

Background & Research Questions

Background:

- Large-scale solar (LSS) energy development can positively and negatively impact local host communities, but those impacts have been understudied.
- Local opposition is increasingly cited as a leading barrier to LSS deployment¹ but sources of that opposition are not well understood.
- The details of siting, planning, design, and engagement processes for LSS and how they might influence attitudes is a significant gap in the literature.
- Interviews in seven communities surrounding LSS projects by this project team provided useful but as-of-yet nationally untested insights into sources of positive and negative attitudes.²

Research Questions:

- What are the key correlates for positive and negative community attitudes toward built LSS projects?
- How generalizable are these findings across a national sample of LSS neighbors?
- What can be learned from individuals living near LSS that could inform how future LSS should be developed?



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Survey, Respondent, and Site Details



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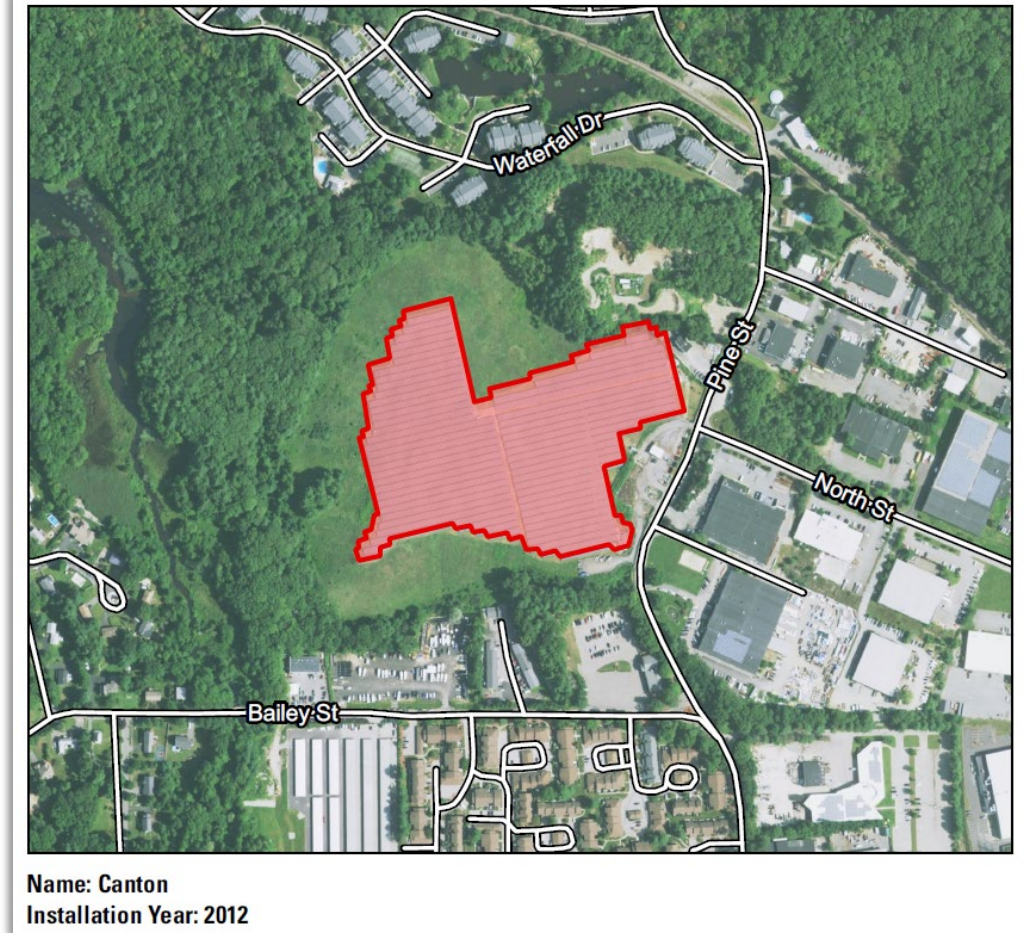
ENERGY ANALYSIS AND ENVIRONMENTAL IMPACTS DIVISION

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Survey Details

Survey Details:

- National, stratified, random sample of residents living *within 3 miles* of large-scale solar (LSS)
- Intentional oversampling:
 - “Innovative” solar sites (e.g., on landfills)
 - Residents within ½ mile of LSS
 - Residents near largest LSS projects
 - Some U.S. regions, to ensure diverse geographic sample
- Multi-modal (mail/paper and web)
- Survey included image chip illustrating each respondent’s local project via aerial imagery
- Data collection period:
 - Pilot survey: April – May, 2023
 - Full survey: June – September, 2023



Example of image chip included in each survey

Overall Response Rate

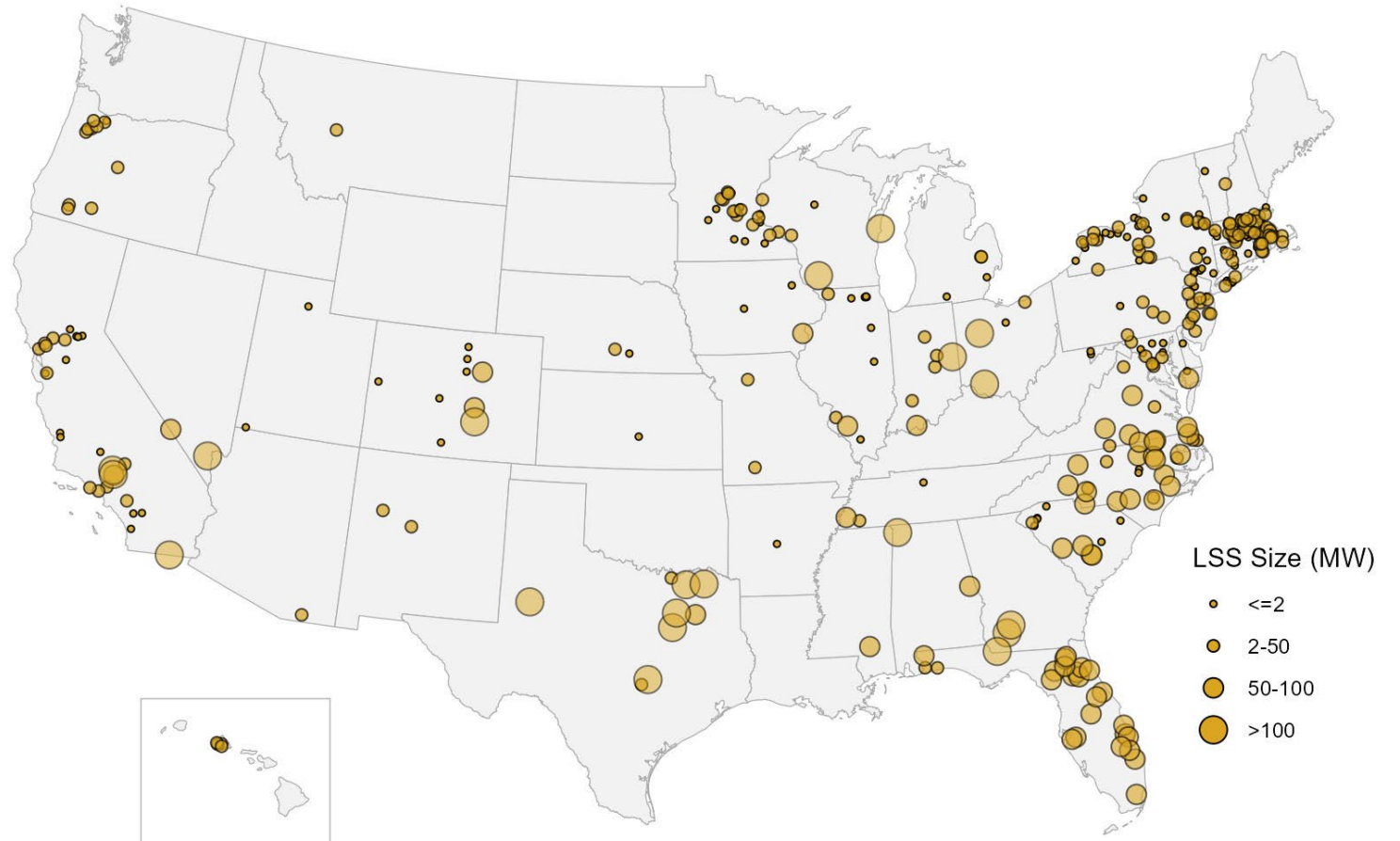
Total invitations sent	4,974
<i>Undeliverable, ineligible</i>	<i>-113</i>
Eligible invites	4,861
Unusable partial completion (<50%):	30
Usable partial completion (50-80%):	33
Full completion (>80%)	951
Full + Usable Respondents:	984
Response rate: sum/eligible	20.2%

*Note: 90% of full/usable responses were mail surveys;
only 10% responded via web survey*



Responses collected from 380 unique LSS projects, representing >9 GW of installed capacity

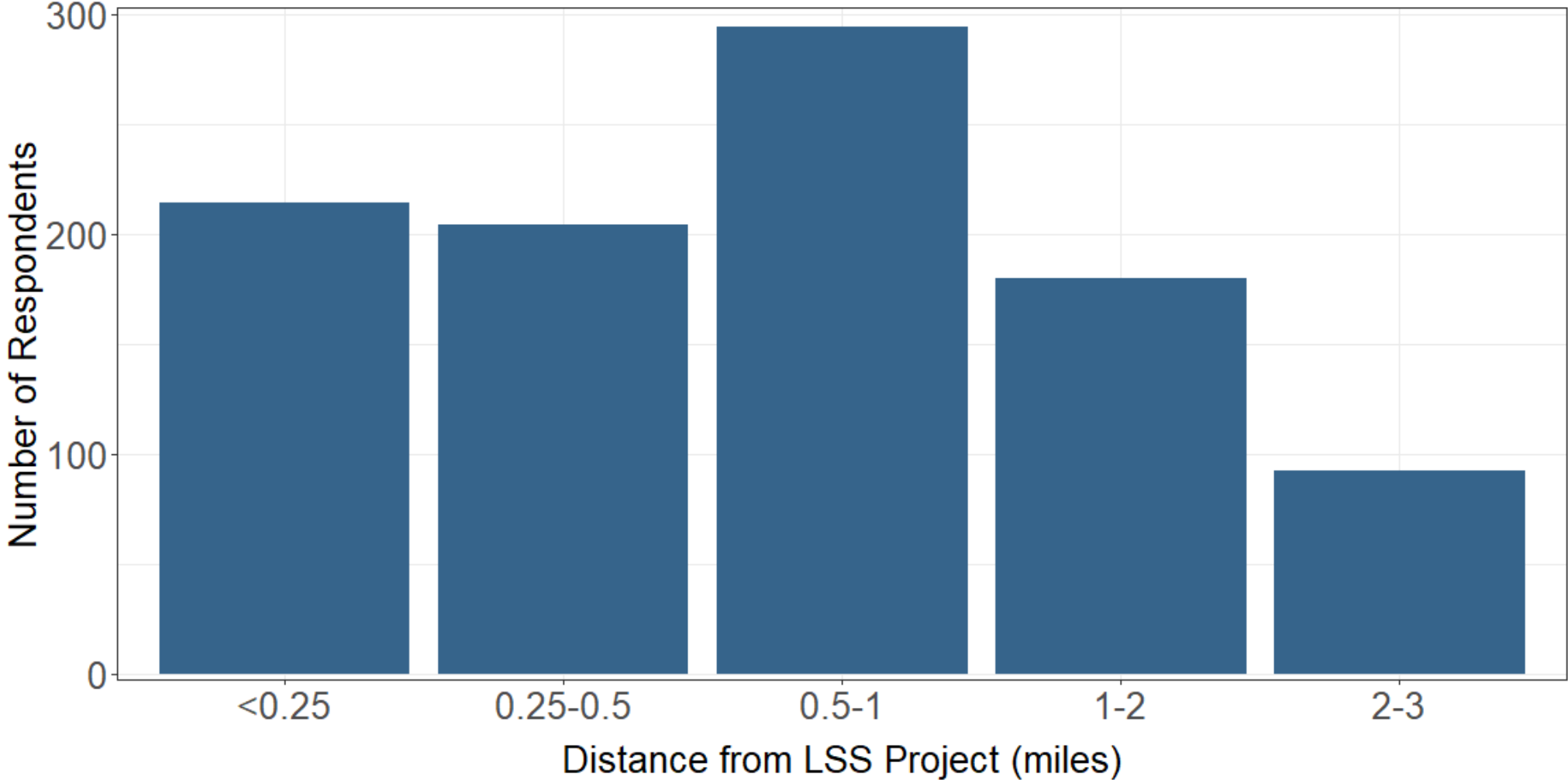
- Represent ~10% of LSS plants (~13% of LSS capacity) installed in the U.S. as of the end of 2021
- Includes projects installed from 2017 – 2021
- Responses span LSS projects from 39 states
- LSS projects range in size from 1 to 252 MW



Respondents are relatively old (median age = 63), predominantly white, and majority male; a relatively high fraction of respondents are retired

Demographic Summary Statistics					
Gender:		Age:		Race:	
Male	53%	Min	20	White	80%
Female	44%	p25	49	Black / African American	5%
Other / Prefer not to say	2%	Median	63	Asian	5%
		Mean	61	Am. Indian / AK native	1%
		p75	73	Hispanic	6%
		Max	96	Other	3%
Income:		Employment Status:		Education:	
< \$25,000	6%	Full-time	44%	High School	20%
\$25,000 - \$49,999	17%	Part-time	4%	Some college	26%
\$50,000 - \$74,999	15%	Retired	43%	College degree	50%
\$75,000 - \$99,999	17%	Homemaker	3%	Mast. / Prof. / Doc.	3%
\$100,000 - \$149,999	22%	Other / unemployed	5%		
\$150,000 - \$199,999	12%				
\$200,000 - \$249,999	4%				
\$250,000 or more	7%				

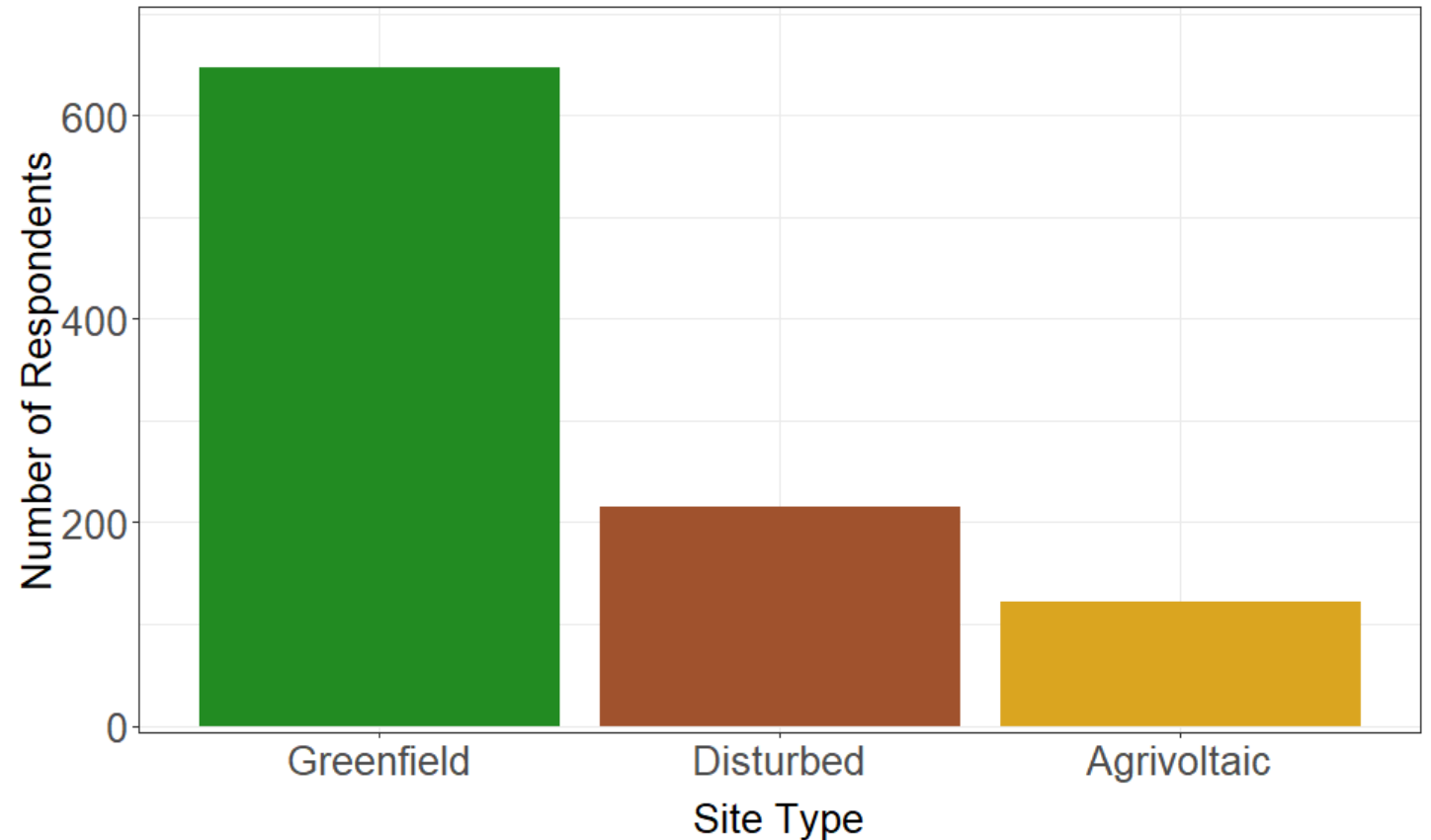
>700 survey respondents live within 1-mile of LSS project



Note: Approximately 10% of respondents moved into the community after the LSS project was constructed

Majority of respondents live near greenfield solar sites, but also good representation from “innovative” site types (e.g. disturbed, agrivoltaic)

- 66% of responses are from “greenfield” solar projects
 - Compared to ~93% of LSS projects (98% capacity)
- 22% from projects on disturbed / contaminated sites
 - Compared to 5% of LSS projects (1% of capacity)
 - Most are landfill projects
- 12% from “agrivoltaic” sites
 - Compared to 2% of LSS projects (< 1% of capacity)
 - Most are pollinator habitats



Analysis data were weighted to account for oversampling, as well as demographic differences between respondents and underlying population

We intentionally oversampled residents:

- Living closest to LSS
- Near ‘innovative’ sites (e.g., agrivoltaic)
- Near largest projects
- In some geographic regions

Survey respondents also differed slightly from the underlying population on several key demographic variables:

- Gender
- Age
- Educational attainment

We correct for these differences by applying weights to the analysis, so that the results are representative of the population of residents within 3 miles of LSS.

- Survey methods employ sampling weights in descriptive statistics in order to describe the population
- The (intentionally) unequal probability of selection in the stratified random sample was reversed (i.e., corrected) in the analysis
- Weighting followed the method known as “iterative raking” or “sample balancing” ¹
- Extreme weights were trimmed to reduce variance²
- The following slides show *weighted* results
 - Appendix slides illustrate the effect of weighting on demographics, stratification variables, and key variables.

Other important notes for interpretation of following slides:

Distributions shown are weighted; sample sizes are unweighted

- All subsequent slides (up to appendix) show *weighted* results.
- We use 100% stacked bar charts to illustrate distributions of responses. Those distributions are weighted to represent the population.
- Sample sizes shown are *unweighted* counts of responses in each category.

Polychoric Correlation:

- Polychoric correlation measures the level of agreement (correlation) between ordinal variables (ordered categorical data) like Likert scales (e.g., 5-point 'agree' to 'disagree' scales) and binned data¹.
- We utilize polychoric correlation tests regularly in this analysis and report the correlation coefficient.
- We define the *strength* of these correlation coefficients according to the table below:

0.8 to 1.0	Very strong
0.6 to 0.8	Strong
0.4 to 0.6	Moderate
0.2 to 0.4	Weak
0.0 to 0.2	Very weak or negligible

(1) Note: polychoric correlation tests assume variables have a normal distribution. When there is a skewed distribution, the correlation test is performed sub-optimally



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Overall Attitudes + Support for Additional LSS



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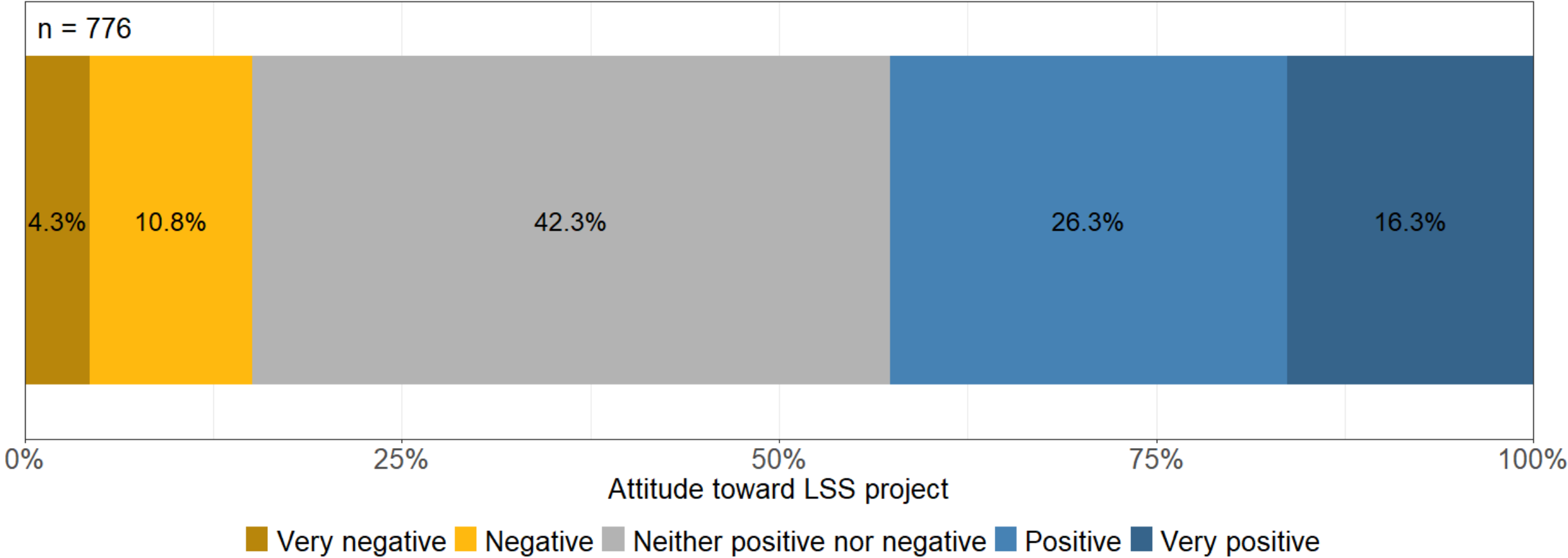
ENERGY ANALYSIS AND ENVIRONMENTAL IMPACTS DIVISION

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85% of respondents have a 'positive' or 'neutral' attitude toward the project

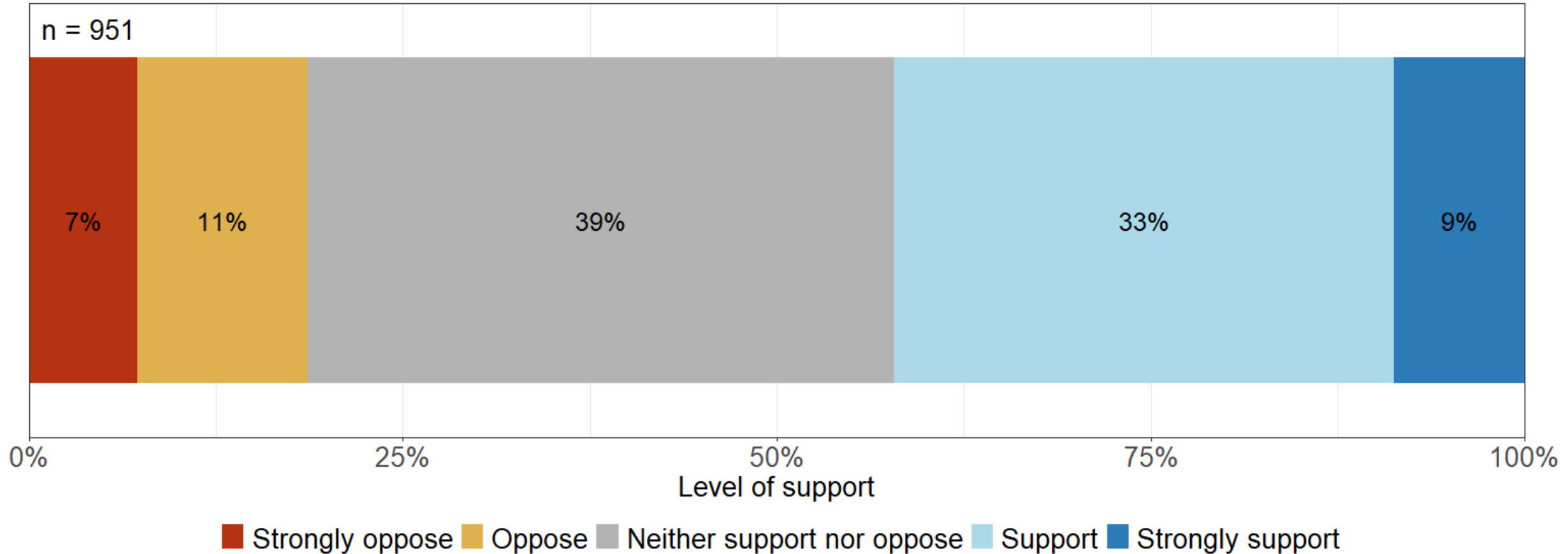
Overall, 'positive' attitudes outnumber 'negative' by nearly a 3 to 1 margin

Which describes your current attitude about the solar project?



Similarly, respondents who support *additional* LSS in their community outweigh those opposed to it by more than 2 to 1

To what extent would you support additional LSS in your community?





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Attitudes & Site Characteristics

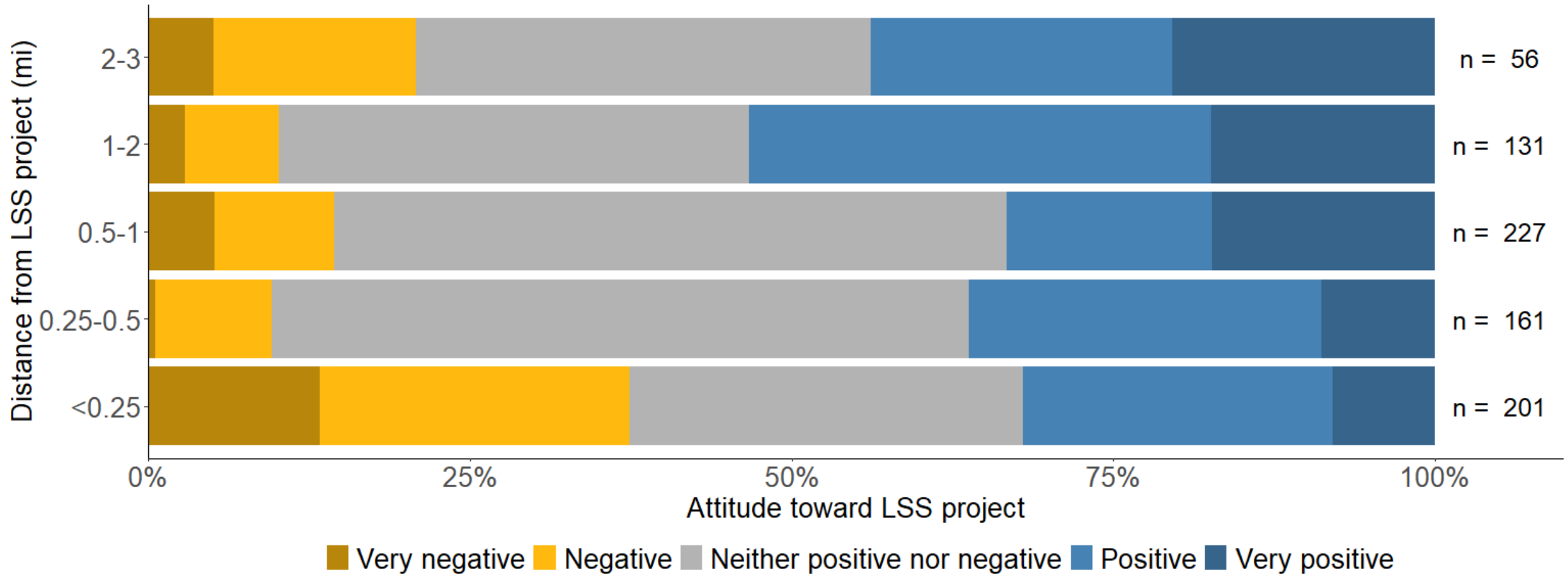


ENERGY TECHNOLOGIES AREA

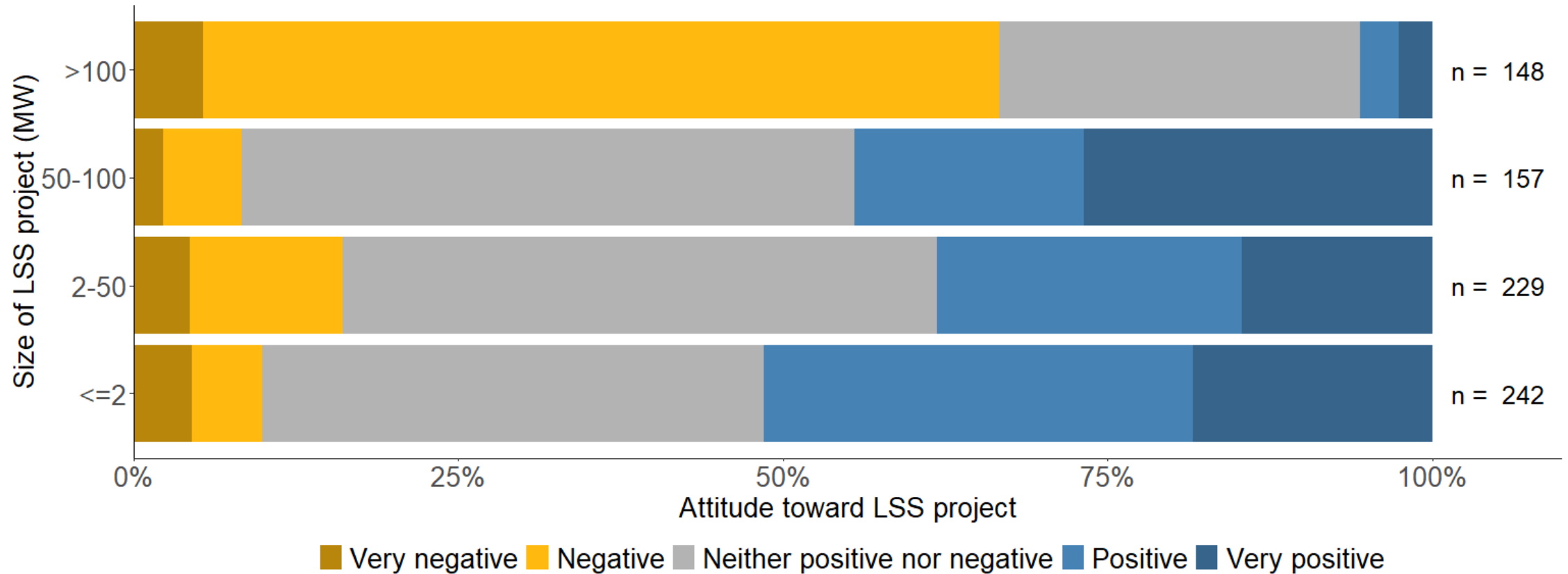
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Positive attitudes outweigh negative attitudes except for respondents within 1/4 mile, where positive and negative attitudes are roughly evenly split



Very large (>100 MW) projects elicit substantially more negative attitudes compared to smaller and mid-sized projects

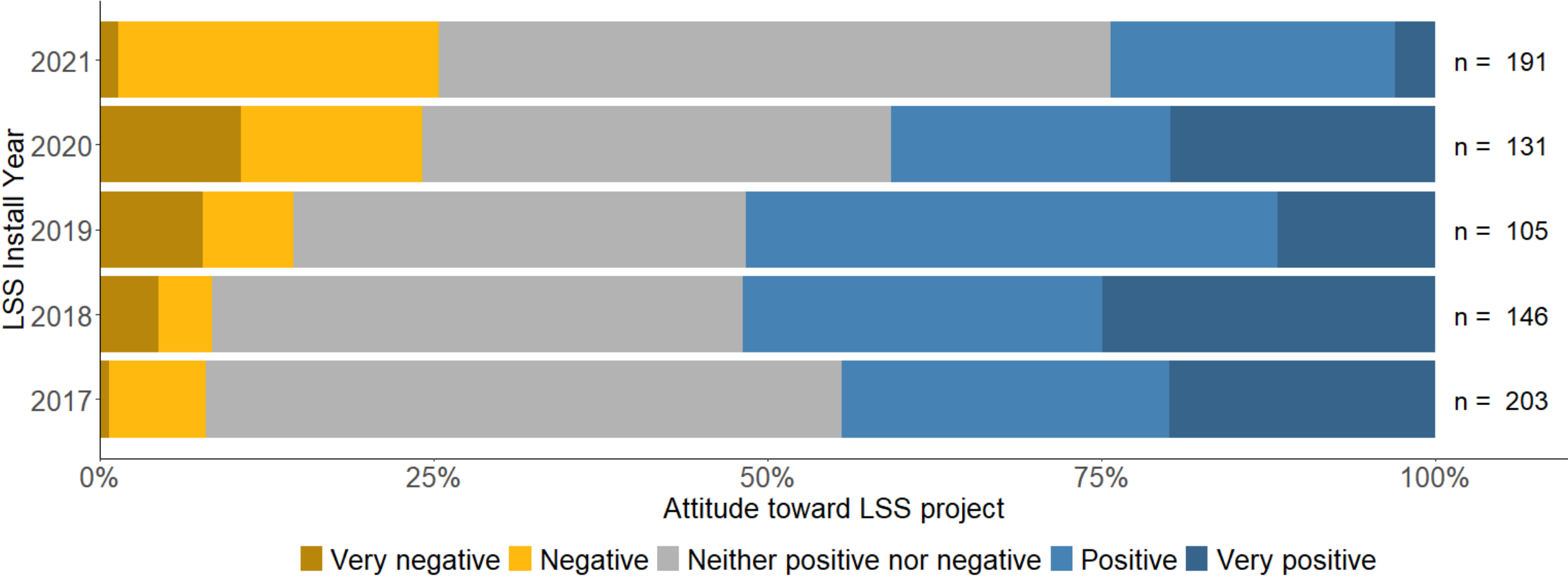


Polychoric Correlation: **-0.20** (weak)

Attitudes around largest projects (>100 MW) are roughly 12:1 *negative to positive*, compared to:

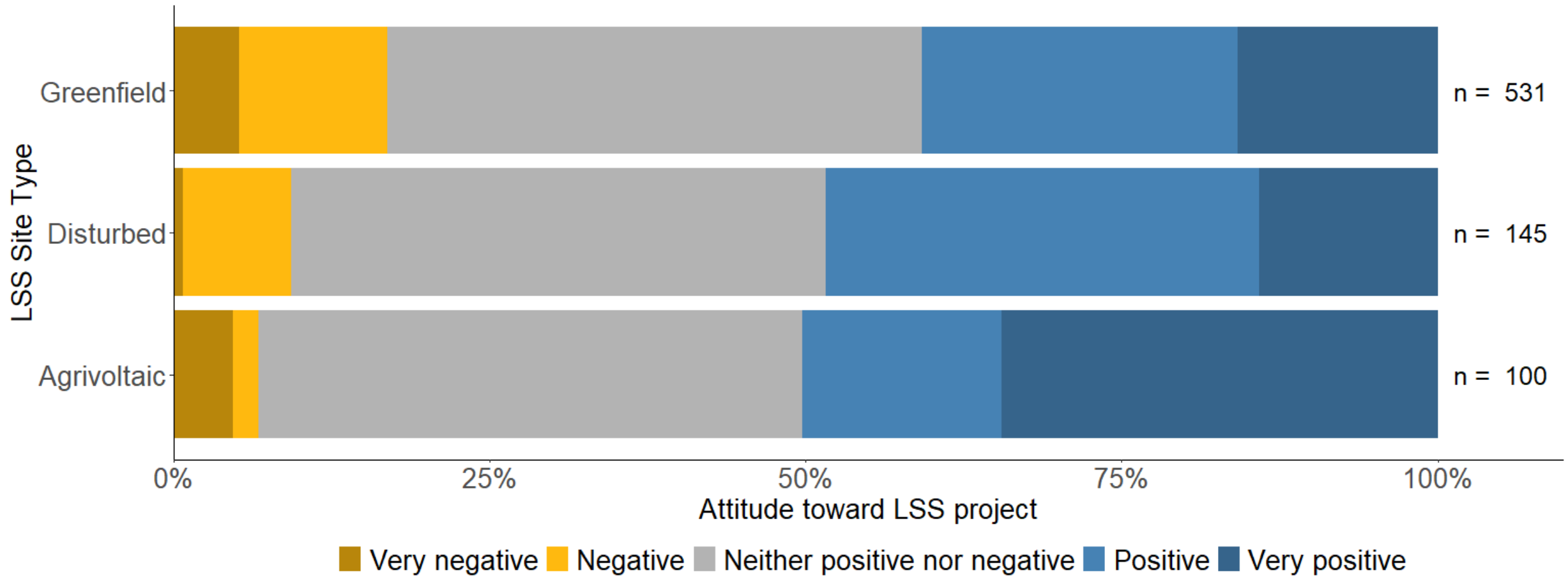
- 5:1 positive to negative for 50-100 MW projects
- 2:1 positive to negative for 2-50 MW projects
- 5:1 positive to negative for 1-2 MW projects

More recent projects are weakly associated with more negative attitudes



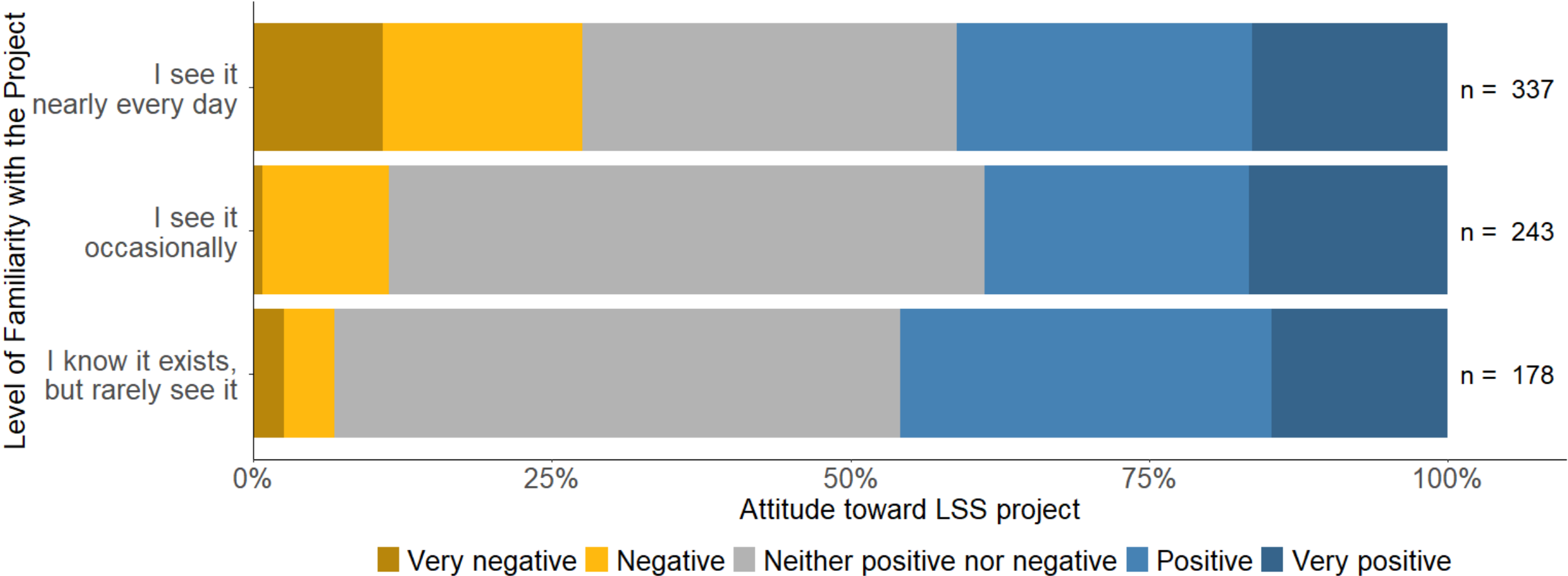
Polychoric Correlation: **-0.22** (weak)

All site types have more positive than negative attitudes. Agrivoltaic sites have the highest share of positive attitudes (>7:1 positive)



Seeing LSS more frequently elicits stronger (and more negative) opinions, but even those seeing the LSS project daily are more positive than negative

Those who rarely see the project are overwhelmingly (nearly 7:1) positive





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Aesthetic Impacts and Related Perceptions



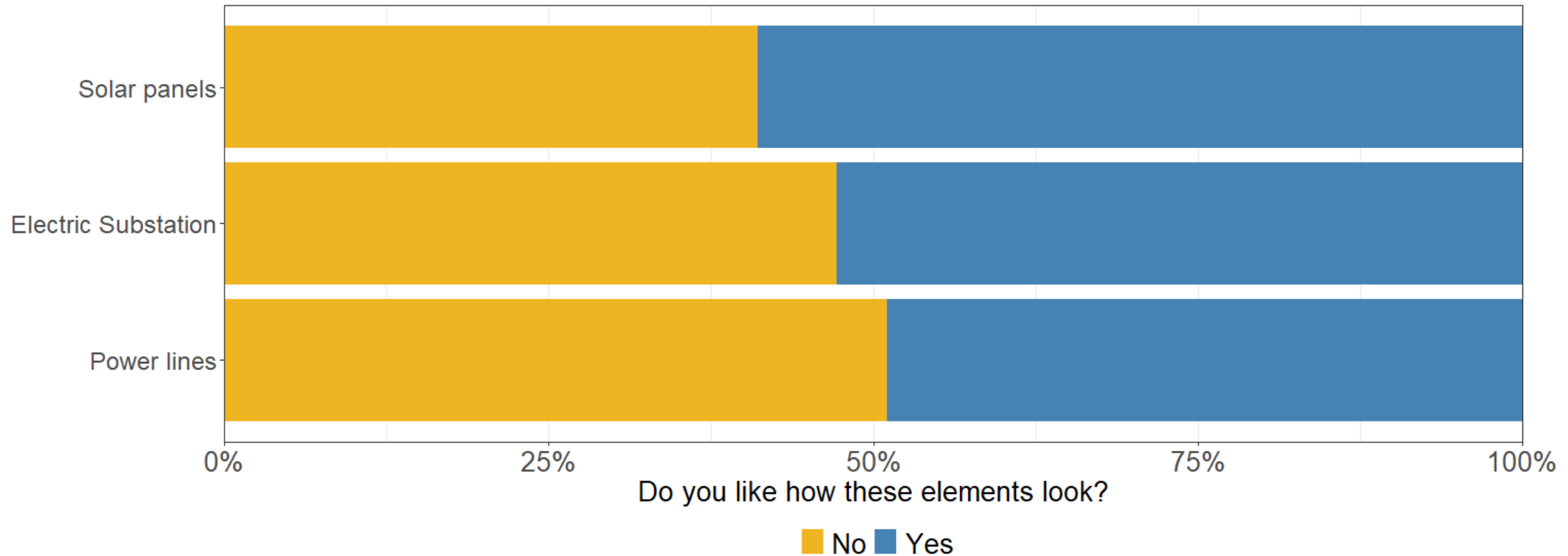
ENERGY TECHNOLOGIES AREA

ENERGY ANALYSIS AND ENVIRONMENTAL IMPACTS DIVISION

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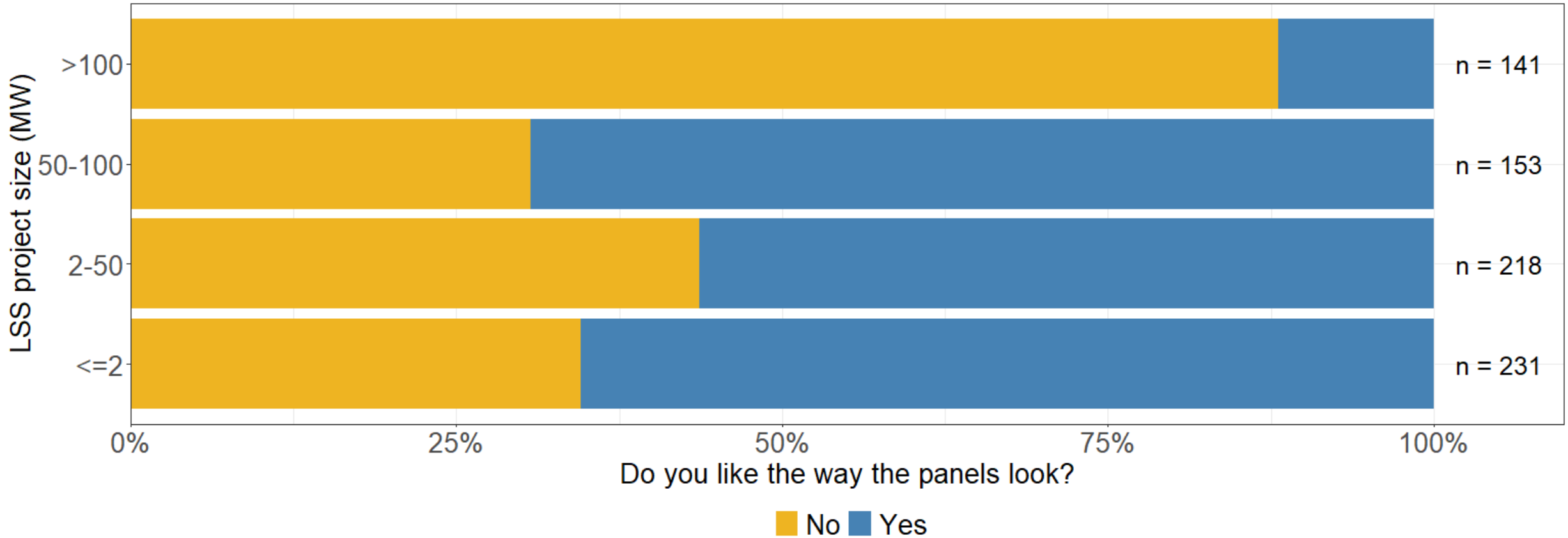
Just over half (60%) like the way the panels look, fewer like the look of electric substations and power lines associated with LSS projects

Do you like the way these elements of the solar project look? (n = 705-743)



Those living near the largest projects (>100 MW) are much more likely to dislike the look of the panels

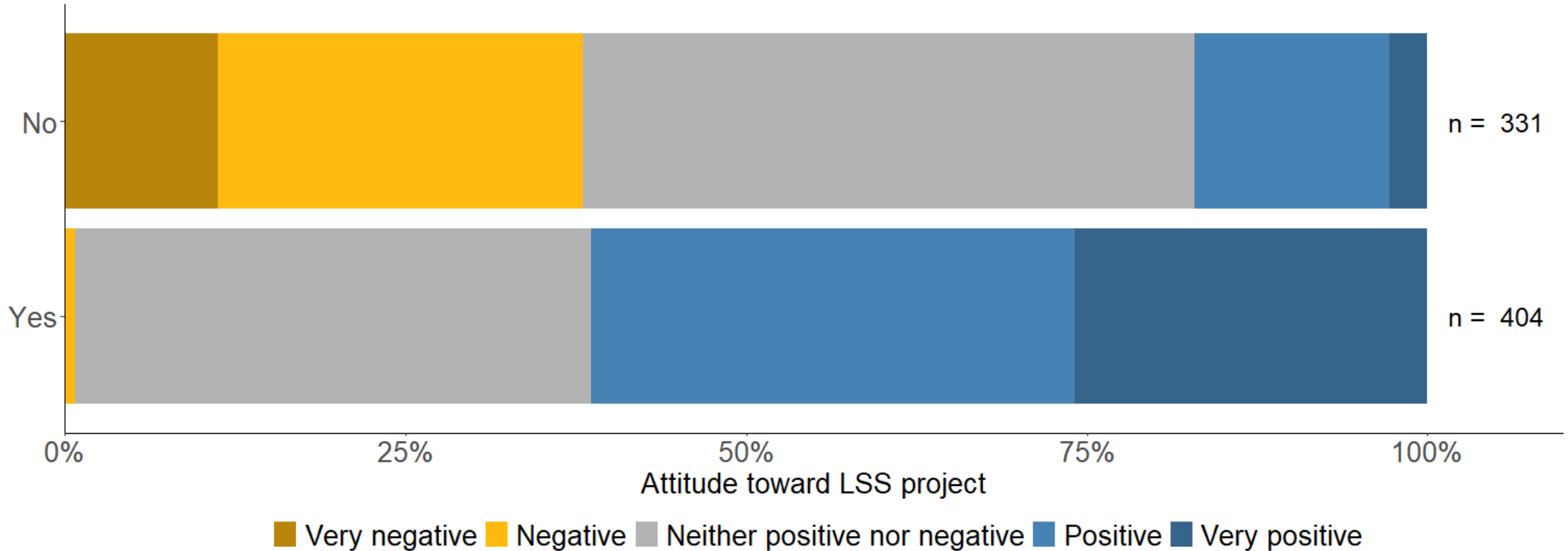
Do you like the way the panels look?



Polychoric Correlation: **-0.22** (weak)

Liking how the panels look is strongly correlated with one's attitude about the project overall

Do you like the way the panels look?

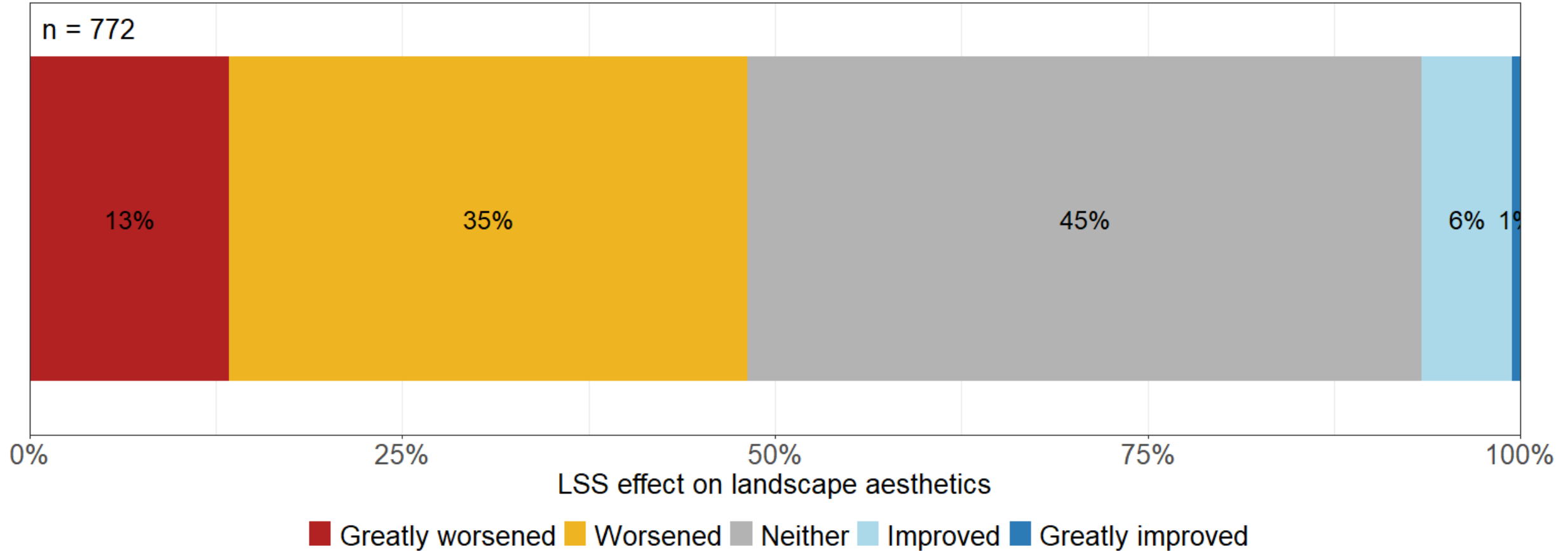


Polychoric Correlation: **0.73**

Nearly half (48%) perceive that the project worsened landscape aesthetics

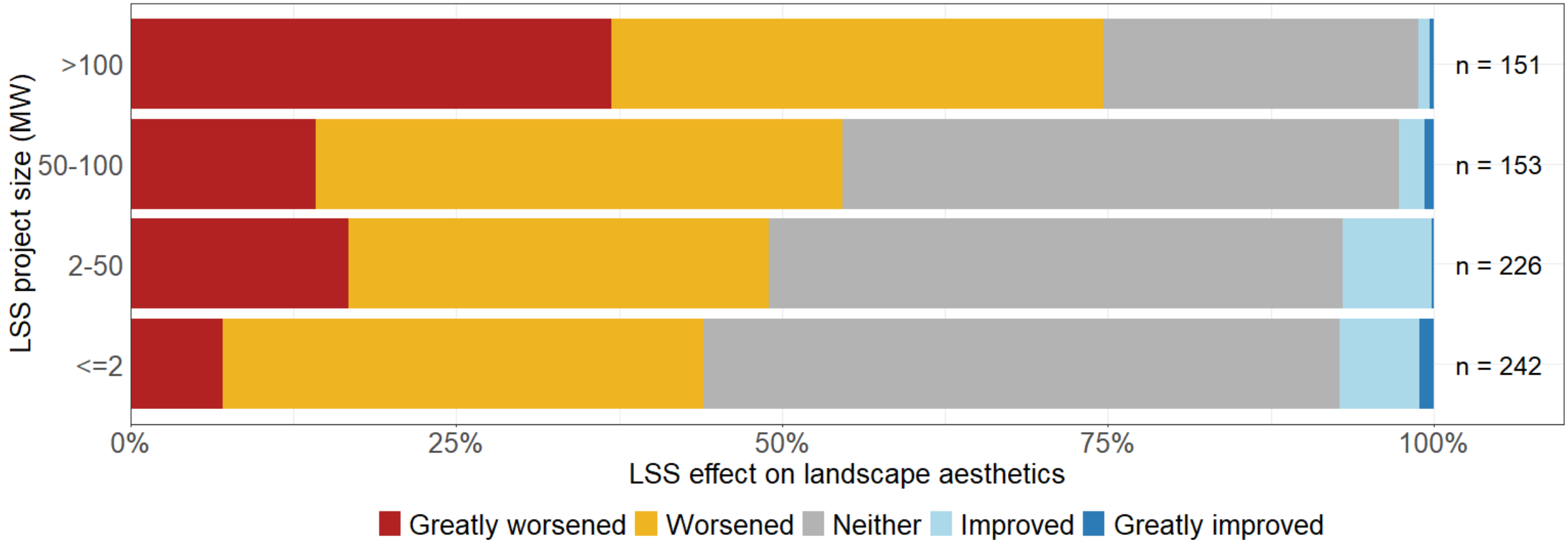
Negative aesthetic perceptions outweigh positive by nearly 7:1

What effect has the project had on aesthetics of the landscape?



The majority of those around larger (>50 MW) projects perceive that the local project worsened landscape aesthetics, including nearly ¾ of those near projects >100 MW

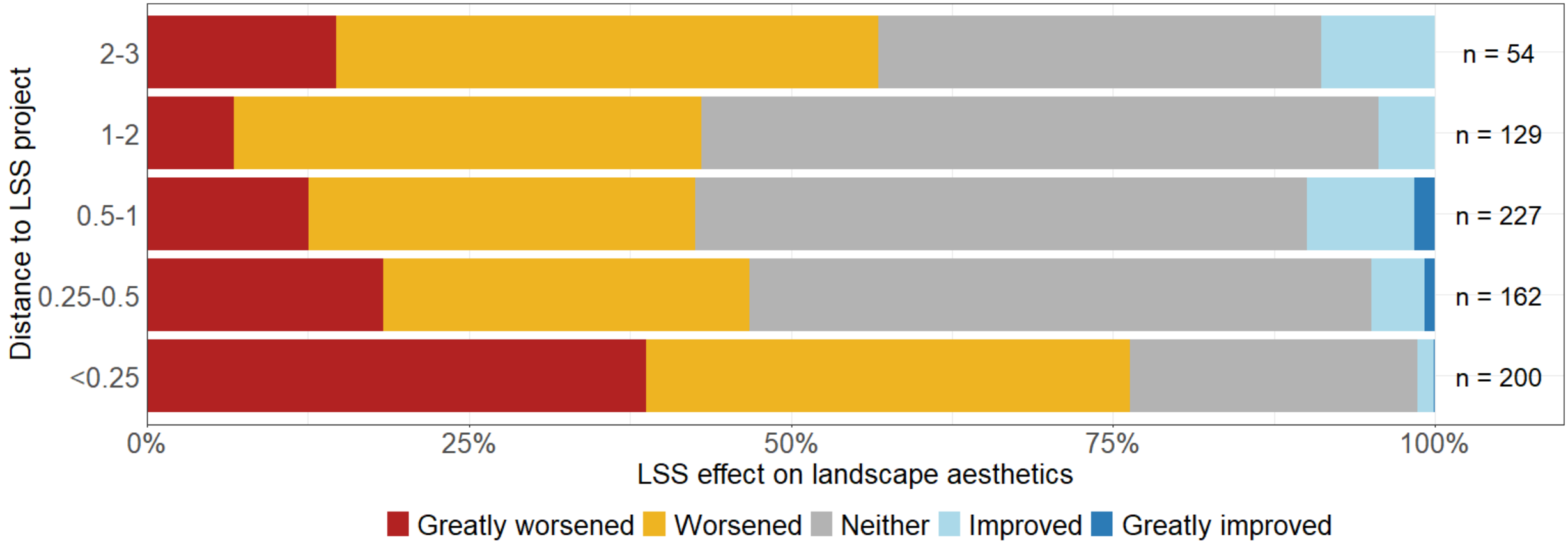
What effect has the project had on aesthetics of the landscape?



Polychoric Correlation: **-0.22** (weak)

75% of those within ¼ mile of LSS report worsened landscape aesthetics; negative aesthetic perceptions vastly outweigh positive at all distances

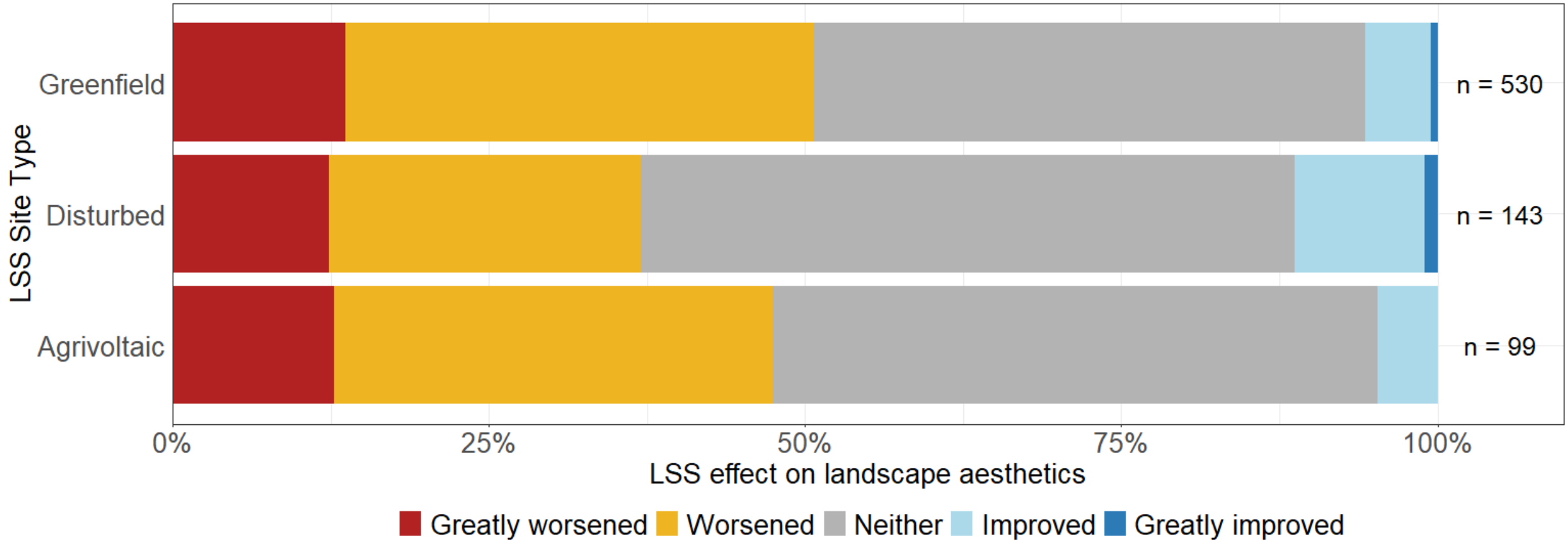
What effect has the project had on aesthetics of the landscape?



Polychoric Correlation: **0.08** (negligible)

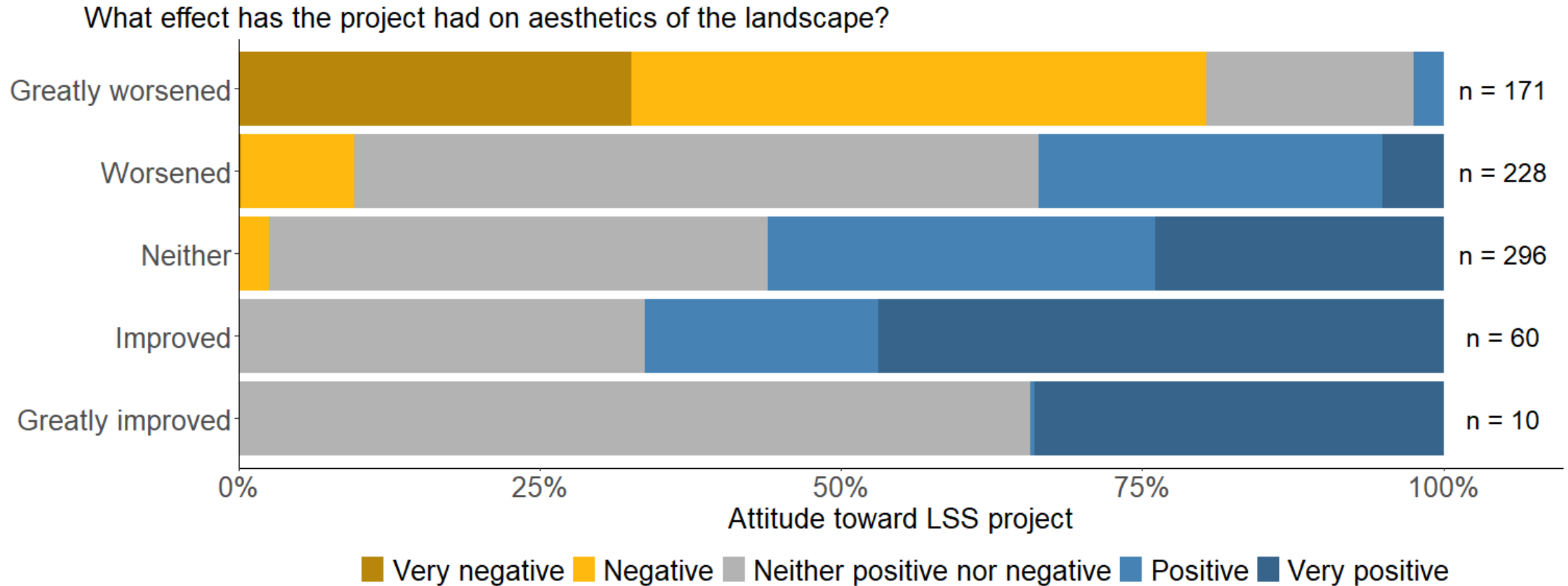
Aesthetic perceptions are more negative than positive regardless of LSS site type, though negative aesthetic effects may be less prominent at disturbed sites

What effect has the project had on aesthetics of the landscape?



Perceived aesthetic impacts are strongly correlated to attitudes:

Yet, of those who perceive 'worsened' landscape aesthetics, 'positive' attitudes outnumber 'negative' ~3.5 to 1



Polychoric Correlation: **0.68** (strong)



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Quality of Life, Economic Impacts, and Related Perceptions



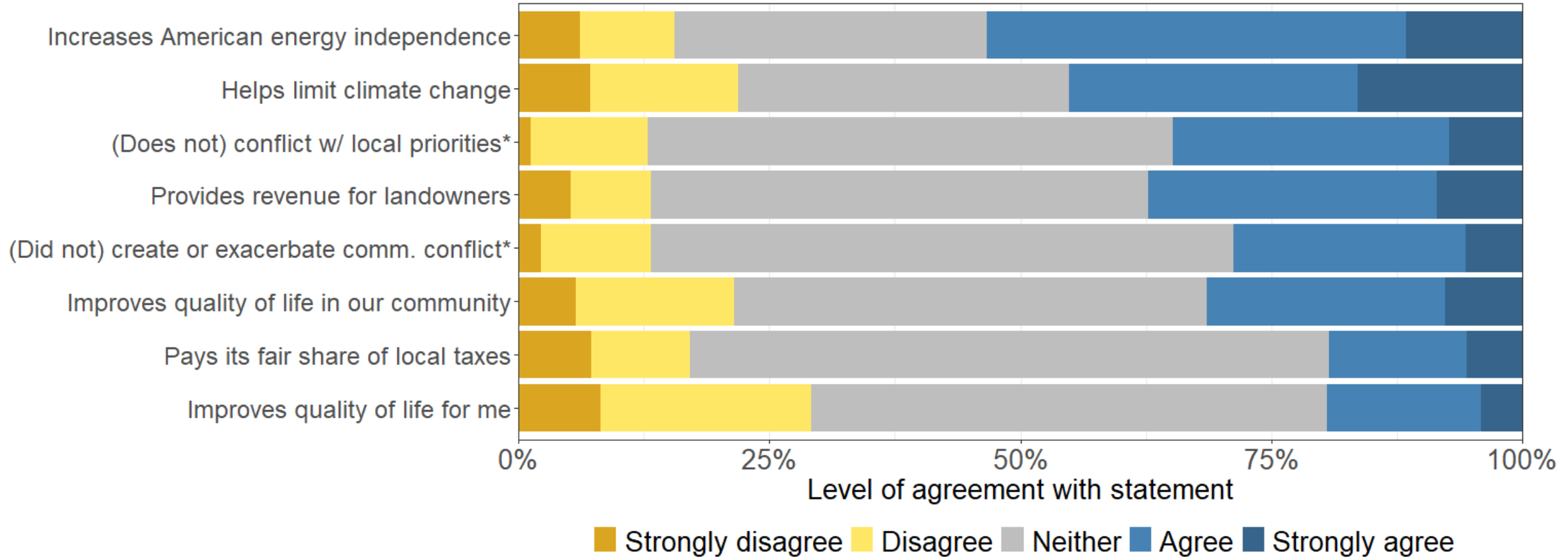
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Many have not formed opinions on LSS impacts but generally find they are more positive than negative, especially for ‘energy independence’, ‘limiting climate change’

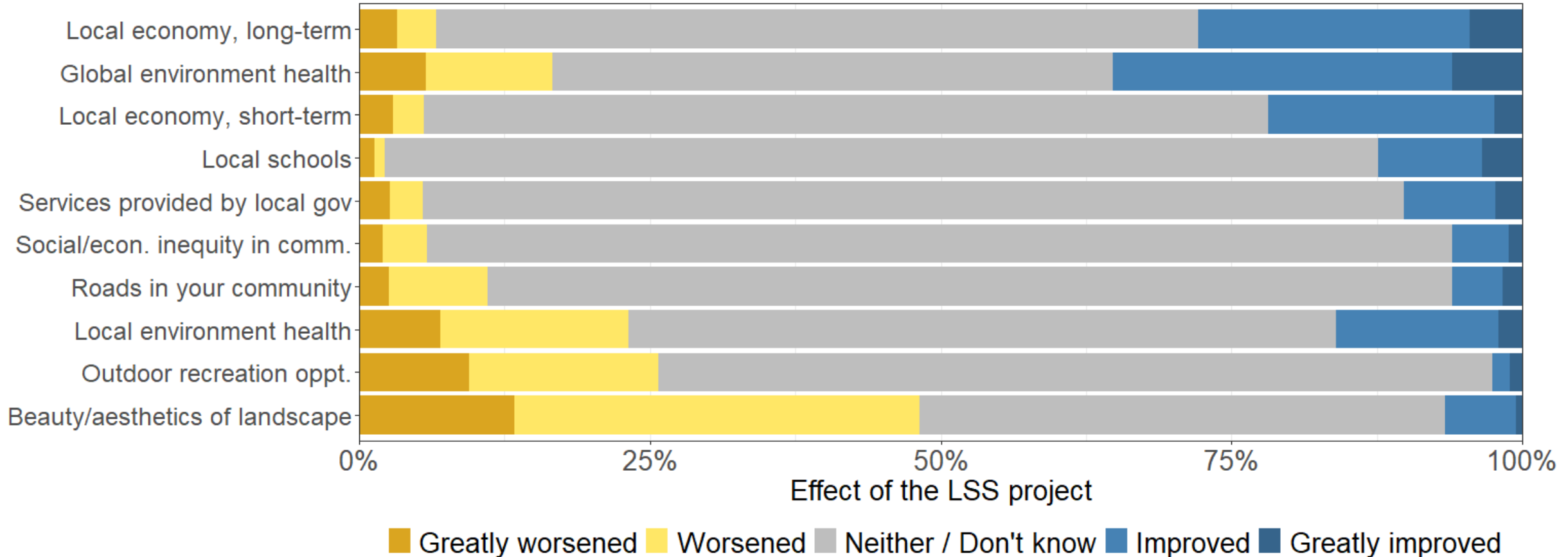
Overall, the solar energy project... (n = 755-776)



* These two items are reverse-coded from how they appeared in the survey instrument to aid interpretation

Most respondents do not perceive changes due to LSS across a range of economic and quality-of-life measures

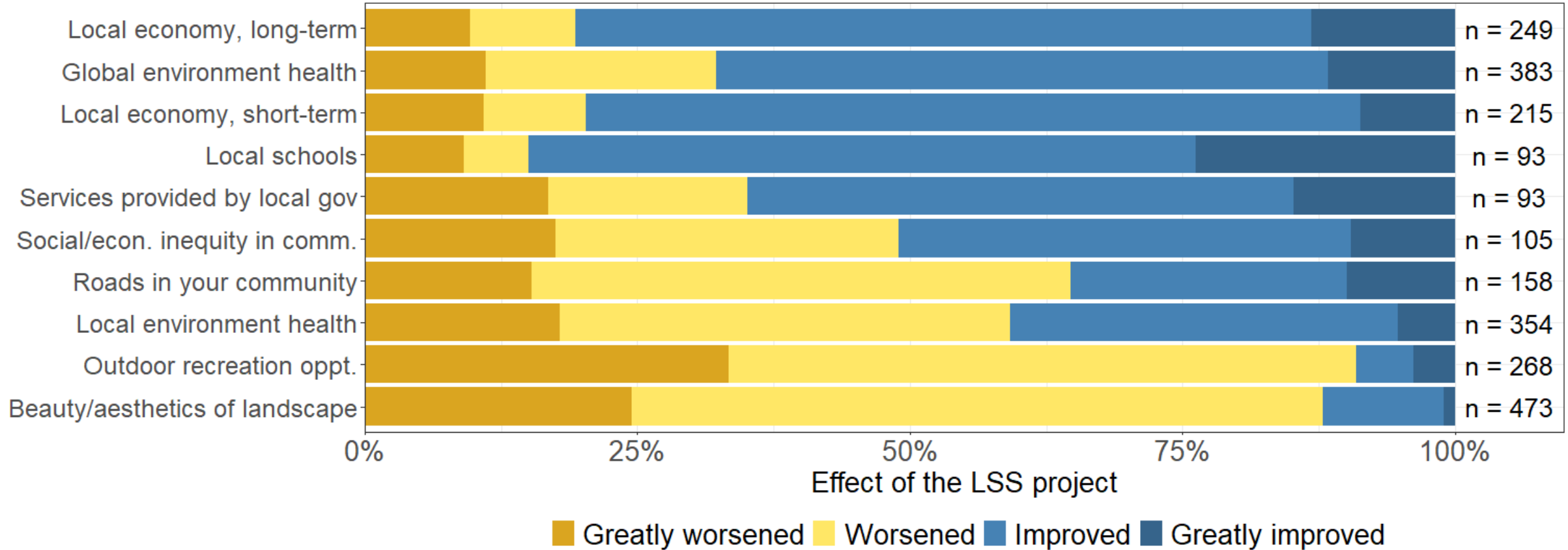
What effect has the LSS project had on... (n = 759-775)



Note: The following slide examines the same question, but excludes the "Neither / Don't know" category

Among those who noted change due to LSS, local economy, schools, and global environmental health improved; aesthetics and outdoor recreation worsened

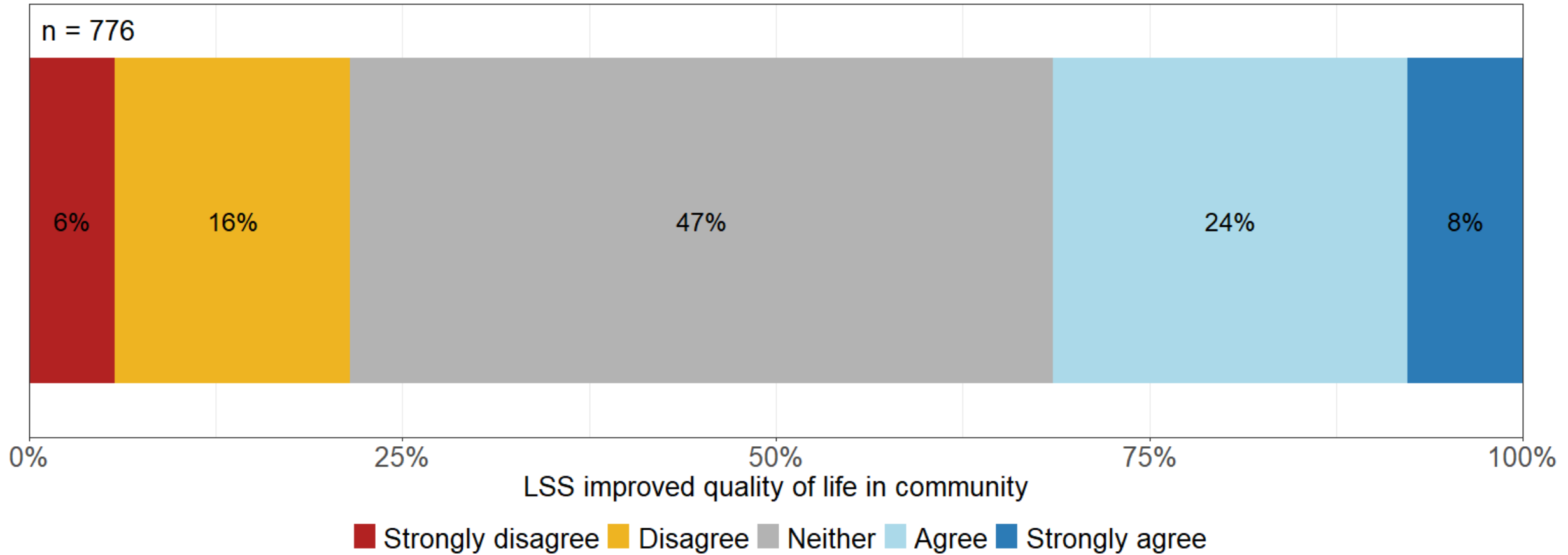
What effect has the LSS project had on...



Note: This figure excludes those who answered "Neither improved nor worsened" or "Don't know"

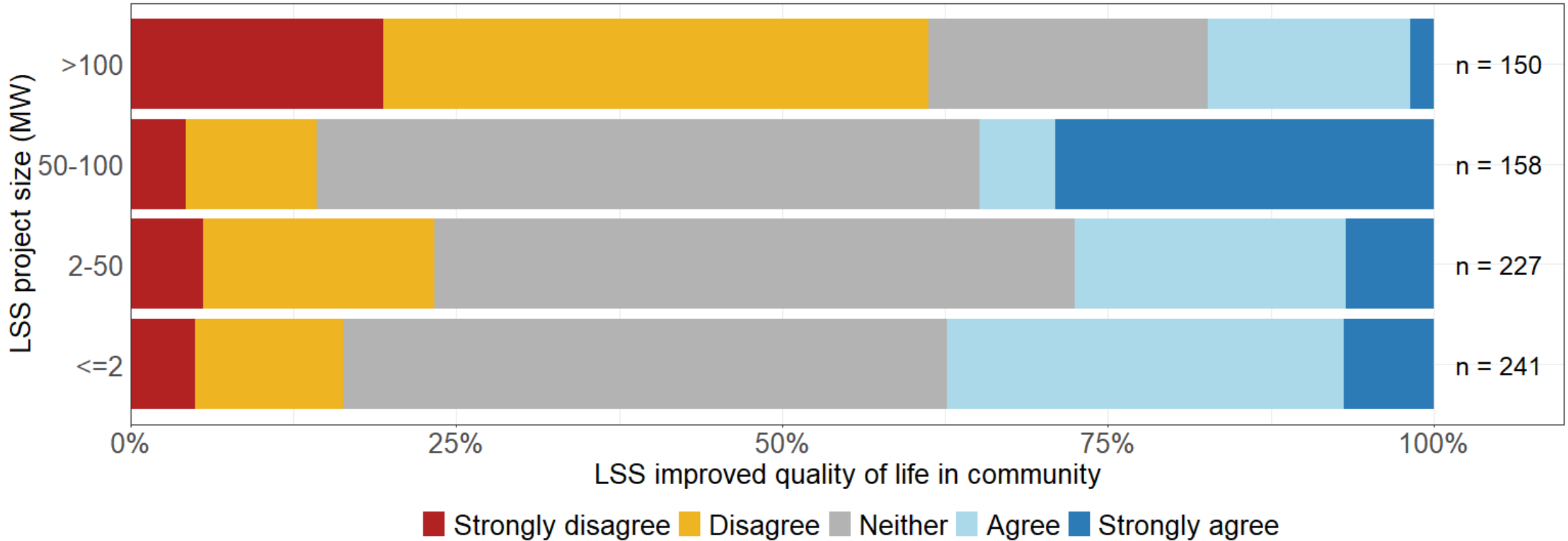
Respondents are somewhat split on whether the LSS project has improved quality of life in their community, with nearly half seeing no effect

The LSS project has improved quality of life in our community



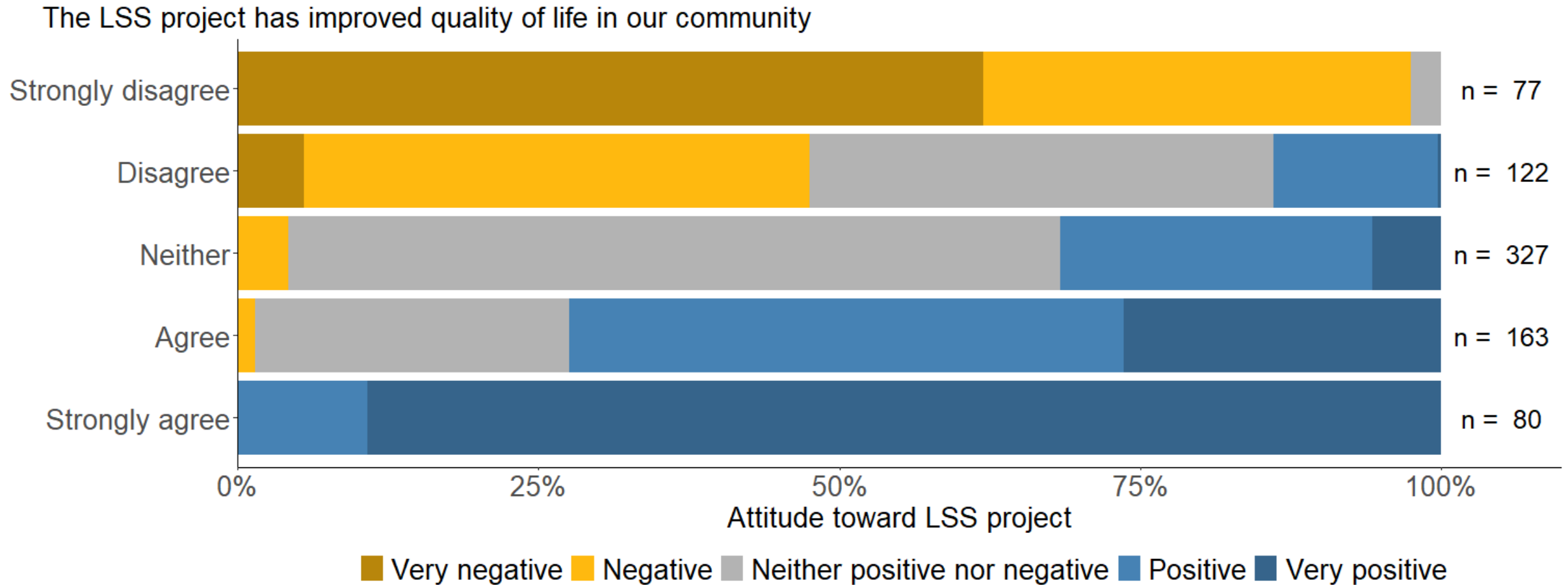
Those living near the largest LSS projects (>100 MW) are less likely to perceive that local quality of life has improved on account of the project

The LSS project has improved quality of life in our community



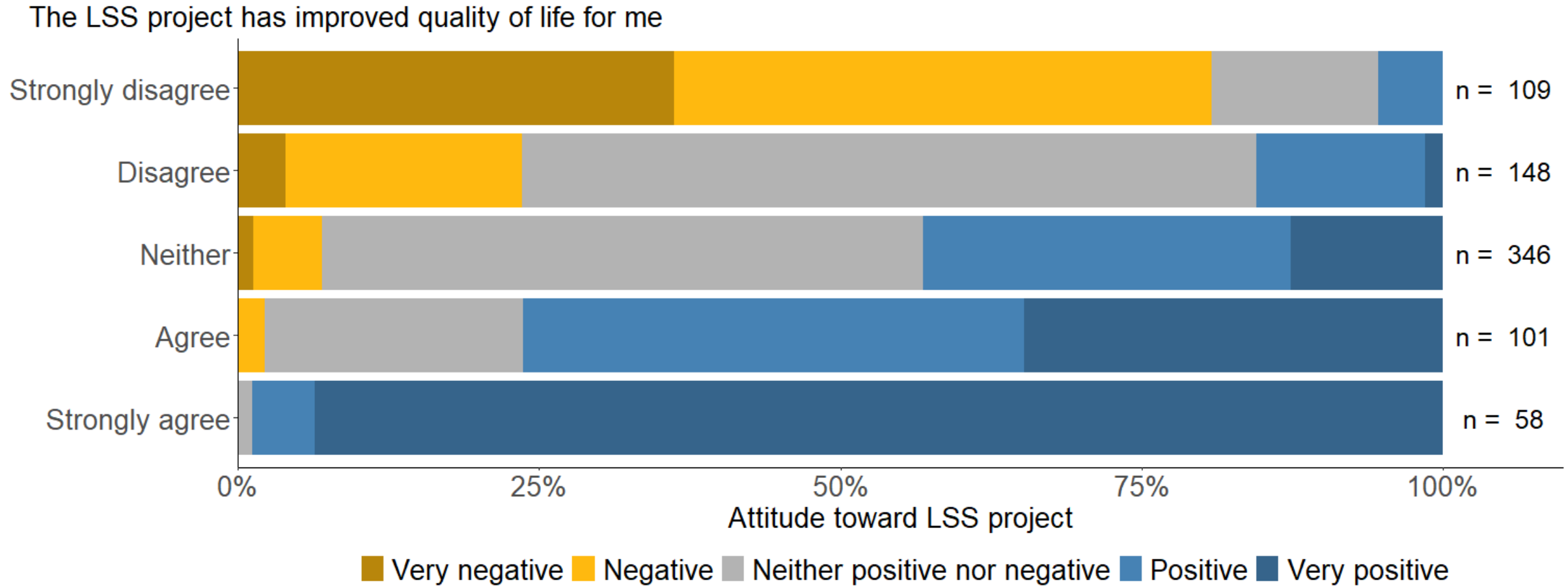
Polychoric Correlation: **-0.13** (very weak)

Respondents' perception of how the LSS project has impacted community quality of life are very strongly correlated with their attitudes about the project overall



Polychoric Correlation: **0.80** (very strong)

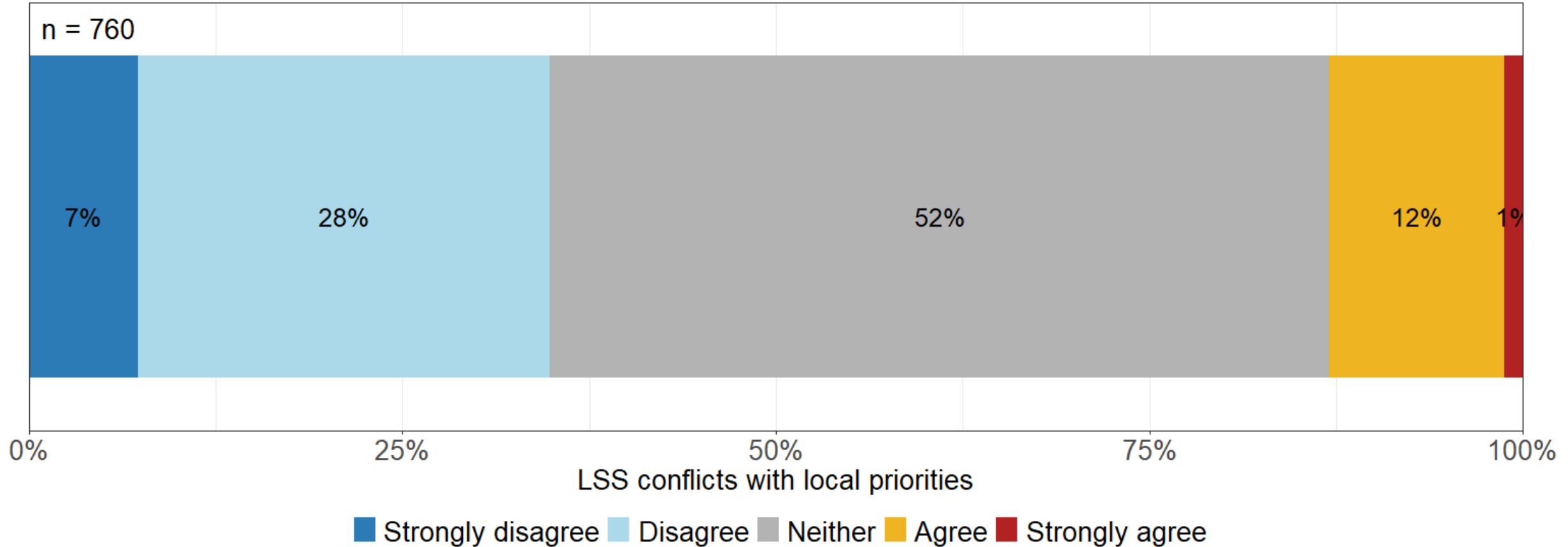
Individual of quality of life impacts are also correlated with attitudes (though slightly less strongly than *community* quality of life impacts)



Polychoric Correlation: **0.69** (strong)

Only 13% believe the project conflicts with local priorities (35% say otherwise; more than half see no impact)

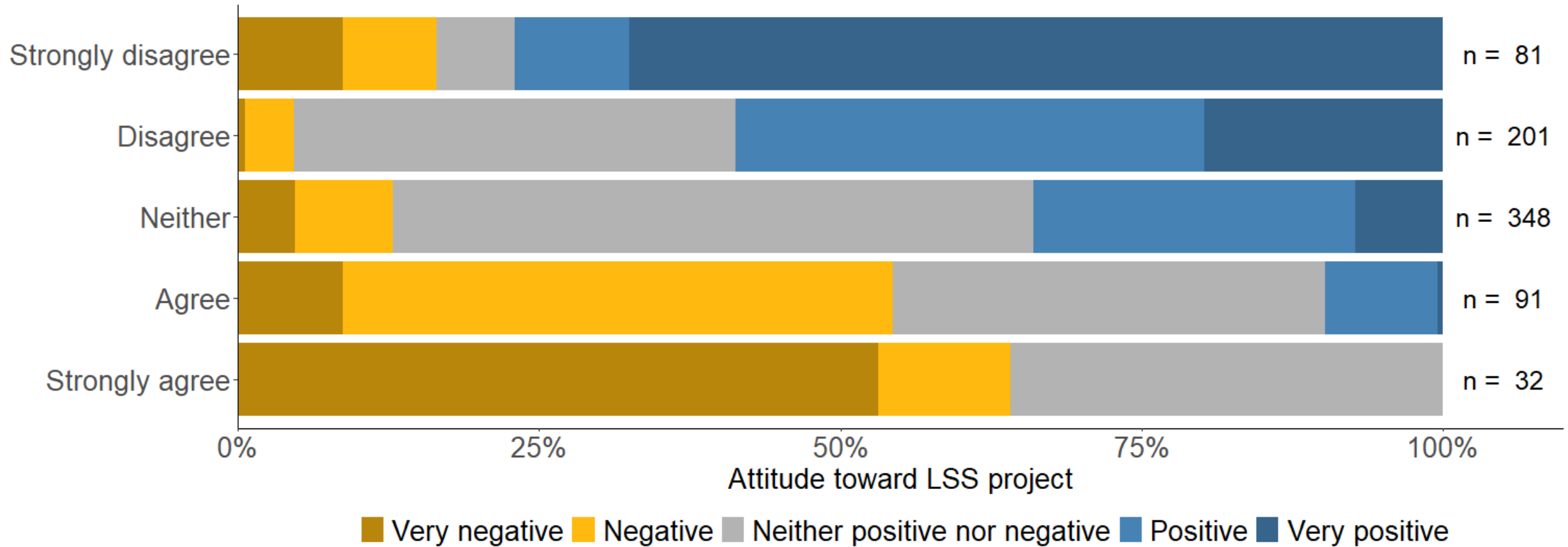
The LSS project **conflicts** with local interests and priorities



* Color scale on this slide is reversed to aid interpretation (since disagreeing connotes a positive perception)

Perceptions of the project's fit with local interests and priorities are moderately correlated with attitudes¹

The LSS project **conflicts** with local interests and priorities

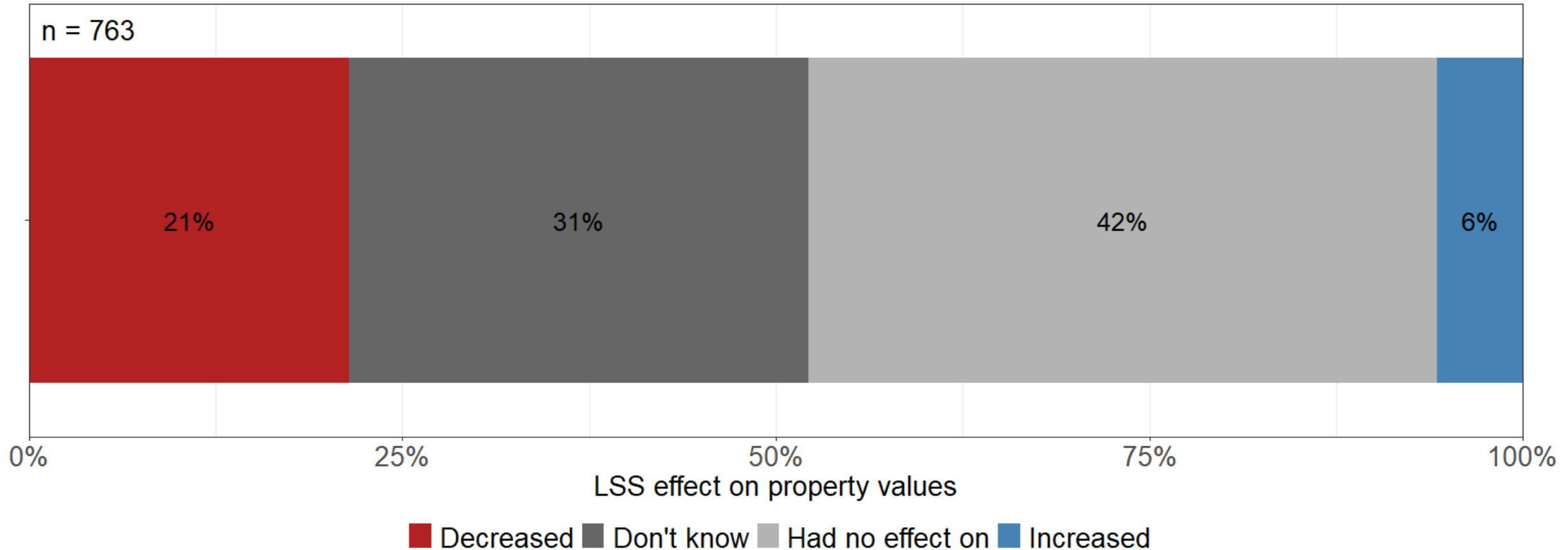


Polychoric Correlation: **-0.44** (moderate)

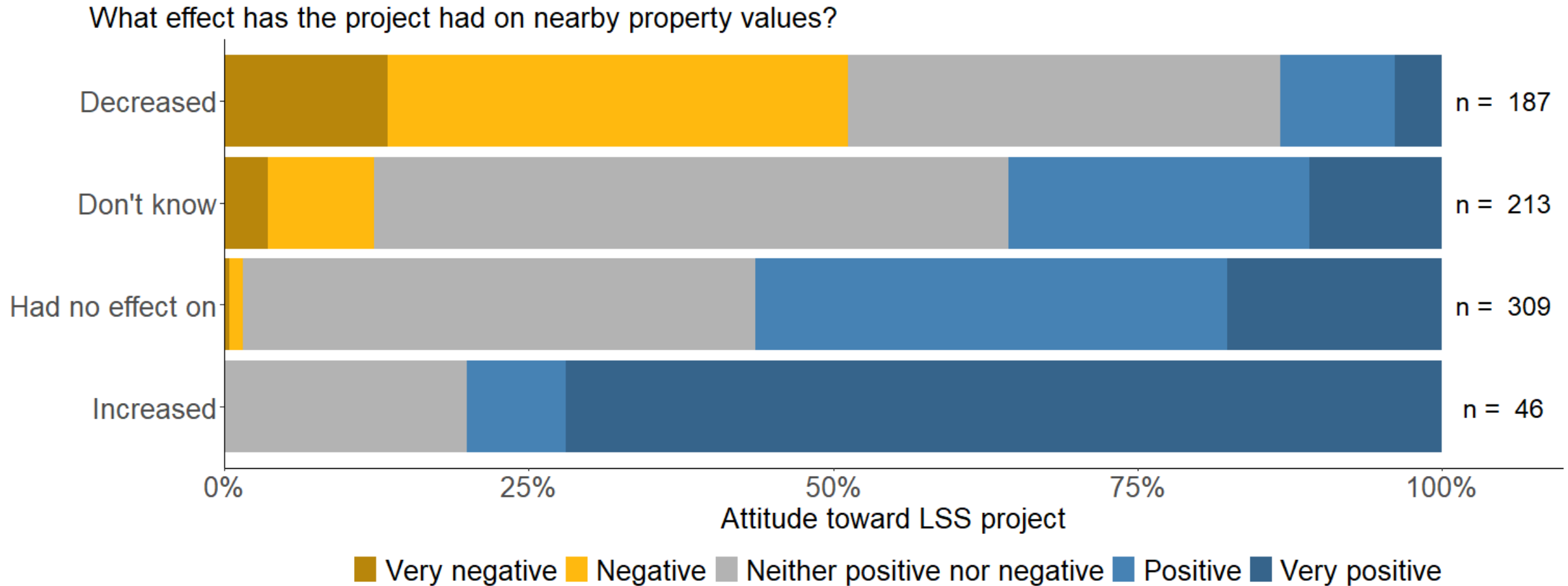
(1) Some respondents who had negative attitudes toward their local project may have misinterpreted this question and chose strong disagree assuming it meant the project aligned with local interests and priorities

Roughly 1/5 believe the project has reduced local property values, while almost 50% believe the values were unchanged or increased

What effect has the project had on nearby property values?



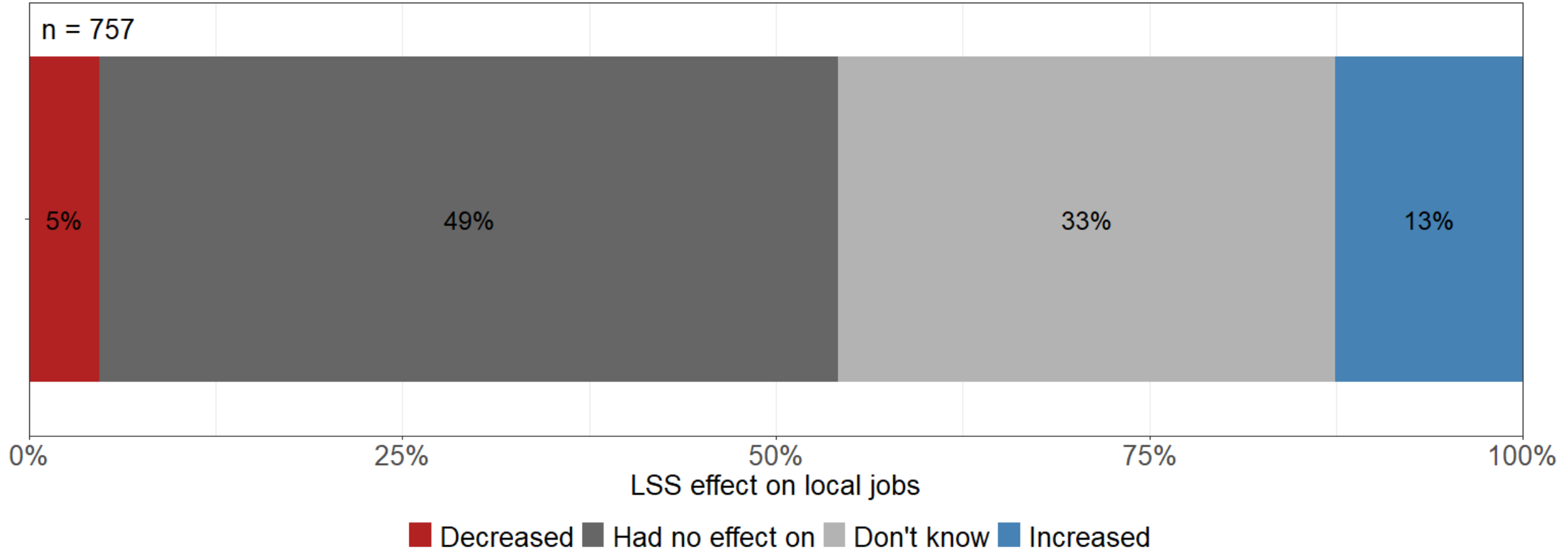
Those who think property values decreased have more negative attitudes (~4:1 margin)
Those who think LSS had no effect or increased property values have largely positive attitudes



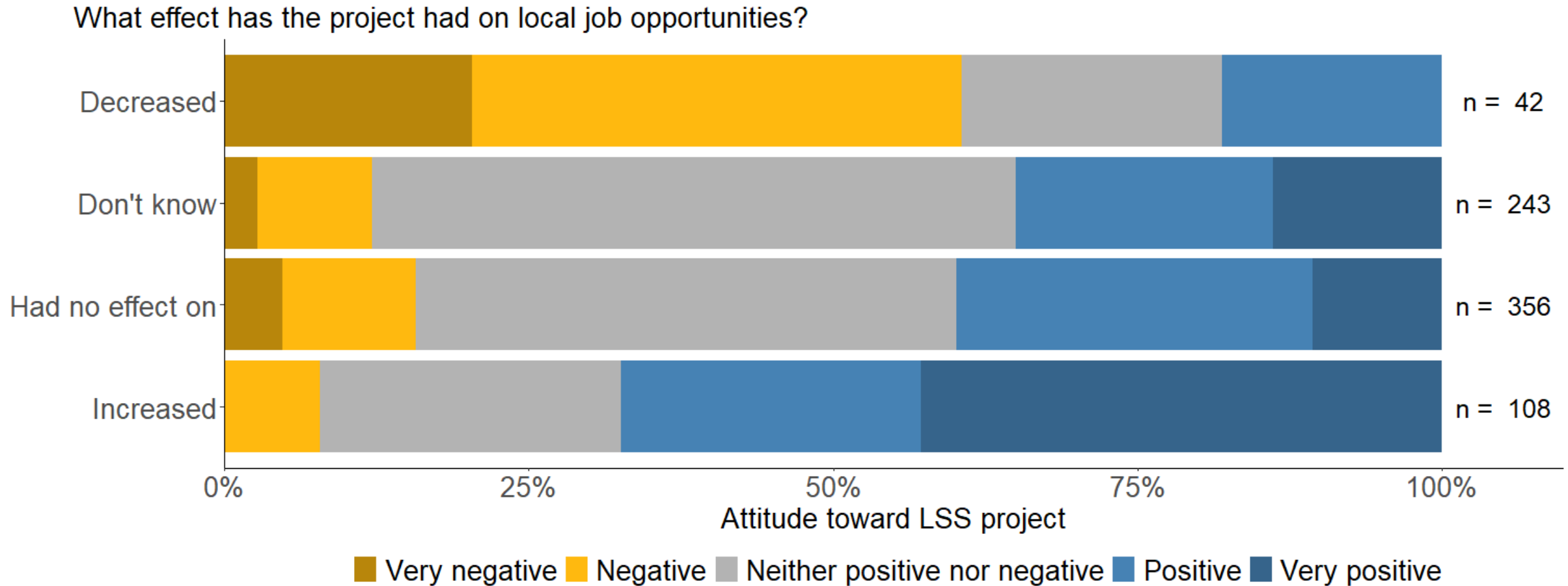
Polychoric Correlation: **-0.71** (strong; excludes "Don't know")

Only 18% think the project impacted local job opportunities - 13% 'increased' and 5% 'decreased' – while almost 50% said “no effect”

What effect has the project had on local job opportunities?



Those who say LSS decreased local job opportunities were largely negative about the project, while most who thought local jobs increased were positive

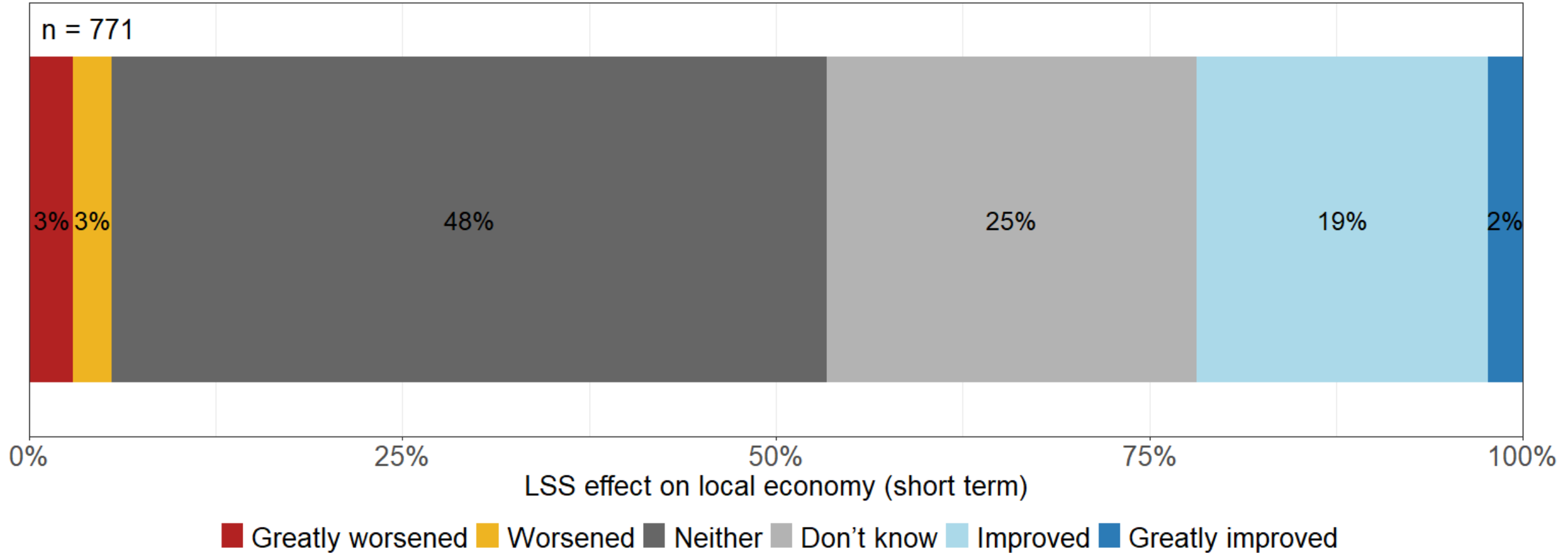


Polychoric Correlation: **-0.47** (moderate; excludes "Don't know")

The majority do not notice any short term impact to the local economy

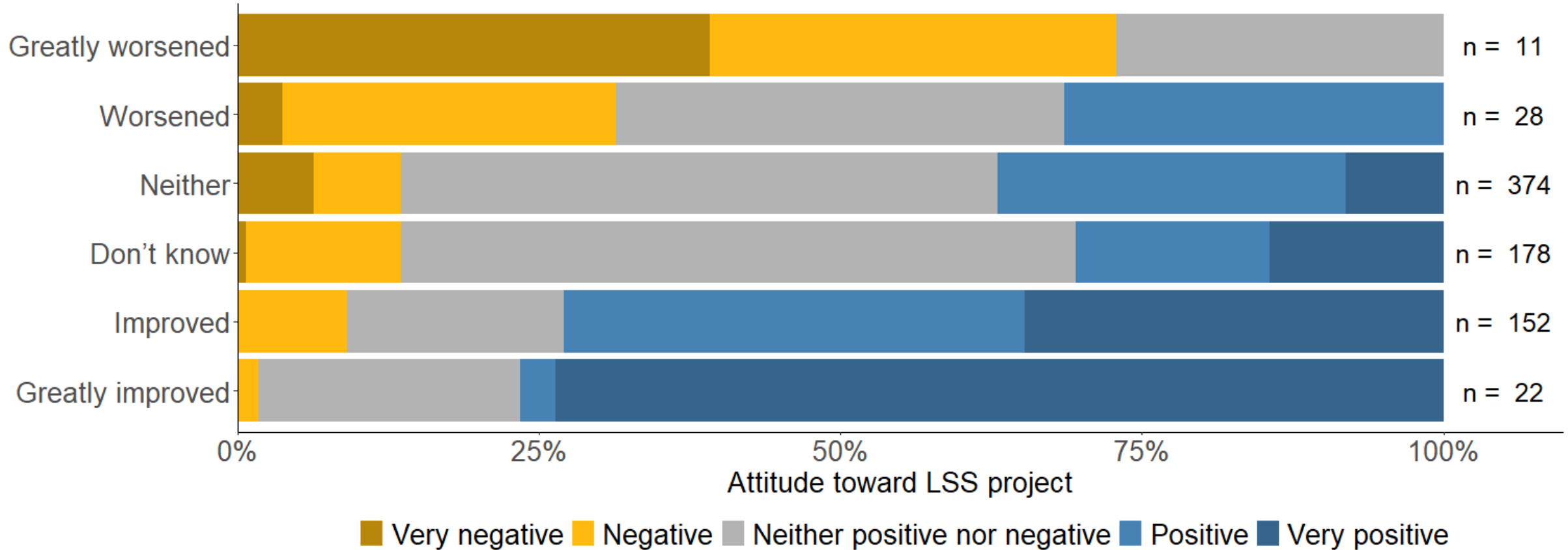
Though, among those who do, >3:1 perceive economic improvement

What effect has the project had on the local economy in the short term?



Perceptions of short term local economic impacts are moderately correlated with attitudes about the project overall

What effect has the project had on the local economy in the short term?

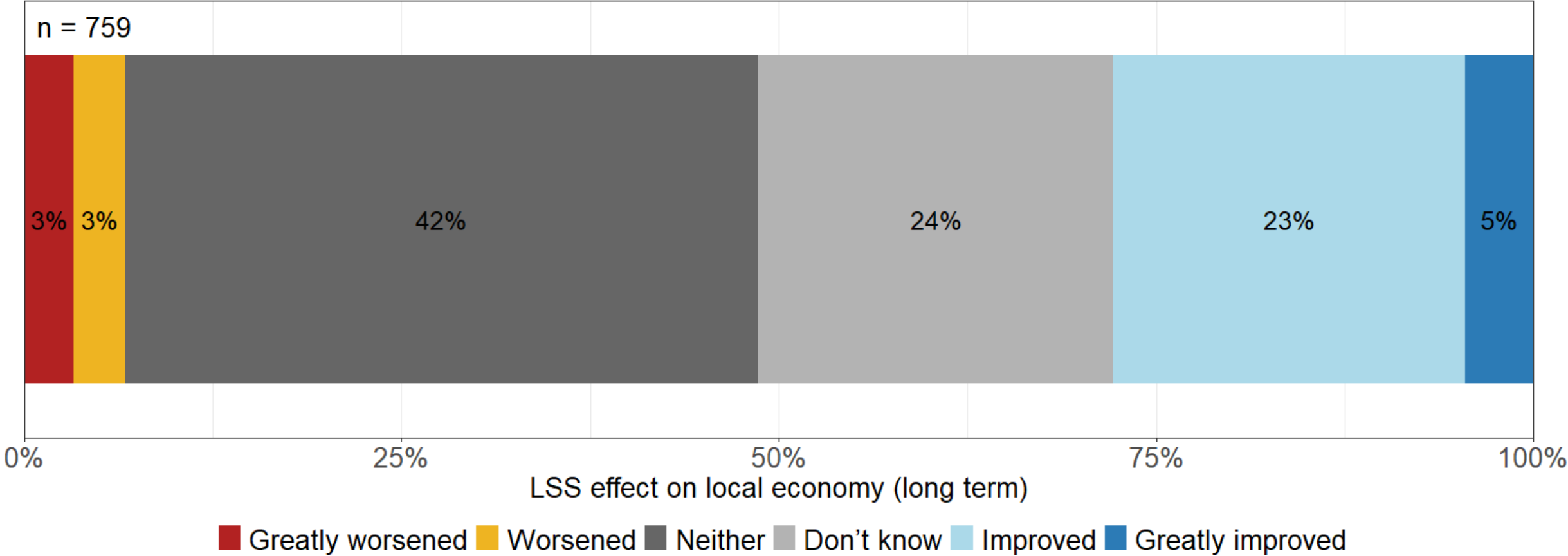


Polychoric Correlation: **0.53** (moderate; excludes "Don't know")

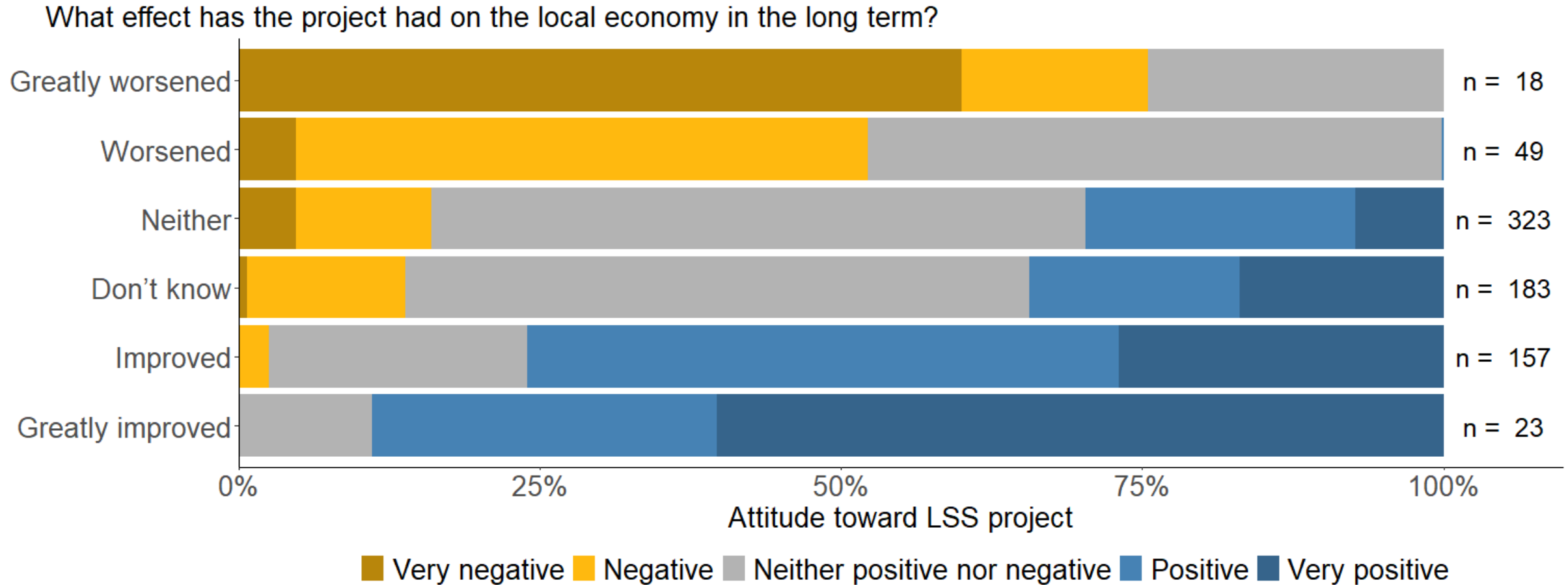
Most respondents do not perceive any long term local economic impacts

Though, among those who do, nearly 5:1 perceive economic improvement

What effect has the project had on the local economy in the long term?



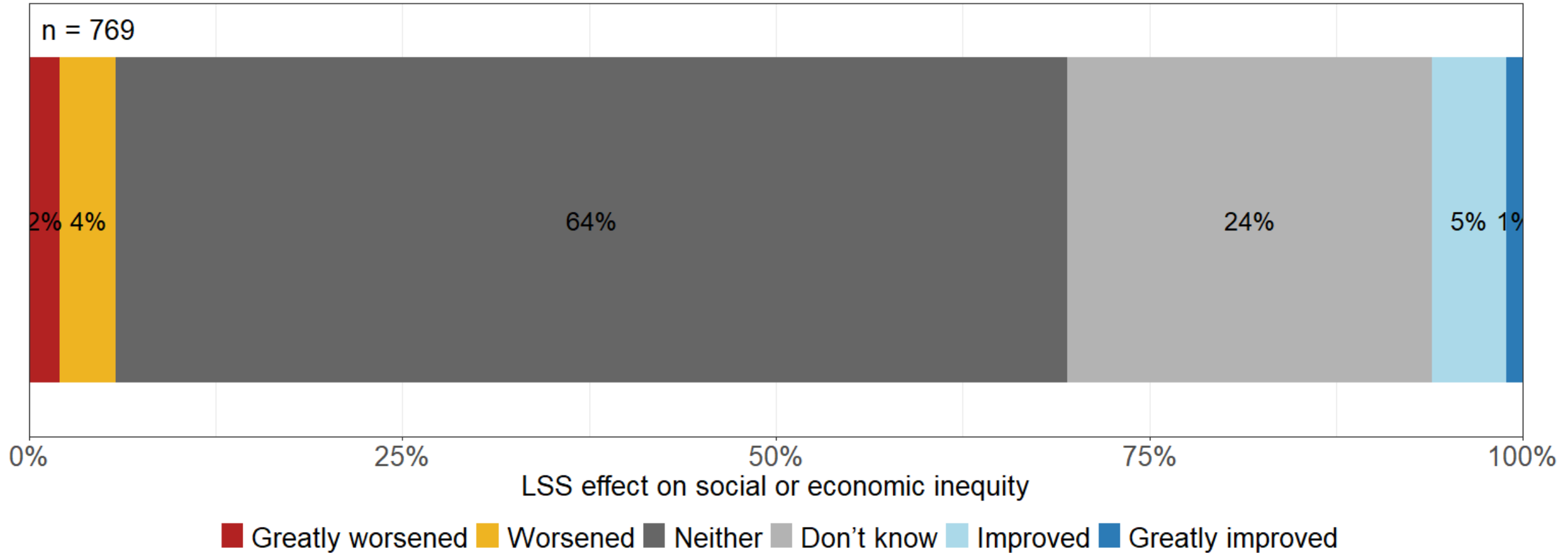
Perceptions of long term local economic impacts are strongly correlated with attitudes about the project overall



Polychoric Correlation: **0.69** (strong; excludes "Don't know")

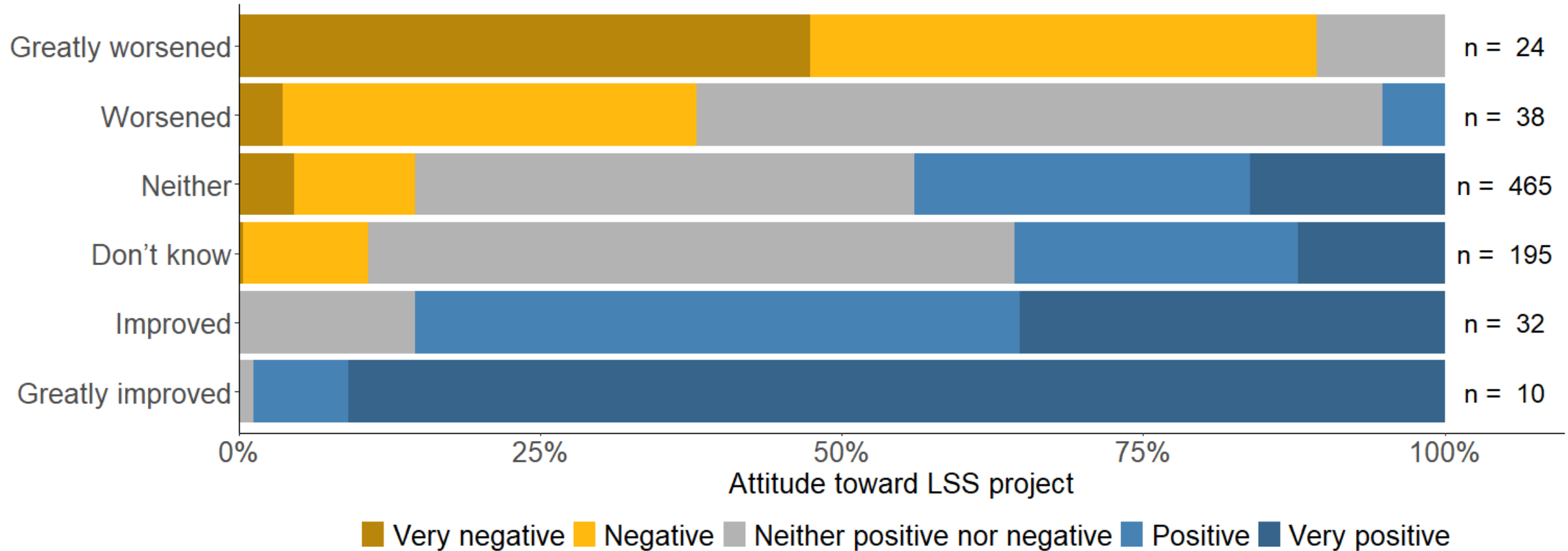
The vast majority do not think the project impacted local economic inequality

What effect has the project had social or economic inequality in your community?



Perceptions of local equity impacts are moderately correlated with attitudes about the project overall (though few thought the project affected equity locally)

What effect has the project had on social or economic inequity in your community?



Polychoric Correlation: **0.59** (moderate; excludes "Don't know")



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Climate, Energy, and Related Perceptions



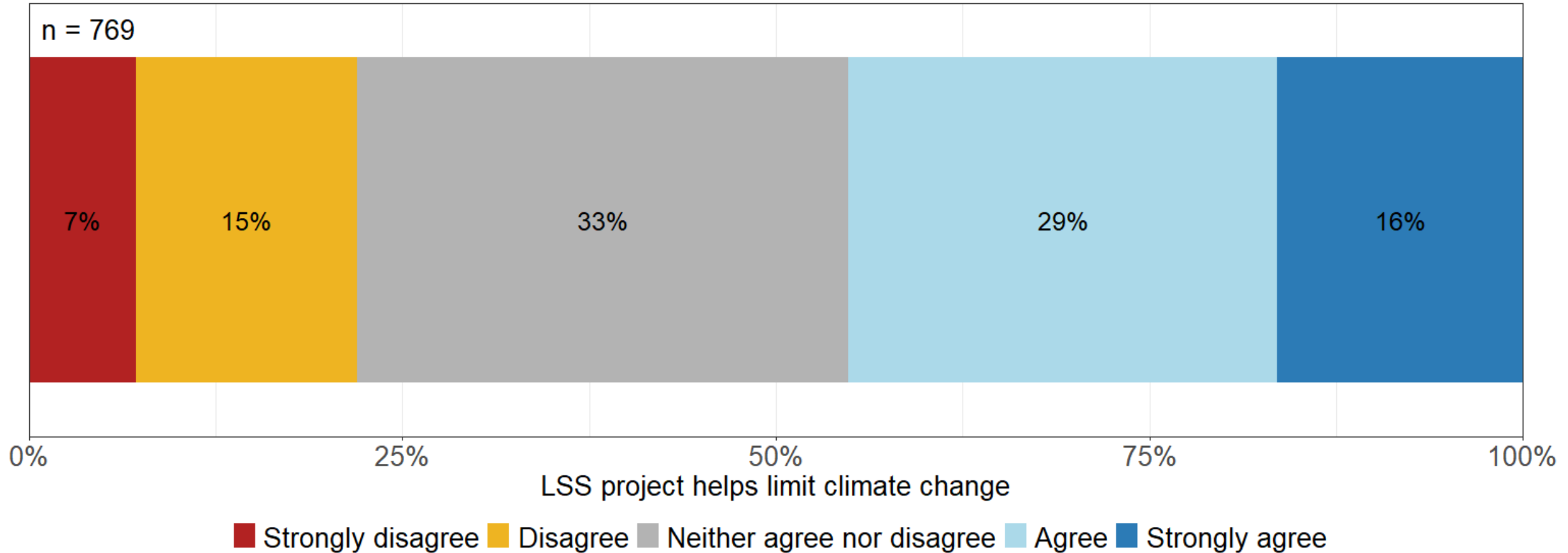
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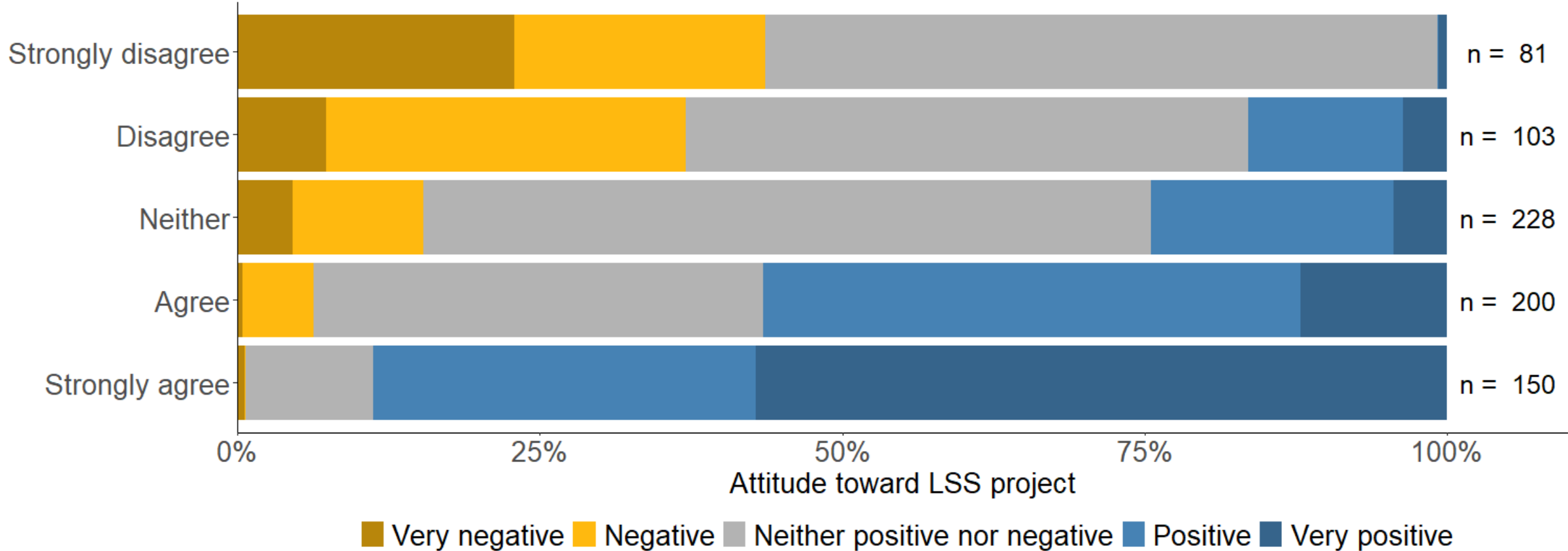
Almost half agree that the local solar project helps limit climate change

The solar project helps limit climate change



Perceptions of the local solar project's impact on climate change are strongly correlated with attitudes about the project overall

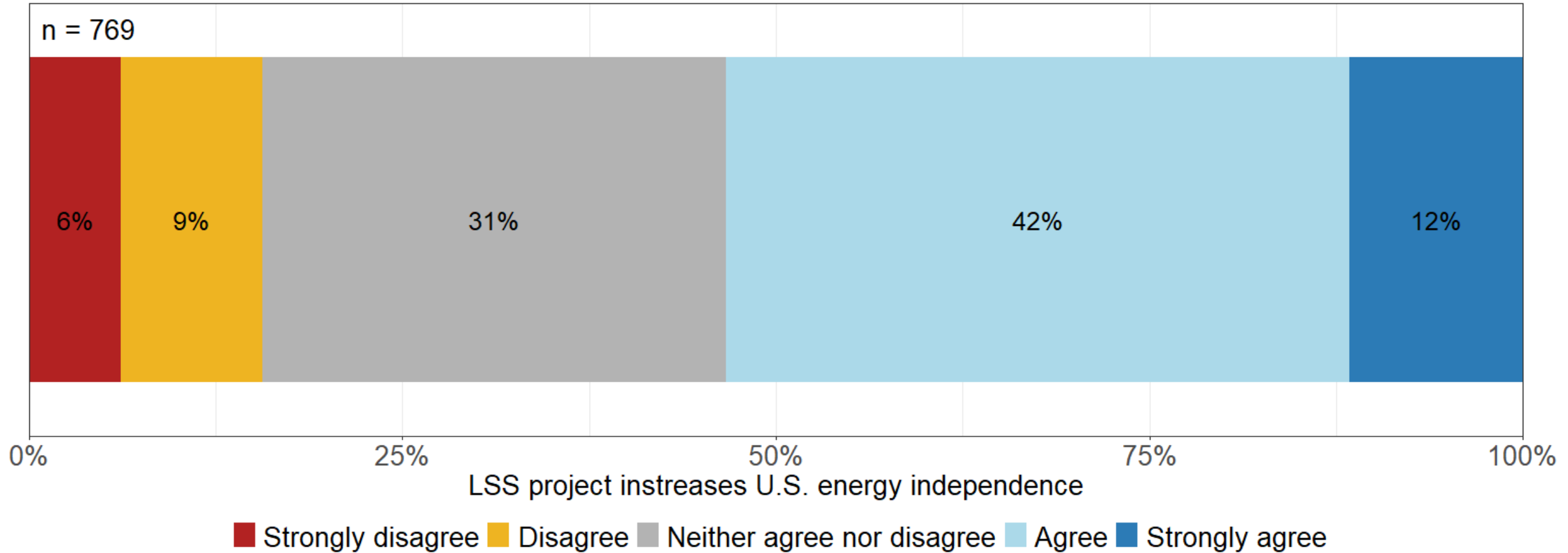
The solar project helps limit climate change



Polychoric Correlation: **0.65** (strong)

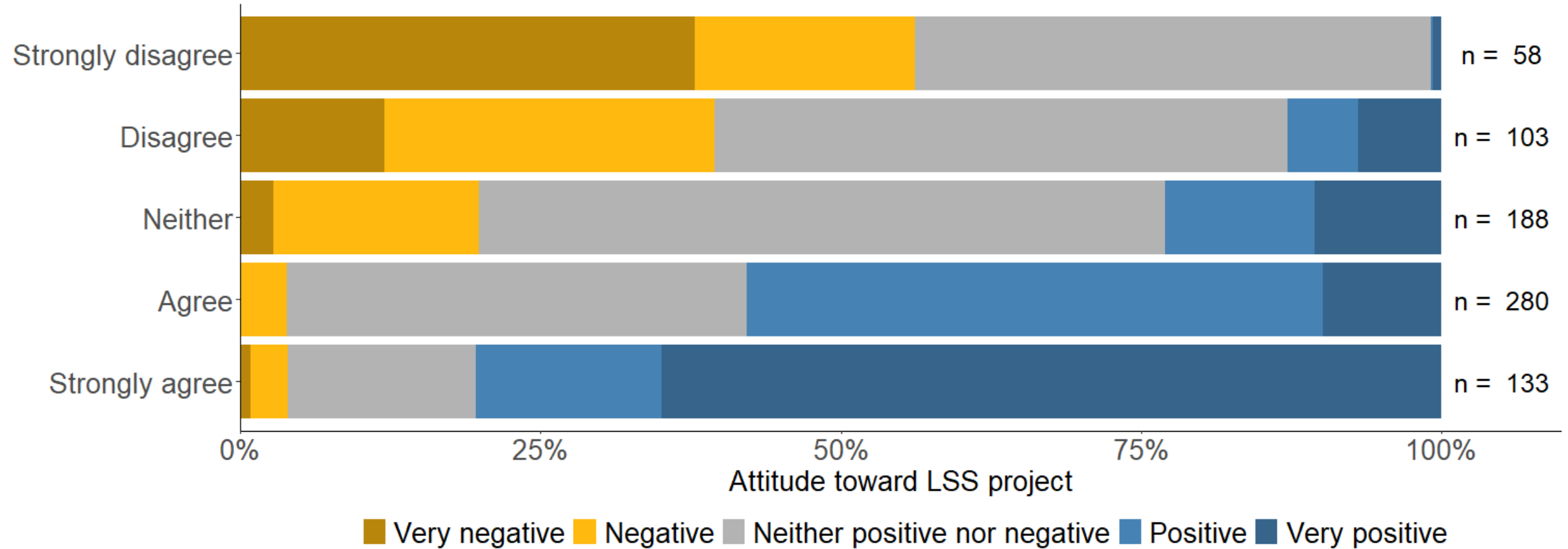
Most agree that the LSS project increases American energy independence

The solar project increases American energy independence



Perceptions of the solar project's impact on energy independence are also strongly correlated with attitudes about the project

The solar project increases American energy independence



Polychoric Correlation: **0.62** (strong)



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Familiarity, Process Fairness, Engagement, and Participation



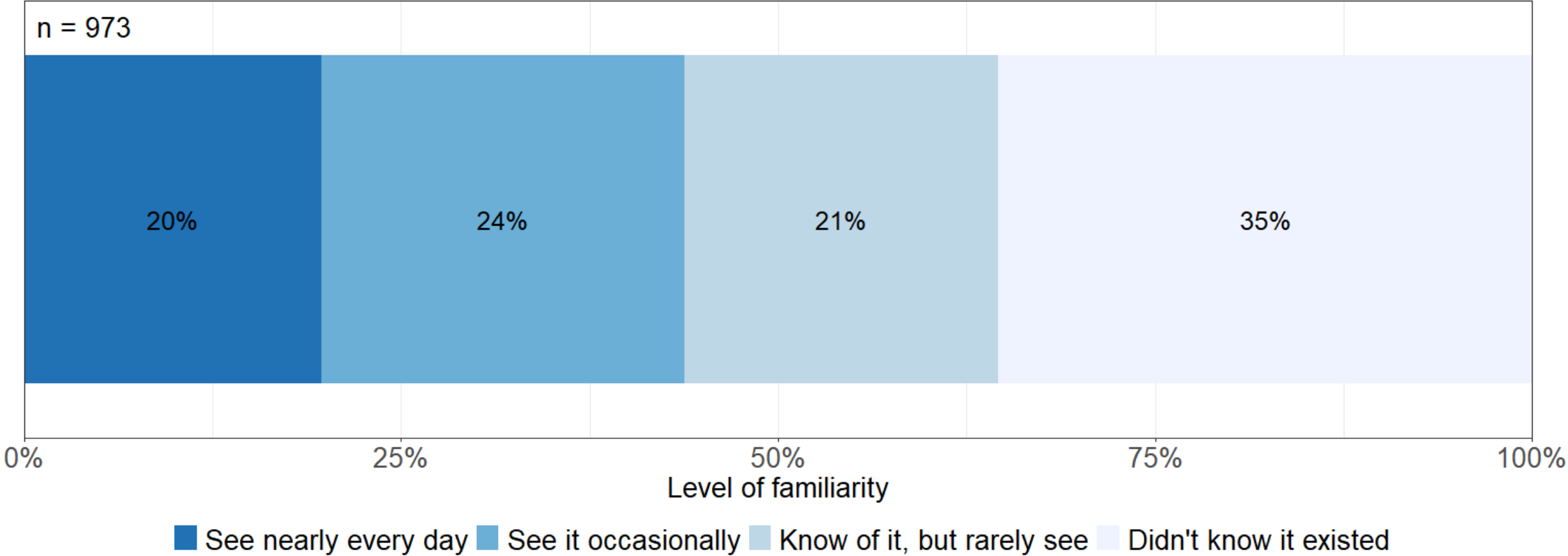
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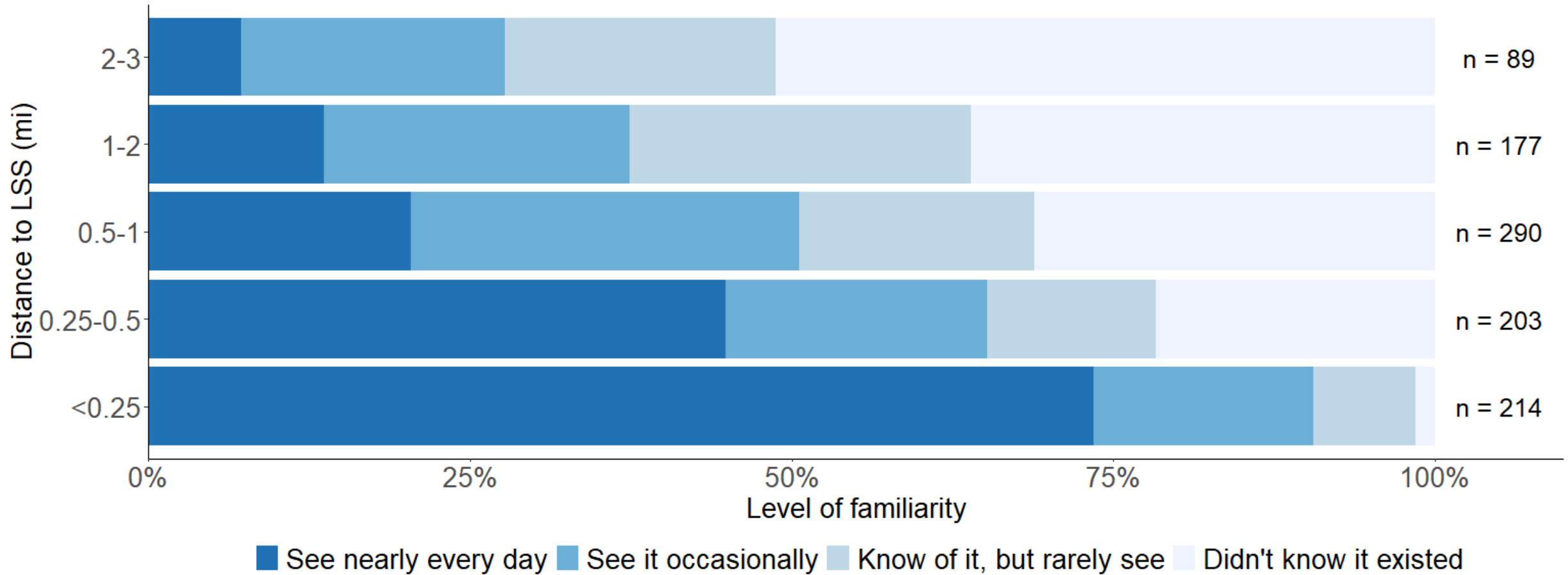
ENERGY MARKETS & POLICY

More than 1/3 of the population within 3 miles were not aware of the local solar project

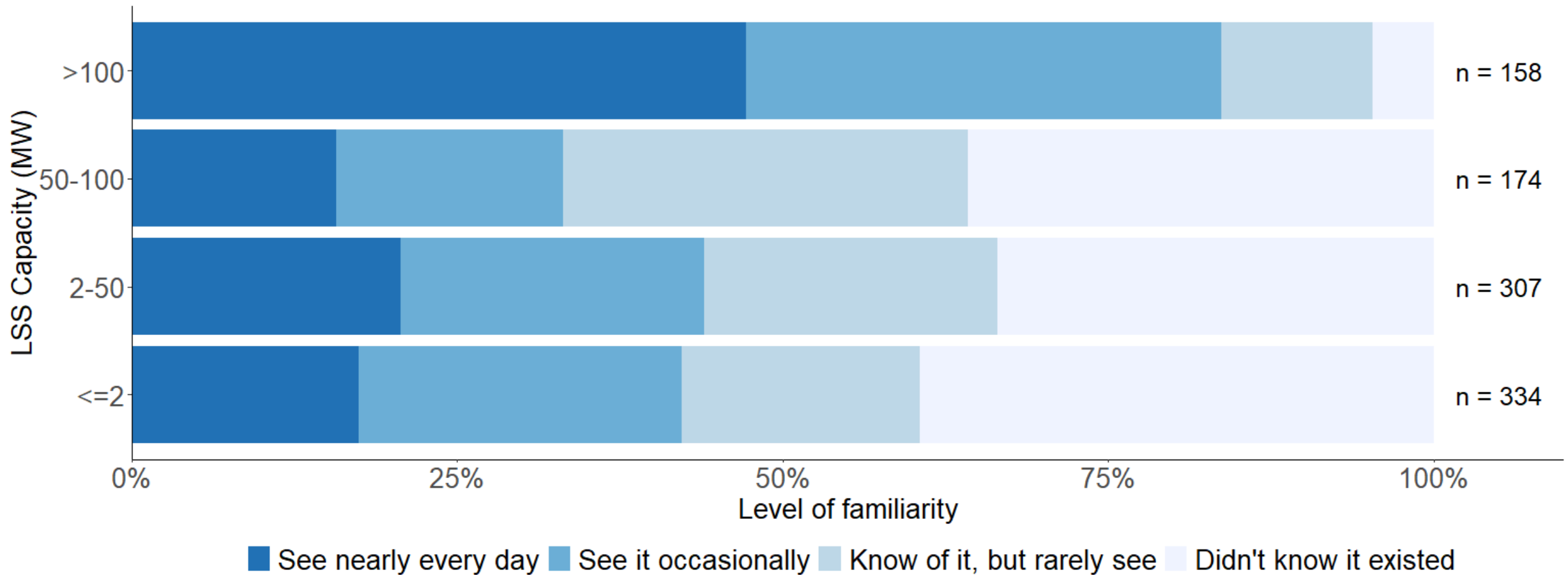
How familiar are you with the local LSS project?



Those living closest tend to be more familiar, but even some respondents within 1/2 mile were unaware of their local LSS project

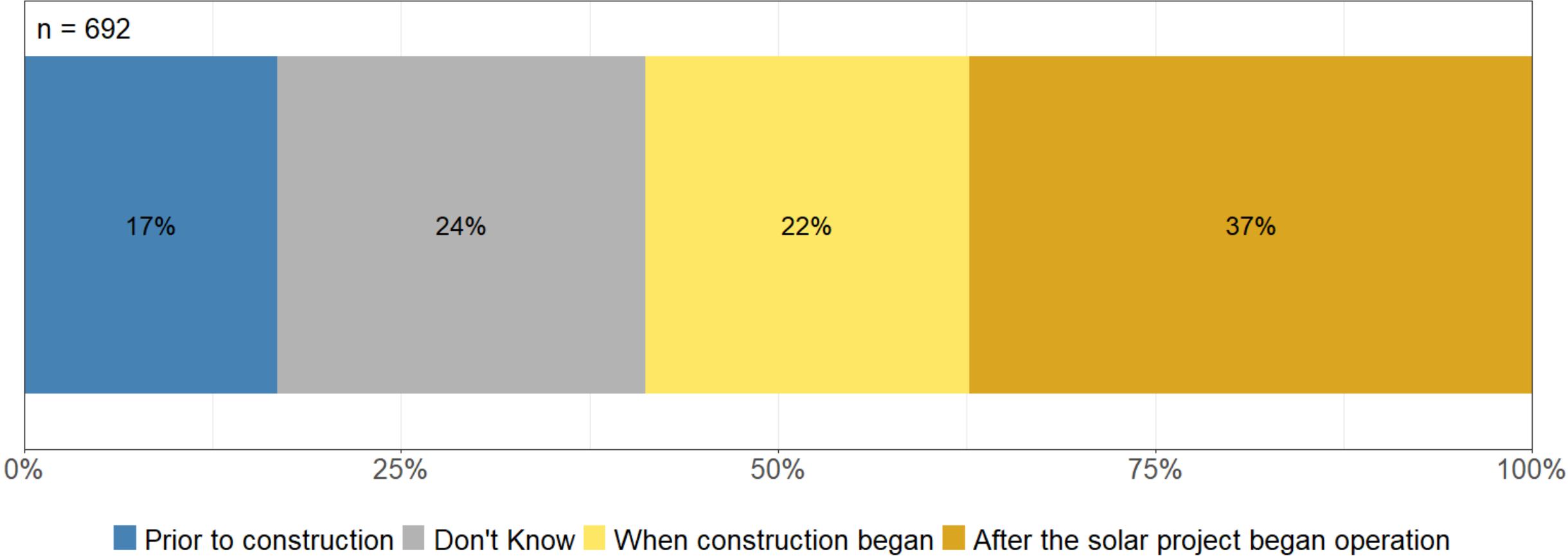


Respondents near the largest LSS projects tend to be very familiar with them; More than 1/3 of respondents from projects <100 MW did not know they existed



Only 17% of respondents were aware of the project prior to construction, suggesting room for improvement in planning & community engagement

When did you first learn about the solar project?

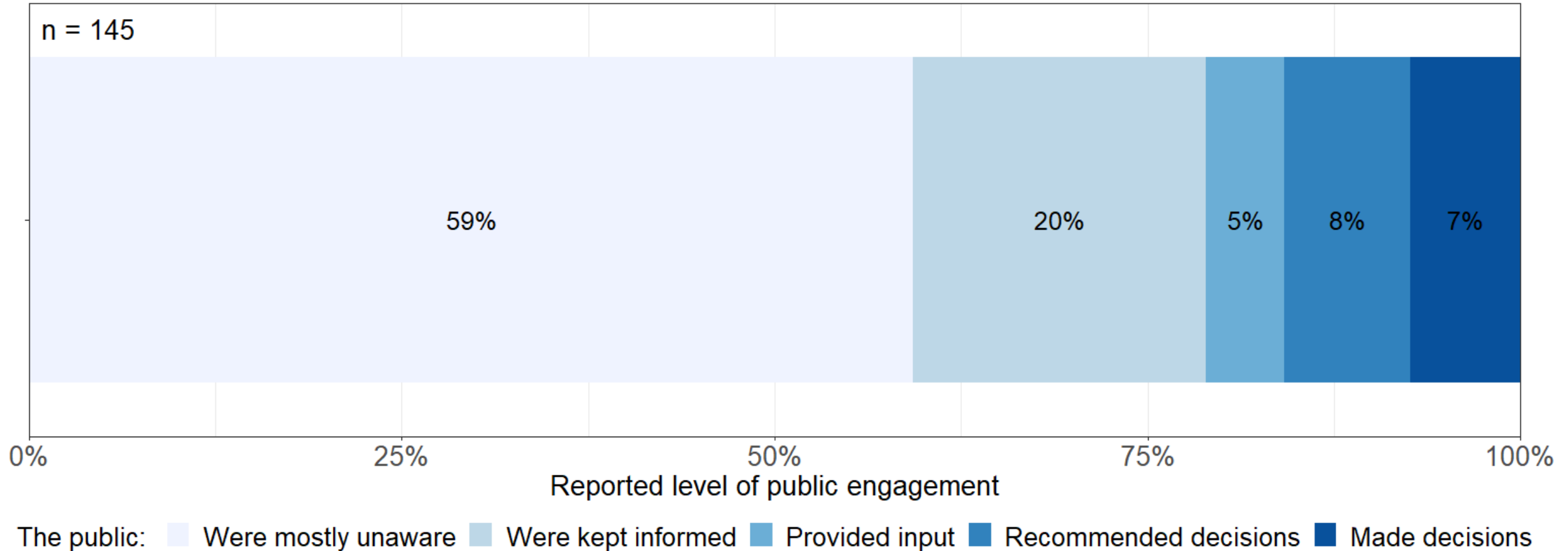


Note: Excludes those who moved into the area after project construction



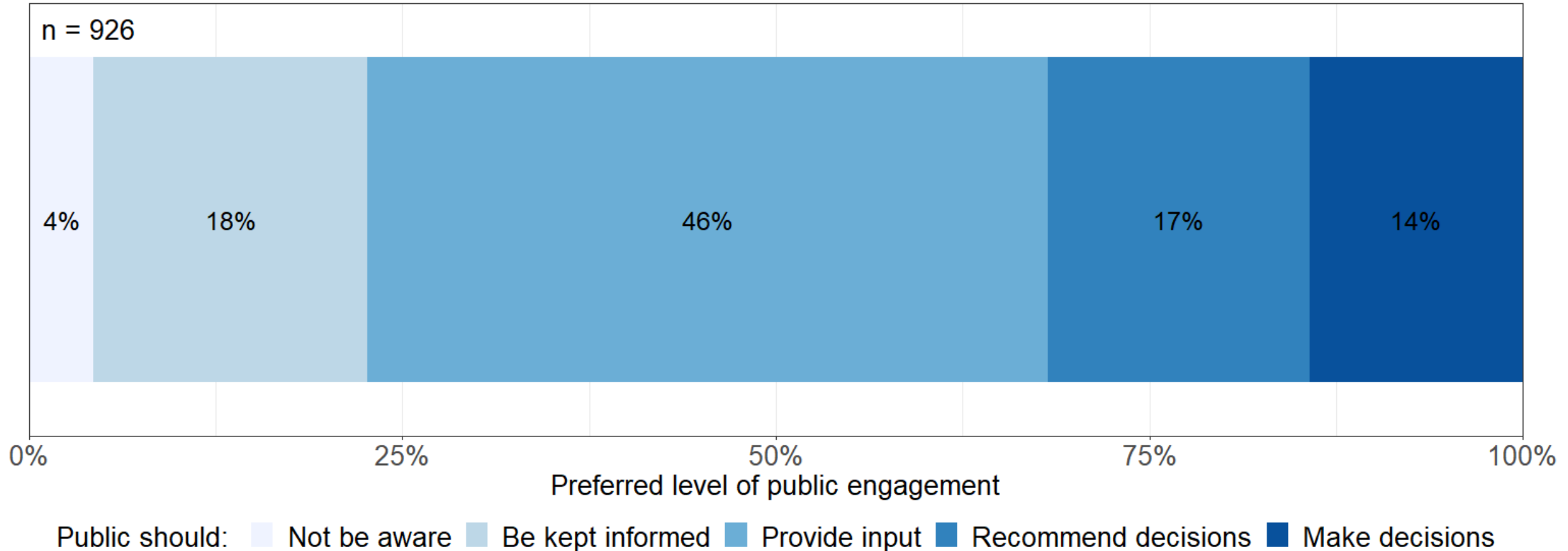
Of those aware of the project prior to construction, most report that the public was not informed / engaged

Which best describes how public were engaged in decisions about the project?



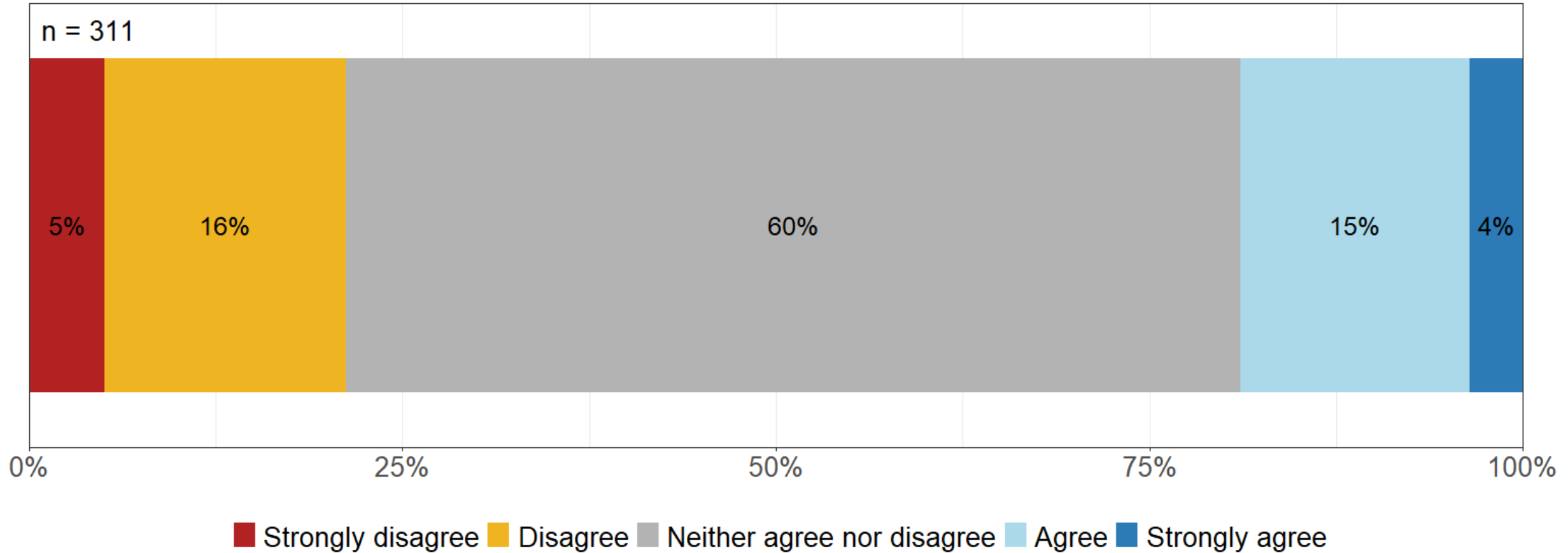
1/3 of respondents think the public should *recommend* or *make* decisions about LSS siting, compared to just 6% of solar developers¹

Which is the most appropriate way for public to engage in project decisions?



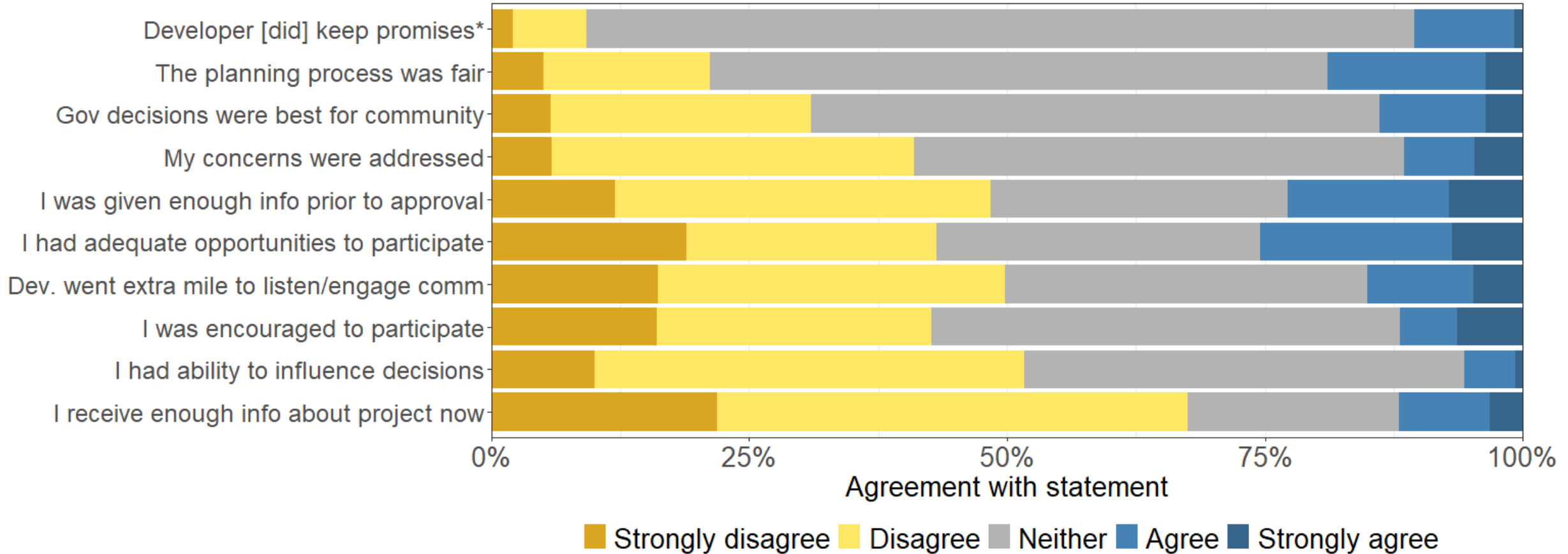
The majority (60%) of those aware of the planning process had no opinion about whether it was fair. The remainder were roughly split between “fair” and “unfair”

The planning process was fair



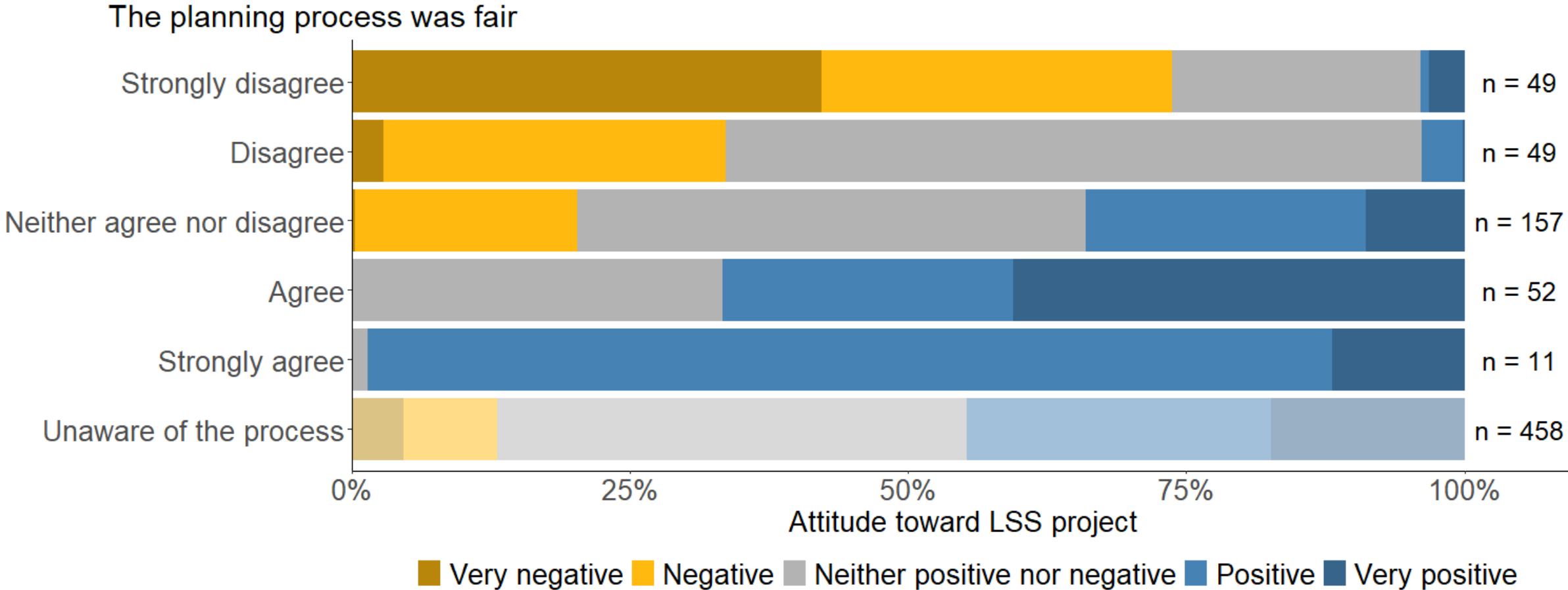
There are numerous opportunities to improve participation, information provision, and fairness. Respondents want more information about the project after it is constructed

Perceptions of planning process fairness (n = 306-316)



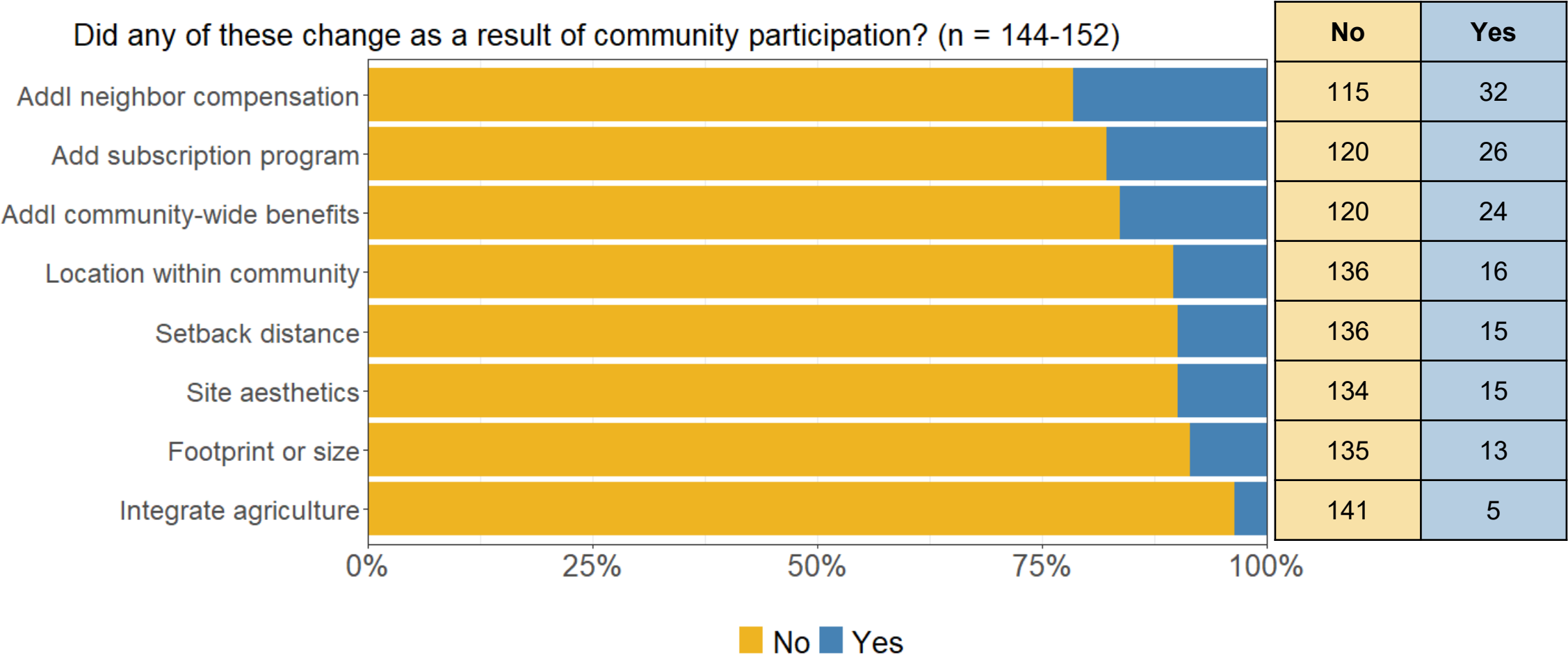
* This item is reverse-coded from how it appeared in the survey instrument to aid interpretation

Perceptions of the fairness of the planning process are strongly correlated with attitudes; those 'unaware' of the process have largely positive attitudes



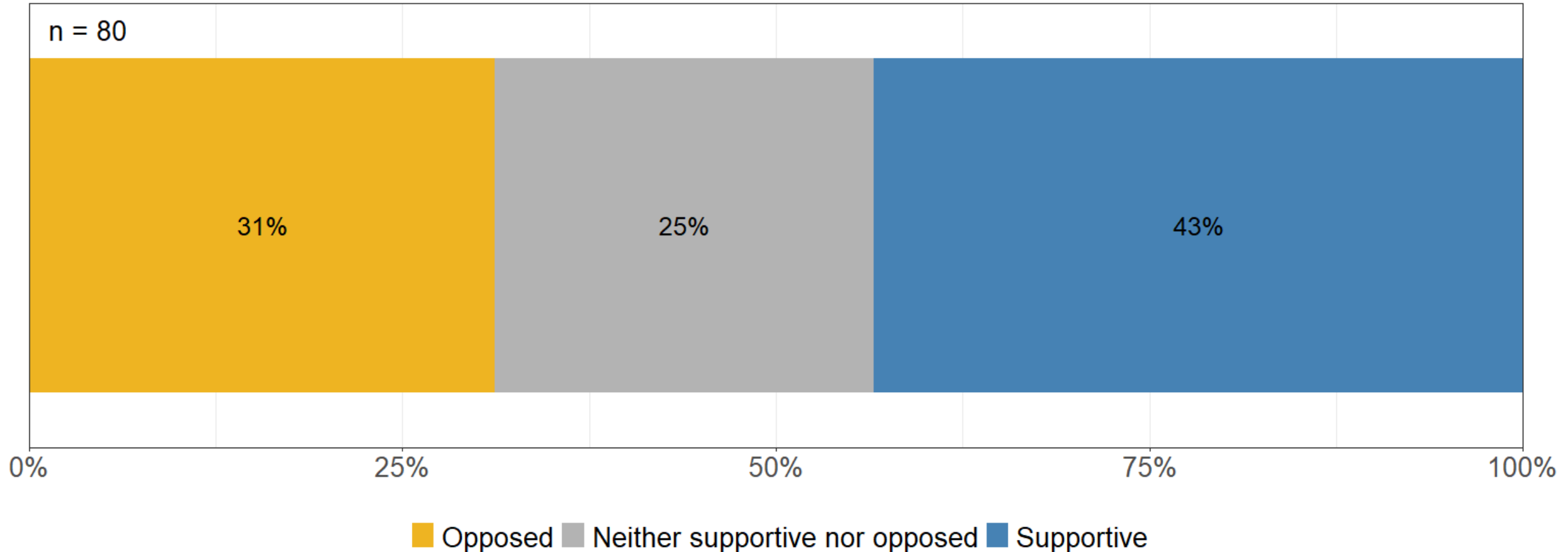
Polychoric Correlation: **0.62** (strong; excludes those unaware of planning process)

Project changes resulting from community planning process participation are rare. When they do occur they often involve compensation and rarely project characteristics



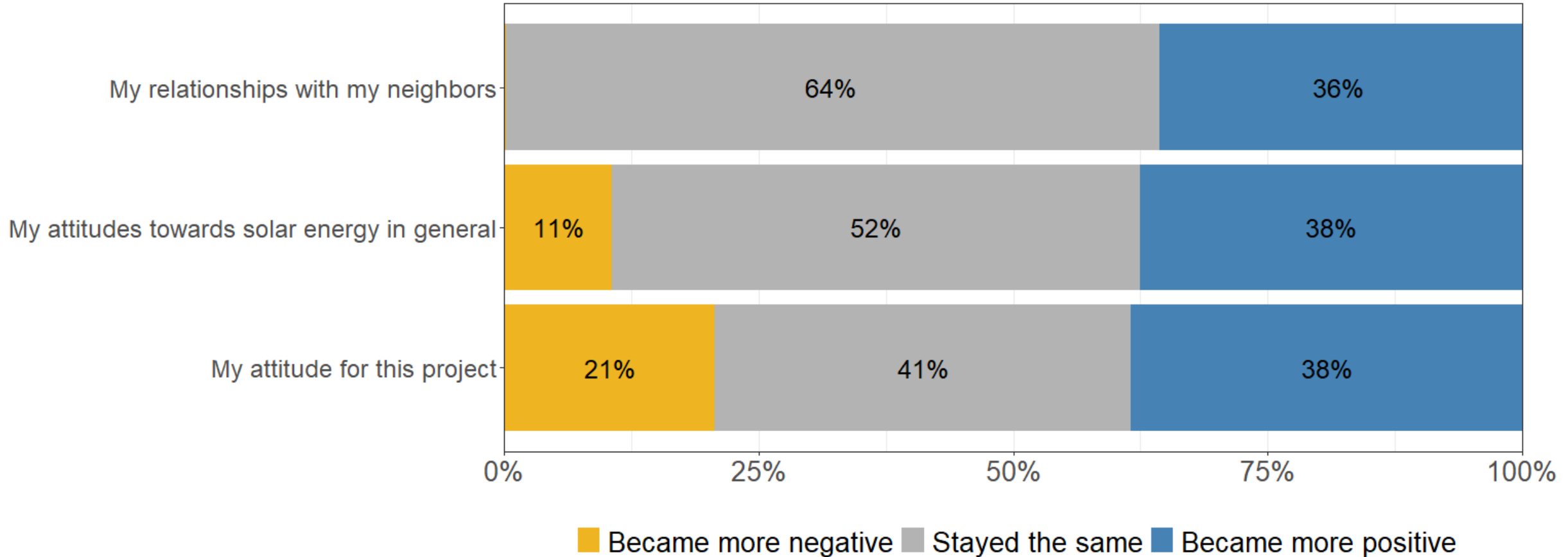
80 respondents took specific actions during the planning process; 43% of those took supportive actions, compared to 31% opposed

Were your actions during the planning process supportive of or opposed to the LSS project?



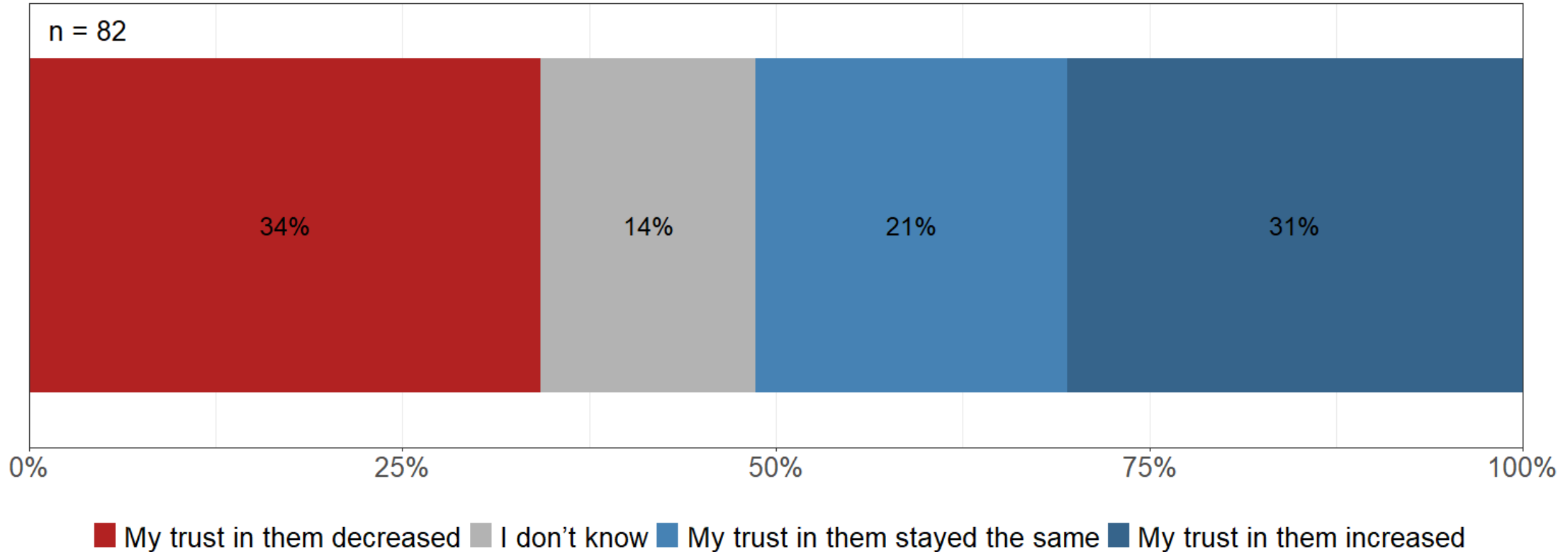
The planning process resulted in more positive attitudes toward solar (and their specific LSS project) among nearly 40% of those who actively participated

How did participation in the planning process change... (n = 82)



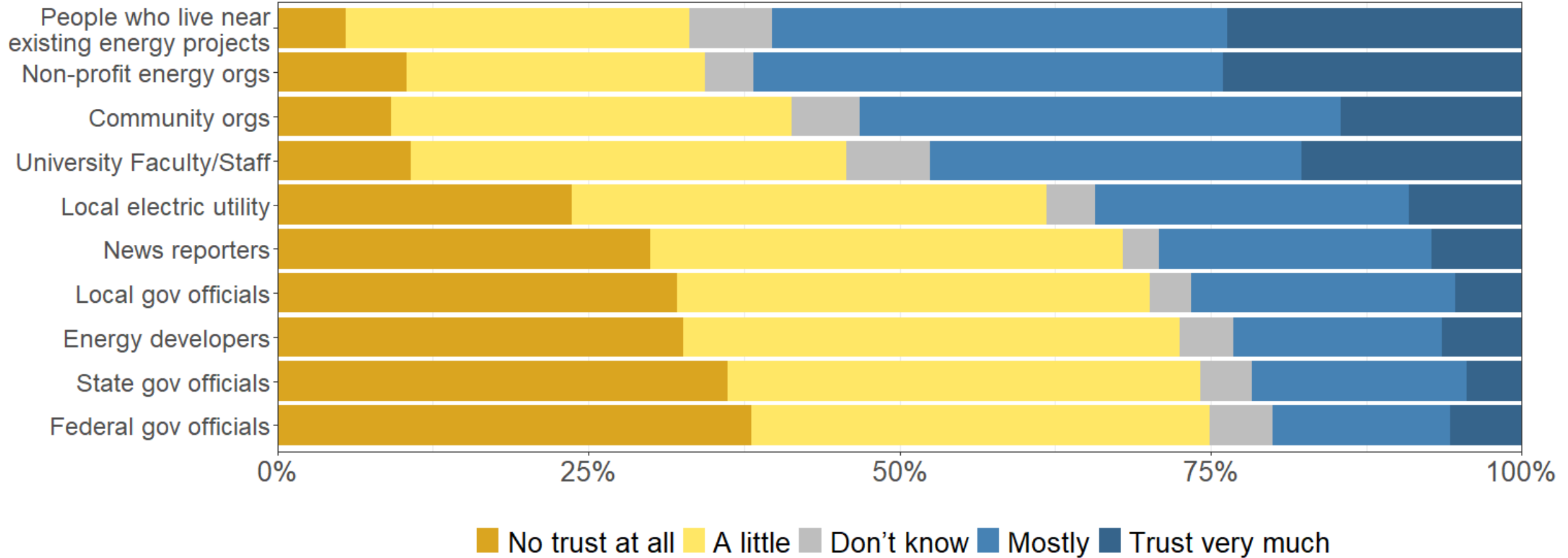
1/3 of those who actively participated in the planning process report that it *decreased* their trust in local government officials, but a nearly equal portion report the opposite

How did the planning process change your trust in local government officials?



Energy project neighbors, non-profit orgs, and university staff are most trusted sources of information; government officials and developers are least trusted

Which entities do you trust to provide information about energy projects? (n = 955-965)





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Considerations for Future LSS Development



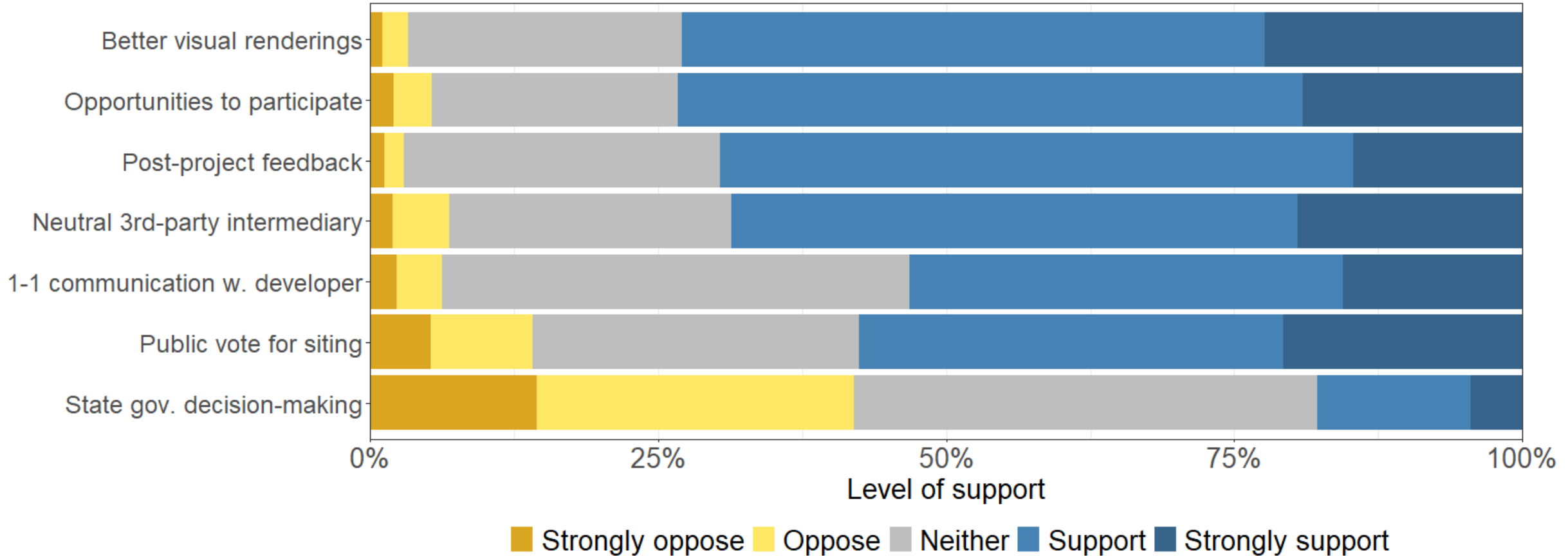
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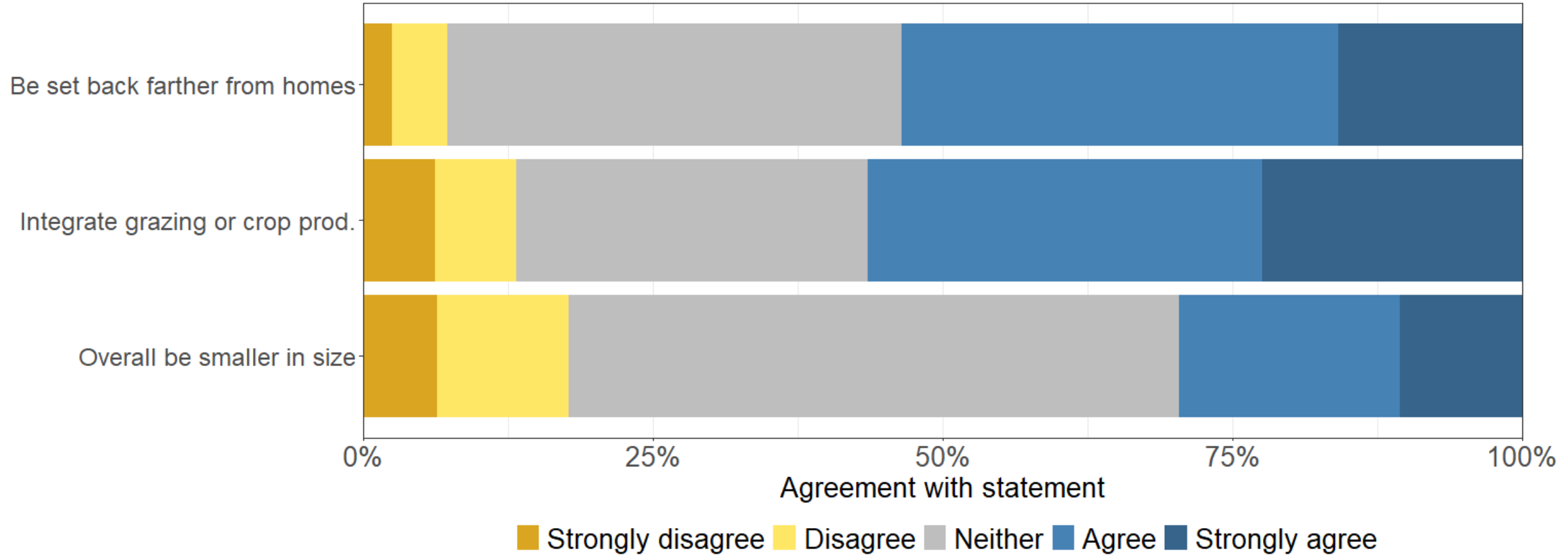
For future projects, neighbors support better visual renderings, more participation opportunities, and third-party intervenors, and oppose increased state-level decision-making

Preferences for additional LSS projects in your community (n = 942-956)



When thinking about additional projects, most LSS neighbors would prefer integrated agriculture and larger setbacks; size less important

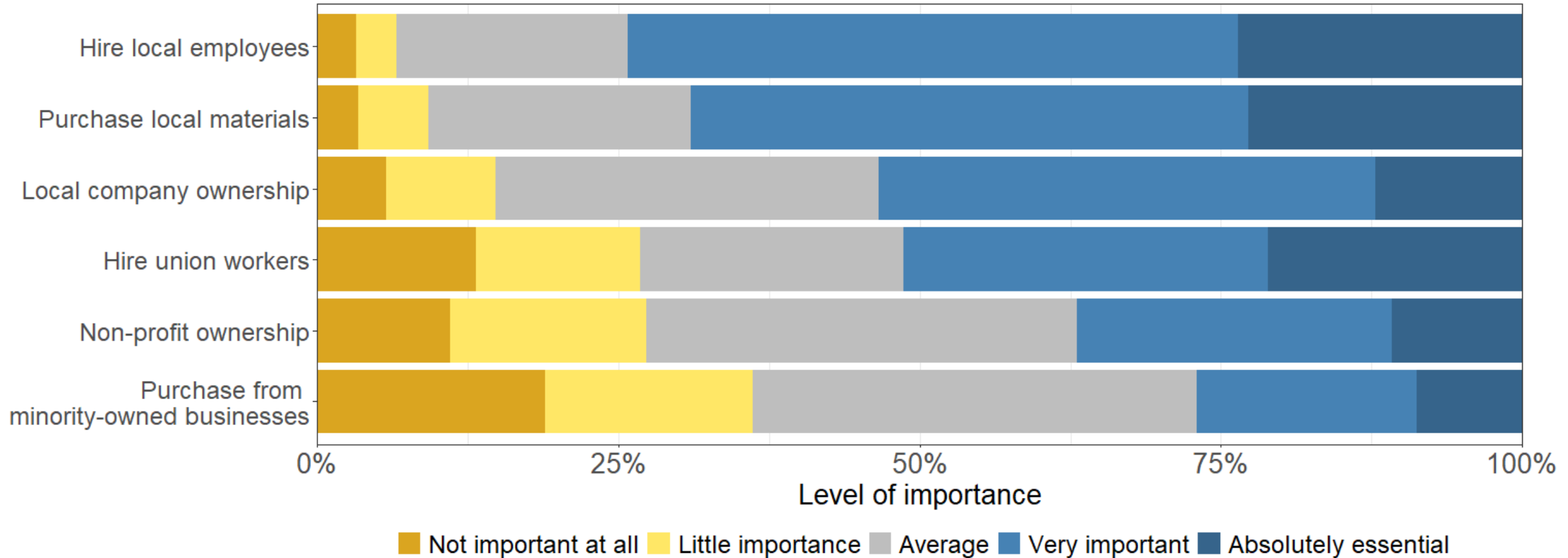
If another project were sited in my community, I would prefer... (n = 757-765)



Note: For those who “agree” or “strongly agree” that they would prefer a smaller size, the mean LSS capacity was 69 MW. For those who “disagree” or “strongly disagree”, the mean LSS capacity was 44 MW.

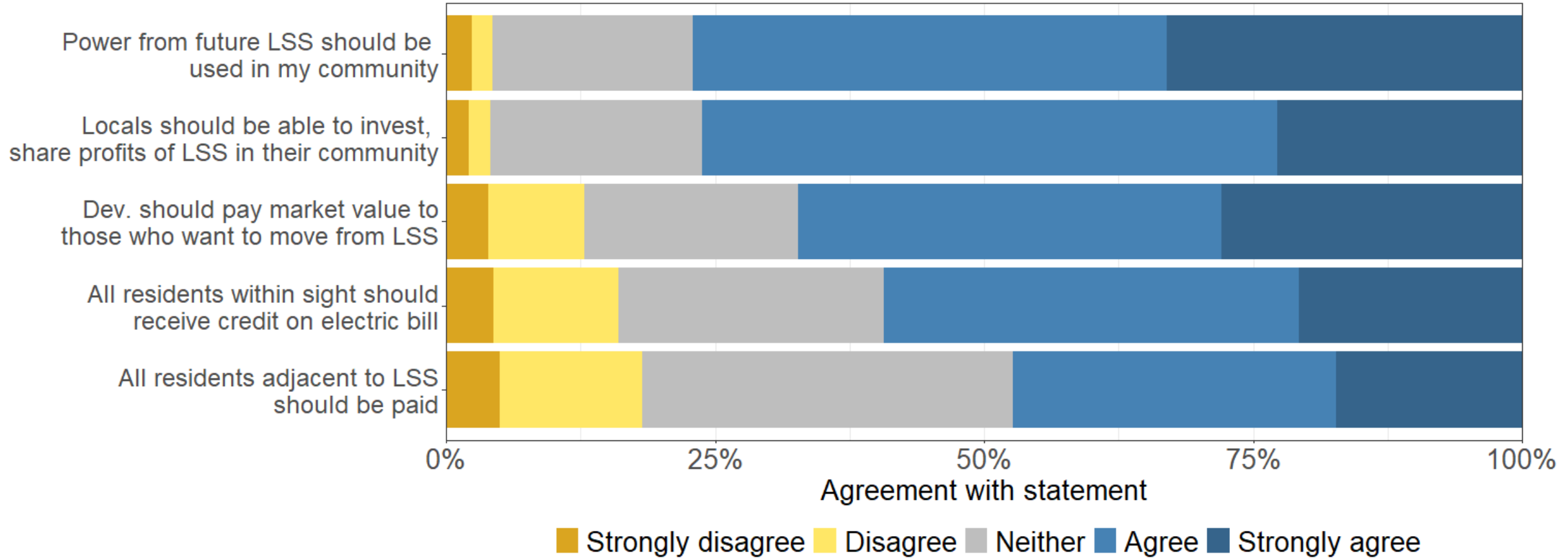
For future LSS projects, respondents strongly suggest using local employees, purchasing local materials, and having local companies own the project

For another project in your community, how important is... (n = 948-960)



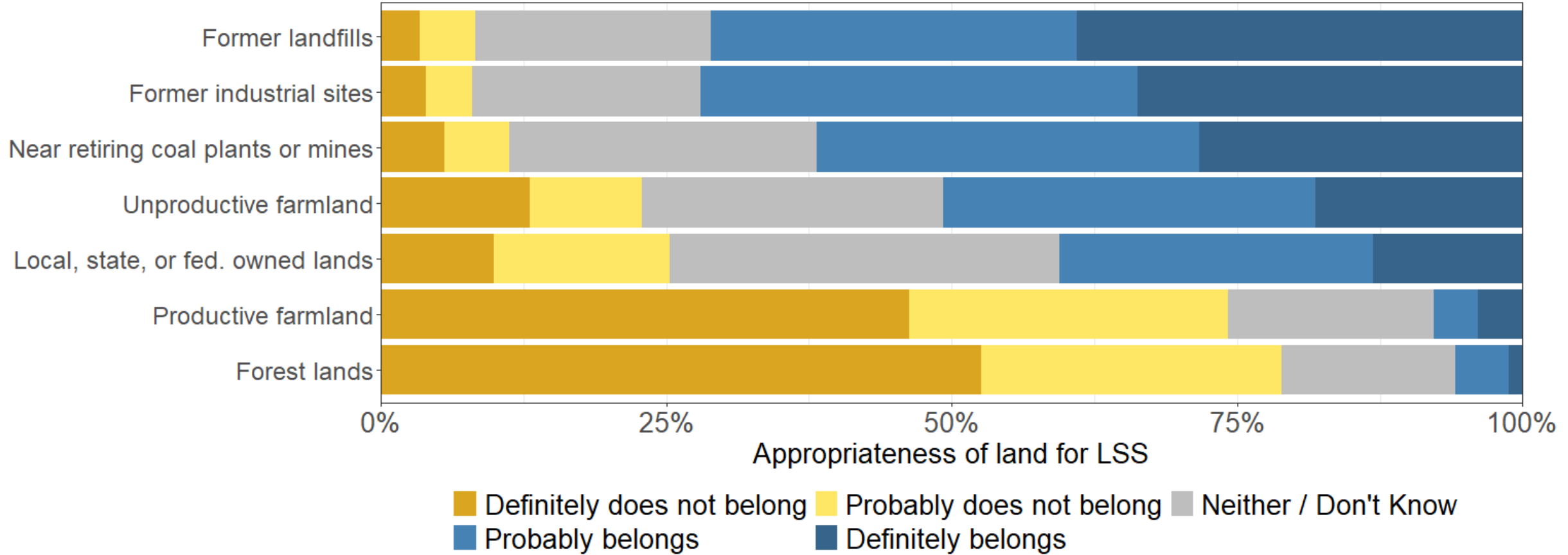
Strong support for a variety of compensation mechanisms; LSS neighbors especially like local power use and investment opportunities

Compensation preferences for future LSS projects (n = 958-964)



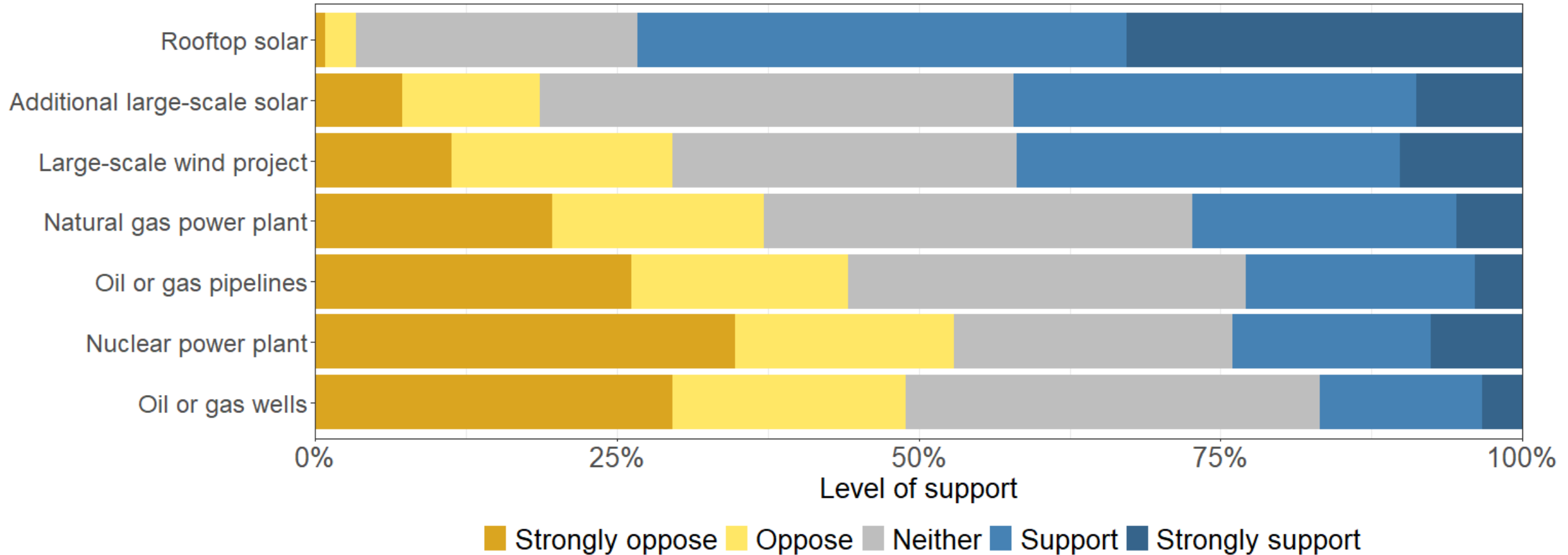
Currently or formerly disturbed sites are strongly preferred for future LSS development; forest and productive farmland strongly disapproved for LSS

Land-use preferences for future LSS projects (n = 944-963)



LSS neighbors strongly support additional *rooftop* solar in their community, and cautiously support additional large-scale solar and wind, but show more opposition for fossil fuel and nuclear

Support for other energy project development in your community (n = 940-951)





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Reflections and Takeaways



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Reflections and Key Takeaways:

- We estimate that there are now >10 million homes within 3 miles of large-scale solar (LSS, >1 MW) plants in the U.S.
 - We surveyed a nationally representative sample of these “LSS neighbors”
- Among LSS neighbors, ‘positive’ attitudes outnumber ‘negative’ by nearly a 3 to 1 margin
 - 43% of respondents report positive attitudes, compared to 15% negative
 - A similar proportion (~42%) say they would support additional LSS in their community
- Physical characteristics of LSS facilities are only weakly correlated with attitudes
 - But there is a notable decline in attitudes around the largest projects (>100 MW) in our sample and for those within ¼ mile from projects
- Other factors – like perceived aesthetic, economic, and quality of life impacts – are more strongly correlated with attitudes
 - Yet, LSS neighbors negotiate trade-offs with their local projects: Many report positive attitudes toward the project *despite* perceiving some negative impacts
 - Perceptions of planning process fairness are also strongly correlated with attitudes

Reflections and Key Takeaways:

- Less than 1/5 of LSS neighbors were aware of their local project prior to construction
 - This suggests there is room for improvement in planning & engagement with project neighbors
- LSS neighbors tend to believe the public should have more of a say in siting decisions than they typically do in practice
 - Relatedly, changes to the project based on community participation in the planning process are rare
- There is very little support among existing LSS neighbors for increased state-level decision-making in future LSS siting decisions
- Energy project neighbors, community and non-profit orgs, and university staff are most trusted sources of information; developers and government officials are the least trusted
- Respondents suggest that future LSS projects should think local: hire local employees, purchase local materials, offer local investment, provide local power or bill discounts
- Disturbed sites (e.g., landfills, industrial sites) are vastly preferred over forests and productive farmland for siting additional LSS



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More Information:

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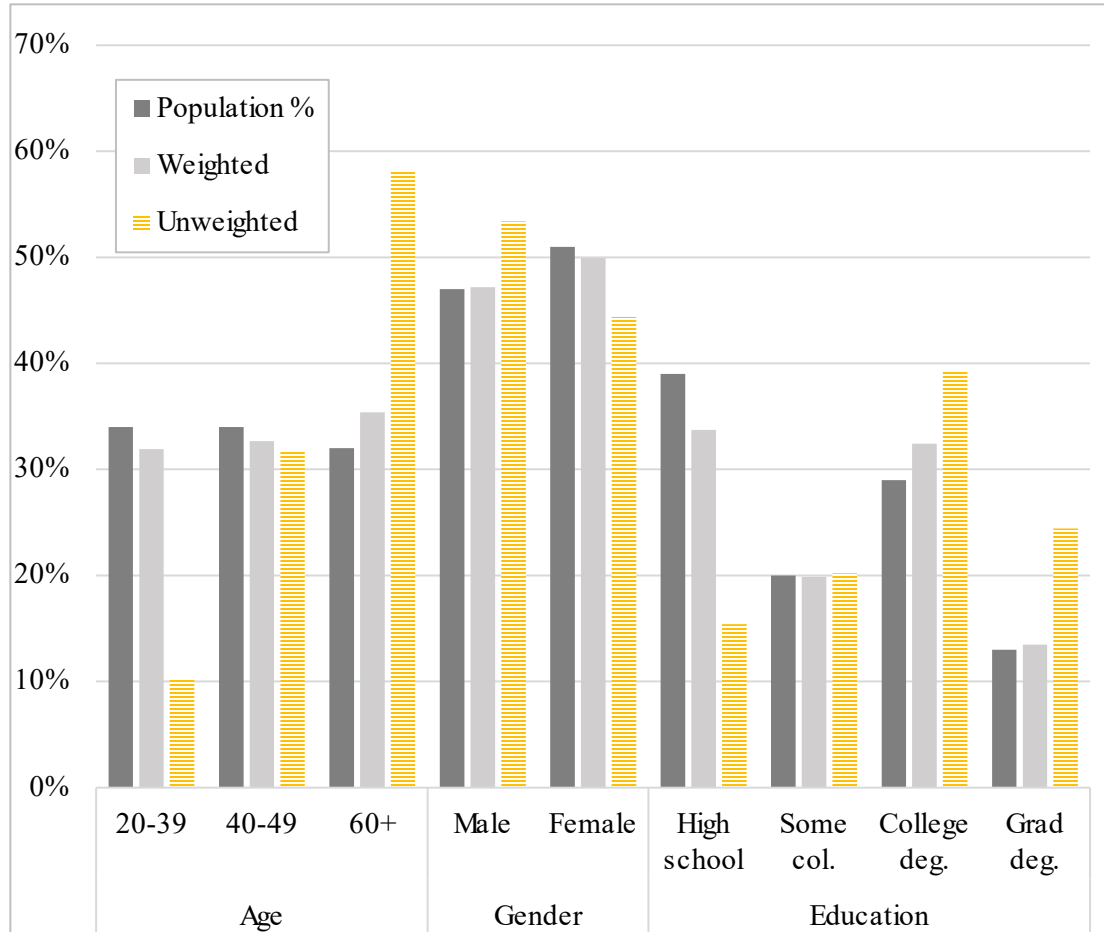


Appendix

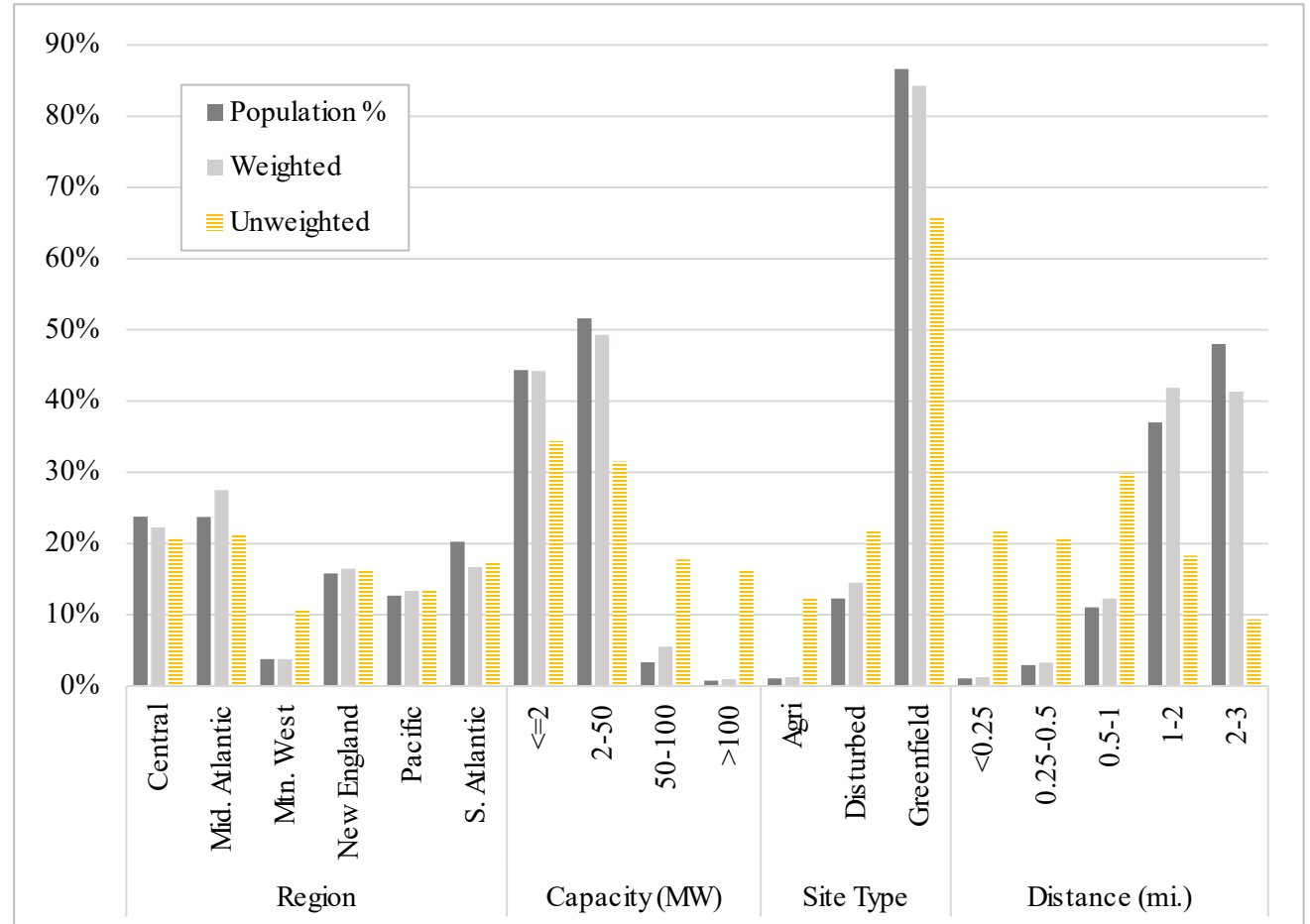


Effect of Weighting on Distribution Across Weighted Variables: Weighted data much more closely represent the underlying population

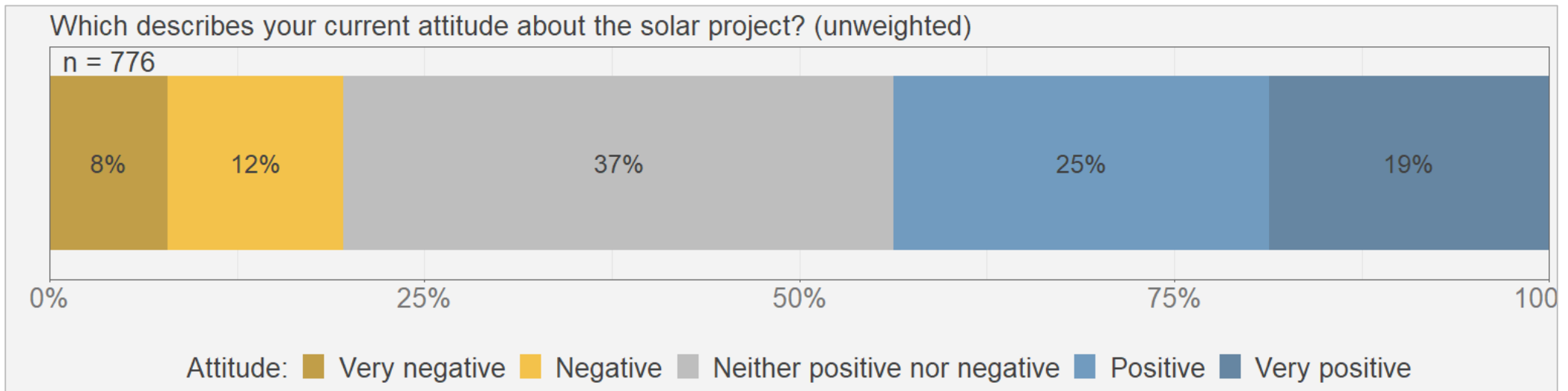
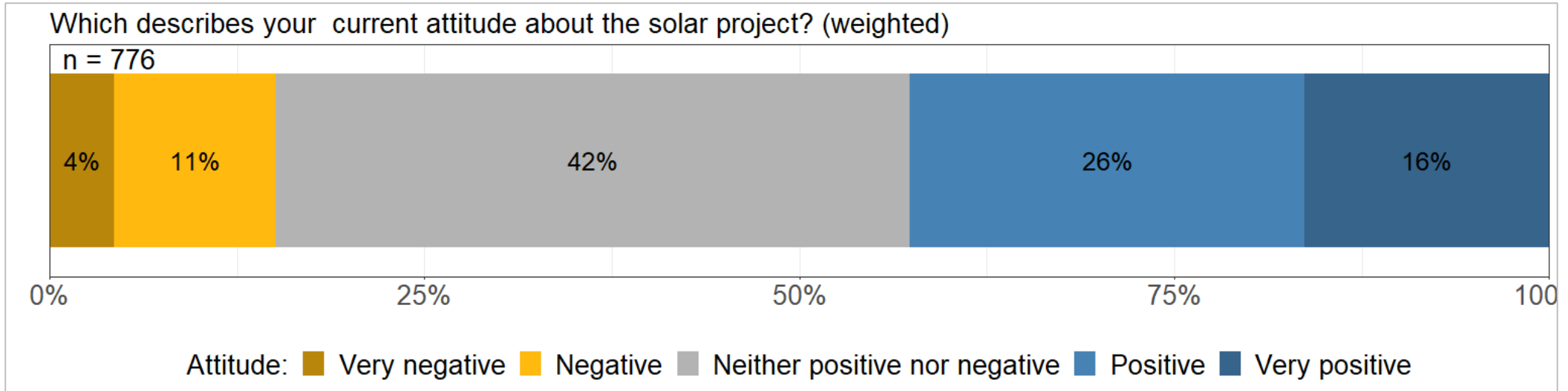
a. Demographic variables



b. Site + respondent stratification variables



Applying weights to represent the underlying population increases proportion of “neutral” attitude, and decreases “very negative” and “very positive”



Weighting to represent the population reduces familiarity with the local project

