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# Willingness to Participate in Demand Response in the US Midwest: A Market with Great Potential?

**Abigail Morton**, Graduate Student, Department of Political Science, Iowa State University, agmorton@iastate.edu

**Yü Wang***, Assistant Professor, Department of Political Science, Iowa State University, yuwang@iastate.edu

**Wendong Zhang**, Assistant Professor, Department of Economics and Center for Agricultural and Rural Development, Iowa State University, wdzhang@iastate.edu

*Corresponding Author

Published by the Center for Agricultural and Rural Development, 578 Heady Hall, Iowa State University, Ames, Iowa 50011-1070; Phone: (515) 294-1183; Fax: (515) 294-6336; Web site: www.card.iastate.edu.

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## Executive Summary

Demand response uses smart technologies to lower peak electricity load by either shifting demand to non-peak hours or directly shaving peak demand. DR is a fast-growing market in which commercial and industrial customers are the primary providers of resources; however, DR helps heavy electrical consumers save energy and avoid demand charges, and it helps utilities save money and deter investment on expensive transmission and distribution lines. DR also has great potential to balance renewables by providing ramping and flexibility services to the electricity market. This capacity is increasingly important to electrical grids, as is the integration of more renewable energy.

This study assesses the potential demand response resources that utilities can harness from residential customers. We use a contingent valuation method survey to discover residential customers' willingness to accept demand response programs offered by utilities. We test for three types of demand response programs: air conditioner cycling, smart thermostats, and an automated real-time pricing program. Air conditioner cycling uses switch controls to turn off customers' air conditioning units for a short period. Smart thermostats allow utilities to adjust the setting point of customers' thermostats to reduce peak load. Automated real-time pricing is a hypothetical program that allows changing load in response to real-time electricity prices. In the survey, we describe how the program works and solicit willingness to participate if offered an annual incentive or no incentive.

In addition to the willingness to accept questions, we also collect information on occupancy, home characteristics, knowledge about demand response, prior experience with smart technologies, demographics, and relevant attitudes, such as trust in utilities, attitudes toward demand response, willingness to give a utility control of appliances, and attitudes on energy conservation and climate change. These questions provide important measurements of key factors that affect customers' willingness to participate in demand response programs.

From July 10 to October 30, 2020, we distributed the survey to a random sample of 3,165 Midwest residents both online and by mail. We received a total of 417 responses (60% online and 40% mail responses), a 13.1% response rate. Data from valid survey responses suggests that 50% of the respondents are willing to enroll in a demand response program. This rate suggests great potential for utilities to harness demand response resources to curb residential peak load in summer, as half of surveyed Midwest residents are willing to participate in one of the programs for a less-than-$50 annual incentive or no incentive. Overall, respondents show a varied degree of intention to participate for the three types of programs: 54% for air conditioner cycling, 50% for smart thermostats, and 46% for automated real-time pricing. This result indicates that customer participation rate drops when the demand response technology is less mature.

Respondents' participation intention differs significantly when offered no incentive versus a certain level of incentive. When offered a random annual incentive from $10 to $50, 47% are willing to enroll in the program. Specifically, respondent participation intention is 38%, 47%, 48%, 43%, and 56% for programs offering a $10, $20, $30, $40, and $50 annual incentive,

respectively. However, when asked about willingness to enroll without mentioning any incentive, 63% of respondents are still willing, which suggests that a low level of incentive decreases willingness to participate. Thus, offering the demand response program without incentives is more efficient at recruiting customers than offering an annual incentive of less than \$50. Alternatively, the incentive has to be high enough, probably higher than \$50/year, to effectively recruit customers.

Respondents' willingness to give a utility control varies by time of the day, day of the week, and type of equipment/appliances. Survey data suggests about 20% of residents are willing to let utilities control their home equipment and appliances anytime of the day and an additional 3%–15% of respondents are fine with utilities controlling their appliances at different times of the day.

## Introduction

Demand response (DR) is a type of demand side management (DSM) that aims to reduce electricity load during peak hours via load shifting and shaving strategies. Eid et al. (2016) define DR as reflective of electricity demand that is intentionally flexible to economic signals. Peak load is expensive because utilities keep less energy efficient and higher-cost generators on standby to ensure there is enough energy during a potential future peak period. These periods of peak costs add to the amount consumers pay for electricity. Utility-run DR programs motivate customer participation via utility bill rebate (incentive) to reward less electrical consumption during peak times (Walawalkar et al. 2010).

There are a few different types of DR programs. Utilities typically tailor programs targeted at large commercial and industrial customers to meet the customers' needs. However, the DR programs aimed at residences and small businesses include air conditioner cycling, smart thermostats, thermal storage through water heating, and behavioral programs. Air conditioner cycling programs allow grid operators to lower load demand by remotely controlling customers' air conditioner compressors. Smart thermostats can raise and lower building temperature based on peak load hours. Water heater programs restrict the use of electricity for heating water during event hours. Behavioral programs incentivize consumers to reduce their electricity demand during peak periods—usually for a monetary incentive—with or without a smart device (SEPA 2018).

DR has many financial, reliability, and market performance benefits (DOE 2006). Participants receive incentive payments and/or bill savings for adjusting electricity demand during peak hours. DR lowers wholesale prices because it averts the need to use expensive generators during peak demand times. When employed for longer periods of time, DR lowers system capacity requirements, which allows load-serving entities to build less new capacity. Furthermore, DR increases reliability of the electrical grid because it lowers the likelihood of forced outages (DOE 2006). The services DR provides to electrical grids rewards customers with lower electricity rates.

However, DR not only benefits consumers, it also aids suppliers. DR allows utilities to save money by investing less in distribution and transmission lines and can promote more robust retail markets wherein market-based choices provide chances for innovation. DR can also improve choice of desired degree of hedging and provide market performance benefits, such as elastic demand that reduces capacity for market power. DR provides environmental benefits, such as reducing carbon dioxide emissions through decreased use of polluting peaker plants, and balancing renewables in the electricity market. Finally, DR can support energy independence by keeping resources local (DOE 2006).

The DR market has grown fast in recent years. From 2018 to 2019, DR participation in wholesale markets increased by approximately 2,734 MW, or 9%, of the total of 32,408 MW (DOE 2006). Midwest Independent System Operator reported one of the biggest absolute increases in DR regionally—an increase of 681 MW (11%) from 2018 to 2019—primarily because of the newly added 531 MW of DR resources registered as load modifying resources (FERC 2020).

As DR becomes a more important player in the electricity market, many studies assess its potential and develop better models and devices for reducing peak load. What is still unknown is how to effectively motivate customer participation in DR. This study targets the currently under-utilized residential DR programs using a survey instrument. We collected data using a questionnaire (online and mail) to assess Midwest residents' willingness to participate, and to better understand the reasons not to participate in different types of DR programs.

### Data Collection

From July 10 to October 30, 2020, we distributed a survey questionnaire to a random sample of 3,165 Midwest residents both online and through mail. We received a total of 417 responses (249 online and 168 mail responses), a response rate of 13.1%. We randomly assigned respondents to one of the three types of DR programs and one of the annual incentive levels ($0, $10, $20, $30, $40, $50). We cleaned the data by removing repetitions, empty entries, and information from respondents who are not responsible for paying utility bills, which resulted in 376 valid responses. Table 1 shows descriptive statistics of the respondent sample.

**Table 1. Descriptive Statistics of Respondent Sample**

| Variable | Obs | Mean | Std.Dev. | Min | Max |
|---|---|---|---|---|---|
| Age | 309 | 59 | 15.803 | 24 | 94 |
| Female | 356 | .40 | .49 | 0 | 1 |
| Household Income (est.) | 293 | 86,391 | 50,816 | 12,500 | 175,000 |
| # Children (<18) | 370 | 0.5 | 0.94 | 0 | 6 |
| # Adult (<65) | 370 | 1.3 | 1.15 | 0 | 6 |
| # Senior (≥65) | 370 | 0.7 | 0.82 | 0 | 3 |

Compared with the general Midwest population, our sample of respondents were of relatively older age, composed of more men than women, and had a higher household income. Our sample of respondents also have a higher level of education, more retirees, more homeowners, and more people living in single-family homes (see figure 1).

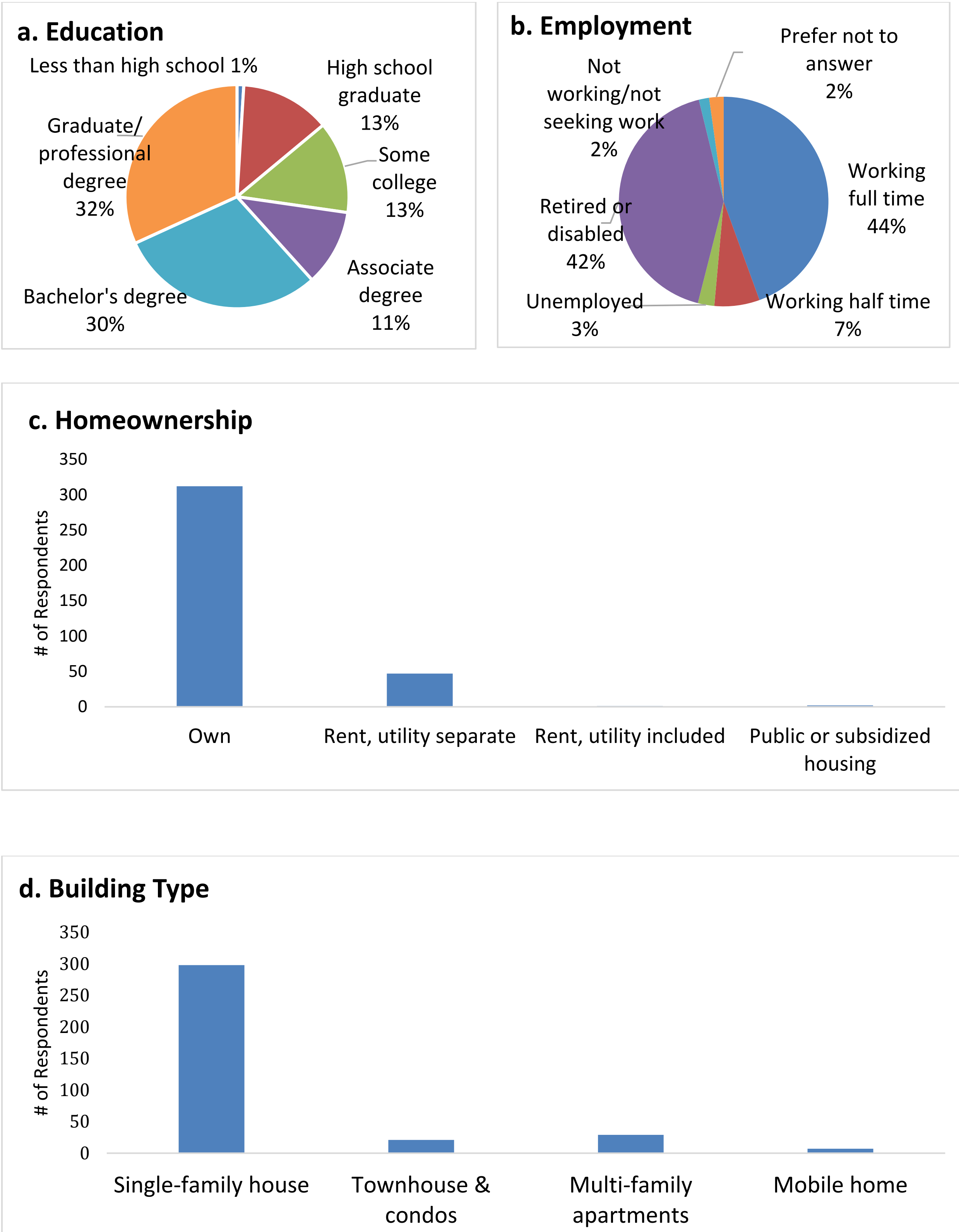


**Figure 1. Descriptive statistics of respondent sample (a: Education; b: Employment; c: Homeownership; d: Building Type).**

**Participant Home Demographics**

More survey respondents have energy supply from investor-owned utilities than municipal or rural co-ops (see figure 2). Twenty-two percent of respondents don't know the ownership of their utilities. Most respondents pay a fixed rate for electricity (see figure 3). Of those who know their rates, only 14% pay time-varying rates for electricity.

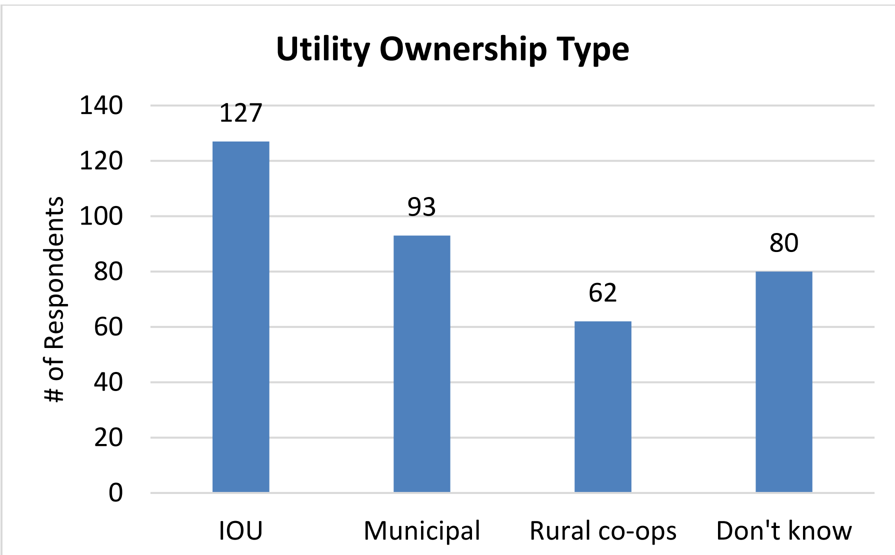


**Figure 2. Ownership type of respondents' utilities.**

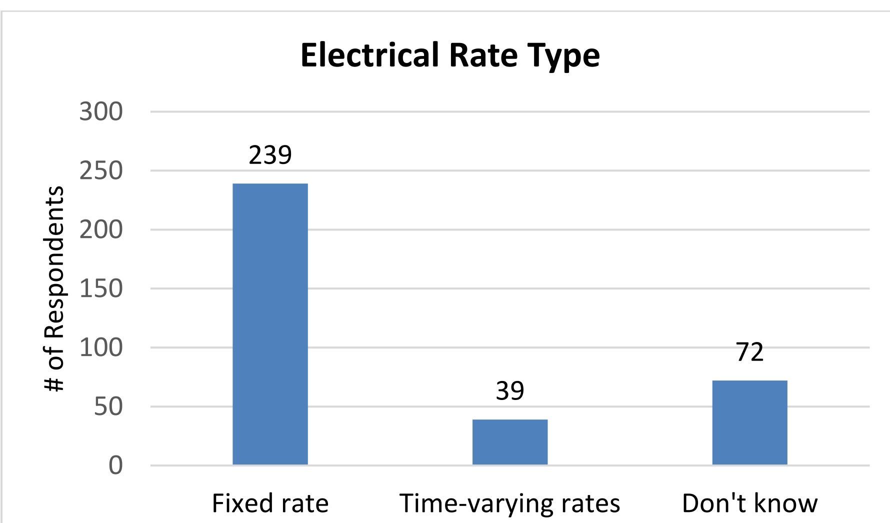


**Figure 3. Respondents' electricity rate types.**

## Occupancy

*Weekdays*

Figure 4 shows the times of day respondents reported being at home on weekdays during the summer. We sent out our survey after the start of the COVID-19 pandemic, which may have resulted in more participants being at home more often than if the pandemic were not present. Participants were asked to choose “Not occupied,” “Sometimes occupied,” or “Always occupied” for each time slot. It is important to note that we separated participants that selected “All day” from the participants who selected different times of day to avoid redundancy. Figure 4 shows that people tend to leave their residences during the middle day, which creates a dip in the middle of the chart on both weekdays and weekends.

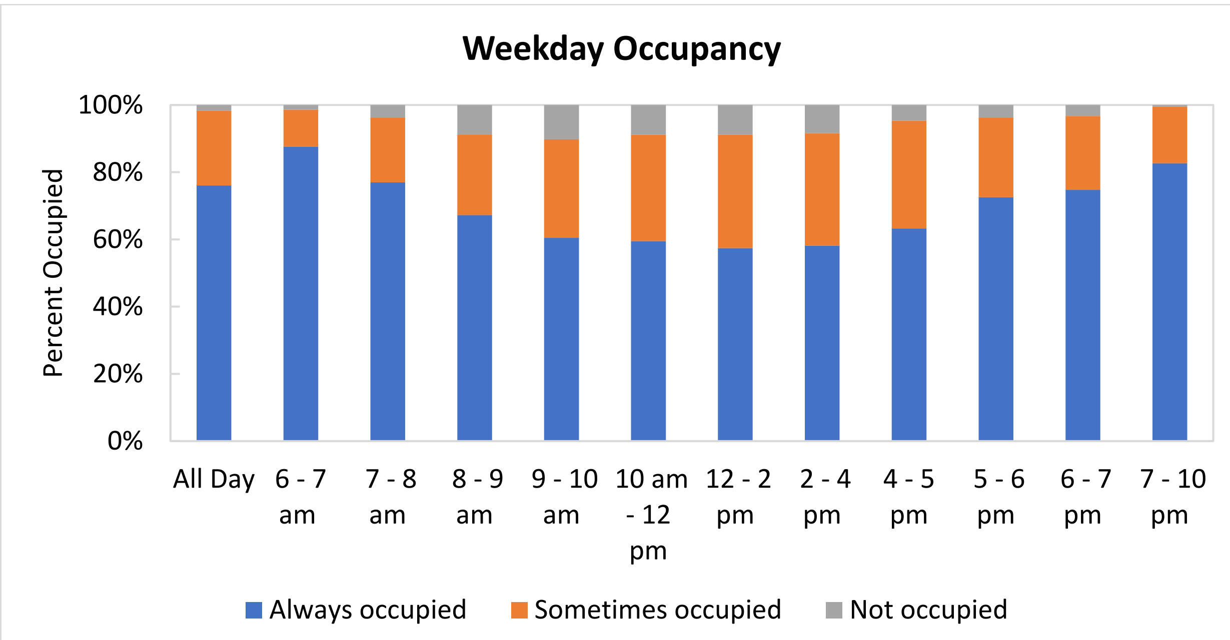


**Figure 4. Resident occupancy, weekdays (current routine).**

*Weekends*

We structured the question of weekend occupancy shown in figure 5 similarly to the weekdays chart. As figure 5 shows, more people are home throughout the day on weekends.

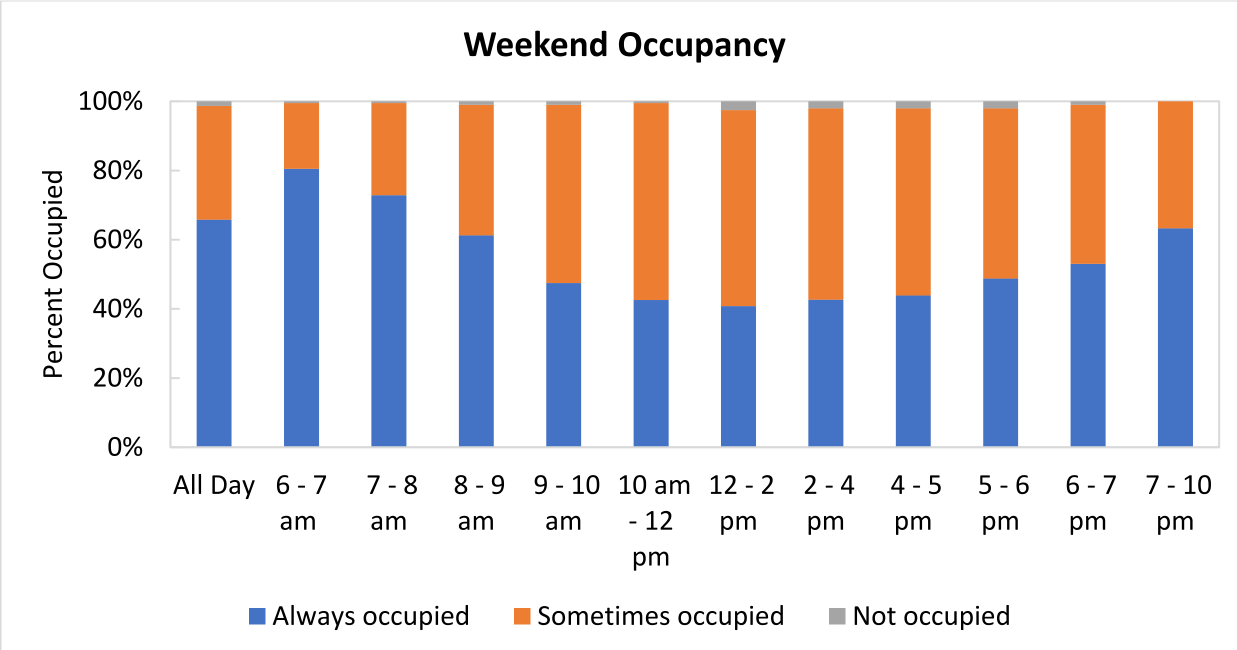


**Figure 5. Resident occupancy, weekends (current routine).**

**Control of Appliances**

Figures 6–13 all show bars labeled "Post-pandemic projection," as we asked respondents if they would be willing to let their utility company to control their appliances after the pandemic passed.

*Air Conditioner*

Figures 6 and 7 show respondents' answers when asked how they would feel about their utility company controlling their air conditioners on summer days. Most (51%/weekdays and 50%/weekends) said they did not want their utility company controlling their air conditioners at any time during the day. However, 23% and 18% of participants responded they would allow their utility company to control their air conditioner at any time of day on weekdays and weekends, respectively. The non-response rate was 19%.

Some respondents noted that they already had their air conditioner on a higher temperature than needed to save money and curb emissions.

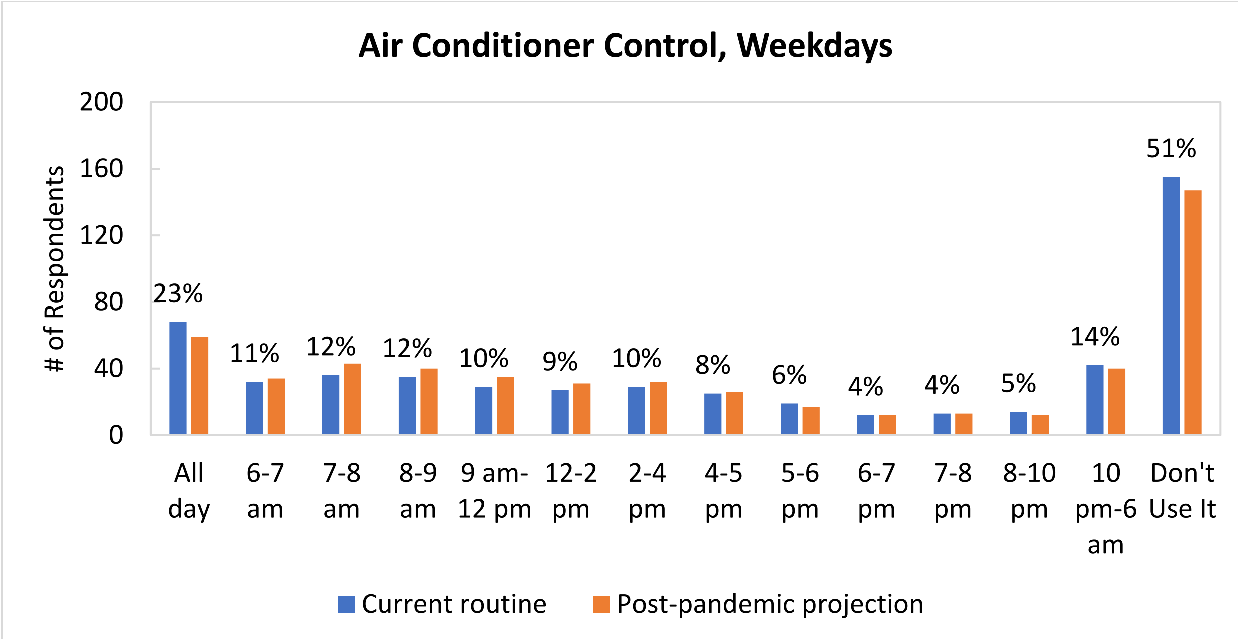


**Figure 6. Respondents' willingness to give air conditioner control to utility, weekdays.**

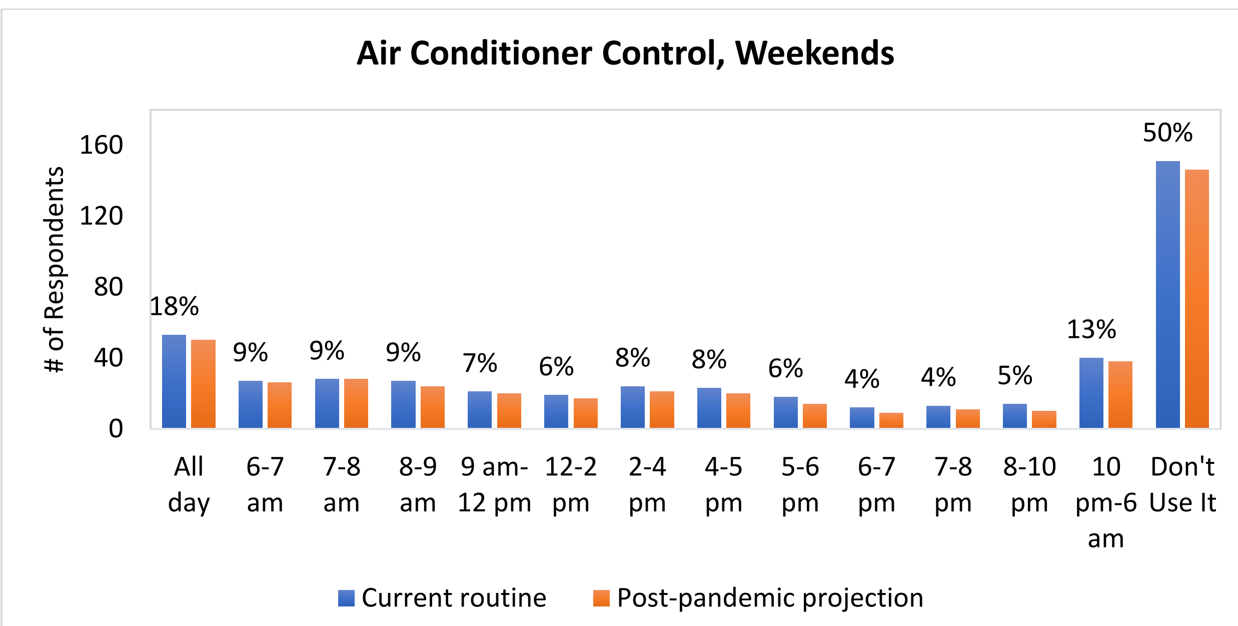


**Figure 7. Respondent's willingness to give air conditioner control to utility, weekends.**

*Electric Water Heater*

Figures 8 and 9 show respondents' feelings about allowing their utility to control their electric water heater. The most popular current/post-pandemic options were "Don't use it" at 52% and 51%, respectively, and "All day" at 25% and 21%, respectively. There was a non-response rate of 25%. One common reply to this question is that the respondent owns a gas water heater rather than electric.

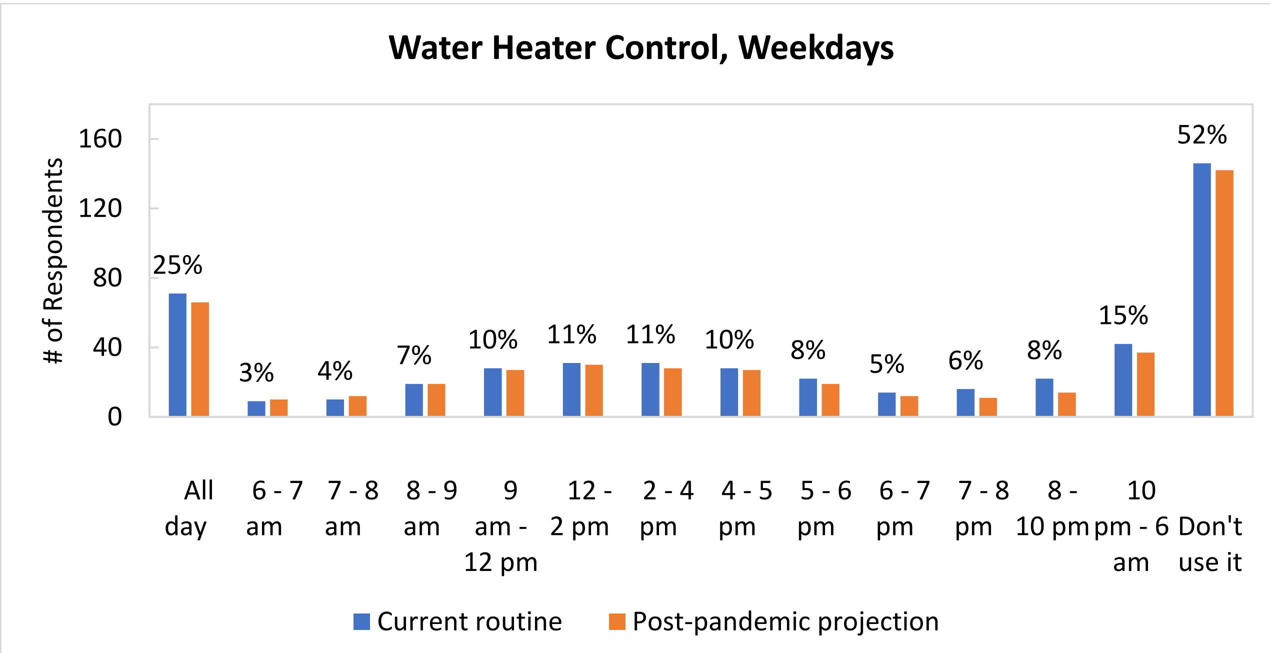


**Figure 8. Respondents' willingness to give water heater control to utility, weekdays.**

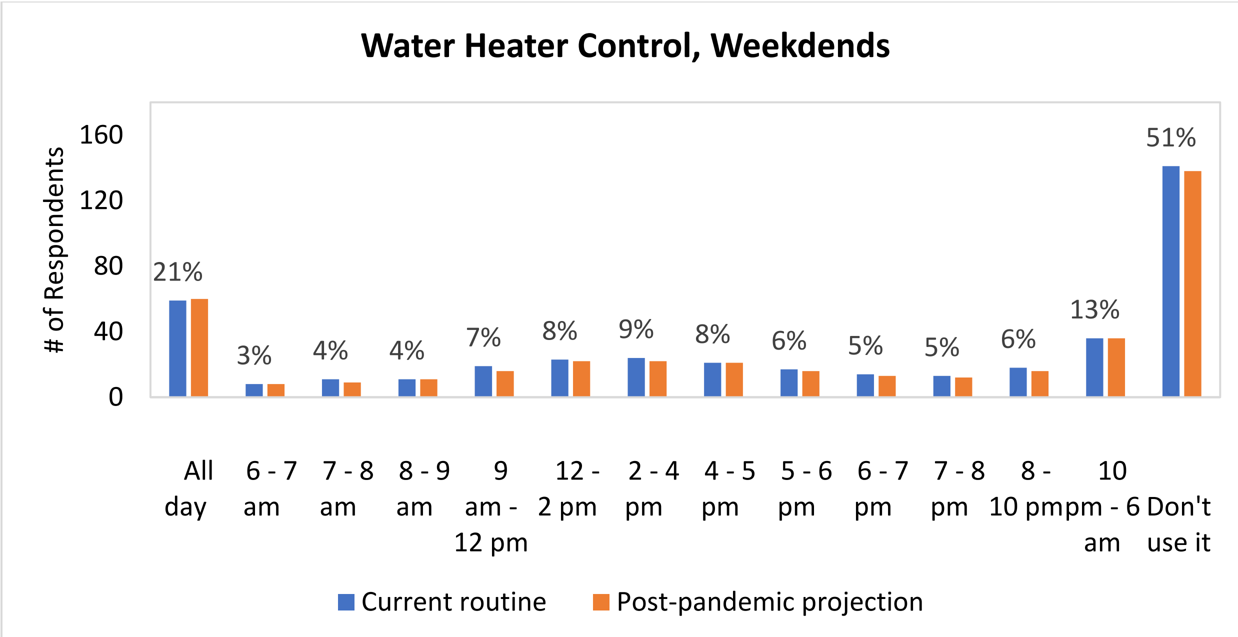


**Figure 9. Respondent willingness to give water heater control to utility, weekend.**

*Clothes Washer and Dryer*

When asked about giving their utility control of their washer and dryer, the most common responses were “Don’t use it” at 51% and 53% and “All day” at 18% and 14% for current and post-pandemic projections, respectively (see figures 10–11). There was a non-response rate of 23%.

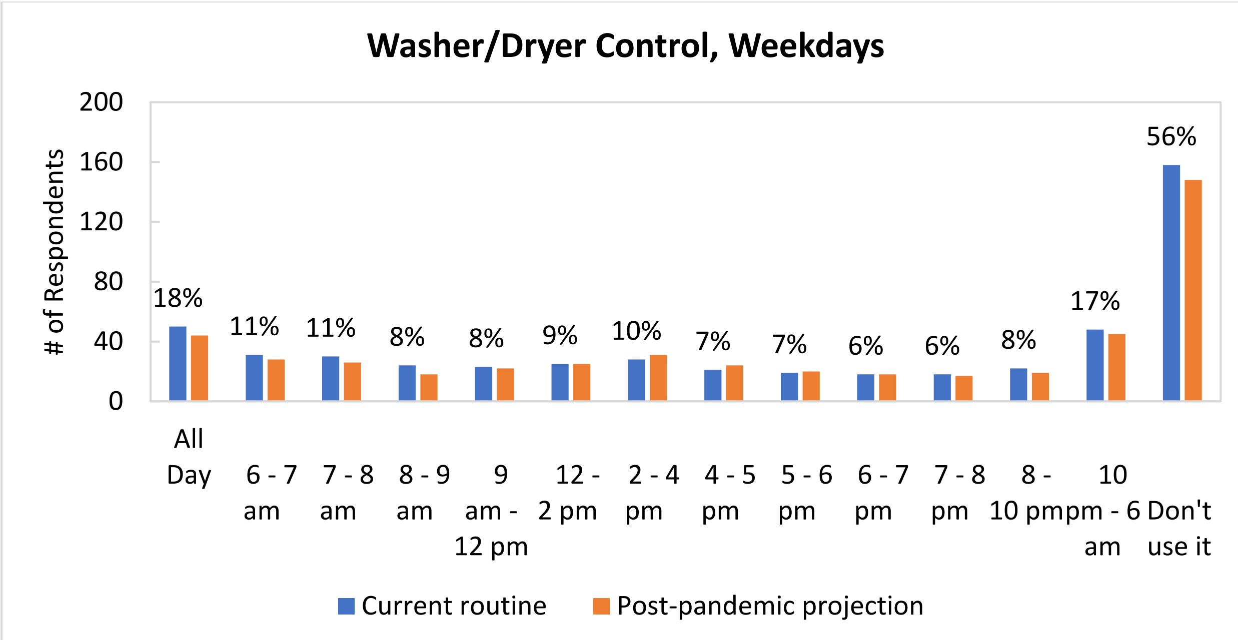


**Figure 10. Respondents' willingness to give washer and dryer control to utility, weekdays.**

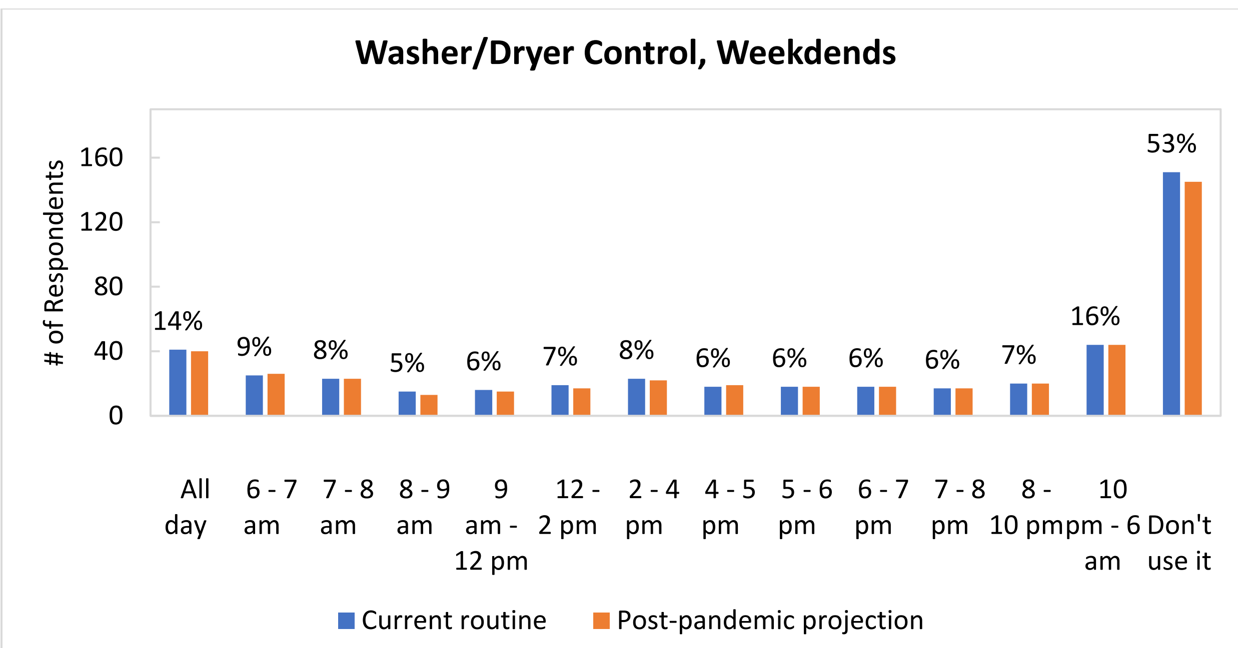


**Figure 11. Respondents' willingness to give washer and dryer control to utility, weekends.**

*Dishwasher*

As figures 12 and 13 show, when asked about their utility controlling their dishwasher, “Don’t use it” was the most popular current and post-pandemic option at 60% and 60%, respectively followed by “All day” at 19% and 18%, respectively. There was a non-response rate of 26%.

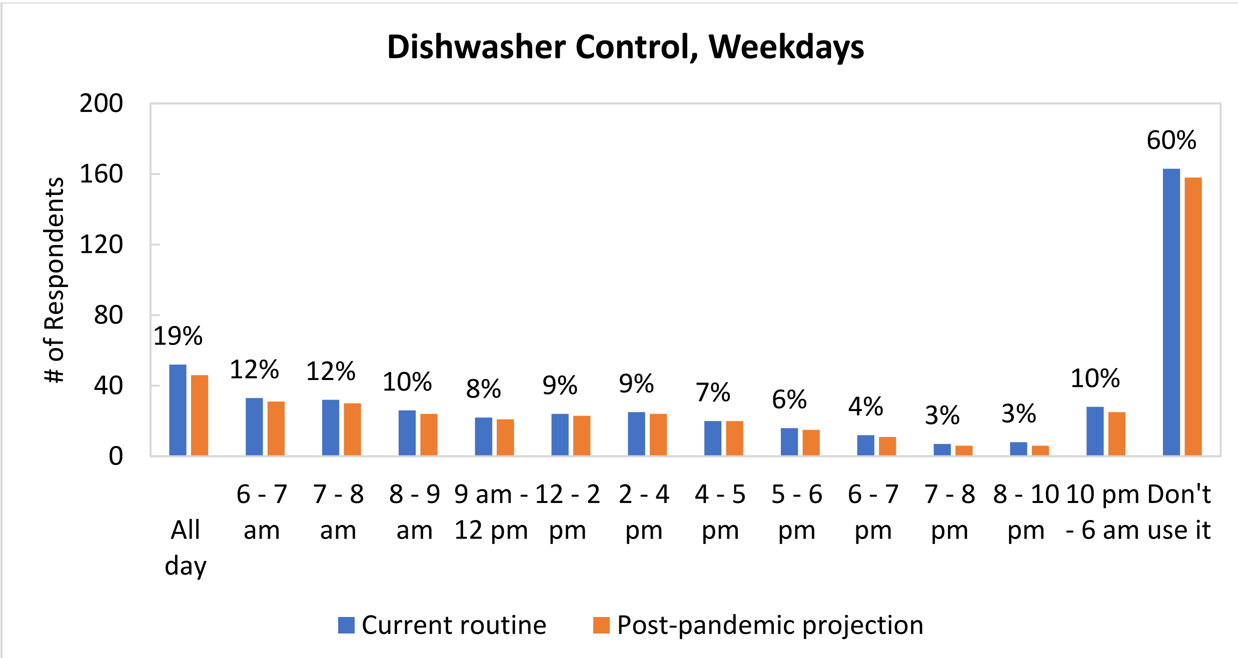


**Figure 12. Respondents’ willingness to give dishwasher control to utility, weekdays.**

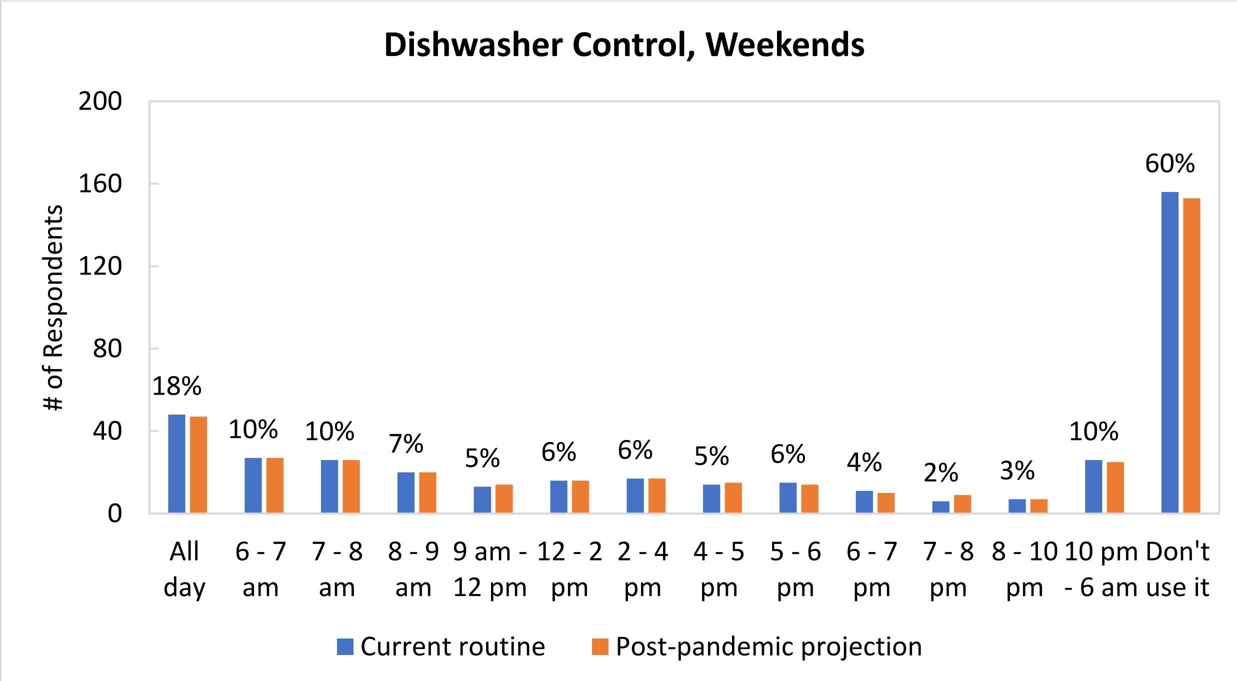


**Figure 13. Respondents' willingness to give dishwasher control to utility, weekends.**

### Willingness to Participate

Figure 14 shows the number of respondents that indicate they would participate in a DR program at all incentive levels ($0, $10, $20, $30, $40, and $50 annual incentive). Out of the respective programs, most participants (54%) were willing to enroll in air conditioner cycling, 50% were willing to use a smart thermostat, and 46% were willing to use automated real-time pricing.

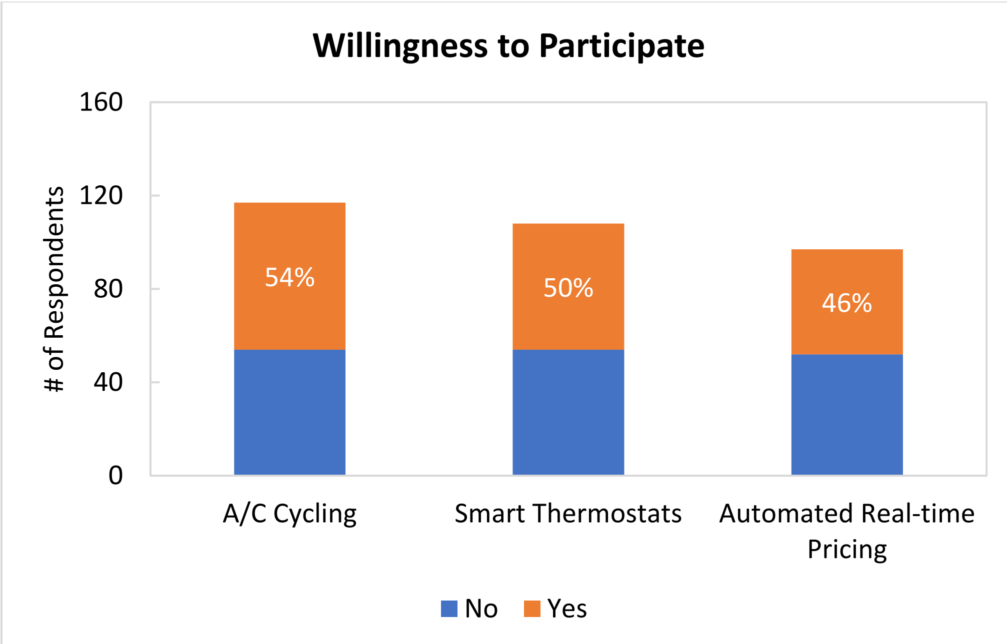


**Figure 14. Percentage of respondents willing to participate in each demand response program.**

Figure 15 shows the percentage of respondents willing to participate in any of the three DR programs at each incentive level. As figure 15 shows, most people (63%) are willing to enroll in a hypothetical DR program when offered no incentive ($0).

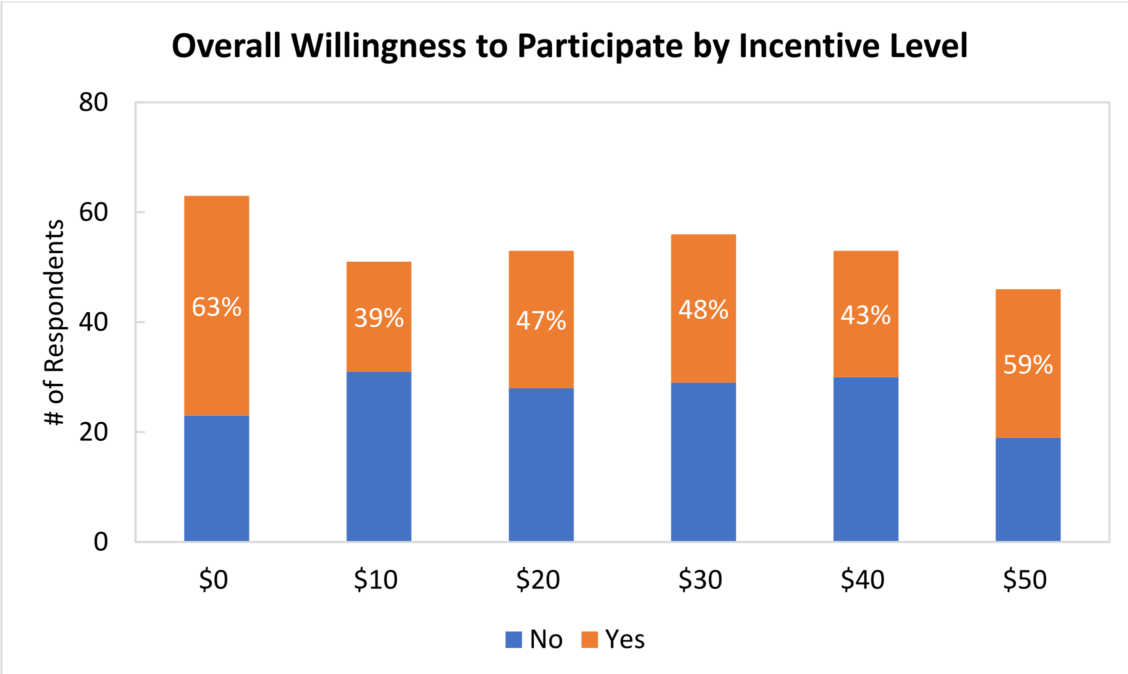


**Figure 15. Percentage of respondents willing to participate in any demand response program by incentive level.**

Figure 16 shows respondents' willingness to participate in the air conditioner cycling program by each incentive level. At 64%, "No incentive" ($0) is still more attractive than any other incentive. However, $50 is also a popular choice.

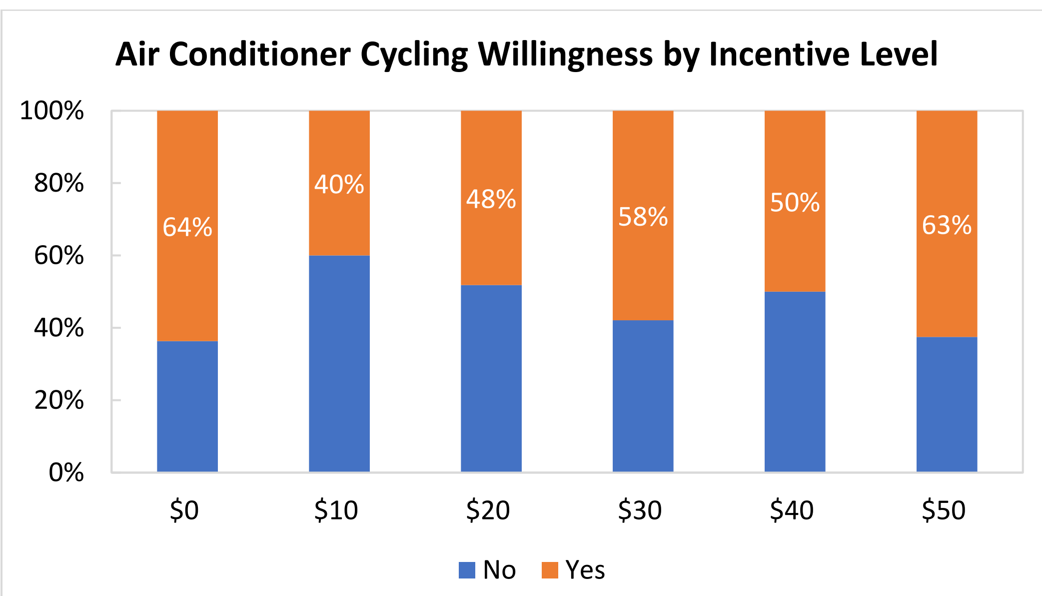


**Figure 16. Respondents' willingness to participate in air conditioner cycling by incentive level.**

Figure 17 shows respondents' willingness to participate in the smart thermostat program by incentive level. As is true with air conditioner cycling, "No incentive" ($0) is the most popular answer (74%).

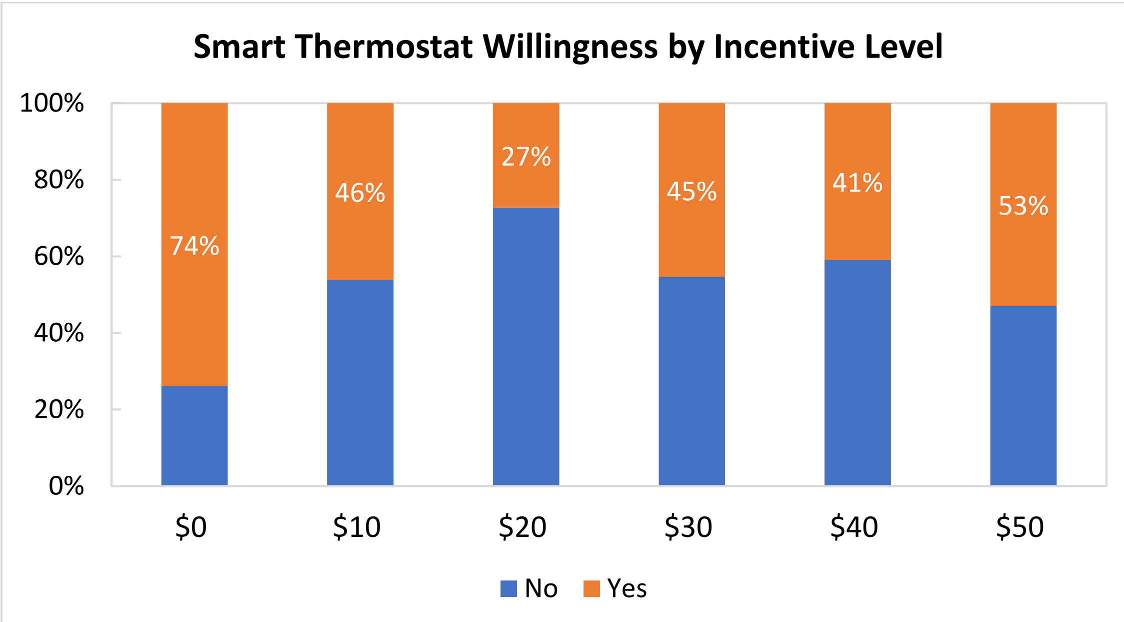


**Figure 17. Respondent's willingness to participate in a smart thermostat program by incentive level.**

Figure 18 shows respondents' willingness to participate in the automated real-time pricing program by each incentive level. Participants were most attracted to the $50 incentive level followed by $20 (60%) and $0 (50%).

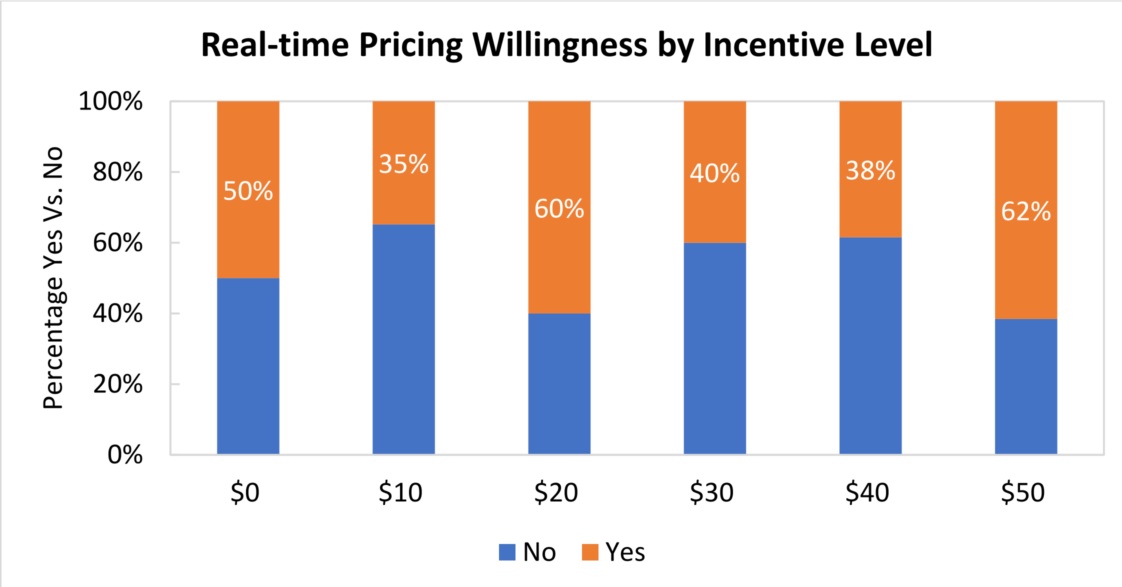

**Figure 18. Respondents' willingness to participate in automated real-time pricing.**

**Reasons for Rejection**
Figure 19 shows respondents' stated reasons for not enrolling in DR programs. We gave participants a list of pre-written reasons for not enrolling in a specific program and incentive level. Respondents' were allowed to check more than one of the following: "Not understanding how it works," "Too many control events," "Potential technical risks," "Privacy concerns," "Comfort concerns," "Loss of control of the appliances," "Incentive not high enough," and/or respondents could specify other reasons. When not mentioning an incentive, most respondents noted concerns over the impact on occupants' thermal comfort level as the most common reason not to enroll in a DR program. When offered incentives, "Incentive is not high enough" is one of the most cited reasons for not enrolling.

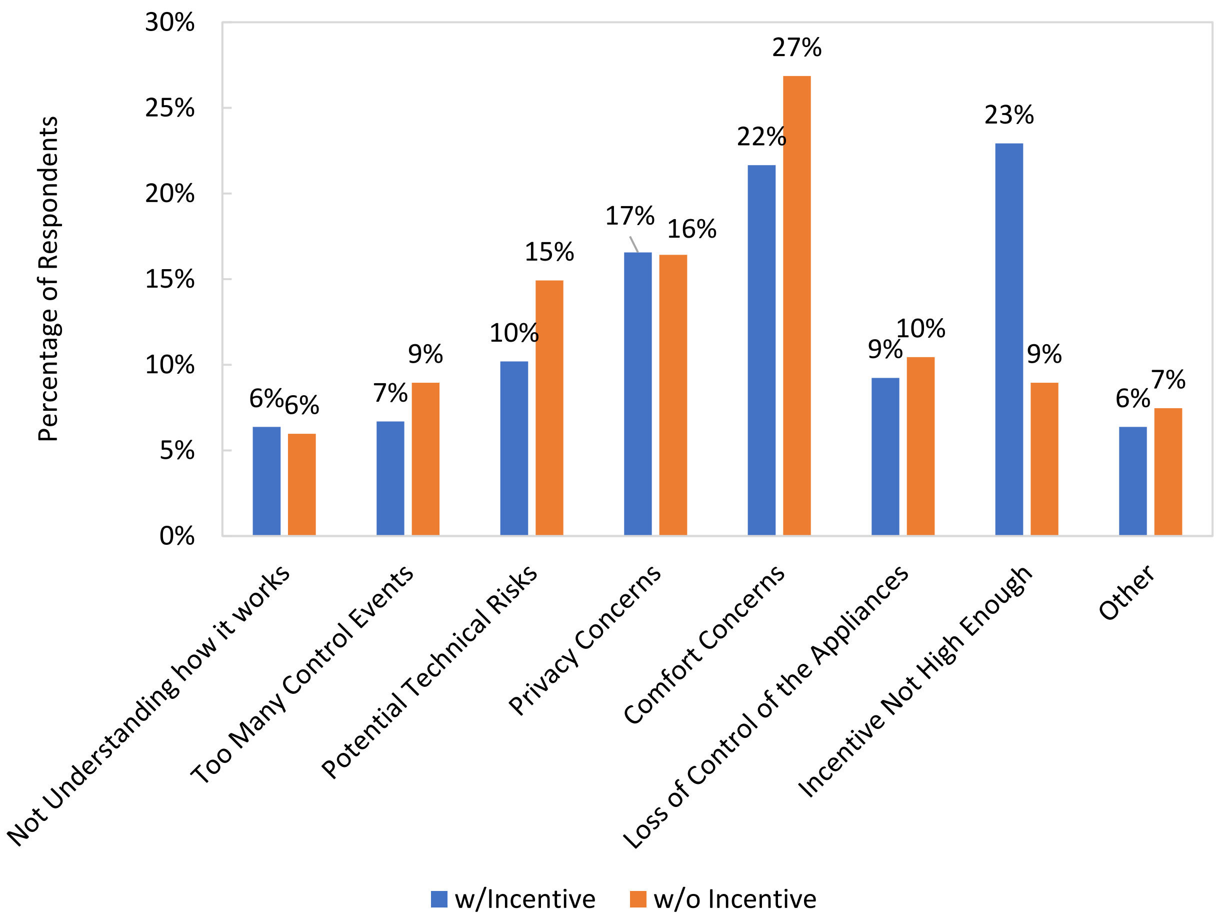


**Figure 19. Respondents' reasons for rejecting demand response, with and without incentives.**

Table 2 shows the most common reasons respondents reject a hypothetical DR program by incentive level. Table 2 displays percentages for the most commonly cited reason that respondents reject a DR program within a respective incentive level. In most cases in which a utility offers an incentive, respondents are not willing to enroll in the program due to low incentive, comfort concerns, and privacy concerns. It is important to note that only seven participants responded to the $50 incentive level.

**Table 2. Respondents Most Common Reasons to Reject Incentives of $10-$50**

| | Not understanding how it works | Too many control events | Potential technical risks | Privacy concerns | Comfort concerns | Loss of control of the appliances | Incentive not high enough | Other |
|---|---|---|---|---|---|---|---|---|
| $10 | | | | 16% | 26% | | 22% | |
| $20 | | | | 19% | 19% | | 25% | |
| $30 | | | | 20% | 22% | | 20% | |
| $40 | | | 10% | 10% | 22% | 10% | 23% | 10% |
| $50 | 14% | | 29% | 14% | | 14% | 29% | |

**National Demand Response Legislation**

DSM programs began in the 1970s because of growing concerns about the effects of foreign oil on the economy (Eto 1996). In addition, interest in DSM rose in popularity during the 1970s because the rise of air conditioners in US residences resulted in "needle peaks and reduced load factors in system demand profiles" (Cherrelle et al. 2016).

In the early 1980s, Congress passed the Public Utilities Regulatory Policy Act, which promoted load-management programs, including price-based and direct-control based programs for the industrial sector, designed to reduce peak demand (Cherrelle et al. 2016). In order to implement DR, utilities have created educational campaigns for the public, provided technical services, such as audits and retrofits, and provided financial incentives, such as loans and rebates. Specifically, for the residential sector, utilities upgrade walls and attics, undertake energy audits for retrofitting, and purchase more efficient products, such as those labeled with ENERGY STAR. For the commercial sector, utilities upgrade windows, implement more energy efficient office equipment, and optimize heating, ventilation, and air conditioning systems. For the industrial sector, utilities can recover waste heat streams, and perform maintenance and upgrades for motors and other control systems (EPA 2015).

According to the National Resources Defense Council, critics of DR tend to misunderstand how DR works. Opponents often think that participation in DR means surrendering control of your electricity despite your wants or needs. However, critics often do not understand that DR is voluntary and that utilities pay participants for cutting back on electricity use (Clements 2014). We also observe this phenomenon in our survey results—when asked why participants did not agree to a hypothetical DR program, many responded "I would not have enough control over the comfort of my home" and "I have difficulties in understanding how the program works" as reasons why.

However, there are indeed a few downsides to DR. For example, some DR programs cannot be considered carbon free. Sometimes municipal, commercial, and industrial participants agree to lower their electricity consumption from the grid, but then use their own diesel generators to power themselves as a cost reduction. Another problem is that it is not wide-spread enough yet to abandon backup power plants (Clements 2014).

## Effective DR Legislation in the US Midwest

*Minnesota*

According to Swirbul (2012), the state of Minnesota ranks third, behind only California and Texas, among US states in terms of DR implementation. In an interview, Phyllis Reha, vice chair of the Minnesota Public Utilities Commission said:

"Minnesota has adopted a dollar-for-dollar cost recovery under our conservation improvement program...[they] provide incentives to utilities for meeting certain savings requirements. [They] have tried lost revenue recovery mechanisms that have not been very successful because the numbers were growing so high that the cost-benefit analysis indicated that it was not working. Then [they] came up with a program cost recovery approach that had been measured as energy efficient and [they] added incentives to it" (Swirbul 2012).

## Energy Efficiency Resource Standards

Statewide Energy Efficiency Resource Standards (EERS) either encourage or require utilities or third-party companies to strive for specific targets to reduce energy consumption and/or lower peak load. Percentage of electric sales and peak demand reduction as required by state EERS were found on various websites including DSIRE. Table 3 shows Midwest states that have energy efficiency standards according to the Midwest Energy Efficiency Alliance.

**Table 3. Energy Efficiency Resource Standards for US Midwest States**

| State | Electric Standard | Mandatory or Voluntary | % Electric Sales Reduction | % Peak Demand Reduction |
|---|---|---|---|---|
| **Illinois** | Yes | Mand | 0.2% of energy delivered in EY 2009, increasing to 2% of energy delivered in EY 2016 and thereafter. | 0.1% reduction in peak demand each year for 10 years (EY 2009-2019). |
| **Indiana** | — | — | — | — |
| **Iowa** | Yes | Mand | Utility-specific standards set by IUB. | Utility-specific standards set by IUB. |
| **Kansas** | — | — | — | — |
| **Michigan** | Yes | Mand | 1.0% annual reduction of previous year retail electricity sales (MWh). | N/A |
| **Minnesota** | Yes | Mand | 1.5% reduction of average retail sales beginning in 2010. | N/A |
| **Missouri** | Yes | Vol | Increasing annual benchmarks beginning in 2012. Cumulative savings of 9.9% by 2020, increasing by 1.9% each year thereafter. | Annual benchmarks beginning in 2012 which increase by 1.0% per year. Cumulative reduction of 9% by 2020, increasing by 1% each year thereafter. |
| **Nebraska** | — | — | — | — |
| **North Dakota** | — | — | — | — |
| **Ohio** | Yes | Mand | Annual reductions leading to 22% cumulative reduction in retail electricity sales by the end 2027. | 1% reduction in peak demand in 2009. 0.75% reduction in peak demand each year through 2014 and from 2017 to 2020. |
| **South Dakota** | — | — | — | — |
| **Wisconsin** | Yes | Mand | 0.75% in 2011, ramping up to 1.5% in 2014. | 0.75% in 2011, ramping up to 1.5% in 2014. |

For the sake of this policy brief, we think that EERS with specified peak load reduction goals will better motivate utilities to curb peak demand and to encourage customer participation to ensure program success.

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