Understanding Emerging Building Technologies in Federal Performance Contracting Markets

Sarah Turner and John Myhre

National Renewable Energy Laboratory

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

This report is available at no cost from the National Renewable Energy Laboratory (NREL) at www.nrel.gov/publications.

Contract No. DE-AC36-08GO28308

Technical Report
NREL/TP-7A40-85549
May 2023

Understanding Emerging Building Technologies in Federal Performance Contracting Markets

Sarah Turner and John Myhre

National Renewable Energy Laboratory

Suggested Citation
Turner, Sarah and John Myhre. 2023. *Understanding Emerging Building Technologies in Federal Performance Contracting Markets*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-7A40-85549. https://www.nrel.gov/docs/fy23osti/85549.pdf.

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

This report is available at no cost from the National Renewable Energy Laboratory (NREL) at www.nrel.gov/publications.

Contract No. DE-AC36-08GO28308

Technical Report
NREL/TP-7A40-85549
May 2023

National Renewable Energy Laboratory
15013 Denver West Parkway
Golden, CO 80401
303-275-3000 • www.nrel.gov

NOTICE

This work was authored by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by the U.S. Department of Energy Federal Energy Management Program. The views expressed herein do not necessarily represent the views of the DOE or the U.S. Government.

This report is available at no cost from the National Renewable Energy Laboratory (NREL) at www.nrel.gov/publications.

U.S. Department of Energy (DOE) reports produced after 1991 and a growing number of pre-1991 documents are available free via www.OSTI.gov.

Cover Photos by Dennis Schroeder: (clockwise, left to right) NREL 51934, NREL 45897, NREL 42160, NREL 45891, NREL 48097, NREL 46526.

NREL prints on paper that contains recycled content.

Acknowledgments

The authors wish to thank the Alliance for Sustainable Energy for funding this research. The National Renewable Energy Laboratory (NREL) is a national laboratory of the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy operated by the Alliance for Sustainable Energy, LLC.

The authors appreciate the subject matter expertise provided by NREL colleagues Otto Van Geet, David Sickinger, and Tom Harris and the critical feedback they offered on the selection of building technologies used for the survey. The authors would also like to thank Sheila Hayter and Philip Voss for their guidance on the project as well as Courtney Hausler and Heidi Blakley for their edits on the survey and on the final report. Lastly, the authors are grateful for the work provided by Gregg Tomerblin in his 2017 study talking to ESCOs working on Department of Defense sites, which provided a lot of the groundwork for this report.

All judgements and interpretations of the research methodology as well as final survey results are the responsibility of the authors and not of the experts listed above.

List of Acronyms

DOE	U.S. Department of Energy
ESCO	energy service company
ESPC	energy savings performance contract
ESTCP	Environmental Security Technology Certification Program
FEMP	Federal Energy Management Program
GPG	Green Proving Ground
MBCx	monitoring-based commissioning
NREL	National Renewable Energy Laboratory
O&M	operations and maintenance

Executive Summary

This report contains the results of a market-research survey conducted by the National Renewable Energy Laboratory (NREL) to understand how emerging building technologies are currently being incorporated into federal energy savings performance contracts (ESPCs). Reaching out to energy service companies (ESCOs), the authors wanted to learn more about ESCO experiences with specific emerging building technologies and how deployment barriers could be addressed within the federal sector.

ESCOs confirmed how often risk reduces the deployment potential of new technologies and how ESCOs use performance indicators to assess a technology's risk. Payback periods as well as operations and maintenance (O&M) costs were important factors to an ESCO's decision-making, but the survey revealed they were not the only performance indicators ESCOs considered. The scalability of a technology, its product life expectancy, its life cycle costs, and its return on investment were all listed as additional metrics ESCOs look for when assessing a technology's performance risk. Some ESCOs suggested federal technology evaluation programs could be improved to address these considerations as well as how to navigate cybersecurity requirements for monitoring-based commissioning (MBCx).

The report ends with an examination of recommendations for how the U.S. Department of Energy's (DOE's) Federal Energy Management Program (FEMP) can assist agencies in deploying emerging building technologies through ESPCs. Most ESCOs advocated for risk-sharing solutions that included funding pilot projects, reducing the measurement and verification burden for ESCOs, or providing information to agencies so that facilities could handle their own O&M responsibilities. The authors hope to continue this research by reaching out to agencies to understand their risk preferences and how federal facilities engage in ESPCs to determine an emerging building technology's potential.

Table of Contents

List of Figures

List of Tables

1 Background

Every year, federal technology evaluation programs test and assess the performance of building technologies that are being considered for wider deployment in federal facilities. These programs include the Department of Defense's Strategic Environmental Research and Development Program and Environmental Security Technology Certification Program (ESTCP), the General Services Administration's Green Proving Ground (GPG) and Pilot to Portfolio programs, and the Department of Energy's (DOE's) High Impact Technology (HIT) Catalyst program.[1] Many of these evaluated building technologies are shown to deliver energy savings or reduced carbon emissions but have not been widely deployed in the federal building inventory.

Federal technology evaluation programs evaluate and validate the benefits of these innovative building technologies by performing technology demonstrations, often in operational federal facilities. Validating the performance of a technology in a real-life scenario can increase confidence and market acceptance among federal facility managers, contracting officers, and contractor partners. Despite these investments in technology validation, many of the technologies evaluated by federal programs struggle to achieve broad penetration into the federal performance contracting market.

Facility investments made through third-party financed performance contracts, such as energy savings performance contracts (ESPCs) and utility energy service contracts, can be executed without up-front capital costs or special appropriations from Congress, making them attractive procurement vehicles for many agencies. Agencies set aside part of their annual utility budgets to repay the energy service companies (ESCOs) or utilities and financiers that made the initial investment.[2] These contracting partners also play a large role in evaluating the suitability of technologies for use in performance contracts.

The National Renewable Energy Laboratory (NREL) conducted a market-research survey of ESCOs to understand how emerging building technologies are currently being incorporated into federal ESPCs. The goal of this research is to understand barriers to wider adoption of validated building technologies in the federal performance contracting market and how this information can be used to increase their deployment. The initial phase of this research focuses on the ESCO community and the barriers they perceive to wider adoption of these evaluated technologies.

1.1 Developing the Adverse Selection Model

The authors considered multiple perspectives when identifying the scope of the report. One methodology they consulted for drafting the survey was the adverse selection model. The adverse selection model in economics refers to a market dynamic where informational asymmetry exists between the customer and the buyer for a product or service. Informational asymmetry occurs when one party has more information than the other and that party has the incentive to not share information. These conditions introduce risk into a vertically differentiated

[1] Please see the glossary for more information on these programs.
[2] Information on federal ESPCs can be found at https://www.energy.gov/femp/energy-savings-performance-contracts-federal-agencies.

market since the party with the least amount of information will have a harder time differentiating between market participants.

For this report, the authors chose to focus on the adverse selection model where informational asymmetry exists on the buyer's side and where ESCOs are the customers, purchasing emerging building technologies from technology companies. Working under this perspective, owners of emerging building technologies have the strongest technical expertise on how to install, operate, and maintain their technology; yet they are also the party that has the strongest incentive not to share information since developing new building technologies is a significant investment.[3] As such, there exists an incentive for companies to downplay a technology's risks and O&M costs while over-selling the technology's performance in other areas.

If unchecked, the adverse selection model predicts that information asymmetry could lead to high-quality emerging technologies getting pushed out of the market, crippling innovation in the building technology field. Historically, solutions to correct adverse selection have promoted increasing available information on the product or employing risk-sharing mechanisms, such as offering warranties. These solutions work because of an economic concept known as signaling. Signaling under federal performance contracting markets occurs when owners of high-quality emerging building technologies send "signals" to ESCOs that convey information about the quality of their product. Signals can help ESCOs determine which emerging building technologies are high-risk or low-quality, which in turn informs the selection of technologies that can be included in ESPCs.[4]

---

[3] It should be noted that even technology developers may not always have all the information regarding their product as there are many small technology companies that begin with a handful of engineers. As a result, technology developers may have limited information regarding all the applications of their technology, such its mass production. See Appendix A.1 for more information.
[4] See Appendix B.1 for a more in-depth view behind developing the adverse selection framework.

2 Survey Results

The goal of NREL's ESCO survey was three-fold: (1) to determine if the adverse selection model was a good fit to study the federal performance contracting market, (2) to establish how many specific emerging building technologies validated by federal programs are currently considered high-quality by ESCOs, and (3) to propose recommendations that will increase the deployment of emerging technologies.

In total, the survey received eleven responses from nine different ESCOs that opted to say which companies they represented. No names were collected in the survey to keep the responses anonymous.[5]

2.1 Employing the Adverse Selection Model

2.1.1 Current Signals to ESCOs

From prior research and conversations with industry specialists, the authors knew payback periods and O&M costs were important signals ESCOs looked for before they considered deploying an emerging building technology.[6] To determine their significance during an ESCO's decision-making, the survey asked ESCOs to elaborate on their experiences and to specify how longer payback periods and O&M costs factor into an ESPC.

The majority of ESCOs confirmed that longer payback periods have a negative impact on projects since they usually increase the risk of using a new building technology. One ESCO explained that longer payback periods typically cause customers and financiers to place 100% of the performance risk on ESCOs, which triggers a cost and benefit analysis. If the risk is determined to be too great by that ESCO, then that "technology will not be installed." Another ESCO reflected similar concerns, emphasizing that customers are usually looking for projects that will give them a "bang for their buck." This coupled with rising inflation and interest rates collectively make it difficult for ESCOs to financially "pencil out" even "proven technologies," much less emerging building technologies with longer payback periods.

Yet some ESCOs indicated that longer payback periods were not always dealbreakers if they could be mitigated through other means, such as if they made up a small percentage of the project or offered other benefits like avoided capital costs. One ESCO suggested modifying lowest price technically acceptable contracts for facility maintenance to include energy performance metrics so that "vendors are forced to operate the system efficiently, rather than just making sure it works." This, they argued, helps federal agencies share some of the risk of emerging building technologies with ESCOs since agencies commonly keep the O&M responsibilities and bid them out to other companies. These companies, however, may have a difficult time providing O&M to a new technology and, in the ESCO's assessment, will prioritize maximizing the technology's functions "without concern for the energy being consumed."

[5] See Appendix B.2 for information regarding how the authors drafted and distributed the survey.
[6] See Appendix A.2.

This tension was also highlighted by some ESCOs when answering how O&M costs affect the deployment of an emerging technology. While most of the ESCOs emphasized how damaging O&M costs can be when they begin to outweigh the energy savings, one ESCO indicated that O&M decisions are often made by facility O&M staff "who have a natural reluctance to change." Even in cases where an emerging building technology offers O&M savings that could reduce the payback period, federal agencies can be "resistant to [their] inclusion" in an ESPC (this ESCO noted that the one exception was DOE).

These initial responses demonstrate that payback periods and O&M costs continue to act as signals to ESCOs when deploying an emerging technology, but that these signals can have an especially powerful effect on customers in an ESPC. One ESCO explained how they can usually afford their customers the discretion to choose a few long-payback energy conservation measures to implement, but that "they are rarely interested in a new technology." This dynamic suggests that customers in the federal performance contracting market are looking for signals themselves and that these signals may be different than the ones ESCOs respond to.

The authors knew that warranties have historically acted as signals under the adverse selection model as well and wanted to determine how receptive ESCOs were to this signal when assessing an emerging building technology.[7] When technology companies offer warranties, the adverse selection model argues that they are sending a signal to ESCOs that their product is high-quality because they can afford to share the risk of their technology by replacing it or repairing it for free. Yet some ESCOs may feel that there is a corporate financial risk to these warranties as a lot of companies for emerging building technologies are small and relatively new.[8] This can undermine how effective their warranties are, in turn weakening the use of warranties as a signal in the federal performance contracting market.

---

[7] See Appendix B.1.
[8] See Appendix A.1.

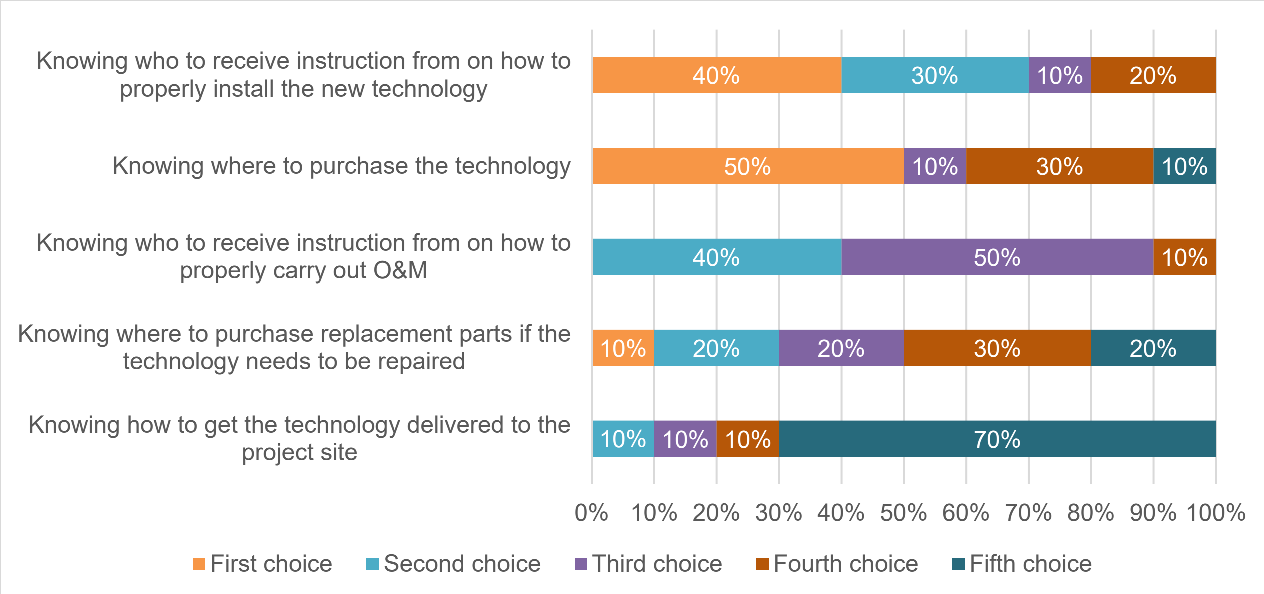

Figure 1. Ranking five stages of the distribution process

ESCO responses to the following question, "When considering whether to include a new technology in a performance contract, which of the following factors are the greatest concern to your company? Rank them in order of the greatest concern (1) to the least concern (5)."

To address this, the authors had ESCOs rank five stages of the distribution process in the order of their greatest concern to their least concern when working with a new technology (Figure 1). "Knowing where to purchase replacement parts if the technology needs to be repaired" was ranked low by ESCOs, averaging a fourth-place position on their overall list of concerns. This ranking could indicate that warranties are effective in mitigating some of the risk ESCOs experience with new technologies since repairing the technology does not appear to be a top concern. Another explanation could be that if emerging building technologies have standardized components like HVAC technologies, they can be repaired relatively easily by purchasing the parts from other distributors. One industry specialist the authors spoke to before drafting the survey explained that electrical components are more difficult for ESCOs to repair. So, when a technology with custom electrical components stops working—without a standing warranty—ESCOs might have to remove the technology, which can represent a serious loss.[9]

Notably, "Knowing who to receive instruction from on how to properly install the new technology" and "Knowing where to purchase the technology" were ranked as the top concerns ESCOs had when working with a new technology. This relates to another insight the industry specialist shared on how ESCOs consider themselves to be a construction group and that they need more information on the distribution process of a technology to make a deployment decision. In this way, technologies that do not have a distribution system already set up could represent a potentially significant barrier since the ESCOs would have to expend time and resources to find this information themselves.

[9] See Appendix A.2.

In addition to the valuable information the authors gained from the survey on known signals, the authors also wanted to explore if there were any other signals or performance indicators ESCOs looked for when assessing a new technology. The survey asked ESCOs to describe how they evaluate an emerging building technology's ability to have broad deployment potential, to which three themes emerged:

- The first theme addressed assessing the actual properties of the technology to see if it is scalable "across a variety of systems" or other projects with similar characteristics. This included looking at the energy performance of the technology, its O&M costs, its product life expectancy, and its degradation curves, as well as its raw materials.

- The second theme involved assessing the overall risk of that technology, which often came from the opinions of additional specialists, such as an internal risk governance board or an internal group of subject matter experts. While these risk evaluations do involve looking at the properties of the technology, they are also more complex, such as looking at the company's IRS tax ownership rules or the technology's manufacturing origin. One ESCO noted looking at "the financials of the providing vendor/contractor to evaluate the likelihood or corporate failure" during the contract period while another stated that even the risk assessments of facility and agency personnel could significantly shape their evaluation.

- Finally, several ESCOs stated that personal experience, case studies, and pilot projects help them determine if a technology has broad deployment potential, which is an area that federal technology evaluation programs can directly target.

2.1.2 Federal Technology Evaluation Programs

Looking at survey results through the lens of the adverse selection model, the authors wanted to assess how effective federal technology evaluation programs currently are in sending signals to ESCOs. To tackle this, the authors first asked ESCOs to identify which federal technology evaluation programs they recognized from a pre-made list (Figure 2).

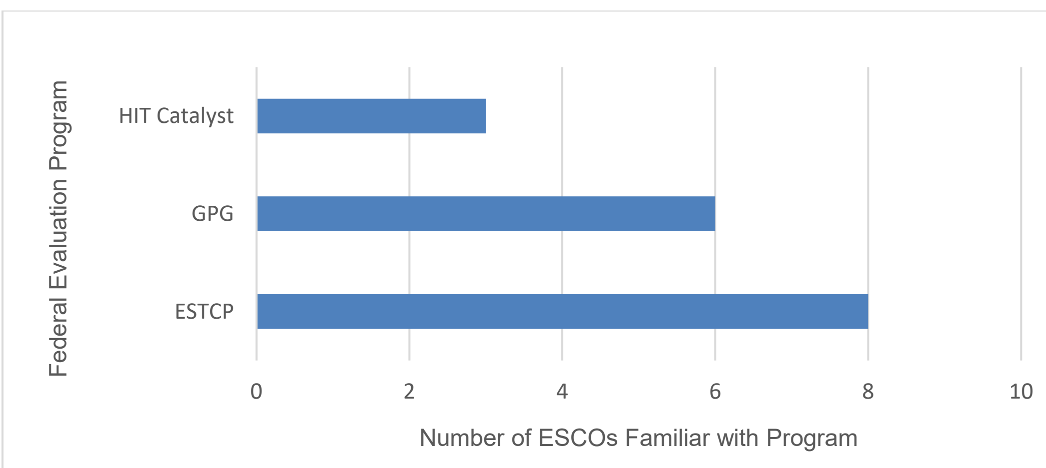

Figure 2. Recognition of federal technology evaluation programs by ESCOs

ESCO responses to the following question, "Which of the following federal technology evaluation programs has your company heard of? Select all that apply."

Most ESCOs recognized at least one federal technology evaluation program, and ESTCP was the most recognized program out of the three listed. Understanding which federal technology evaluation programs ESCOs consult and trust the most is important to the authors as it can help them decide which aspects of the programs are successful and how individual programs could be improved. For example, when the survey asked ESCOs to describe how often and how extensively they read technical reports from federal programs, ESCOs familiar with GPG indicated that they receive regular email updates from the program and that this helped them stay up to date on GPG's publications. One ESCO even expressed that they usually "search the web" when looking for reports and "would love to get them directly."

This sentiment is reflected in another section of the survey where ESCOs were asked to rate how strongly they agreed with the statement "My company has the time and resources to research market-ready building technologies and stay up to date on technology developments" (Figure 3). While 50% of the ESCOs responded that they either agreed or strongly agreed with the statement, 40% of the ESCOs responded that they disagreed.

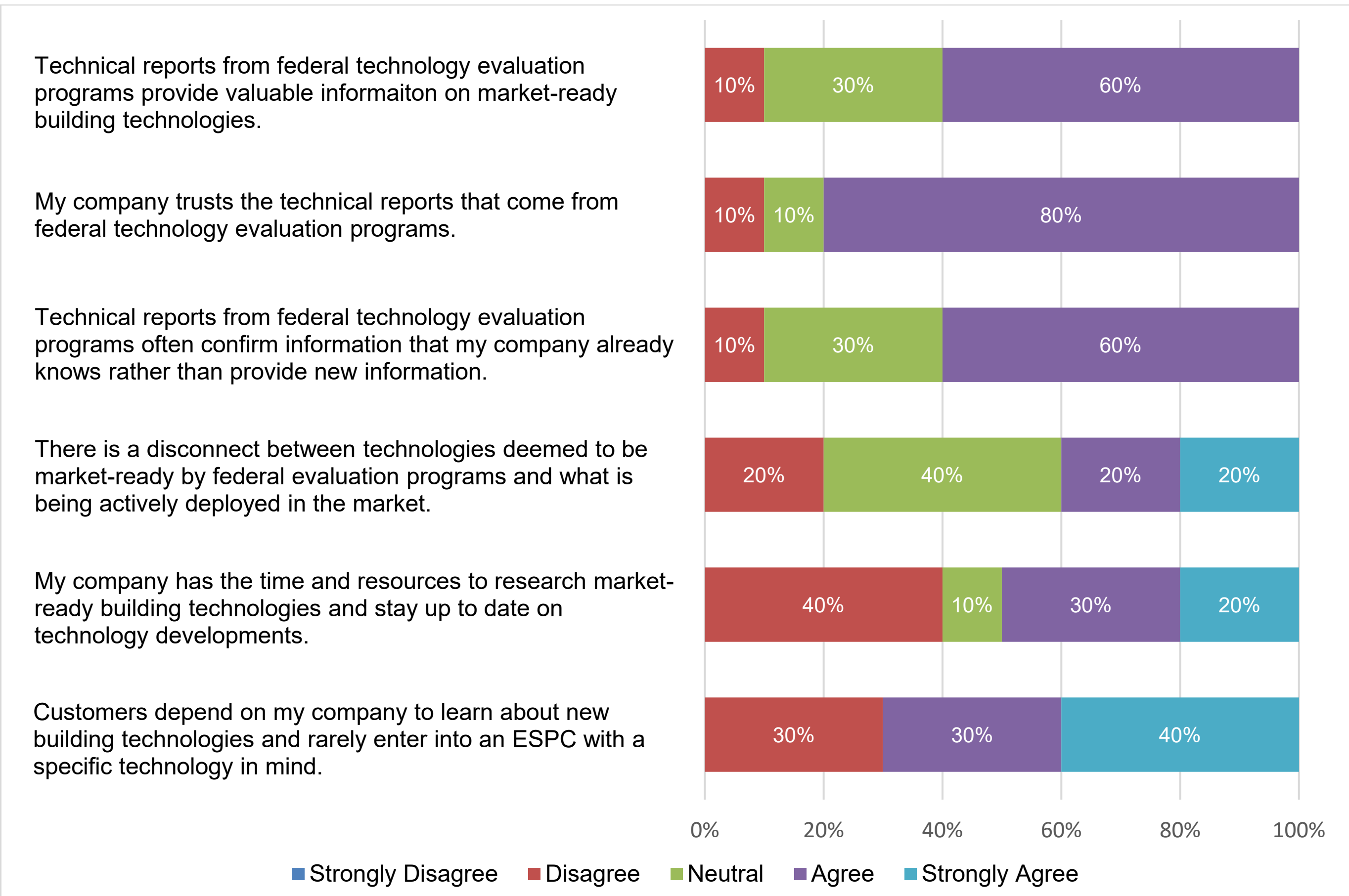

Figure 3. Evaluating how ESCOs view federal technology evaluation programs

ESCO responses to the following question, "Please rate the following statements on how strongly you either agree or disagree with them."

These responses may indicate that an information barrier exists between ESCOs and federal technology evaluation programs where technical reports on emerging technologies are regularly posted, but they are rarely looked at by ESCOs. Indeed, three ESCOs responded that they "never" or "rarely" look at technical reports published by federal technology evaluation programs. When ESCOs were asked about nine specific emerging building technologies in the survey, they were prompted to estimate how many of the technologies had been tested by a federal program (Figure 4). Four out of the eleven ESCOs thought that the number was less than 50% when really all the included technologies except for one had been tested by a federal technology evaluation program. While a small majority of the responding ESCOs did recognize that most of the technologies had been validated, this gap seems to support the idea of an informational barrier among ESCOs.

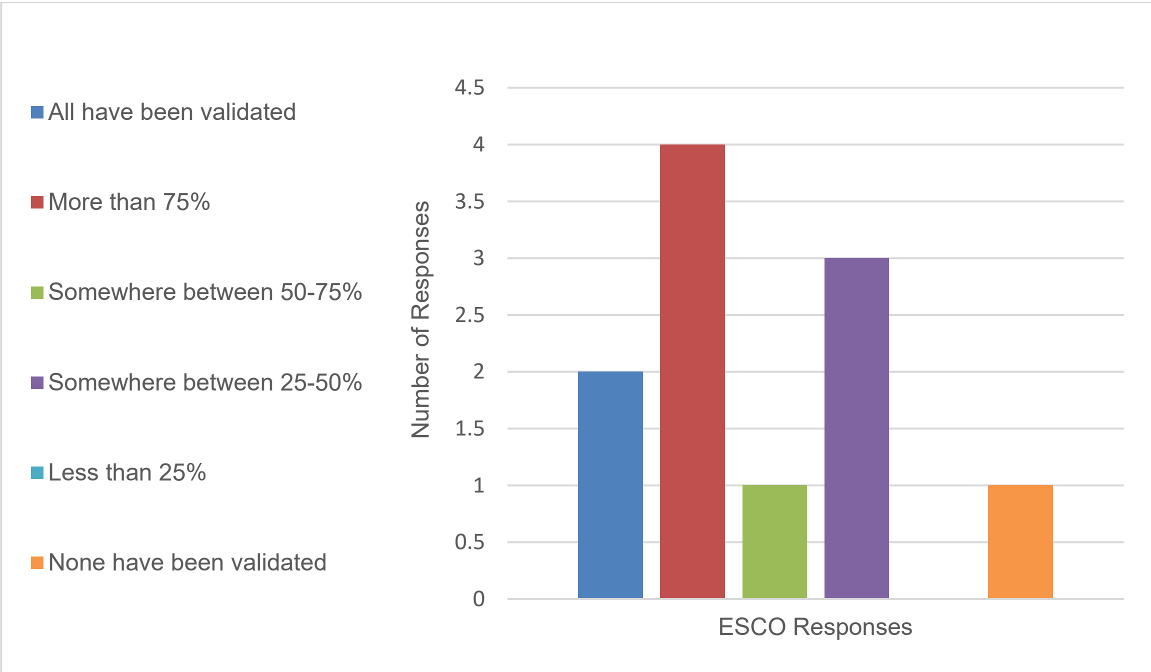

Figure 4. Examining ESCO recognition of federally validated building technologies

ESCO responses to the following question, "Out of the nine technologies listed in the previous question(s), how many of these building technologies would you estimate have been evaluated by a federal program?"

If this barrier is due to a lack of awareness that these reports exist, then the signaling of federal technology evaluation programs could be improved with meaningful outreach initiatives, such as offering periodic email updates. Hosting more webinars may be another helpful outreach initiative since one ESCO noted that was how they primarily kept up to date with different topics.

Another explanation could be that ESCOs are not interested in reading technical reports published by federal programs because they do not trust their ability to accurately measure a technology's performance and characterize its risks. Yet when the authors asked ESCOs how strongly they agreed with the statement that "My company trusts the technical reports that come from federal technology evaluation programs," a noteworthy 80% of ESCOs agreed. This trust in federal programs is strengthened by 54.5% of ESCOs agreeing with the statement that "Technical reports from federal technology evaluation programs provide valuable information on market-ready technologies."

These numbers suggest that there may not be as much of a broad mistrust in federal technology evaluation programs as prior research would indicate.[10] The ESCOs, however, also collectively agreed with the statement that "Technical reports from federal technology evaluation programs often confirm information that my company already knows rather than provide new information on building technologies." This could reveal an issue of confirmation bias among ESCOs where they trust the results of federal technology evaluation programs only insofar as they already agree with those results. In other words, if a federal technology evaluation program released a technical report endorsing a technology that goes against an ESCO's prior assessments, it may do little to change their minds. In the long run, this could hurt the ability of these programs to effectively signal high-quality technologies to ESCOs.

ESCOs also revealed a mixed response to the statement that "There is a disconnect between the technologies deemed to be market-ready by federal evaluation programs and what is being actively deployed in the market." As many ESCOs agreed with the statement (40%) as those that opted to stay neutral while 20% of ESCOs disagreed with it. When ESCOs were given the chance to elaborate on their answers, two ESCOs used the space to directly address their responses to the listed statements. One ESCO described some of the limitations they had seen with the technical reports, noting that they had been theoretical or contained small sample sizes. They commended the California Public Utility Commission for performing robust tests, but they explained that this information was not as helpful to them as most the program's work is targeted at residential buildings. Another ESCO touched on the point that "market ready means something else to each ESCO and each customer" and that some of the new market-ready technologies have extremely limited information for ESCOs to work from. This includes life cycle cost information, cost and benefit analyses, and return on investment figures that help customers assess a technology's performance. If federal technology evaluation programs cannot address these concerns, then their ability to assess the quality of a technology is significantly restricted.

2.2 Identifying High-Quality Emerging Building Technologies

In consultation with NREL subject matter experts, the authors selected nine emerging building technologies to highlight in the survey that they felt are currently being underutilized by the market (Table 1). The authors hoped to use this section of the survey to assess how many ESCOs have actual experience with these technologies and to gain an in-depth understanding of why they have not been deployed.

By far, the most successful technology reviewed by ESCOs were heat pump technologies (Figure 5). Nearly every ESCO had experience with the technology as well as positive reviews on its performance. Among the different types of heat pump technologies surveyed, ground-source heat pumps were among the most considered technologies followed by variable refrigerant flow heat pumps.

[10] See Appendix A.1.

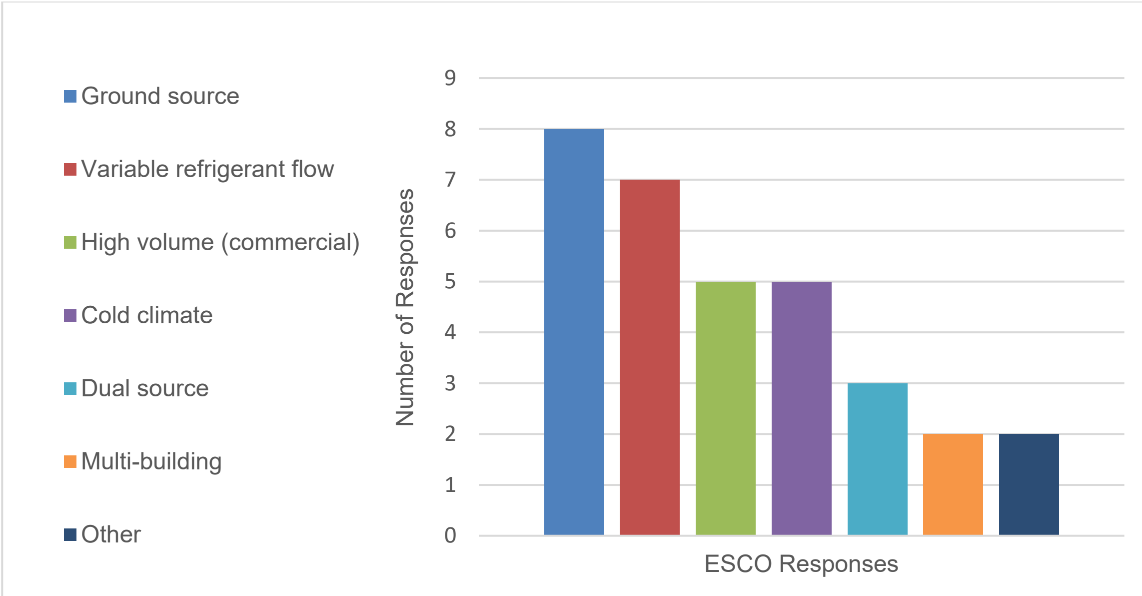

Figure 5. Different types of heat pump technologies considered by ESCOs

ESCO responses to the following question, "Which specific heat pump technologies has your company considered? Select all that apply."[11]

This feedback suggests that heat pumps are an especially promising technology in the federal performance contracting market and that ESCOs may see them as having broad deployment capability. When ESCOs were asked to explain what they felt were some of the biggest opportunities or drawbacks of the technology, they listed regionalism and the age of buildings as some of the most significant barriers to heat pumps. Some ESCOs noted that the payback period of heat pumps is not always what manufacturers indicate and that accurate measurement and verification processes are hard to establish. ESCOs also described how difficult it can be for heat pumps to compete against mainstream technologies since they are already in most buildings and are costly to upgrade. This limitation, in addition to a lack of installing subcontractors and the cheap price of natural gas, make it hard for ESCOs to move past "the traditional mindset of using central equipment," even when there are sizable energy savings at stake.

Six ESCOs left suggestions to the authors on how federal technology evaluation programs could be used to address these barriers, including evaluating future refrigerant options and recommending heat pumps by appropriate climate zones. Several ESCOs referenced the cost of heat pumps and how federal programs could be used to estimate accurate implementation costs and long-term O&M costs as well as guaranteed energy savings. One ESCO even recommended federal programs create "case-based electrical upgrade costs" that agencies could use as a benchmark during ESPC preliminary assessments.

[11] None of the ESCOs responded that they had experience with grid-interactive heat pump water heaters. The Other responses included "heat recovery chillers" and "unknown," potentially indicating no prior experience.

Table 1. Highlighted Emerging Building Technologies in NREL's Survey

This table describes how many of the nine selected technologies have been deployed by ESCOs and how many ESCOs viewed the technology with positive prospects or with concerns. Predicted estimates on payback period and O&M cost were summarized in consultation with NREL subject matter experts.

Technologies	Deployed by ESCOs	Viewed Positively	Expressed Concerns	Payback Period	O&M Costs
Energy management information systems	9	9	0	<5 years[a]	Lowered
Next generation high-performance chillers	8	10	0	2-5 years[b]	Minimal to lowered
High volume (commercial) heat pump water heater	8	9	2	3-4 years[c]	Minimal
Low-cost submeters	6	8	2	1 year[d]	Minimal
Alternative water treatment for cooling towers	5	8	2	2-3 years[e]	Lowered
LED light fixtures with integrated demand control	5	9	2	2-12 years[f]	Lowered
High-performance rooftop units	4	5	0	3-4 years[g]	Minimal
Hi-R Lo-E window inserts	3	5	4	7-9 years[h]	Minimal
Sorbent air cleaning for HVAC load reduction	2	5	2	<5 years[i]	Minimal

a GSA. 2022. "Energy Management Information System with Automated System Optimization GPG Findings." Accessed May 2023. https://www.gsa.gov/governmentwide-initiatives/climate-action-and-sustainability/center-for-emerging-building-technologies/published-findings/energy-management/energy-management-information-system-with-automated-system-optimization.

b Technical reports have been written on both variable-speed direct-drive screw chillers and variable-speed magnetic bearing chillers. Subject matter experts estimate a 2-year and 5-year payback period for each technology, respectively. Full reports can be found at https://www.gsa.gov/governmentwide-initiatives/climate-action-and-sustainability/center-for-emerging-building-technologies/published-findings/hvac/variablespeed-directdrive-screw-chiller and https://www.gsa.gov/governmentwide-initiatives/climate-action-and-sustainability/center-for-emerging-building-technologies/published-findings/hvac/variablespeed-magnetic-bearing-chiller.

c Emerging Technologies Coordinating Council. 2015. *Commercial Heat Pump Water Heaters*. Accessed May 2023. https://www.etcc-ca.com/reports/commercial-heat-pump-water-heaters?dl=1545270229.

d GSA. 2019. "Submeters and Analytics: Full Panel." Accessed May 2023. https://www.gsa.gov/governmentwide-initiatives/climate-action-and-sustainability/center-for-emerging-building-technologies/published-findings/energy-management/submeters-and-analytics-full-panel.

e GSA. 2020. "AWT: GSA Guidance for Cooling Towers." Accessed May 2023. https://www.gsa.gov/governmentwide-initiatives/climate-action-and-sustainability/center-for-emerging-building-technologies/published-findings/water/awt-gsa-guidance-for-cooling-towers.

f LED light fixtures with integrated demand control have a payback period of 9–12 years for retrofits and 2–3 years for new construction. Also see GSA. 2015. "LED Fixtures with Integrated Advanced Lighting Controls." Accessed May 2023. https://www.gsa.gov/governmentwide-initiatives/climate-action-and-sustainability/center-for-emerging-building-technologies/published-findings/lighting/led-fixtures-with-integrated-advanced-lighting-controls.

g GSA. 2018. "High-Performing Commercial Rooftop Units." Accessed May 2023. https://www.gsa.gov/governmentwide-initiatives/climate-action-and-sustainability/center-for-emerging-building-technologies/published-findings/hvac/highperforming-commercial-rooftop-units.

h GSA. 2013. "Hi-R Low-E Window Retrofit System." Accessed May 2023. https://www.gsa.gov/governmentwide-initiatives/climate-action-and-sustainability/center-for-emerging-building-technologies/published-findings/building-envelope/hir-lowe-window-retrofit-system.

i Full technology demonstration report did not include payback figures, but performance metrics for the technology can be found at: enVerid Systems. 2021. "enVerid Systems Launches New HVAC Load Reduction Product, Delivering Immediate Savings for Commercial and Institutional Buildings." Accessed May 2023. https://enverid.com/awards/enverid-systems-launches-new-hvac-load-reduction-product-delivering-immediate-savings-for-commercial-and-institutional-buildings/.

Other successful emerging building technologies that the authors found ESCOs deployed with favorable results included low-cost submeters and next generation high-performance chillers, like magnetic bearing and variable-speed direct-drive screw chillers. Compared to other technologies listed in the survey, next generation high-performance chillers have a reasonably good payback period as well as minimal O&M costs. Next generation high-performance chillers also provide the additional benefit of operating quietly, which one industry specialist the authors spoke to believed was the primary reason ESCOs were being asked to include them in ESPCs. "Brand-ask" technologies like these can reveal important signals federal agencies look for when assessing emerging building technologies, which can be used to accelerate their deployment.

Energy management information systems were viewed favorably by ESCOs as well and behind heat pumps had the highest deployment rate out of the nine technologies. Energy management information systems fit into a much larger group of technologies for monitoring-based commissioning (MBCx), which the authors and NREL subject matter experts also believed were currently being underutilized in the market (Figure 6).

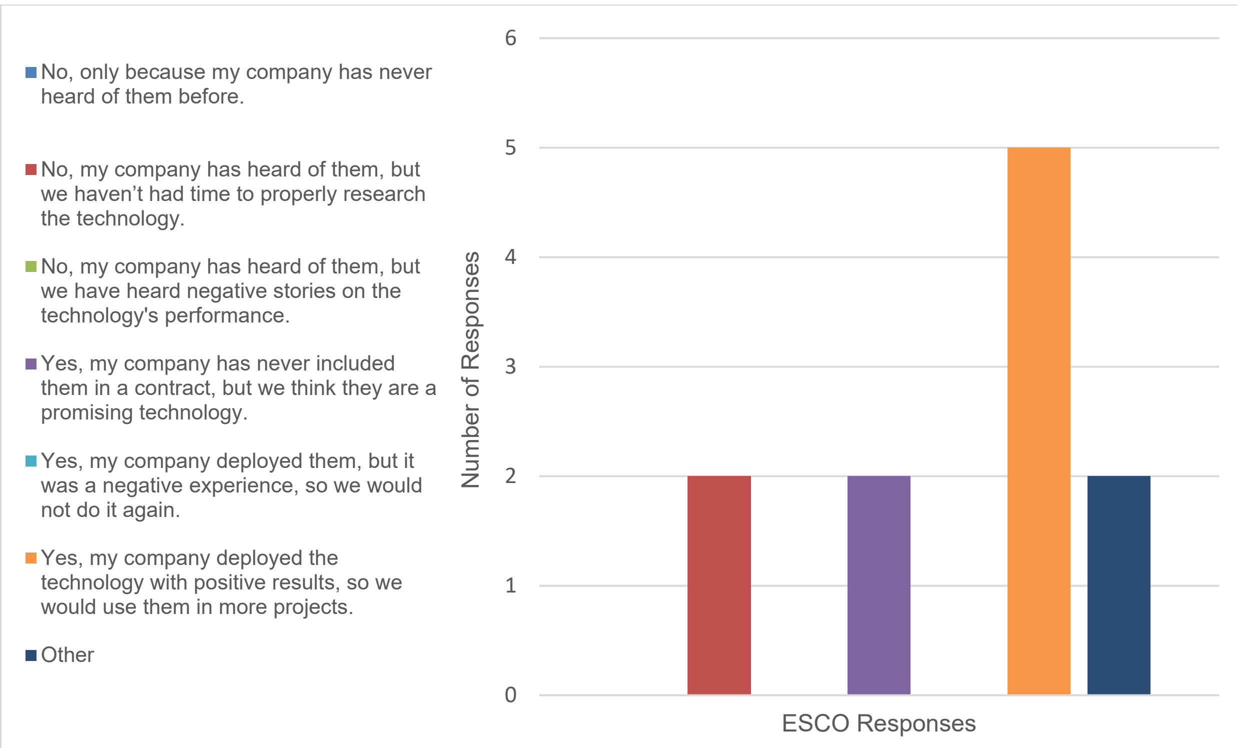

Figure 6. Different types of MBCx considered by ESCOs

ESCO responses to the following question, "Has your company considered deploying any type of MBCx technologies in a performance contract?"[12]

[12] The Other responses from ESCOs included "Yes, [it's] difficult to calculate/guarantee energy savings; real time not typically possible at [Department of Defense] sites due to cybersecurity concerns with off-site data comms" and "Some agencies have heavy [measurement and verification] requirements with [tight] measure so its economics can be prohibitive."

When the authors asked ESCOs to describe their experiences with MBCx and whether they considered deploying any type of MBCx in a performance contract, their responses were mostly positive but hesitant. Overall, the majority of ESCOs had positive impressions of MBCx with five of the eleven ESCOs deploying MBCx with favorable results. Yet several ESCOs detailed how difficult MBCx can be to implement at federal sites, particularly for the Department of Defense that has stricter cybersecurity requirements.

Federal agencies typically maintain tight cybersecurity regulations to protect themselves from adversaries, but these regulations can work against MBCx if it prevents ESCOs from using operational data to identify meaningful energy conservation measures. ESCOs also expressed concerns in arming facility staff with enough knowledge and confidence to interpret the data and use the information effectively in the long run. These issues in addition to expensive annual licensing costs at least in part explain why MBCx has not been able to make as many gains into the federal performance contracting market.

When asked how federal technology evaluation programs could help, some ESCOs argued the programs could publish more case studies on the standards ESCOs would need to meet in order to successfully implement MBCx. These suggestions included working with the Federal Information Services or creating a set of systems that allow agencies to export their energy use. One ESCO highlighted working with automated scriptwriting "since the technology is already widely available on the market," but the primary request was to overcome cybersecurity regulations.

Energy management information systems, heat pumps, next generation high-performance chillers, and low-cost submeters were among the top technologies ESCOs appeared to consider high-quality and were expected to incorporate into future ESPCs. While there were other notable technologies with strong deployment numbers, these technologies were either not regarded as positively or encountered more apprehension from ESCOs. Hi-R Low-E window inserts, however, and sorbent air cleaning technologies for HVAC load reduction were among the most contentious technologies ESCOs were surveyed about as they had the lowest deployment numbers.

Hi-R Low-E window inserts received the most criticism in ESCO responses, with three of the eleven ESCOs explaining how they had either heard poor stories on their performance or had deployed them with negative results. One ESCO explained that "window inserts have never offered an attractive payback" for the company. In contrast, while sorbent cleaning technologies had the lowest deployment numbers, a significant portion of ESCO responses would indicate that this is mostly due to unfamiliarity. Three of the ESCOs answered that they had either never heard of the technology or that they still needed the time to properly research it. High maintenance costs, however, were cited as an issue one ESCO had with the technology when evaluating it. Looking across the portfolio of selected technologies, ESCO responses seem to support how powerful payback periods and O&M costs can be in an ESCO's decision-making and how even successful demonstrations can still encounter challenges in changing an ESCO's perspective.

2.2.1 Recommendations for Deploying Emerging Building Technologies

The adverse selection model has historically recommended markets correct informational asymmetry by creating systems or incentives that encourage information exchange across all parties so that participants can make informed decisions. In absence of exchanging information, the adverse selection model also recommends implementing risk-sharing mechanisms that allow parties with the least information to engage in market transactions without suffering a complete loss. Responses from ESCOs revealed similar suggestions, such as improving federal technology evaluation programs to incorporate more performance metrics or sharing the risk of new technologies by shifting O&M responsibilities to federal agencies.

Yet ESCOs detailed their struggles to authors in finding agreeable risk-sharing solutions, describing how often agencies will not take on the risk of emerging building technologies. One ESCO noted that there is “a great reluctance by agencies to utilize new technologies” and that “some agencies outright refuse to change.” These comments relate back to a separate conversation the authors had with an industry specialist who resisted the assumption that ESCOs were a risk-adverse industry. The specialist explained how ESCOs have a whole business model dedicated to risk management, so risk by itself is not always the issue when it comes to deploying emerging technologies. Finding a way to manage risk with an energy-savings guarantee can be the real barrier as it may create a larger contingency with a longer payback period, which is usually unappealing to customers financially.

To find solutions, the authors asked ESCOs to list how DOE’s Federal Energy Management Program (FEMP) could help ESCOs navigate these challenges and deploy more market-ready technologies. Half of the ESCOs specified risk-sharing as the primary vehicle that would help them deploy more technologies, such as awarding more grants to pay or shorten the payback for emerging technologies or altering their measurement and verification requirements. Several ESCOs pointed out how funding pilot programs would generate more case studies and larger sample sizes that ESCOs could use to work out the economics for future projects. Even outside of risk-sharing solutions, one ESCO described how FEMP could help the deployment of emerging building technologies by developing “predictive energy savings calculations that are easily adaptable and could be used for measurement and verification.”

Three ESCOs, however, believed FEMP’s most important role should be in distributing information to agencies on emerging building technologies, such as creating “a list of approved products” agencies could refer to when executing building renovations. Indeed, FEMP is in the best position to target federal agencies, which can have a measurable impact on exposing federal facility staff to more emerging building technologies and how to perform O&M. FEMP can expose agencies to emerging technologies by encouraging them to sign up for mailing lists from federal technology evaluation programs or publishing technical guides that detail proper O&M for building technologies. These strategies can provide agencies with the resources they need to feel confident in accepting O&M responsibility and create more brand-ask technology pathways.

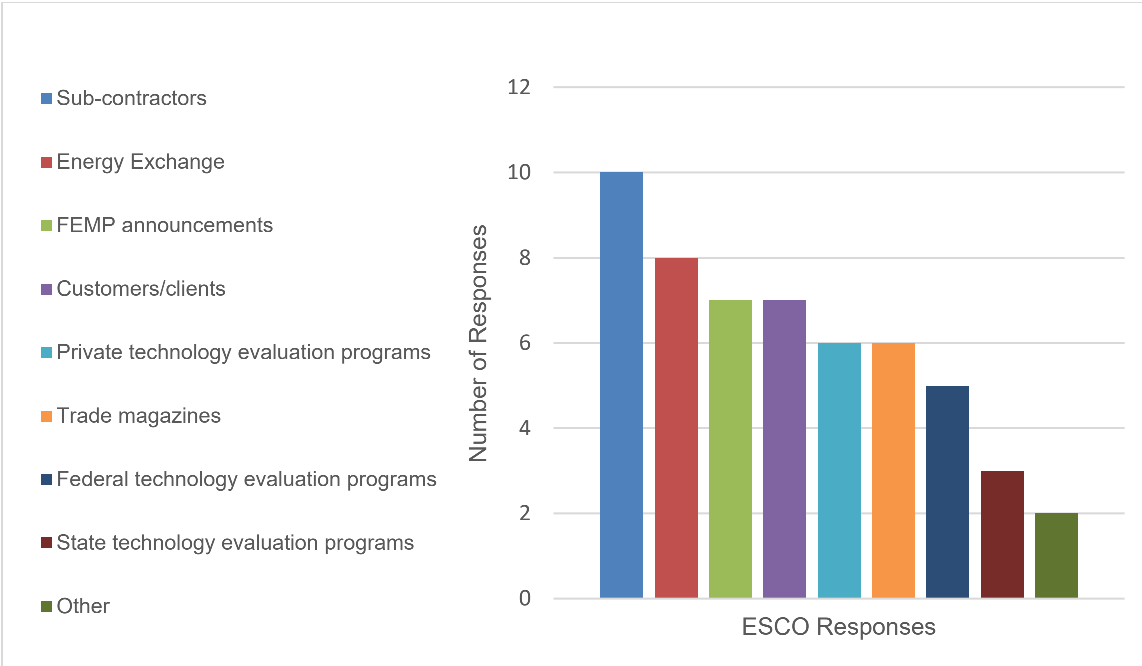

Figure 7. ESCOs sources of information on potential new technologies

ESCO responses to the following question, "From where does your company receive information on potential new technologies and innovation? Select all that apply."[13]

One industry specialist the authors spoke with suggested that owners of emerging building technologies should be invited to more forums designed to exchange ideas and information. One forum included FEMP's Energy Exchange since there are ESCOs that attend the conference every year.[14] When ESCOs were asked from where they receive most of their information on potential new technologies, Energy Exchange was among the highest rated responses following sub-contractors (Figure 7). In this way, inviting owners of emerging building technologies to Energy Exchange does not just benefit ESCOs but federal agencies as well. FEMP announcements and ESCO customers/clients, meanwhile, had the third-highest rated response, revealing how much of an influence FEMP has in this space to drive deployment decisions. Notably, only half of the ESCOs indicated that they get their information from federal technology evaluation programs.

[13] The Other responses from ESCOs included the Association of Energy Engineers as well as researching incubators to invest in new technologies "that are consistent with our core business."
[14] See Appendix A.2.

3 Conclusion

Overall, these early survey responses by ESCOs indicate that federal technology evaluation programs do have the potential to act as signaling mechanisms in the federal performance contracting market. ESCOs generally trust the reports that federal technology evaluation programs produce but feel that they are incomplete without more performance metrics and robust testing. These metrics include current signals like payback periods and O&M costs, as well as life cycle costs and returns on investment. ESCOs may additionally face constraints on their ability to consume all the reports these programs generate, which is why meaningful outreach initiatives could strengthen the effect of these signals and their impact on the market. Concurrently, technologies like heat pumps and next generation high-performance chillers can provide pathways to study the deployment and branding of successful emerging technologies. The survey also highlighted the importance of O&M expertise for both ESCOs and federal facilities in addition to the availability of warranties and parts. Successful and commercially available emerging building technologies depend not just on the technology's ability to be cost-effective but its access to a distribution network that can maintain the technology for the long-term.

While the adverse selection model was a helpful lens to view the current market dynamic between ESCOs and the owners of emerging building technologies, it is an ultimately incomplete picture since the federal performance contracting market contains notably more players. Among these players, federal agencies were heavily referenced by ESCOs in their responses on driving the deployment of emerging technologies, aiding the authors in understanding how agencies respond to different incentives and have their own risk profile and preferences. FEMP in this regard can help agencies navigate the challenges of O&M to new technologies and even help ESCOs share the risk of new projects. Considering these factors, future areas of research for this topic should address the customer-side of federal performance contracting and what signals federal facilities look for when acquiring a new technology. Such research would help the authors find more creative solutions to the barriers of underutilized technology deployment.

Glossary

Term	Definition
GPG	Green Proving Ground is a federal technology evaluation program funded through the General Services Administration, which owns and leases over 8,600 buildings that include offices, laboratories, and courthouses.[15] This range of access to different building types helps GPG test technologies under multiple conditions and most closely replicate real-life scenarios to validate the technology's performance.
ESTCP	Environmental Security Technology Certification Program is a federal technology evaluation program funded by the U.S. Department of Defense. ESTCP uses the agency's facilities to identify building technologies that can not only meet the Department of Defense's energy requirements but its tight security and reliability standards as well.[16]
HIT Catalyst	High Impact Technology Catalyst is a federal program designed to accelerate the deployment of energy-efficient technologies within the commercial buildings industry. The program does this by identifying pathways for technology integration, such as innovation challenges, technology demonstrations, application resources, and adoption campaigns.[17]

[15] A description of the General Service Administration and its building inventory can be found at https://www.gsa.gov/real-estate/gsa-properties.
[16] To learn more about the ESTCP strategy and process, consult https://www.serdp-estcp.org/about/programs?Id=cf88fbc0-872d-4b9b-9673-d08833e7bb9a.
[17] For more information about the HIT Catalyst program, visit https://www.energy.gov/eere/buildings/high-impact-technology-catalyst.

References

Domitrovic, R. 2015. *Commercial Heat Pump Water Heaters: Evaluation of Field Performance for San Diego Gas & Electric (SDG&E)*. Palo Alto, CA: Electric Power Research Institute. 3002005496. https://www.etcc-ca.com/reports/commercial-heat-pump-water-heaters?dl=1545270229.

enVerid. 2021. "enVerid Systems Launches New HVAC Load Reduction Product, Delivering Immediate Savings for Commercial and Institutional Buildings." Accessed March 23, 2023. https://enverid.com/awards/enverid-systems-launches-new-hvac-load-reduction-product-delivering-immediate-savings-for-commercial-and-institutional-buildings/.

Environmental Security Technology Certification Program. "About." Accessed March 23, 2023. https://www.serdp-estcp.org/about/programs?Id=cf88fbc0-872d-4b9b-9673-d08833e7bb9a.

Federal Energy Management Program. 2023. "DOE Qualified List of Energy Service Companies." Accessed March 23, 2023. https://www.energy.gov/eere/femp/articles/doe-qualified-list-energy-service-companies.

Federal Energy Management Program. "Energy Savings Performance Contracts for Federal Agencies." Accessed March 23, 2023. https://www.energy.gov/eere/femp/energy-savings-performance-contracts-federal-agencies.

Federal Energy Management Program. "Federal ESPC Process Phase 5: Post-Acceptance Performance." Accessed March 23, 2023. https://www.energy.gov/eere/femp/federal-espc-process-phase-5-post-acceptance-performance.

General Services Administration. "GSA Properties." Accessed March 23, 2023. https://www.gsa.gov/real-estate/gsa-properties.

General Services Administration. December 2013. "Published Findings: Variable-Speed Magnetic Bearing Chiller." https://www.gsa.gov/governmentwide-initiatives/climate-action-and-sustainability/center-for-emerging-building-technologies/published-findings/hvac/variablespeed-magnetic-bearing-chiller.

General Services Administration. December 2013. "Published Findings: Hi-R Low-E Window Retrofit System." https://www.gsa.gov/governmentwide-initiatives/climate-action-and-sustainability/center-for-emerging-building-technologies/published-findings/building-envelope/hir-lowe-window-retrofit-system.

General Services Administration. August 2015. "Published Findings: LED Fixtures With Integrated Advanced Lighting Controls." https://www.gsa.gov/governmentwide-initiatives/climate-action-and-sustainability/center-for-emerging-building-technologies/published-findings/lighting/led-fixtures-with-integrated-advanced-lighting-controls.

General Services Administration. November 2017. "Published Findings: Variable-Speed Direct-Drive Screw Chiller." https://www.gsa.gov/governmentwide-initiatives/climate-action-and-sustainability/center-for-emerging-building-technologies/published-findings/hvac/variablespeed-directdrive-screw-chiller.

General Services Administration. April 2018. "Published Findings: High-Performing Commercial Rooftop Units." https://www.gsa.gov/governmentwide-initiatives/climate-action-and-sustainability/center-for-emerging-building-technologies/published-findings/hvac/highperforming-commercial-rooftop-units.

General Services Administration. May 2019. "Published Findings: Submeters and Analytics: Full Panel." https://www.gsa.gov/governmentwide-initiatives/climate-action-and-sustainability/center-for-emerging-building-technologies/published-findings/energy-management/submeters-and-analytics-full-panel.

General Services Administration. January 2020. "Published Findings: Alternative Water Treatment For Cooling Towers." https://www.gsa.gov/governmentwide-initiatives/climate-action-and-sustainability/center-for-emerging-building-technologies/published-findings/water/awt-gsa-guidance-for-cooling-towers.

General Services Administration. September 2022. "Published Findings: Energy Management Information System with Automated System Optimization." https://www.gsa.gov/governmentwide-initiatives/climate-action-and-sustainability/center-for-emerging-building-technologies/published-findings/energy-management/energy-management-information-system-with-automated-system-optimization.

Office of Energy Efficiency and Renewable Energy. "High Impact Technology Catalyst." Accessed March 23, 2023. https://www.energy.gov/eere/buildings/high-impact-technology-catalyst.

Appendix A. Background and Preliminary Research

Even though prior research on this topic has been limited, the authors were able to investigate early leads on potential deployment barriers, which enabled them to narrow the scope of their questions and eventually draft a survey to ESCOs.

A.1 NREL Study With ESCOs at the Department of Defense

One of the most important sources the authors consulted for this report was an unpublished study done by the National Renewable Energy Laboratory (NREL), where researchers polled ten different ESCOs specifically working at sites for the U.S. Department of Defense in 2017. Although the research was geared more toward understanding the deployment of renewable technologies in ESPCs, researchers gained several important insights into the federal performance contracting market that directly speaks to the issues raised in this report.

The first insight they gained was that risk, like labor and equipment, is a cost for ESCOs, which must be accounted for when drafting an ESPC. The larger the risk is for an ESCO, the larger their potential costs can be for a project, which can ultimately disincentivize ESCOs from deploying emerging building technologies.

Through interviews with ESCOs, the researchers identified four main categories of risk that can occur when working with an emerging building technology:

- **Corporate financial risk,** which occurs when a small technology company goes out of business, leaving ESCOs on the line for a technology's long-term maintenance. Warranties for technologies are only as good as the companies that offer them, and if ESCOs are not confident that a company will stay in business long enough to fulfill warranties, it decreases their trust in the technology.

- **Corporate execution risk,** which refers to the risk that can happen when a business grows too quickly. If a technology company cannot keep up with the demand for different technologies or technology parts, it can create supply delays, which can lead to customer dissatisfaction. This increases the risk for ESCOs as it damages the relationship ESCOs establish with their clients.

- **Schedule risk,** which describes the risks ESCOs can incur if scheduling times for a project take longer than anticipated. ESPCs are drafted to reflect the expected costs of a project as closely as possible, but these costs can grow more vulnerable to volatility as time passes, such as sudden price changes in fuel, labor, commodities, or interest rates. For this reason, if an emerging building technology has a longer payback period, it can deter ESCOs from deploying it in an ESPC.

- **Scaling up risk,** which transpires whenever ESCOs perform a demonstration for an emerging building technology. Due to the novel nature of an emerging building technology, ESCOs will typically want a demonstration that can be scaled up to ten times larger than the average demonstration site to ensure accurate performance results. The larger demonstration scales, however, will likely require higher costs to execute, which will introduce more risk to a technology's deployment. Even then, the demonstrations may not reveal the building technology's long-term maintenance costs.

These risks, some of the ESCOs felt, are not fully addressed by the current federal performance contracting structure when to comes to emerging building technologies since ESCOs bear the ultimate responsibility for the contract. ESCOs must guarantee energy savings and ensure that a building technology is functioning as it should.

Underlining all the categorized risks was also a fifth implicit risk that ESCOs might suffer the loss of their reputation if a project went badly. Many ESCOs expressed how important their reputations were to building client relationships, so one risky technology's disastrous performance could not only jeopardize the current project but future ones as well. Clients place a lot of trust in ESCOs to properly execute their projects and they will not want to hire ESCOs if they have the perception of "not knowing what they are doing," as one ESCO put it.

The researchers conducted follow-up interviews with five of the ten ESCOs to determine if any of the identified risks for building technologies could be resolved. One idea the researchers brought up to ESCOs included facilitating more ESCO engagement in federal technology evaluations so that they could see the steps involved in the demonstration and develop a "hands on" comfort level with that technology. None of the ESCOs, however, exhibited keenness for this idea as they felt this would be an expensive diversion of time and resources for a process they would still likely do internally.

The ESCOs interviewed instead seemed more interested in "risk-sharing" solutions, such as updating the FEMP Risk Matrix or offering emerging building technologies at a lower price.[18] The ESCOs also noted that they work with a lot of risk-adverse clients who just want to get a chiller or boiler replaced as opposed to investing in a new technology. While a client may exhibit an initial interest in including a cutting-edge technology in the ESCP, this interest would usually fade as concerns over maintenance and risk became more prominent. In which case, clients, particularly federal agencies, would default to technologies that their operations and maintenance (O&M) staff already understood.

The researchers ultimately concluded that more research was needed to understand the barriers to innovative technology deployment.

A.2 Preliminary Research With Industry Specialists

The authors held meetings with specialists in different fields of the industry to assess whether they had seen similar barriers and if they could offer any new information on how these barriers may be addressed.

Speaking to researchers, two specialists with experience in federal technology evaluation programs confirmed the difficulty emerging building technologies can face in the federal

[18] The full FEMP Risk Responsibility & Performance Matrix can be found at https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiV1Kiq7cr-AhXskmoFHbR5DZsQFnoECBQQAQ&url=https%3A%2F%2Fwww.energy.gov%2Ffemp%2Farticles%2Fespc-risk-responsibility-and-performance-matrix&usg=AOvVaw3kxEba_JqhWyyQE1tmYO7y.

performance contracting market. They described how many of the innovative building technologies that have gone through these programs either have long payback periods or are difficult to quantify from a measurement and verification perspective. Neither of these qualities have historically made emerging building technologies a good fit for a typical ESPC where savings must be guaranteed, even when they are net-zero or carbon-free technologies. While there are some ESCOs who are interested in utilizing innovative technologies, the specialists explained that ESCOs consider themselves largely to be part of the construction industry and can be conservative in taking on innovative technologies and their associated risks.

Both specialists also confirmed how important the customer's own risk aversion can be when trying to implement emerging building technologies. They noted that agency teams managing ESPCs are primarily interested in reducing energy use and utility costs, and that the upside benefits of championing an innovative technology do not commensurate the downside risks of championing a failed or unsupported technology. This is particularly true if the technology's O&M costs are significant and require ongoing management by the agency's O&M staff.[19] In addition to these barriers, both specialists explained how many of the new technologies being developed by small companies are critically derailed by an agency's cybersecurity validation requirements, such as if a technology has a cloud component.

They suggested how policies targeting customer concerns over emerging building technologies can encourage their deployment. This includes revising federal building standards to promote innovative technologies, updating cybersecurity provisions, or even focusing efforts to deploy technologies that have benefits that go beyond energy savings. One specialist noted that magnetic bearing chillers have had significant up-take from ESCOs in large part because they are a "brand ask" technology. Building managers frequently request that magnetic bearing chillers be included in ESPCs because they appreciate how quietly they operate, demonstrating how important of a role customers can play in encouraging the deployment a technology, especially if the technology has non-energy benefits.

The authors held another meeting with a different industry specialist who came from an ESCO-related background. The specialist confirmed that many ESCOs see themselves as a construction group hired to execute building renovations, which is why they need more information on the distribution process of a new technology before including it in a contract. This includes who to talk to about installing the technology, buying it, delivering it, and receiving proper training to perform O&M. Technologies that do not have a comprehensive distribution system set up represent a significant barrier, especially if ESCOs have to invest time and resources to gather this information.

The specialist rejected the assumption that just because ESCOs are a construction group meant that they were a risk-averse industry. ESCOs have a whole business model dedicated to risk management, so risk by itself is not always the issue when it comes to deploying newer technologies. If a customer really wants a technology, most ESCOs will install that technology, regardless of risk. Finding a way to manage that risk with an energy-savings guarantee, though,

[19] For information on the ESPC process, visit https://www.energy.gov/eere/femp/federal-espc-process-phase-5-post-acceptance-performance.

can be more complicated as it may have a larger contingency with a longer payback period, which is usually unappealing to customers financially.

Another important distinction the specialist made that separates ESCOs from other construction groups is the fact that ESCOs usually have a longer relationship with their customers, even years after the ESPC has ended. While most construction projects have a one-year warranty, ESCOs tend to live with a project much longer than the warranty period, especially if the ESCOs are working with an advanced technology. The specialist reaffirmed how important reputations are for this reason and how most ESCOs have to weigh making their customers happy against managing a high-risk technology.

The specialist also agreed that cybersecurity issues can represent a significant barrier to ESCOs in deploying new technologies since there are no clear standards on what to do to meet a customer's cybersecurity requirements. By the time a cybersecurity evaluation is done, the product could become obsolete where the next model of that technology is out and the one that was approved is no longer available. A cybersecurity check involves making sure that there are "no bugs" in the technology, but that can be nearly impossible to determine upfront. This is why technology companies perform continuous updates to clean up the bugs as they find them, making it more difficult in the long run for ESCOs to navigate which technologies can be approved.

Overall, these meetings provided the authors with valuable information that they had not previously considered, making them beneficial points of reference to draw upon when drafting the survey.

Appendix B. Survey Design and Distribution

The authors used this prior research to narrow the survey's focus and develop a framework to analyze survey responses.

B.1 Developing the Adverse Selection Model (continued)

Working under the adverse selection model, the authors identified the owners of emerging building technologies as the parties with the most information regarding their technology's performance. The adverse selection model, however, also contends that this is an informational dynamic that ESCOs are aware of, which could affect how ESCOs view emerging building technologies in general.

In NREL's 2017 report, one ESCO described how participating in a federal technology demonstration would be "a waste of time" since their staff could be chasing meaningful work instead of "playing around" with "science projects."[20] The thought of emerging building technologies as "science projects" if widespread enough could potentially jeopardize market transactions and create the assumption that all emerging building technologies are high-risk and unprofitable. In other words, fair and surplus-generating transactions could have happened if ESCOs had all the information on a technology's performance and could have used this information to identify high-quality emerging building technologies from low-quality ones. This is similar to the breakdown documented in the Technological Valley of Death where, due to a lack of funding and support, innovative technologies fail to achieve broad market penetration and these business ventures fail completely.

This is why the adverse selection model identifies signaling as a powerful tool to aid both parties in collecting information and in creating fair, surplus-generating transactions. For signaling to be effective, owners of high-quality emerging building technologies must send signals that owners of low-quality technologies cannot afford to; otherwise, these companies would just replicate those signals.

Previous research on this topic has helped the authors identify small payback periods and minimal O&M as signals ESCOs use to assess the viability of an emerging building technology.[21] These are signals that can be validated through a federal technology evaluation program. Indeed, this is the role federal technology evaluations programs are meant to serve where evaluators can act as impartial third parties to test and validate the performance of an emerging building technology. Not only can federal technology evaluation programs validate signals that ESCOs are already looking for, but they can also act as a filter by only selecting the most promising technologies for demonstrations. In this way, just participating in a federal technology evaluation program can be a signal in of itself since technology companies have to go through a rigorous selection process to even be considered.

Yet federal technology evaluation programs have not been able to make as significant of an impact as they should be under this framework. The reasons for this relate back to some of the concerns stated by ESCOs in NREL's 2017 study. Short demonstration timeframes, limited

---

[20] See Appendix A.1.
[21] See Appendix A.2.

sample sizes, and small demonstration scales were all listed as potential explanations ESCOs had for being weary of federal technology evaluation programs and their ability to accurately collect performance data.[22]

There was also the sentiment among ESCOs that federal evaluators would not approach demonstrations with the same level of scrutiny as ESCOs would, considering ESCOs are the parties bearing the risk for that technology. ESCOs explained that they tend to trust their own validation process the most and one ESCO even expressed apprehension to researchers that federal technology evaluation programs are driven by technology companies. Their reasoning stemmed from the observation that the goal of federal technology evaluation programs is to validate technologies and positively review them in order to increase their market acceptance. A technology demonstration is a lengthy process and can cost millions of dollars to execute, so federal evaluators may feel pressure to create a “win” for that technology and would not review demonstration results with the same objectives as ESCOs would.[23] This possible mistrust in federal technology evaluation programs may explain why their ability to send signals to ESCOs is severely restricted.

The authors wanted to explore these questions and more when drafting the survey.

B.2 Designing and Distributing the Survey

Considering how wide-ranging the scope of the survey could be, the authors intentionally narrowed down their questions to address four topics, acknowledging that a longer survey could impact the response rate of ESCOs. For each of the four sections, the authors described their objectives to ESCOs and what information the researchers hoped to gain by creating the survey.

The authors designed the first section of the survey to gather information on how ESCOs identify market-ready building technologies. This included asking questions on how ESCOs perceive federal technology evaluation programs and how they receive information on emerging building technologies in general. Questions drafted for this section targeted some of the statements made during the authors’ preliminary research, such as whether ESCOs trusted the results from federal technology evaluation programs.

The second section of the survey addressed the actual deployment of market-ready building technologies and asked ESCOs what their experiences were with a specific list of technologies. The authors selected nine building technologies to highlight in the survey after consulting NREL subject matter experts on which technologies they believed were ready to be deployed on a commercial level. The authors also only selected building technologies that had already been validated by a federal technology evaluation program. The goal for this section was to collect real deployment data on emerging building technologies since this information has been limited and to determine the motivations behind their deployment. In other words, the authors wanted to see if ESCOs had any experience in deploying these technologies and if they had positive or negative impressions of the technology.

---

[22] See Appendix A.1.
[23] See Appendix A.1.

The last two sections of the survey were drafted to provide the authors with more in-depth responses regarding two building technologies that NREL subject experts had expressed particular interest in understanding why they were being currently underutilized. These two technologies were heat pump technologies and monitor-based commissioning (MBCx) technologies. The survey asked ESCOs to specify which variations of the technologies they had considered deploying and to elaborate on what they perceived as being the greatest opportunities and the greatest drawbacks of incorporating them into an ESPC.

In total, the survey contained thirty-three questions and the authors estimated that the survey would take ESCOs no longer than fifteen minutes to complete after sending the survey to NREL colleagues and averaging their completion times.

Once the survey was finalized, the authors distributed it to ESCOs during two stages of outreach in order to cast the widest net of possible responses. The first distribution period involved emailing ESCOs that had been identified by DOE to have the proper qualifications to work with federal agencies. DOE updates and publishes this list of qualified ESCOs every year in accordance with the Energy Policy Act of 1992 to let federal agencies know which ESCOs have experience carrying out federal contracts.[24] The authors sent two emails to all 111 contacts on this list, the first email to inform them of the opportunity to take the survey and the second one to remind ESCOs to complete it.

The second distribution period occurred during the 2022 Energy Exchange where the authors directly spoke to ESCOs attending the conference about the survey and handed them business cards with a QR code to take the survey online. A final email was sent out to alternate DOE-Qualified ESCO contacts a month after Energy Exchange who the authors believed had more experience in sales compared to the first list of contacts who were more involved in managing the company. In this way, the authors worked thoroughly to ensure ESCOs with federal performance contracting experience were targeted for the survey and that a diverse background of ESCO employees had the opportunity to take the survey before closing the response window.

[24] To see the complete list of DOE-Qualified ESCO contacts, visit https://www.energy.gov/eere/femp/articles/doe-qualified-list-energy-service-companies.