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The Current State of the Data Center Optimization Initiative: Lessons Learned & Opportunities for Improvement

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EXECUTIVE SUMMARY

Established by the U.S. Office of Management & Budget (OMB) in 2016, The Data Center Optimization Initiative (DCOI) seeks to improve data center operations across 24 federal agencies and aid them in realizing significant energy and cost savings. As of March 2021, these federal agencies operated 2,596 data centers under the purview of DCOI. This report assesses the current state of DCOI implementation among federal agencies and makes recommendations for how the U.S. Department of Energy's (DOE's) Federal Energy Management Program (FEMP) can help support agencies in their quest for not only DCOI compliance but also achieving energy and cost savings in one of the most resource intensive facility types in the federal building stock. We find that while significant progress (in terms of data center cost savings, closures, and optimization metrics) has been made, inconsistencies in reporting, data quality issues, and policy changes compromise the overall impact of DCOI. For example, the exclusion of non-tiered data centers in the 2019 DCOI policy update (M-19-19) leaves thousands of federal data centers unreported and unaddressed (many of which are sizable – over 1,000 square feet). Our review also finds that certain DCOI components have proven difficult to implement. In particular, agencies responsible for implementation or oversight of DCOI have had difficulty in developing accurate data center counts (further complicated by shifts in policy), in continuing to close and consolidate data centers, in communicating and enforcing an agency-wide DCOI strategy and in meeting optimization metrics – particularly monitoring and virtualization. FEMP and other stakeholders could improve DCOI implementation and outcomes across agencies by developing tools, trainings and reporting templates, and bolster integration with other agency energy management efforts more broadly.

1. INTRODUCTION

The trend towards digital transformation has demanded the quick scaling up of Information Technology (IT) capacity among U.S. Federal Government agencies. As agencies increasingly rely on data centers to carry out their missions, managing the energy consumption associated with federal data center operations has become ever more critical. Nationally, data centers consumed an estimated 70 billion kWh in 2014, representing approximately 1.8% of total U.S. electricity consumption.¹ The proliferation of federal data centers prompted the 2010 Federal Data Center Consolidation Initiative (FDCCI), which aimed to contain and reverse data center growth in the federal sector.² This first consolidation effort in turn led to the Federal Information Technology Acquisition Reform Act (FITARA) in 2014, which mandated that agencies consolidate and optimize their data center fleet.³ The Office of Management and Budget (OMB) responded by issuing M-16-19, the Data Center Optimization Initiative (DCOI),⁴ which set priorities for data center consolidation and closures as well as efficiency improvements through the end of Fiscal Year (FY) 2018. At the onset of DCOI in 2016, an estimated 11,700 government data centers were in operation.⁵ In 2019, OMB extended DCOI and updated key targets, metrics, and other requirements through M-19-19. Though outside the scope of this research effort, it is worth noting that in addition to DCOI, federal agencies must comply with other efforts to efficiently manage and operate their data centers through the Energy Act of 2020⁶ and the CloudSmart⁷ strategy, among others.

At the start of 2020, federal agencies reported operating a total of 2,596 data centers under DCOI (note that the number of data centers in operation in the 2016 count includes “non-tiered” data centers, whereas the 2020 count does not). The number of data centers operated by each agency varied considerably, with some agencies reporting that they did not operate any data centers, to another agency reporting a total of 691 data centers.⁸ This report assesses the current state of DCOI implementation among federal agencies. We recommend ways that the U.S. Department of Energy’s (DOE’s) Federal Energy Management Program (FEMP) can support agencies in their quest for not only DCOI compliance but also achieving energy and cost savings in these resource intensive facilities. We identified these areas of improvement through review of the existing literature, including agency DCOI Strategic Plans, annual reviews of DCOI progress conducted by the U.S. Government Accountability Office (GAO), various DCOI Audits, and other literature on DCOI (e.g. surveys of Federal IT staff, webcasts, and other reports).

This report is organized as follows: First, we provide a brief overview of the current DCOI requirements and agency reporting requirements. Second, we discuss the general progress agencies have made towards DCOI goals and optimization metrics thus far. Third, we identify opportunities for improvement where agencies have encountered difficulty in making progress towards their DCOI goals. Fourth, we identify opportunities whereby FEMP can leverage its capabilities to aid agencies in achieving DCOI compliance. Finally, we offer concluding remarks.

2. BACKGROUND

Broadly speaking, DCOI seeks to help agencies achieve both energy and cost savings through data center energy efficiency improvements and optimization. As mentioned previously, current DCOI requirements are consistent with OMB’s M-19-19 memo, issued in June 2019.⁹ This memo made several

changes to DCOI policy (as established in the M-16-19 version), for example - the removal of an average power usage effectiveness (PUE) target. Perhaps the largest shift in policy resulting from the M-19-19 update, however, was the exclusion of “non-tiered” data centers from DCOI reporting - spaces *not* designed to be a data center. According to OMB M-19-19, a data center generally is a “purpose-built, physically separate and dedicated space that contains one or more racks of servers, mainframes, and/or high performance computers; has a dedicated uninterruptible power supply and/or backup generator for prolonged power outages; and/or has a dedicated cooling system or zone.”¹⁰ Note that this dedicated zone does not require a dedicated chiller, but instead refers to climate control capabilities. This revision was implemented, because “optimizing and consolidating these spaces not designed to be data centers generally incurs large costs for agencies, with little or no benefit from efficiencies gained.”⁹ This revised definition of what qualifies as a data center for the purposes of DCOI reduced the number of reported facilities by approximately half – from 4,907 in 2018 under the previous guidance to 2,727 in 2019.¹⁰

a. Current DCOI Requirements

Current DCOI requirements as outlined in M-19-19 include broader data center reporting, as well as more prescriptive optimization metrics. M-19-19 extends the data center development freeze, which prohibits agencies from “budgeting funds or resources toward initiating a new agency-owned data center or significantly expanding an existing agency-owned data center without approval from OMB.”⁹ Agencies must submit an analysis of alternatives (e.g., shared services, third-party colocation, cloud services) or demonstrate to OMB that a new or much expanded data center is a “key mission facility.”^{9,a}

Agencies are required to report a comprehensive inventory of data centers closed/consolidated (or targeted as such), owned, operated, or maintained by or on behalf of the agency. Agencies must also report anticipated and realized cost savings resulting from DCOI activities. Cost savings and consolidation/closure targets are developed in collaboration with OMB in order to set custom goals that are appropriate to an agency’s individual mission and budget. Additionally, OMB developed metrics by which to measure progress towards data center optimization. Over the lifespan of DCOI, these metrics have been modified and updated. In 2019, OMB released a revised inventory of optimization metrics, with one novel and three updated metrics: virtualization, advanced energy metering, server utilization, and data center availability.⁹ These optimization metrics are summarized in Table 1 below.⁹

Table 1. DCOI Optimization Metrics

<p>Virtualization</p>	<p>Agencies are required to report the number of servers and mainframes that are currently serving as hosts for <i>virtualized or containerized systems</i> in their agency-managed data centers. All new agency applications are to use virtualization or containerization whenever possible and appropriate.</p>
<p>Advanced Energy Metering</p>	<p>Agencies are expected to have advanced energy metering and sub-metering, sufficient to accurately estimate Power Usage Effectiveness (PUE), for all remaining data centers over 100 kW that they are planning to keep open. Agencies are required to report the number of data centers that have advanced energy metering systems in place in the majority of</p>

^a M-19-19 states that the M-16-19 definition of what qualifies as a “key mission facility” was too narrow and expands the definition.

	their floorspace. Agencies can request an exemption for data centers that are slated to close or where installing such systems is deemed too costly. ⁹
Server Utilization	For the purposes of DCOI reporting, utilization is reported as an agency’s count of underutilized servers. Agencies are expected to identify and report the number of underutilized production servers in each data center, with the expectation that agencies should reduce the number of these servers over time. Due to mission-specific, hardware-specific, and application-specific requirements that may influence efficient operations, OMB did not establish a specific methodology for determining server utilization evaluation for each agency. However, OMB expects agencies to consider central processing unit (CPU) usage and storage space at a minimum.
Availability	Agencies are expected to report the planned hours of availability for each data center, as well as any unplanned outages for that data center over the reporting period, also measured in hours. Unavailability will include unplanned outages of a majority of the facility due to disaster, systems failure, cybersecurity events, or other negative events as well as any other hours that would otherwise be planned as available hours. This metric will track the data center’s availability, not individual server or application uptime or availability.

b. DCOI Reporting Requirements:

Twenty-four federal agencies (those subject to the Chief Financial Officers Act) are required to participate in DCOI.¹¹ Agency Chief Information Officers (CIOs) are responsible for implementing DCOI, as well as tracking and reporting progress. Agencies must submit a strategic plan that outlines their proposed activities, including their target closure goals to OMB on an annual basis. Additionally, agencies are required to report their data center inventory as described above to OMB each quarter. Lastly, agencies must identify a minimum of five FITARA milestones that will be achieved through DCOI for a given fiscal year.¹² In 2020, four of the 24 agencies reported that they did not have any applicable agency-owned data centers in their inventories under DCOI and therefore did not report on any of the DCOI optimization and progress metrics.⁸ Additionally, two agencies reported that they “had completed their optimization efforts.” Therefore, these agencies did not report on optimization metrics.⁸

3. DCOI PROGRESS

Agencies have demonstrated mixed success in meeting the various data center energy management goals set out by DCOI. Further, agencies have consistently met or exceeded some DCOI goals and measures, while others have proved more difficult to achieve. Expectedly, agencies have experienced varying levels of success with DCOI implementation. It is worth noting that given the shift in policy resulting from the issuance of M-19-19, there is a relative lack of continuity of data for the DCOI optimization metrics and inventorying. The subsequent sections present an overview of the progress made thus far on key DCOI goals.

a. Cost Savings

Arguably, one of the most notable accomplishments made through DCOI thus far is the agencies' progress towards cost savings. Largely through consolidation and closure of data centers, federal agencies have achieved significant cost savings. FITARA requires that OMB establish a three-year government-wide cost savings goal for DCOI.³ Initially, OMB set out to reduce federal spending on data center operations by \$270 million in 2016, \$460 million in 2017, and \$630 million in 2018, for a total savings of \$1.4 billion.¹³ The current OMB policy target for FY2019 through FY2021 is \$5.3 billion.¹⁴ Agencies anticipate that cumulative total cost savings and avoidances^b attributable to DCOI will reach over \$6 billion from FY2012 through FY2020.⁸ It is worth noting that agency savings targets vary significantly – for example, in FY2020, nine agencies planned for zero dollars in cost savings, while another agency anticipated cost savings of over \$178 million.^c

One agency staff member estimated that over the last two years, the agency had avoided spending \$28 million as a result of actions taken in accordance with DCOI. They estimated that through further consolidation of their data centers, they would save another \$27 million the following year. As mentioned previously, agencies develop individual cost savings targets each year. Four agencies did not meet their planned FY2020 cost savings targets.¹⁵

Figure 1 below reports the cumulative cost savings achieved thus far by each fiscal year, which currently total \$5.9 billion. Additionally, the annual savings gain between each FY is reported – for a given year, the amount reported represents the savings gain since the prior year. The largest annual cost savings were achieved between FY16 and FY17, with annual cost savings tapering off in the last few years.¹⁴ Part of the lower savings reported in more recent years could be attributed to the exclusion of non-tiered data centers, which accounted for a significant share of data center closures and savings under DCOI.^d According to OMB's 2019 report, 67% of the 9,798 non-tiered data centers were either closed by August 2018, or slated for closure by the end of FY2018, as compared with only 28% of the 2,368 tiered data centers.¹⁶

^b OMB defines cost savings as a reduction in actual expenditures below the projected level of costs to achieve a specific objective and defines a cost avoidance as the result of an action taken in the immediate time frame that will decrease costs in the future.

^c Some of the agencies that reported anticipated cost savings of zero are those that reported that they do not own or operate any data centers, and thus do not report further DCOI metrics.

^d Under M-16, OMB's goal for each agency was to close at least 25 percent of tiered data centers and at least 60 percent of non-tiered centers <https://www.gao.gov/assets/gao-18-264.pdf>

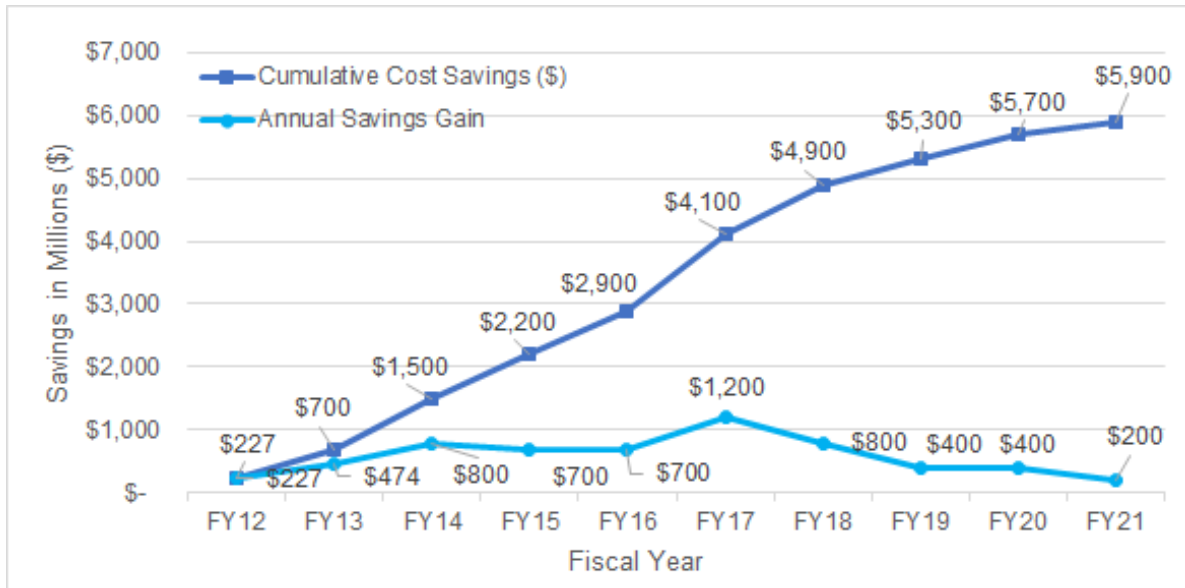


Figure 1. Cumulative and Annual Cost Savings by Fiscal Year

b. Data Center Closures

Each year, agencies are responsible for identifying the number of data centers they plan to close.⁹ Prior to M-19-19, agencies were expected to close at least 25% of their tiered data centers, and 60% of their non-tiered data centers. The exclusion of non-tiered data centers from DCOI requirements per M-19-19 has this significantly eased the closure goals. OMB’s 2019 report (the last year agencies were required to report on non-tiered data centers) indicated total data centers before DCOI closures, achieved closures, and additional planned closures for FY18 for both tiered and non-tiered data centers. As shown in Figure 2 below, non-tiered data centers accounted for a majority of federal data centers, as well as achieved and planned data center closures prior to 2019.¹⁶

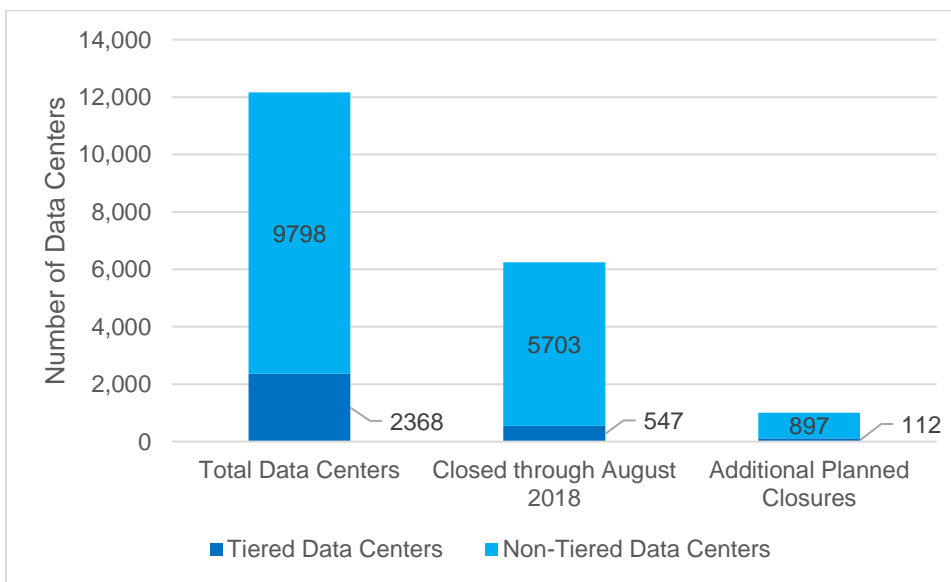


Figure 2. Data center Closures for Tiered vs. Non-Tiered Data Centers

Closure goals are developed in collaboration with OMB and can vary significantly between agencies. Generally speaking, closure targets do not appear to be proportional to the number of data centers an agency operates. Agency closure goals for FY2020 ranged from zero^e to 17, for a total of 46 closures. The flexibility of these individual closure goals help ensure that agency needs and missions are taken into account. Agencies have generally been successful in meeting the closure goals as outlined in their DCOI strategic plans. As of August 2020, agencies had closed 67 data centers in FY2020, exceeding their collective FY2020 closure target of 46 data centers, though there were some agencies that had not yet achieved their individual closure goals (while others exceeded their goal). Further, every agency met (or planned to meet) their FY2020 goal.^f Agencies have indicated a planned 112 additional closures for FY2021-FY2025. A single agency accounts for a majority of these closures (79). Another agency plans to close 10 of its 14 data centers, while another with nearly 300 data centers plans to close only seven.^g

c. Optimization Metrics

The various optimization metrics (virtualization, advanced energy metering, server utilization, and availability) have been met with various levels of success. As shown in Figure 3 below, seven agencies met all four optimization metrics, five agencies met three of the four metrics, two met two of the four metrics, three met only one metric, and one agency met none of the metrics.^g

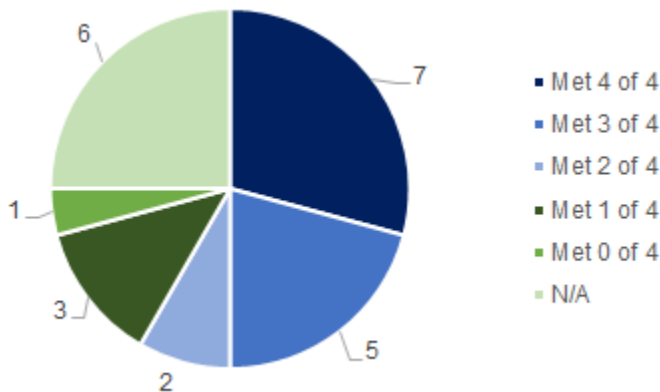


Figure 3. Number of Optimization Targets Met for FY2020 (Agency Count)

Virtualization: Eleven agencies reported meeting or exceeding their virtualization targets as of August 2020, compared to seven which did not. The challenges relating to virtualization were diverse. One agency reported that cloud computing support required for COVID-19 had disrupted on-site virtualization goals. Another agency reported that its virtualization target was internally set before the reclassification of

^e Thirteen agencies reported a closure goal of zero data centers for FY20, including six agencies that either do not report having any agency-owned or operated data centers, or reported that they had completed their optimization metrics and thus did not have to report progress.

^f GAO reports the number of closures achieved as of August for a given fiscal year, thus some closures that are still anticipated for a given fiscal year may not have yet occurred.

^g Additionally, the metrics did not apply to the six agencies that either reported not owning or operating data centers, or reported that they had completed optimization.

data centers in 2019, and that in light of the update they would be moving to align their virtualization practice to revised metrics.¹⁸ Two agencies have fully met OMB targets for all metrics in FY2020.¹⁶ For one of these agencies, virtualization was already an action item on the technology update plans of the component offices of the agency. This virtualization emphasis was in part to enable the capability to dynamically shift computing resources in response to shifts in need, such as weather related increases in traffic to one of their websites. The second agency adopted a “virtual first” policy, virtualizing not only servers, but storage and network applications as well. Virtualization is understood as an instrument by which the agency can achieve goals of “data center disaster recovery...and load balancing between data centers.”¹⁷

Advanced Energy Metering: Progress on the advanced energy metering metric (which was established by M-19-19), has been relatively minimal, though uptake may be slowly improving. Nine agencies reported meeting the FY2019 metering requirements; in August 2020, 11 agencies had met the FY2020 target. There is significant room for improvement, however, considering that currently, the number of federal data centers with metering installed is reportedly 298 (as of June 2021).¹⁸

Server Utilization: Twelve agencies reported meeting or exceeding their server utilization metrics, compared to six which did not. FITARA tasked OMB with developing a metric for server efficiency and utilization.³ The metric developed by OMB measured the percentage of time a server was busy according to automated tracking meters, with a discount rate applied based on the proportion of servers with automated monitoring. The 2019 revision instead tasked agencies with reporting their number of underutilized servers. What exactly constituted an underutilized server was left to each individual agency to internally define. The current server utilization metric does not provide agencies with guidance towards efficiency as it does not measure how efficiently the agencies total server infrastructure is being utilized but instead what quantity of servers are defined internally as underutilized.^h This does not provide agencies with a clear pathway toward continuous improvement.

Availability: Availability is one of the metrics introduced by M-19-19 and was defined by that memo as the ratio of uptime to downtime in tiered servers. Of the optimization metrics, agencies have been most successful in reaching their availability targets.⁹ 16 agencies reported to the GAO meeting or exceeding availability metrics compared to two which did not as of August 2020. This is approximately the same level of compliance in 2019. It is worth noting that the redefinition of DCOI to include only tiered data centers functionally restricted measurement only to high availability centers, so a high level of server availability is somewhat to be expected.

4. OPPORTUNITIES FOR IMPROVEMENT

Efficiently inventorying, managing, and tracking the entire federal data center stock is undoubtedly a logistical challenge that requires thoughtful, resource-intensive attention and solutions. Through review of current literature on DCOI, we identify key areas of DCOI in which agencies have struggled with implementation. While many agencies have seen success and have made commendable strides in

modernizing and improving the energy efficiency of their data center stock, it is also clear that agencies have experienced a range of technical, organizational, and other barriers throughout implementation.

a. Inventory Management

Data center inventory management is a critical element in assessing the scope of federal data center operations and in achieving savings. DCOI requires that agencies report their data center inventory, including agency-owned data centers and colocation facilities (though cloud providers are excluded).¹⁰ These inventory counts inherently underpin all other DCOI activities, as they define the relevant facilities associated with cost savings and closure targets, as well as the four optimization metrics. Agency staff responsible with implementing DCOI have stressed the importance of developing an accurate data center inventory from the start – noting the challenges in developing detailed plans for subsequent DCOI requirements when portfolio baseline energy consumption and operating costs are unknown.¹⁵

Despite the critical nature of these inventories, discovering and documenting all data centers within an agency has proved to be difficult. One audit found that on average, for every one data center that an agency reported, another three were not.²⁴ Another audit found the count and closure status of data centers as reported by an agency to be inaccurate.¹⁹

It is difficult to draw conclusions on the scope of the inventorying issue across all agencies. The reason behind these difficulties in implementation are varied but include a lack of personnel and/or bandwidth to physically inspect facilities, a lack of procedures in place to validate reporting inventories, a lack of authority over data center systems that certain staff manage, and a lack of coordination and communication between personnel responsible for DCOI implementation and facilities staff. One agency staff member responsible for DCOI implementation echoed the attention to detail required when inventorying an agency's data centers, stating "You have to go and look in those closets. You have to go and look under the desk or that office that was converted into a test lab and you have to count those things. Discovery of all those products can be daunting but is absolutely necessary in the consolidation process."¹⁵ Documentation for legacy and smaller data centers is often difficult to find, or even non-existent. Given the exclusion of non-tiered data centers in M-19-19, however, most these smaller data centers and server closets are no longer subject to inventory reporting under DCOI. The director of IT management issues at the GAO expressed concerns over the removal of non-tiered data centers, particularly with regard to how it impacted the quality of reporting data. At a subcommittee hearing on M-19-19, she noted that "the committee will lose the ability to track and measure progress in this area since the initial scorecard, because the baseline for comparison will have changed."²⁰

b. Data Center Closures

Agencies have generally made progress towards meeting their stated DCOI closure goals. However, there are opportunities to be more aggressive with closure targets. As mentioned previously, agencies develop closure targets in collaboration with OMB, as each agency has a distinct mission and unique circumstances that warrant individual treatment for this metric. However, we observe that there does appear to be a reduction in the number of data centers slated for closure – even when examining tiered data centers alone. For example, agencies identified 799 tiered data centers targeted for closure in

FY2018,²¹ compared with 94 in FY2019,¹⁰ and 46 in FY2020.⁸ Agencies identified another 112 total data centers for closure for FY2021 through FY2025, an average of just over 22 data center closures on average per year.⁸ While it is logical to assume that after years of consolidation agencies may have already picked off the low-hanging fruit, the sheer number of federal data centers that remain lends credence to the notion that efficiencies can still be gained through further consolidation and closures.

Another important consideration is how the exclusion of non-tiered data centers from DCOI has impacted closure opportunities. This change has drastically reduced the number of data center closures under DCOI. Data from previous years (when non-tiered data centers were subject to DCOI) indicates that non-tiered data centers were closed at a much higher rate than tiered data centers.²¹ It is unclear whether agencies have continued to consolidate and close non-tiered data centers despite their exclusion from DCOI.

c. DCOI Implementation Strategy

There is anecdotal evidence that a robust implementation plan yields improved DCOI outcomes. DCOI mandates that the office of the chief information officer (CIO) of each agency comply with the reporting requirements as outlined earlier, including annual submittal of a strategic plan. GAO has noted several instances in which agencies either do not submit strategic plans as required by DCOI, submit incomplete plans, or submit plans that do not actually detail how the agency plans to achieve their stated DCOI goals. According to a recent report which surveyed federal IT staff, 84% reported having a formal data center modernization strategy but only 47% reported applying this strategy consistently agency-wide.²² Those that did have a formal implementation strategy, however, were more likely to report satisfaction with their experience and progress thus far. One staff member responsible for DCOI implementation stressed the importance of developing a detailed optimization plan from the beginning, and to be prepared to hold responsible individuals accountable. While developing a coherent internal strategy and processes to aid in implementation was time consuming, anecdotal evidence suggests that developing the necessary human and organizational infrastructure to meet DCOI requirements was time well spent. One staff member noted that this was particularly the case given that DCOI is an ongoing effort, and that agencies will need to comply for the foreseeable future. Given the enormity of the task at hand, another individual stressed the importance of having a backup plan and adapting an agile management strategy.¹⁵ These plans should be developed in collaboration with key stakeholders, including management – whose buy-in is critical for success.

d. Staffing & Communications

Aside from developing a formal implementation strategy, staffing and communications also play a role in DCOI success. DCOI is implemented by organizations, teams, and ultimately individuals, all of whom have their own priorities, incentives and responsibilities. As such, it is inevitable that organizational and human factors also play a role in successful (or unsuccessful) DCOI implementation.

At least one agency reported executive turnover as the reason for lackluster DCOI compliance. In a ten year period, eight different CIOs cycled through leadership of at once agency. For this reason, leadership was not positioned to properly develop, implement, and report on DCOI strategy and

workforce. Further, this void in IT leadership led several offices within the agency to develop their own IT organizations outside of the OCIO, which further exacerbated a piecemeal DCOI implementation approach.²³ Another agency attributed lack of DCOI progress to an internal communication breakdown between the CIO and facilities staff responsible for operating each data center. Key staff responsible for maintaining IT systems were left out of critical communications on DCOI requirements and reporting instructions. These staff were also left out of meetings that provided guidance on DCOI requirements. Staffing and communications issues thus are closely linked with the development of a coherent strategy and implementation plan.²⁴

e. Silos Between DCOI & Other Agency Energy Management Efforts

While implementing a consistent and coherent DCOI strategy and plan is crucial for compliance, agencies also have opportunities to coordinate (or harmonize) those plans with other agency energy strategies. Some agencies may coordinate DCOI efforts alongside their energy management efforts, though the extent and frequency of these activities are unclear. While DCOI is often described in conjunction with the CloudSmart Strategy⁷ and the Modernizing Government Technology Act,²⁵ it is seldom discussed in the context of other agency energy management strategies – such as ISO 50001.²⁶ While ISO 50001 has its own set of requirements, there are synergies between ISO 50001 and DCOI that may make it more efficient to implement both simultaneously. ISO 50001 can help provide a structured framework for agencies that have struggled with implementation. One of the main benefits is that it helps institutionalize and develops common communications, checklists, and other resources that will be used agency-wide, which can reduce the overall data reporting burden. Considering that DCOI is an ongoing process, setting up processes that will endure staff turnover would not leave agencies scrambling to report their DCOI metrics each year or quarter. Agencies may decide that borrowing components of the 50001 Ready programⁱ without pursuing full certification is most beneficial for their DCOI goals. If an agency did decide to pursue full certification for their data centers, they may find that it makes sense for data center 50001 Ready efforts to be completely separate from their other agency ISO efforts, for them to share certain organizational elements/structure, or, for them to be fully integrated together.

f. Exclusion of Non-tiered Data Centers

As mentioned previously, M-19-19 revised DCOI policy to exclude non-tiered data centers. This reduced the number of federal data centers subject to DCOI by approximately half – from 4,907 under the old guidance to 2,727.¹⁰ The types of data centers that may qualify as “non-tiered” are varied – from server closets, to individual servers, to small and medium sized data centers. Some of these data centers are not trivial in server count and size – one analysis found over 260 “non-tiered” data centers are each over 1,000 square feet that would continue operating, but would no longer be subject to DCOI.¹⁰ This change in policy has received some public scrutiny, with the cosponsor of the 2014 FITARA legislation claiming that removal of the non-tiered data centers from tracking and DCOI requirements enabled circumvention of FITARA.²⁰

ⁱ <https://www.energy.gov/eere/amo/50001-ready-program>

Often, smaller data centers are overlooked when it comes to energy efficiency opportunities. They may have fewer devoted staff and/or resources, and can often benefit from simple, inexpensive energy efficiency measures.²⁷ Further, these data centers may be less sophisticated from a security and resiliency standpoint but still could facilitate mission critical activities. They also may be particularly vulnerable to attacks, which led OMB to make a key recommendation in their 2020 DCOI report to include tracking of these data centers to ensure effective cybersecurity oversight.¹⁰ Given the significant presence of these data centers in the federal sector, as well as the savings opportunities they present, their outright exclusion from DCOI not only weakens the policy's impact, but also poses security concerns. Ultimately, their exclusion makes it difficult to accurately assess the federal data center stock and its energy impact and precludes important energy savings actions and the achievement of true data center optimization.

g. Slow Progress on Advanced Energy Metering

Progress on DCOI's Advanced Energy Metering optimization metric has been mixed, with approximately half of all agencies achieving the stated DCOI goal in 2020. As mentioned previously, agencies are required to implement advanced energy metering in the majority (>50%) of their floor space. Agencies can request exemptions from this optimization metric if it is deemed to be too costly - though it is unclear what the criteria are for determining whether the cost is an undue burden, or how frequent or numerous these exemption requests are. Additionally, data center facilities that are slated for closure are not required to comply with this optimization metric.

Agencies have stated a number of reasons for slower uptake of this metric, including difficulties securing a contract to install metering and monitoring equipment, high metering operation and maintenance (O&M) costs, not wanting to invest in data centers that may be eventually closed, or schedule delays in integrating the monitoring systems agency-wide.¹⁰ Many barriers to metering are related to technical expertise, cost, and physical infrastructure. One agency attributed delays in electrical modifications to one of their data center sites caused them to fail to meet their metric. Another agency cited high implementation cost, staff time, and perceived low return on investment (ROI) as reasons for not deploying advanced metering systems.²⁸ There have been some inconsistencies in terms of what agencies report for this metric. For example, one agency reported that they failed to meet this metric as it was not cost effective to install metering in a facility that they planned to close - though it appears that they had zero closures planned for FY2021-FY2025.⁸ It is reasonable to expect that this metric will improve over time as agencies continue to deploy metering systems throughout their data center stock. Despite the fact that the number of federal facilities that have metering installed is incrementally increasing, accelerating the uptake of metering and assisting agencies in implementing these systems should be a top priority. Not only do these systems provide important feedback for continuous data center improvement, but they also can help overcome organizational challenges associated with the IT and facilities silo common to data centers.⁸ Thus, metering installation plans and procedures should be a key component of an agency's DCOI implementation plan. Further, more transparent or robust criteria should be provided for exempting a data center from this metric due to cost concerns, as these systems can pay themselves back through future energy efficiency and/or optimization measures.

h. Inconsistent Server Utilization Metric

M-19-19 “revised the server utilization metric to direct agencies to develop their own definitions of underutilization, and then count their underutilized servers.”⁸ The previous server utilization metric as defined in M-16-19 was (Average Server Utilization) * (% of Data Centers Fully Equipped with Automated Monitoring), and agencies were instructed that this value was to equal or exceed 65%.⁴ The shift from an externally set metric to one defined internal to each agency resulted in widely varying definitions of data center utilization, which has compromised the utility of this metric. The lack of a standardized definition of utilization across agencies also makes comparison between agencies problematic, preventing the sharing of resources and knowledge. Agencies with a stricter internal definition of utilization could report low performance to OMB when in fact they are utilizing their servers more efficiently. The inability to concretely identify standout performers prevents knowledge sharing across and the dissemination of best practices across federal agencies. As a result, agencies adopted widely varying definitions and are no longer required to report actual utilization, a key measure of server efficiency.⁸ This issue has been acknowledged and well-documented, however. Revising the current server utilization metric to one that “more consistently address server efficiency” was one of the key findings from the GAO’s 2021 DCOI status report, and can be addressed by existing metrics in the industry.⁸

i. Virtualization

While current virtualization efforts have been moderately successful, of the optimization metrics, virtualization is most constrained by a lack of knowledge and experience with virtualization within federal agencies.²⁹ Knowledge sharing on best practices between agencies or staff training could address some of these issues. For the time being, virtualization seems best supported by consolidation of data center services to the best performers or by outsourcing to cloud providers.

5. RECOMMENDATIONS:

Based on our assessment of the intent of DCOI, its progress thus far, and the opportunities for improvement as described above, we propose a set of recommendations that could improve federal implementation of DCOI and ultimately its economic and environmental outcomes. These recommendations generally do not suggest revisions to DCOI itself but rather highlight opportunities where key stakeholders (e.g. DOE-FEMP, OMB, GSA, DCCOI PMO, DHS) could help facilitate successful DCOI implementation among federal agencies. As such, the following recommendations should be interpreted as a starting point for collaborative conversations as to what avenues may best advance these goals.

- a. Improve Inventory Management:** Quantifying and characterizing the federal data center stock is a key precursor to ensuring that subsequent DCOI efforts effectively capture energy efficiency opportunities in the federal building stock. While DCOI has enabled the aggregation of data on federal data centers through reporting, audits, and the IT Dashboard, the quality of some of this data is unclear, as is the extent to which it truly captured the quantity of federal data centers. Inaccurate or incomplete data center

inventories compromise our understanding of the current state of federal data centers and all of the subsequent DCOI goals. As mentioned previously, the main barriers to effective inventory management include:

- i. a lack of coordination and communication between the facilities, CIOs, and staff responsible for operating each data center,
- ii. a lack of procedures in place to document data centers, and
- iii. a lack of personnel or bandwidth to physically inspect or validate data center.

Given how pervasive this issue has been, FEMP could create a best practices guide that addresses inventory management for data centers – detailing communication plans, checklists, and internal documentation systems (such as an inventorying workbook template). These resources could be pilot tested with several agencies during development, to ensure that they would help facilitate centralized reporting across an agency’s various facilities. Agencies should also be encouraged to designate a subset of its DCOI implementation team to inventorying, as well as two individuals at each distinct agency location to try to overcome issues of validation. Given the importance of accurate inventorying, it may be worthwhile to expend additional resources in the near-term (in terms of funding and/or personnel) until there is confidence in an agency’s data center inventory and key processes are established. Audits have been useful in determining the underlying issues driving inventorying inconsistencies. Performing audits – possibly a virtual (or a similar exercise) in all agencies – could be useful prior to developing additional resources (e.g. analytical tools, internal processes) to ensure that they address the full range of issues as much as possible. FEMP could also consider whether other tools that are already in place (e.g. Portfolio Manager or the Federal Real Property Profile Management System), might be better equipped (or could be modified) to handle inventory reporting for DCOI.

- b. Return to Requiring Tracking of Non-Tiered Data Centers:** As mentioned previously, the M-19-19 update of DCOI excluded non-tiered data centers from DCOI requirements (a move that was supported by a number of agencies to reduce the reporting burden). While these data centers may be excluded from DCOI requirements, it would be beneficial to (at a minimum) maintain inventory tracking for these data centers – as it is estimated that these represent approximately half of the federal data center stock. Given this, maintaining an inventory of these types of data centers (even if they are not subject to other DCOI requirements) is critical to ensuring that the full scope of federal data centers are known. Federal staff responsible for implementing DCOI have echoed the importance of an accurate inventory assessment early on in the DCOI process. Further, institutionalizing data center inventory management processes is a time-intensive process (particularly for smaller server closets). Disrupting documentation processes that are already in place and halting tracking of these critical (non-tiered) data centers leads to a lack of continuity of data, which also can make it more difficult to understand the scale and possible trends of these types of data centers across the federal building stock. Additionally, it is important to know whether these types of data centers are proliferating while excluded from DCOI requirements. While many of these data centers may be small

server closets, there are also sizeable facilities that fall into this category (one analysis found over 260 non-tiered facilities that are greater than 1,000 square feet).¹⁰ Excluding them from DCOI is resulting in missed environmental and economic benefits. Lastly, these data centers may be more vulnerable from a cybersecurity and resiliency perspective (e.g., they may lack certain software protections or a backup power source). The GAO reported that the exclusion of non-tiered data centers eliminated reporting on cybersecurity risks, limiting agencies' visibility and oversight of their own facilities, increasing risk.³⁰ For these reasons, FEMP should undertake efforts to encourage agencies to include non-tiered data centers in their inventory reports - even if they are not required to do so under DCOI. They also could consider collaborative efforts with OMB and the Department of Homeland Security (DHS) – and could potentially draw upon the Technology Modernization Fund.³¹ Alternatively, though outside of FEMP's purview, an executive order or revision to DCOI could require that at a minimum, agencies report an inventory of non-tiered data centers.

- c. Retain a Focus on Small Data Centers & Server Closets:** It is well documented that there are significant energy savings to be achieved in small data centers, some of which may qualify as non-tiered under DCOI. By implementing simple, inexpensive energy efficiency measures, small data centers can realize energy savings between 20 and 40%.²⁷ These data centers often have fewer resources as compared to their larger counterparts, though they often have low-cost, high-benefit energy efficiency opportunities. Often simple, inexpensive energy conservation measures and adjustments can have large energy savings impacts. So long as non-tiered data centers are exempt from DCOI, FEMP should consider a renewed effort to address and capture energy savings in these types of federal data centers. This could be done through a variety of means, e.g., through the development (or renewal) of a challenge or initiative (such as the Small Data Center Initiative or Better Buildings Data Center Challenge), the creation of catered tools and resources, and facilitation of working groups.
- d. Promote More Aggressive Closure Goals:** Closure goals vary widely between agencies, given distinct agency needs, missions, and facilities. As mentioned previously, agencies set their own closure targets for each fiscal year in coordination with OMB. However, there is an opportunity for more aggressive data center closure targets. Fourteen agencies have reported zero expected total data center closures between FY2021 and FY2025, three data centers have reported a closure goal of one of their data centers, and three have reported a closure goal of two data centers. Further, a single agency accounts for 79 of the 112 data center closures planned from FY2021 through FY2025..⁸ While agencies operate fewer data centers than they did at the outset of DCOI (and thus a lower closure target seems logical), closure goals generally do not appear to be proportional to agency data center stock. Given the significant energy and cost savings associated with operating fewer data centers, as well as ancillary benefits such as having to staff and secure fewer facilities, pursuing additional closures in coordination with agencies is a worthwhile effort. FEMP could provide consultative guidance, tools, analysis and support for closure targets by establishing best practices criteria and providing technical assistance to help

agencies identify which data centers justify closure and/or consolidation with others. As a first step, FEMP could consider conducting an analysis of multiple agencies to characterize the data centers that are not closed or slated for closure to determine to what degree additional closure opportunities remain. FEMP could also develop a tool for agencies to use when determining whether a given data center is ripe for closure. Alternatively, an executive order or revised policy could address this issue by requiring target closure minimums as a percentage of the data centers that an agency operates as was required in M-16-19. While maintaining flexible closure goals to ensure that agencies are capable of carrying out their mission is of utmost importance, agencies should still strive for aggressive yet attainable closure goals.

e. Demonstrate Data Center Improvements Using Alternative Financing Opportunities:

Energy Savings Performance Contracts (ESPCs) and Utility Energy Savings Performance Contracts (UESCs) enable federal agencies to leverage alternative financing mechanisms to invest in valuable energy efficiency improvements. FEMP already has a robust ESPC and UESC program. ESPCs can not only unlock data center energy efficiency improvements that may have been cost prohibitive but also could also improve energy metering of federal data centers, considering that measurement and verification (M&V) efforts are built into (ESPC) contracts. While FEMP has conducted some work around the inclusion of data centers in ESPC projects,³² data center energy conversion measures (ECMs) are still relatively uncommon. There are a number of factors that may prevent an agency from including data centers in their ESPC, including the frequent refresh of equipment, mission-critical nature of data centers, and split incentives between IT (decision makers) and the beneficiary of cost savings (facilities or public works), among other challenges. FEMP could support ESPCs in data centers through a range of activities, including producing specific guidance or playbooks on integrating data center ECMs into an ESPC, developing a training course geared towards ESCO staff or agency IT or facilities managers, or providing technical support on data center ECMs. Additionally, FEMP could create a data center contract template specific to data centers with prequalified, streamlined data center ECMs (similar to the ENABLE contract).³³ Another possible funding source agencies could leverage is AFFECT funding.³⁴ Utilization of these financing mechanisms advances the goals of IT modernization and pursuing energy savings generally but also could simultaneously advance DCOI's advanced energy metering metric.

f. Assessing the Impacts of Outsourcing Data Center Operations: Increasingly, agencies have outsourced various aspects of their data center operations, with multiple agencies now reporting that they do not own or operate any data centers that qualify under DCOI. M-19-19 requires that agencies report metrics for data center services that have been outsourced to a colocation facility, but agencies are not required to report information for cloud service providers. While outsourcing can have many benefits (including environmental ones), it is still important for agencies to contend with the energy impacts of their data center operations – whether in-house or not. To this end, FEMP could work

to develop a tool or best practices guide to help agencies understand how to manage and measure third-party emissions from cloud providers.

- g. Category Management:** Category management is the process by which the federal government makes contracting and purchasing more efficient for agencies by reducing contract redundancies, among other things. The Data Center & Cloud Optimization Initiative Program Management Office (DCCOI PMO), OMB, and the General Services Administration (GSA) already have a collaborative effort in place to develop government-wide contracts and purchasing agreements that pertain to DCOI activities. However, FEMP could play a role in helping to ensure that these contracts reflect best practices and enable a full range of opportunities to reduce energy use and emissions.⁹
- h. Institutionalizing DCOI:** Establishing and institutionalizing the internal agency processes necessary to carry out DCOI has proven to be one of the biggest challenges in implementation. Many agencies struggle to communicate and implement a consistent DCOI strategy and management approach agency-wide. While each agency undoubtedly has its unique internal processes and set of circumstances, it is inefficient for each agency to individually develop the entirety of its DCOI implementation processes and protocols. Though there are forums for agencies to share best practices, agencies could collaborate further to implement the organizational infrastructure necessary to execute DCOI efficiently. In particular, FEMP may be able to leverage its experience with other energy management processes and programs (e.g. ISO 50001) to develop more formalized processes for the key components that make DCOI implementation successful from the outset. For example, this guidance could include a checklist of everything an agency should cover in its comprehensive implementation plan, as well as advice on creating a DCOI implementation team, getting buy-in from key stakeholders, creating internal communication plans, and other key documents such as savings methodologies, checklists, inventory reporting and validation guidance, establishing deadlines, etc. Some agencies may already have sophisticated and well-developed DCOI efforts, while others do not. Aside from reducing communication hiccups and insulating DCOI from negative effects resulting from staff turnover, the benefits of institutionalizing these processes would proliferate to other areas of DCOI – leading to clearer (and hopefully more accurate) inventory reporting, etc.

Furthermore, aligning and integrating DCOI management into other agency sustainability efforts will also help DCOI become an engrained priority for agencies. There could be opportunities to align DCOI implementation planning with ISO 50001, the OMB scorecard, and agency sustainability and implementation plans.^{35,j} Given the other energy management programs that FEMP has in its portfolio, FEMP may be particularly well suited for this task. Additionally, FEMP could coordinate new training opportunities for agency staff responsible for implementing DCOI, or for OMB staff responsible for

^j A review of several agency sustainability reports and implementation plans revealed that some do reference DCOI and data center efficiency plans, though others do not.

approving new data centers (or the relevant criteria to consider when exempting data centers from DCOI).

- i. Developing a Metering Playbook as Part of the Upcoming Federal Metering Best Practice Guide:** The underlying reasons behind the modest success of the metering metric are varied. Metering and monitoring systems lay the groundwork for continuous data center improvement, and work synergistically with leveraging operations information to identify future energy efficiency opportunities. A private-sector chief technology officer with experience in the federal sector echoed the importance of metering and monitoring, stating, “Agency IT officials cannot figure out how to consolidate and optimize without knowing the equipment and data they have, the space and energy demands of that data, the potential security problems and the potential to apply new technology.”³⁶ Additionally, metering and monitoring technologies are an opportunity to help eliminate silos between IT and facilities staff, as well as agency sustainability officers.

Metering and monitoring especially could benefit from knowledge sharing between agencies. Providing a forum (either new or integrated into existing forums such as through the DCCOI PMO) for dialogue between better-performing agencies and those facing challenges could help overcome these challenges. While such conversations would not solve the upfront cost burden of metering and monitoring, agencies could share strategies as well as the technical knowledge to reduce other key challenges. Agencies identified difficulty in finding qualified technicians to implement the metering systems as a pain point. FEMP may be able to help through category management as described above. Another opportunity is to augment the data center metering and monitoring guide³⁷ with case studies that detail metering and monitoring successes. In particular, it may be useful to highlight the capability of these systems to identify important energy efficiency opportunities that rendered energy, emissions and cost savings. Lastly, agencies can request exemption from this metric due to high costs, though it is unclear what criteria are used and to what degree agencies request this exemption for a data center. FEMP could collaborate with the DCCOI PMO to better understand how agencies determined these installation costs were too high given the anticipated monetary returns, and then develop additional criteria and best practices so that these decisions are made more systematically. Further, FEMP should look to existing standards for determining cost effectiveness (such as the 2020 Energy Act), to see whether the same (or similar) criteria should be used. Metering requirements as outlined in the 2020 Energy Act also can work synergistically with DCOI metering requirements. FEMP should review requirements both in DCOI and in the Energy Act as they apply to data centers and ensure guidance is clear and actionable.⁶ Reducing barriers of technical expertise, easing the financial burden, and highlighting the significant energy cost savings that can be achieved from installation of metering and monitoring systems could all help ensure that agencies do not lose out on energy, emissions and cost savings opportunities.

- j. Addressing DCOI Exemptions:** In M-19-19, OMB outlined a process by which agencies could request that OMB remove specific facilities from reporting. Exemption existed in the prior DCOI policy (M-16-19) but applied to a narrower scope of facilities. The active policy states that unless OMB provides written denial or objects to the request within 30 days, an agency should consider that request approved. While it is reasonable to provide avenues for agencies to exempt facilities, there currently is no documentation of the criteria used for these requests, or the volume and frequency of such requests by agency. A better understanding of how this exemption has been used is warranted to ensure that it is not compromising energy management efforts. Additionally, in order to maintain a full picture of the data center stock (including mission-critical facilities), perhaps these data centers should still be required as part of the inventory reports. The exact role that FEMP could play in this effort is less clear but would coincide with any effort to improve federal data center inventory management.
- k. Encouraging Utilization Best-Practices:** FEMP does not possess the authority to set a standardized utilization metric across agencies, but it could provide a best practice guide on how agencies develop their internal metrics and make decisions to optimize utilization. Metrics should be based on how much primary-service work is being performed by a server, and then aggregated at a data center level. Increasing utilization of higher efficiency servers is another important strategy for agencies to pursue, as shifting workloads away from older, lower efficiency hardware saves energy in itself and enables savings through shutdown. A guide could direct agencies on how to go about assessing utilization in their data centers more holistically to ensure that savings are not being left on the table. Additionally, utilization metrics should be revisited, and tied to a policy that pushes consolidation and/or shutdown if server utilization averages below a certain threshold percentage over an extended period of time.
- l. Agency Virtualization Assessment and Case Study:** Agency performance on virtualization merits additional study, as there is a large gap between the highest and lowest performers, and that gap is not well addressed by the existing resources. Individual agency performance is usually described, but a system-wide understanding of what is impeding progress across the federal sector is not well understood. Focusing attention on virtualization specifically would clarify what support could be provided to federal agencies to enable them to virtualize their servers. Additionally, performing case studies on the standout agencies could demonstrate the benefits of virtualization beyond simple compliance with DCOI. These case studies could be publicized through expanded community of practice efforts and featured on FEMP's Center of Expertise (CoE) for Energy Efficiency in Data Centers website.³⁸ Such case studies would enable knowledge transfer between agencies both in how virtualization is an instrument by which to achieve agency goals and how to implement virtualization on an agency level.
- m. Carbon Intensity Reporting**

6. CONCLUSION

Though DCOI has helped propel federal agencies towards more energy- and cost-efficient data processing, there are many opportunities for further improvements. We reviewed the progress that agencies have made towards DCOI thus far, identified opportunities for improvement relative to implementation inventory reporting, closures, optimization metrics, and more. We found that changes in DCOI policy (chiefly the change from M-16-19 to M-19-19) and issues of accurate data center inventory reporting have yielded substantive challenges in establishing a baseline against which progress can be measured. In particular, the exclusion of non-tiered data centers from DCOI and issues with inventory reporting have reduced the utility of DCOI as a means to understand the full scope and energy impacts of federal data center operations. While agencies have undoubtedly made significant progress in closing data centers since the onset of FITARA, there is evidence that these closures have been waning in recent years. Maintaining aggressive closure targets is a key component to manage bloating in the federal data center space. Progress on the various optimization metrics varies, and ultimately, additional resources are warranted to help facilitate their implementation – from the development of a metering & monitoring playbook, to the creation of a uniform utilization metric.

The literature points to a myriad of human and organizational factors and systems that have contributed to stalled DCOI progress, ranging from a lack of agency strategic planning to actually achieve DCOI targets, piecemeal implementation, faulty communication, leadership and staff turnover, among others. This points to the need for agencies to institutionalize DCOI strategies through standardized internal processes, as well as the need to ensure DCOI works synergistically with other energy management priorities. These efforts could also help improve implementation from a logistical and communication standpoint as many agencies operate data centers that are geographically dispersed and under the purview of different types of offices, departments, and teams.

While there are shared resources for DCOI implementation, as well as forums by which agency staff can share best practices, there are many opportunities for FEMP to create additional resources (e.g. pilots, tools contract templates, trainings, etc.), that can help agencies more systematically implement DCOI. This report assesses the requirements and state of DCOI implementation. We then argue that examining DCOI goals alongside the operational needs of federal data centers is critical in order to maximize energy and cost savings, as well as emission reductions. Leveraging other existing policies, programs, and reporting requirements that are synergistic to, yet currently exclusive from, DCOI could remove inefficiencies and result in collaboration between and within agencies that may result in greater energy and cost savings, and ultimately emissions reductions. In particular, future efforts should identify how compliance with the Energy Act of 2020 can advance DCOI's goal of energy efficiency and optimization. Additional investigation is warranted to better understand which of the recommendations as described above could be most effective in solving agency challenges associated with DCOI implementation, as well as the best avenues and stakeholders to participate in these efforts.

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