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Dr. Strangedata, or: How I Learned to Stop Worrying and Love Operations and Support Data Validation

Technical Paper

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ABSTRACT

National Nuclear Security Administration (NNSA) leadership, the Government Accountability Office (GAO), and Congress are increasingly focused on estimates that capture the total life-cycle cost of capital projects, rather than just the acquisition phase. In response, NNSA has undertaken an effort to improve data-driven methods to estimate the operations and support (O&S) portion of life-cycle cost. This effort was challenged when exploratory data analysis on NNSA's O&S database of record turned up multiple inconsistencies, errors, and insufficiencies that precluded method development. This discovery reflects disparate policies at each of the NNSA's laboratories, plants, and sites (LPSs). This paper will document the challenges that had to be addressed, detail the extensive data validation process conducted, and provide recommendations for organizations interested in making their own O&S databases authoritative and functional for the purposes of cost analysis.

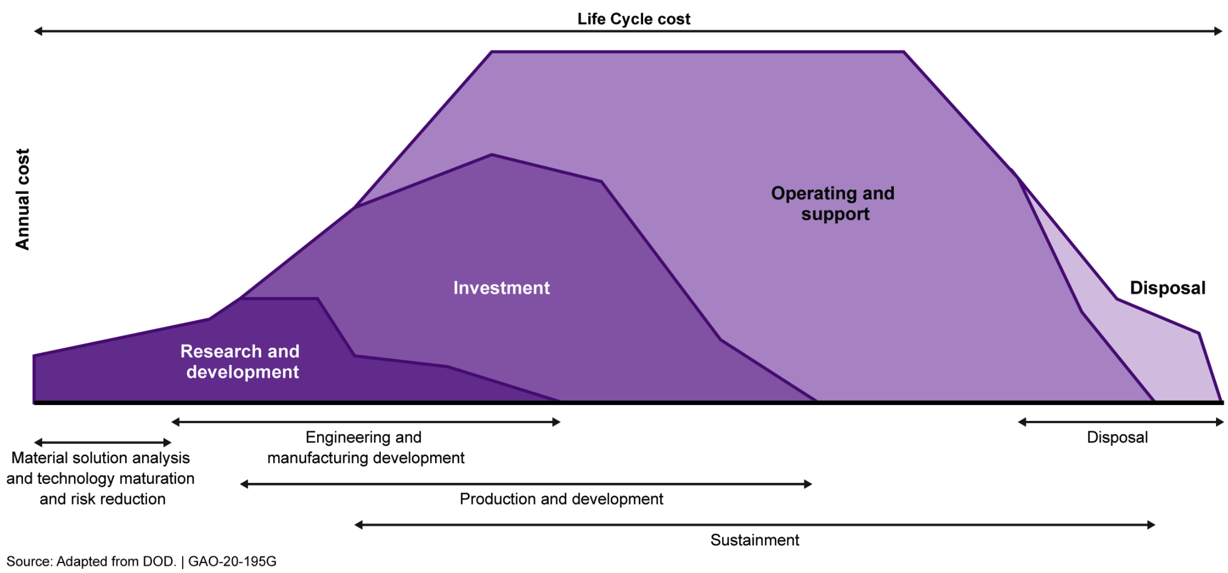
The data validation methods presented in this paper are not groundbreaking, earthshattering, or cutting-edge. Rather, they are foundational practices that are too often overlooked, rushed through, or underappreciated. In an era in which the world collects more data than ever yet misinformation remains a perennial problem, it is our responsibility to ensure the validity of the data we ingest.

1 Introduction – A Need for Better Operations and Support Modeling in Capital Acquisition Projects

Critics of Federal spending and those concerned for the efficacy of critical government missions have been making calls for improved project management and operational efficiency. These calls include many made by the Government Accountability Office (GAO), including a 2023 report (Reference 9) that found that the National Nuclear Security Administration (NNSA) did not establish a life-cycle cost estimate (LCCE) for its plutonium pit production capability, which should be used to inform decision making, portfolio analysis, and investment decisions. In congressional testimony (Reference 4), the NNSA Administrator stated that broad uncertainty, data availability, and data applicability had prevented the NNSA from producing an LCCE, but nevertheless agreed to adhere to the GAO's recommendations and tasked the NNSA's Office of Programming, Analysis, and Evaluation (NA-MB-90, PA&E) to develop an LCCE for pit production by 2026.

This anecdote highlights the growing interest in and requirement for LCCEs in addition to estimates of capital acquisition costs. An LCCE provides decision-makers with a complete picture of the total cost of a capability, as LCCEs include the operations and support (O&S) and disposal costs, in additional to the initial capital acquisition cost, as shown below in **Figure 1**. This information can be used by decision-makers to determine whether an option with lower acquisition cost might be more expensive in the long run because of higher operations or maintenance costs.

Figure 1: A representative life cycle for an asset by phase



O&S costs make up the largest fraction of costs in LCCEs for most assets, but because capital costs are given much more scrutiny during budget negotiations, programming, and in media coverage, the data infrastructure and methods to support O&S estimating often lag behind in their availability and quality.

However, this could change, as observed with the Department of Defense (DOD), which has been criticized for not maintaining their fighter capabilities. The growing importance of studying these sustainment costs was highlighted in the 2017 paper "Sustainment Cost Reporting" (Reference 5).

With this greater interest in LCCEs from decision-makers and oversight bodies, it's becoming critical to develop cost estimating relationships (CERs) for O&S costs so LCCEs can be developed with smaller uncertainties and with more data-driven methodologies. These CERs will be developed based on the standard O&S work breakdown structure (WBS) elements published by NNSA's Cost Estimating and Analysis Group in its Cost Analysis and Estimating Framework (CAEF) 2.0, which evolved out of the work published in the 2023 paper "All in the Hierarchy: Meta-Estimators to Standardize Work Breakdown Structures" (Reference 10). The full CAEF 2.0 Standard WBS Dictionary can be found in Appendix D: CAEF Standard WBS Dictionary. This paper will focus on the data validation phase of CER development for two of the O&S elements in that WBS.

2 FIMS: The DOE's Real Property Management System of Record

At the Department of Energy (DOE), there are only a few sources of information available for analysts to use for developing O&S CERs that relate capabilities within the agency to individual items of infrastructure. The most comprehensive source of this is the Facilities Information Management System (FIMS). FIMS was created because of a GAO report on high-risk Federal real property (Reference 1). The report found that Federal real property suffers from costly space challenges with several assets in deteriorating conditions. Other findings identified that these assets were functionally obsolete, with excess and underused facilities as a long-standing problem. In reaction to the report, Executive Order 13327, Federal Real Property Asset Management (Reference 14), mandated the creation of a centralized real property database for the government's inventory of real property. This executive report was codified into law with the Federal Property Management Reform Act of 2016 (Reference 15) and the Federal Assets Sale and Transfer Act of 2016 (Reference 16).

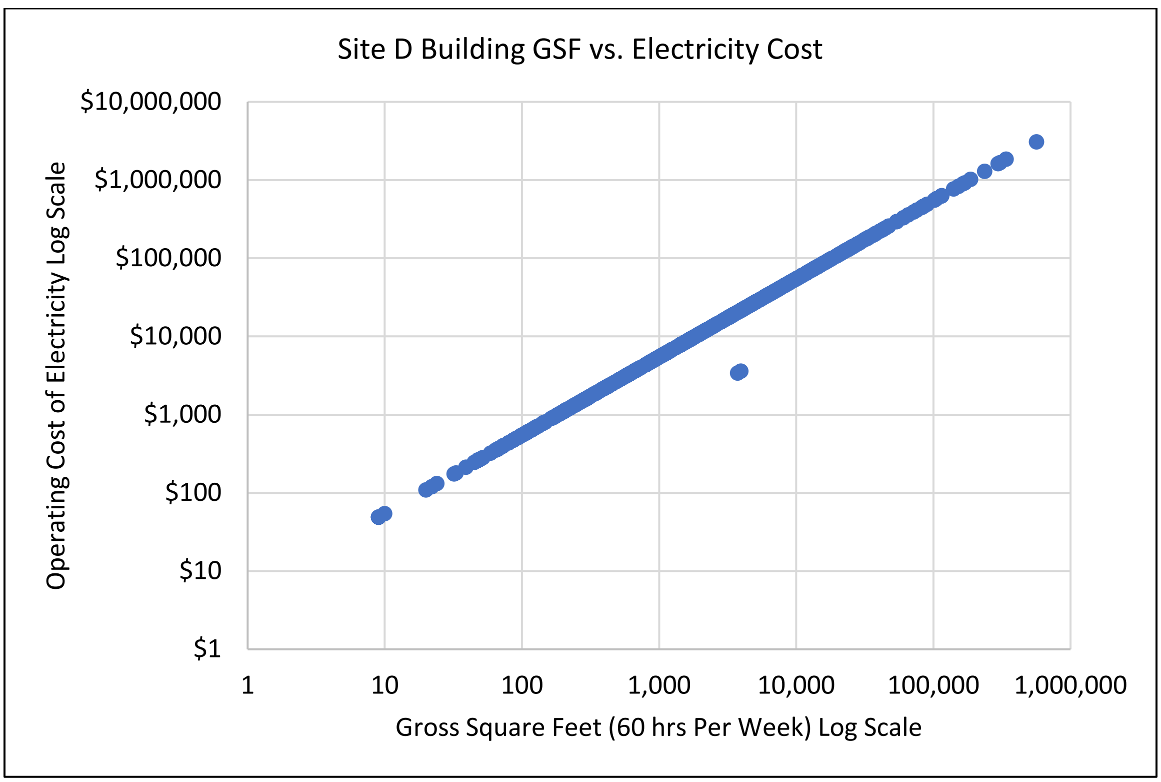
Within the DOE, FIMS is the official corporate real property inventory system that stores real property asset data including data for the Federal Real Property Profile (FRPP) data submission. This data management requirement is mandated by DOE Order (O) 430.1C (Reference 2). The data in FIMS are reviewed on an annual basis before the FRPP information is submitted to the General Services Administration. Once the data have been submitted, the information is published and made available for analysts and decision makers.

FIMS is managed and maintained by the DOE Office of Asset Management (MA-50), comprised of staff from departmental elements across the DOE. Within the NNSA, FIMS is housed in the Office of Infrastructure Planning and Integration (NA-911), who are responsible for working with the LPSs to collect real property information. The data submission consists of various data fields as defined by the Federal Real Property Council (Reference 8), including physical information such as location and size, and programmatic information such as hazard category, mission/usage, and facility condition. There are also several cost elements, including the two elements that align directly to our O&S WBS, utilities, and maintenance. The following sections will detail the process of validating these FIMS costs.

3 What You See is "Watt" You Get – an NNSA Utilities Analysis Deep Dive

Upon our review of the CAEF 2.0 O&S WBS elements and the data available in FIMS, utilities stood out as low hanging fruit that could be quickly synthesized into a group of CERs, with one for each major utility: electricity, water, and gas. Each is a discrete WBS element in the CAEF 2.0, and each is a discrete column in FIMS, with costs for each utility type assigned to individual buildings. Perfect – the data are in the correct form, at the desired level, and published in the DOE's real property asset system of record, with a myriad of other data that can be leveraged as potential cost drivers. For the sake of avoiding redundancy, we will focus specifically on electricity costs in this section, as each of the utilities followed the same story. So, let's throw all the data into our statistical software of choice, and we'll be able to estimate the electricity cost of any building in no time! Perhaps just a few visualizations first, just to take a peek at the data we are working with.

Figure 2: Scatterplot of gross square footage and electricity cost



Oh boy.

Figure 2 shows a scatterplot of building gross square footage (GSF) and building electrical cost per hour of operation. Save a few lonely points, electricity cost increases in a perfect line as GSF increases. This means that electricity cost is purely a function of the size of a building, and the number of hours it operates. There are no other explanatory variables or environmental factors that influence electricity cost. This is an ironclad law, right? Or perhaps there is a chance this chart is not showing actual electricity costs for buildings.

Lesson 1: Slow Down!

We cannot validate or make inferences from data that we do not first intimately understand. Spending time upfront to explore the data, understand how they are created, and what they represent is an exercise that is too often rushed, or skipped altogether. We cannot validate, let alone create accurate CERs from, data that we do not understand. The FIMS Data Dictionary, which is publicly accessible on the FIMS website (and in Appendix G: FIMS Data Definitions and Reference 6), clearly states that all operations costs, including electricity, are site-level costs that are allocated to individual buildings by square footage and weekly hours of operation. So even though each building has an electricity cost assigned to it, these are not actual costs, but rather estimated costs based on a sitewide actual cost. Low-hanging fruit indeed.

With the goal of estimating utility costs at the building level, we have two options:

1) Use the FIMS allocation formula: building electricity cost = site total electricity cost ÷ GSF ÷ hours of operation.
2) Create our own CER and/or allocation formula.

Option 1 would be quick and easy, but there are likely other drivers of electricity costs that should be explored, such as geographic region and the mission of the building. It would make sense that a building in a desert would use more electricity for its HVAC system than one in a more temperate region, and a manufacturing facility with heavy industrial equipment or a data center filled with server banks would use more electricity than a simple warehouse or office building of equivalent size and hours of operation (Reference 7). That these factors are not covered in the FIMS allocation formula makes Option 2 more appealing, despite the need for additional effort and data collection that this would require.

Luckily, the DOE has already spent significant energy on efforts to compile relevant data, one of which is the Federal Energy Management Program (FEMP) (Reference 8). Background information about FEMP can be found in Appendix C: Database Background Information, but FEMP produces energy usage (kWh) benchmarks for various types of buildings, and specifically for buildings at each of the NNSA sites. A couple keywords there to unpack as we begin to understand this new data:

- Usage: how many kWh a building is using. Notably, there are no costs in FEMP. However, is it possible that all the potential cost drivers that have been identified: size, hours of operation, geographic area, and building usage, are all proxies for usage? Meaning, cost is increasing because usage is increasing.
- Benchmarks: estimates, not actuals. How much electricity a building is expected to use under normal operating conditions. So, FEMP is largely just a glorified usage estimating relationship.

Upon reviewing FEMP, we decided to change our approach to estimating electricity costs. Rather than directly estimating cost, first estimate usage. Then, apply a cost per kilowatt-hour (kWh) to the usage estimate to produce a cost estimate. This allows us to incorporate uncertainty around both cost per kWh and usage. That leaves just two questions:

1) Can we use FEMP to estimate usage? Or stated another way, can we derive the equation that FEMP is using to benchmark usage? And can we validate that the equation is producing accurate estimates?
2) How are we going to estimate cost per kWh?

Luckily for us, it turns out that another team in PA&E was already working on answering question 1 and had already produced a simplified form of the usage estimating equation used in FEMP:

$$Usage = a + b * GSF + c * Operating\ Hours + d * Buidling\ Type + e * Location$$

More information on this equation, called the energy intensity estimating relationship (EIER), and that team's work can be found in the 2025 paper, "Sustainability in Cost-Benefit Analyses: Closing the Loop." But what about the second part of that question – beyond the data validation work in that paper, what can we do to validate the accuracy of the FEMP usage equation?

Lesson 2: Trust Nothing

Having trust issues in a relationship is bad. Having trust issues in a relationship with data is a virtue. Any data that you have not personally collected should be met with a healthy skepticism. When you use someone else's data, you are adopting all their assumptions, so you better understand them.

Normally, we would determine the validity of any equation by comparing it to historic actuals outside of the dataset. Meaning, pick a sample of buildings, enter their parameters into the equation, calculate their usage, and compare that to their actual electricity usage. If the historic actual falls within the prediction interval of the equation, then we would have evidence for the accuracy of the equation. The only problem is, there is a shortage of historic actual electricity usage for NNSA facilities. This is largely because most buildings at the NNSA sites are not individually metered, which helps to explain why FIMS allocates down site-level costs. However, there are some facilities that do have their own meters. Refer back to **Figure 2** and note the two points that do not fall on the line. Could it be possible that datapoints that did not use the allocation formula are metered facilities and are reflecting an actual cost of electricity, rather than an allocated cost? Or is there something else going on?

By definition, these points are errors. The FIMS Data Dictionary states that the electricity cost column is always an allocated cost, so any point not using the allocation formula is violating FIMS' data entry rules. More on that later. But for now, what can these "errors" tell us? **Figure 3** shows the FIMS cost/square foot according to the allocation formula, split out by the building type categories used by the EIER. Since the FIMS formula does not take building type into consideration, the cost/square foot is identical (except "Other").

Figure 3: FIMS $/square foot by building type

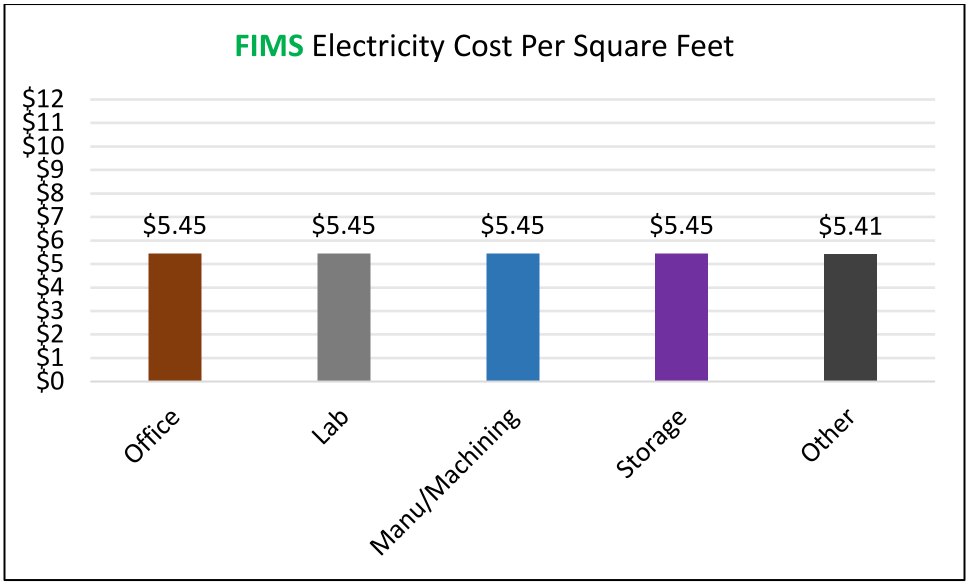
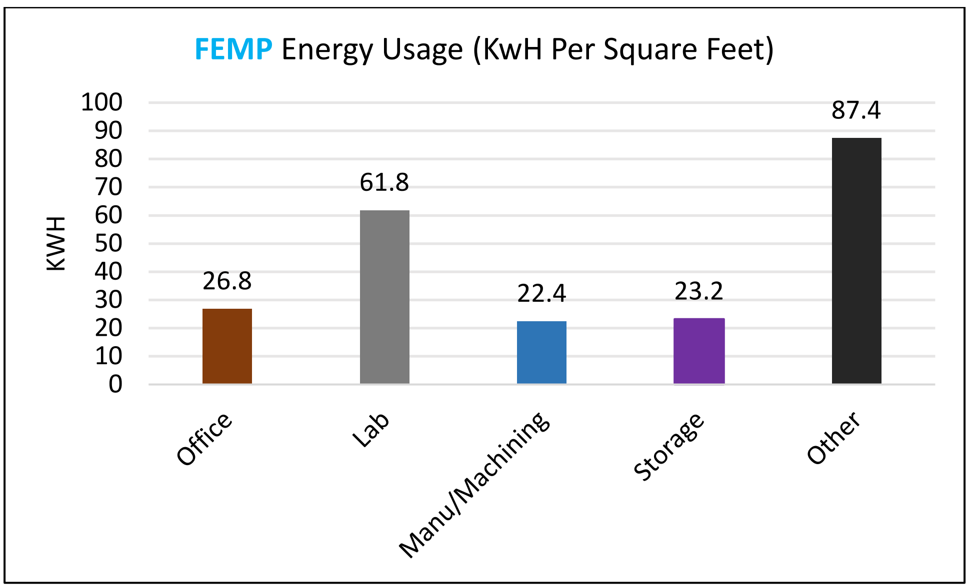


Figure 4: FEMP kWh/square foot by building type



Compare that to the FEMP energy usage/square foot in **Figure 4**, which shows that labs and other (which is driven by data centers and supercomputing facilities) are using significantly more energy than the other three building types. So, what happens when we filter the FIMS data to only the points that are not using the allocation formula?

Figure 5: Comparison of non-allocated FIMS electricity costs per unit and FEMP usage per unit, by building category

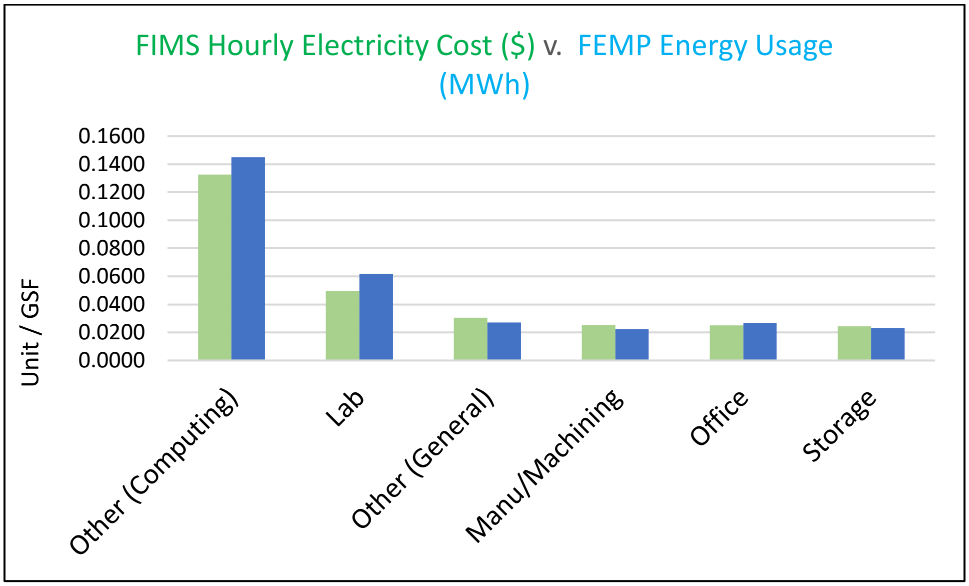


Figure 5 shows this comparison, with the FIMS cost/square footage in green and the FEMP usage/square footage in blue. Remarkably, for each building usage bin, there is a clear correlation between usage and cost. This provides validating evidence that the FEMP benchmarks are a reasonable way to estimate electricity usage. That said, this comparison does not provide enough evidence to suggest that the points in FIMS not using the allocation formula are actual costs derived from individually metered buildings. These points in FIMS could just be using a different allocation formula, perhaps even derived from FEMP. The non-allocated FIMS datapoints were also not representative enough to inform our electricity CER, as most of the points occur at just two of the NNSA sites, and only within a four-year period.

Given this finding of correlation between the FEMP usage and non-conforming FIMS points, FEMP's reputation as an authoritative source, and the EIER Team's previous validation work, we felt comfortable using the EIER as an input to our electricity CER. Now comes the fun part, how do we estimate the cost per kWh if the FEMP data are not sufficiently representative?

The easiest way to estimate cost/kWh would be to take a site's total electricity cost and divide that by the site's total electricity usage. That would give us an average cost/kWh for each site, for each year. Getting a site's total electricity cost is easy – just sum up all the site's assets in FIMS. For usage, we could use FEMP again, but site actuals would be preferred to summing up facility-level estimates. Enter the DOE Sustainability Dashboard.

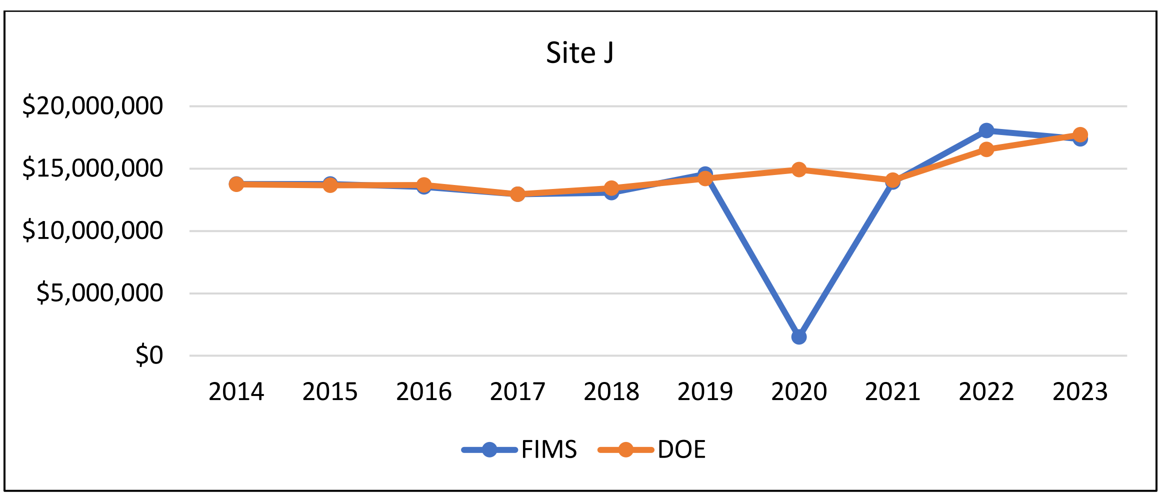
The DOE Sustainability Dashboard collects myriad information to track progress towards sustainability goals, including exactly what we wanted – site actuals for electricity usage and cost. There's only one problem. While the usage figures align to the benchmarks in FEMP, the cost totals do not equal the totals in FIMS across the board. In fact, from 2014 to 2023, every single site had multiple years with a different electricity cost published in FIMS versus the DOE Sustainability Dashboard. This creates quite the conundrum. FIMS is the DOE's real property asset management system of record and touts their data validation process. Surely, we should trust the costs in FIMS more, right? And the DOE Sustainability Dashboard, by policy, is supposed to be directly linked to FIMS, meaning that it shouldn't even be possible for the values to be different. And yet they are. Now we must determine why these sources are showing conflicting information, which one is the most accurate, and what it means for our larger O&S estimating effort. This is where the fun begins.

Lesson 3: Comparison is King

It's not great for your mental health to sit on social media comparing your life with others. It's also not great for your mental health to compare disparate data sources, but it works wonders for the health of your estimating methods. This is a simple best practice, previously explored in the 2017 paper "Expanding the Range of Your Data: A Small Ships Case Study" (Reference 11).

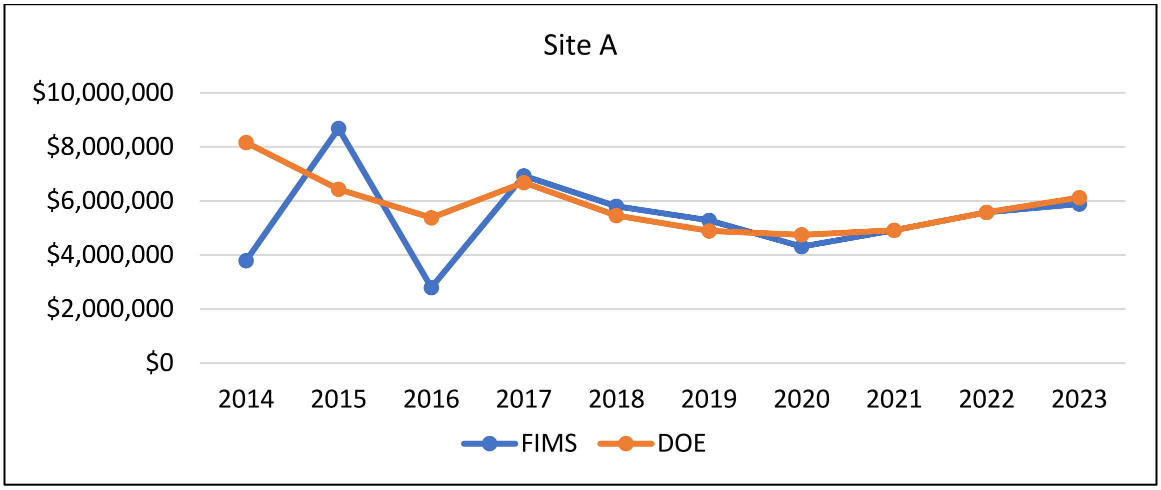
First things first, let's look at how the total site costs in FIMS and the DOE Sustainability Dashboard are different. We were able to identify three discrepancy patterns between the ten NNSA sites that were analyzed. The first discrepancy pattern can be seen in **Figure 6** (and Appendix E: Electricity Comparison Charts), which shows that FIMS and the DOE Sustainability Dashboard perfectly or almost perfectly match every year except for a couple outliers in the middle of the period of study. This pattern was noticed at three of the sites, and each time, it was the FIMS data that appeared to be the outlier. In the case below, it appears that the FIMS number is missing a significant digit in 2020, and it is unclear why the 2022 number is slightly off. Of course, it is possible that a large drop in electricity cost could occur from one year to the next, perhaps due to the COVID-19 shutdown in 2020, but since this precipitous drop is only reflected in FIMS, and since all other years except 2022 align between FIMS and DOE Sustainability, this suggests that the FIMS point for 2020 is more likely to be a data input error.

Figure 6: Data error example – Site J FIMS versus DOE Sustainability electricity cost



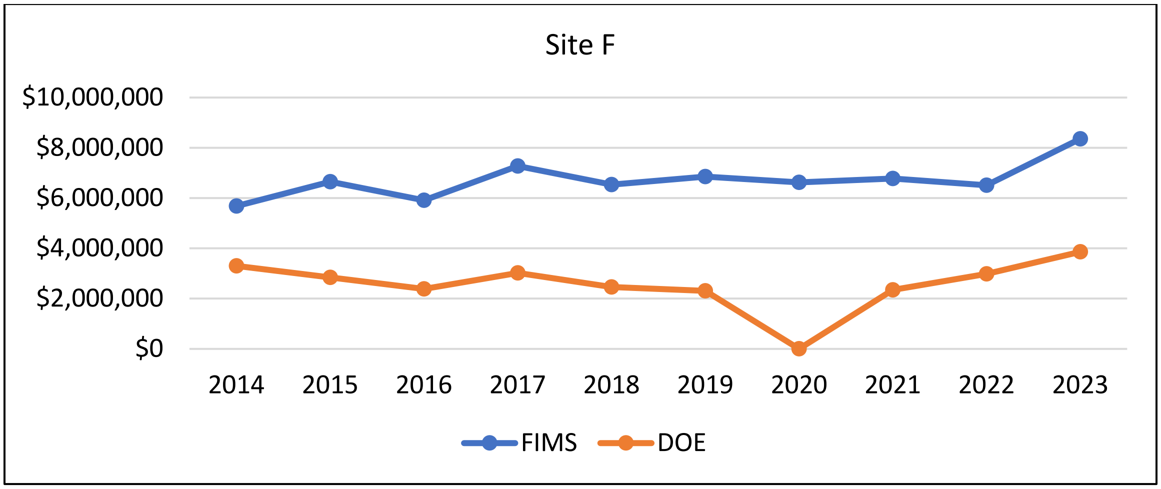
The second identified pattern, also seen at three sites, can be seen in **Figure 7** (and Appendix E: Electricity Comparison Charts). This time, the data show a misalignment between FIMS and DOE Sustainability in previous years before coming into alignment, or vice versa – alignment in previous years and misalignment now. Again, for each of the three sites, the DOE Sustainability data appear to show a consistent trend, while the FIMS data during the misaligned years are more haphazard with inexplicable swings in cost. This suggests for these sites, at the least, FIMS and DOE Sustainability were not linked to each other, and a different methodology was used to arrive at the electricity cost in FIMS versus the electricity cost in DOE Sustainability. However, something since changed to align the methodologies or link the databases so that the costs are identical or near identical.

Figure 7: Reporting practice change example – site FIMS versus DOE sustainability electricity cost



The third pattern, which applies to the remaining four sites is the most intriguing and leads even farther down the rabbit hole. This time, as seen in **Figure 8** (and Appendix E: Electricity Comparison Charts), the FIMS electricity cost is consistently higher than the DOE Sustainability cost. This time, both demonstrate consistent and gradual change over time, suggesting consistent reporting practices and methodology. However, we do see what appears to be a missing significant digit data error in the DOE Sustainability data for 2020, the first instance of an obvious flaw in DOE Sustainability. But other than this, and unlike in the other two patterns, it is not clear which line represents the correct electricity cost. It is clear that FIMS and DOE Sustainability have never been linked at these four sites, and that both sources are using a different methodology to produce the electricity cost, but which one is accurate? After going through the other two patterns, we naturally bias towards trusting the DOE Sustainability data but given that we already have evidence of each site's data being a little different, we should not just blindly trust the DOE Sustainability data. It was time to confront this problem directly at the source and talk to the sites.

Figure 8: Multiplier example – Site F FIMS versus DOE sustainability electricity cost



Lesson 4: Get it Straight from the Source

Primary sources are superior to secondary sources. If you are working with a secondary source, as most databases are, the best way to understand the data is to see the data behind the database. If that is easier said than done, a close second is to build a relationship with those who built the database. Understand how they collect data, if and how they transform data, and if your goals for using the data align with their understanding of how the data can be used. When dealing with multiple, disparate data sources and databases, establishing a hierarchy of data quality is paramount, as described in the paper "Schedule Estimating Relationship (SER) Development Using Missile and Radar Dataset" (Reference 19).

As such, we worked with points of contact (POCs) from several of the sites within NNSA to nail down where these inconsistencies in the data were coming from. Between emails and video teleconferencing, several takeaways were identified. The biggest finding confirmed our suspicion – across all sites, the DOE Sustainability Dashboard costs represent the raw electricity cost, as corroborated by electricity bills and accounting systems. When FIMS shows a different cost, it is either an error or a cost with a multiplier on top of it. For the purposes of CER development, this means the costs from the DOE Sustainability Dashboard should be used.

But what is going on with FIMS? First, we noticed that many of the sites are siloed, in that the FIMS, DOE Sustainability, and financial POCs do not interact with each other. The non-FIMS POCs were confused and surprised when we showed them the comparison charts above, not understanding how and why they reported different numbers. But as discussions continued, the FIMS representatives opened up about their use of multipliers.

Here's how it works: the utilities, maintenance, and other operations cost columns in FIMS sum up to a column called "Total Operations and Maintenance Cost." But the other operations costs columns in FIMS are not an exhaustive list. They only include waste management, pest control, snow removal, and landscaping, leaving off numerous other operations costs (direct labor, anyone?). So, to make the "Total Operations and Maintenance Cost" match the total operations and maintenance (O&M) number that the site requests in the budget, the sites adjust all of the operations costs that are in FIMS with a multiplier.

This ensures that their funding will not be reduced by someone looking at FIMS and seeing a much smaller number than what is reported for budgeting. That's all well and good, but that means that the electricity cost for each of the four sites that use a multiplier is not just the electricity cost, but electricity plus a bunch of other stuff, and thus we will overestimate if just trying to estimate electricity. In addition, this practice violates the definition of electricity cost as defined in the FIMS Data Dictionary (Reference 6) and Appendix G: FIMS Data Definitions). It is also worth noting that the sites that do not use this practice have never had funding issues because of their lower total O&M column in FIMS.

So, for these multiplier sites, DOE Sustainability represents the raw cost of electricity, and FIMS is the electricity cost times the multiplier. Meaning, we can derive the multiplier by dividing the two costs. We also asked the sites to provide the multiplier that was used. At Site C, the FIMS multipliers are dictated each year by senior management, and as seen in **Table 1**, only match the derived multiplier (close enough) in 2 of the 10 years for which we have data, 2020, and 2023. In addition, Site C admitted to a reporting error in 2014 and 2015. They could not find the multiplier used in those years, and the FIMS data itself does not follow the trend of the following 8 years. This means that the FIMS data for this site are clearly not just the raw cost times the multiplier, and the data are completely unreliable for estimating electricity costs. The other three multiplier sites were not willing to share this level of information. But it speaks volumes that even when data are manipulated to violate the FIMS Data Dictionary definition, this is done inconsistently and without traceability.

Table 1: Site C derived multiplier versus reported multiplier

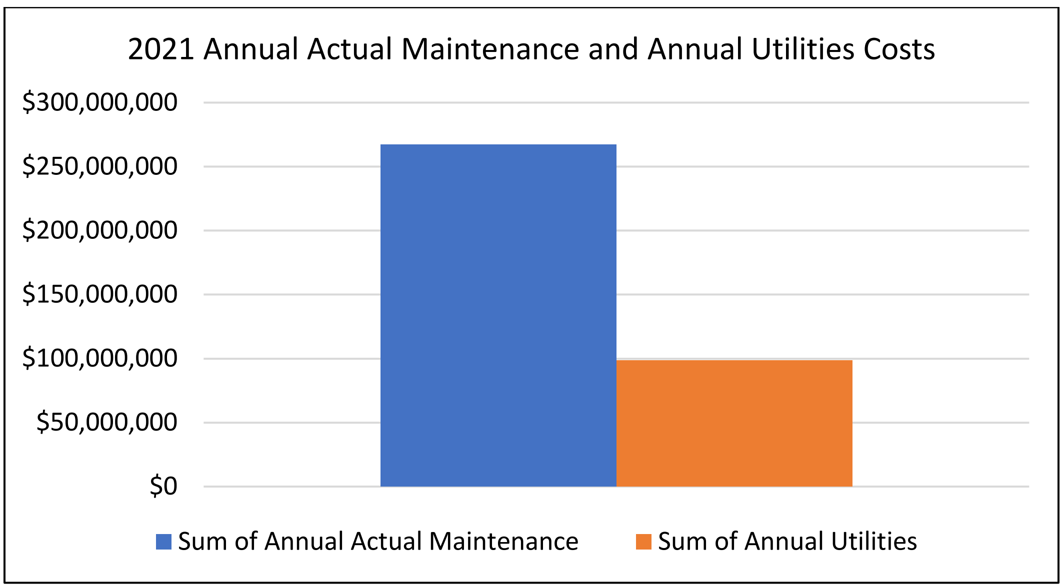
Year	FIMS/ DOE Sustainability	Site C Reported Multiplier
2014	1.02	**"internal reporting error"**
2015	0.15	**"internal reporting error"**
2016	1.99	**1.82**
2017	1.87	**1.76**
2018	2.50	**1.75**
2019	1.79	**1.67**
2020	1.65	**1.66**
2021	1.57	**1.64**
2022	1.96	**1.67**
2023	1.68	**1.67**

In summary, the electricity cost data in FIMS is unreliable. Due to inconsistent reporting practices, data errors, and the widespread yet untraceable use of multipliers, each site's data has its own unique issues that make benchmarking and trend analysis difficult and attempting to produce CERs from it a fool's errand. Instead, having validated that the DOE Sustainability Dashboard always shows the raw actual utility cost, we will simply calculate the cost/kWh from DOE Sustainability paired with the EIER usage estimating equation. One CER down, several to go.

4 Constantly in the Fix – NNSA Maintenance Data Deep Dive and Analysis

All the utilities work discussed above was originally meant to be a quick proof of concept of using FIMS data for O&S estimating (how foolish we were!). The larger goal was to use FIMS to estimate facilities maintenance costs, which accounts for a much larger percentage of total O&S costs than utilities, as seen in **Figure 9**.

Figure 9: Site D 2021 annual actual maintenance versus total utility cost



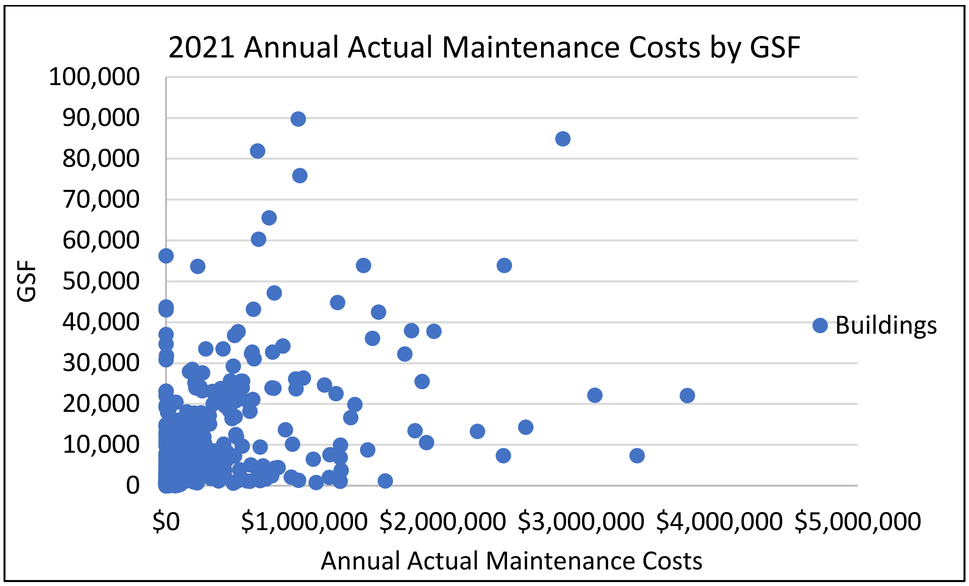
But now that we are wary of systemic data input errors, changes in reporting practices, and multipliers being added to costs, we needed to express extreme caution with the FIMS maintenance data before even considering moving forward with producing a CER. First, we need to understand what FIMS is collecting. There are multiple columns in FIMS that capture maintenance information (Appendix G: FIMS Data Definitions and Reference 6):

- Repair needs
- Deferred maintenance
- Annual required maintenance

- Annual actual maintenance

For our purposes, we only care about annual actual maintenance. Emphasis on the 'actual'. Unlike utilities, annual actual maintenance data in FIMS must be the actual, fully burdened cost of maintenance for each asset and cannot be an allocated cost. Annual actual maintenance also represents the funding-constrained and executable maintenance for each asset, rather than the unconstrained estimates of the other three maintenance columns. This is exactly what we want as data for a CER – asset-level actuals that we can use to estimate the future cost of maintenance at any facility over its life cycle. But let's not forget Lesson 2 about trust issues. They may be listed as actuals, but do the maintenance costs appear to be actuals when we graph them?

Figure 10: 2021 annual actual maintenance costs by gross square footage



So at face value, it does look like we are working with asset-level data, rather than costs allocated down from the site level. That's an improvement. But how do we know that any of the asset-level maintenance costs in FIMS are accurate? We have already concluded that FIMS is not a reliable source, even at the site level, for utilities costs, so what's to say that similar issues do not also plague FIMS' other major cost column? Once again, it's time to look for another data source that can corroborate or refute the FIMS data (Lesson 3: Comparison is King).

Enter CostEx. CostEx translates each site's unique accounting systems into a standard work breakdown structure based on the funding buckets of the NNSA budget. The use of accounting systems as a data validation tool has previously been detailed in the 2018 paper "Diamonds In The Rough: How to Normalize Cost Accounting Data" (reference 12). (See appendices C and D for the differences between the CostEx WBS and the CAEF 2.0 WBS)

One of the WBS elements in CostEx is Maintenance and Repair of Facilities. CostEx's WBS structure does not go all the way down to the asset level, but it will allow us to compare each site's annual actual maintenance cost, as defined by their accounting system, to each site's annual actual maintenance cost enumerated in FIMS. Just as with utilities, the validation exercise is super simple. If the cost for each site and each year in CostEx and FIMS are identical, we have validated data. If not, let the games begin.

Spoiler alert: we're about to play more games than the Paris Olympics.

I'm not sure if this should have been a surprise to us or not, but there was not a single year at a single site that showed the same annual actual maintenance cost in FIMS and CostEx. Granted, CostEx is a relatively new system for the NNSA, so we only have reliable data going back to 2021. And as seen in **Figure 11** and **Figure 12**, this is not a marginal incongruency. Site D represents the worst-case site, where the discrepancy is over $100 million and the FIMS values are approximately 250 percent of the CostEx values. Even in the best-case site, Site F/K, where the discrepancy is only 3 to 10 percent, this is still a difference of several million dollars. That's hardly something that could be chalked up to a rounding error. Also note that at Site F/K, the CostEx value is higher than the FIMS value, the opposite problem from Site D.

Figure 11: Site D FIMS annual actual maintenance versus CostEx maintenance and repair of facilities

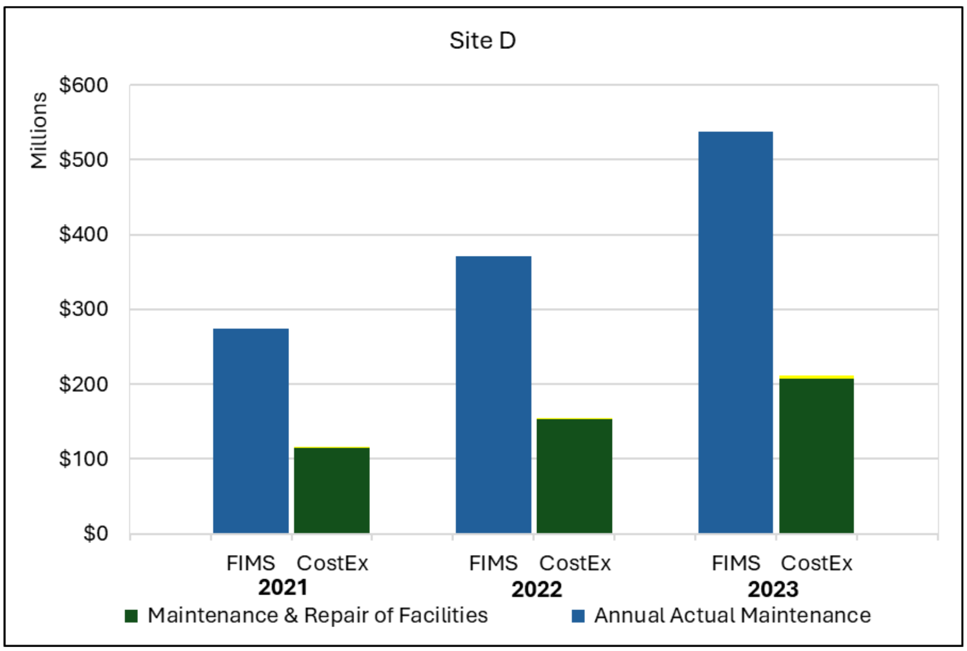
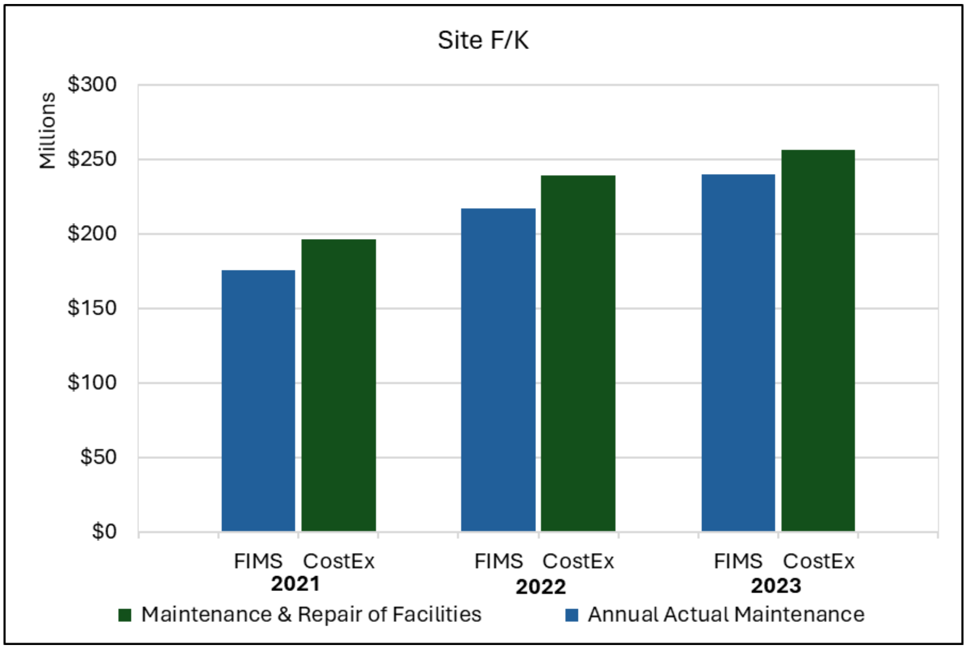


Figure 12: Site F/K FIMS annual actual maintenance versus CostEx maintenance and repair of facilities



So, what's going on here? Some sites using multipliers again? Systemic data input errors? Time to round up the usual suspects? Not quite yet – turns out we were missing some crucial data in CostEx. (Lesson 1: Slow Down). Now the untrained analyst may have been ready to believe that a system using a standard WBS would have bucketed all of its maintenance and repair of facilities costs under the bucket labeled "Maintenance & Repair of Facilities." But not us. Too many trust issues. Being the skeptics we are, we decided to go line by line through the CostEx WBS and identify any other elements that were labeled as maintenance. And there were quite a few.

Starting with the most obvious, at the same level of the WBS as "Maintenance and Repair of Facilities," there is another WBS element called "Operations and Maintenance." Many of the subelements within this category appear to be operations costs rather than maintenance costs, such as "Safeguards and Security Planning and Procedures" and "Access Authorizations," but there are also several lines that could be maintenance, such as "Protective Force Facilities." There is not a lower level of detail than this in CostEx, so it is not clear what activities fall under these descriptors. They each could have a mix of operations and maintenance costs that are known to the FIMS personnel but not to us. They could also solely be operations costs, and this is just a poorly named WBS element, hence why Site F/K does not appear to include any costs from this bucket. Or the opposite could be true for other sites such as Site D – all these costs are (or are taken as) maintenance costs for FIMS. Regardless, there are other WBS elements to investigate.

Our next group of elements took us to the lowest levels of the CostEx WBS. As seen below in the example in **Table 2**, we discovered maintenance costs hidden under parent elements that seemingly have no relationship to maintenance.

Table 2: Example of lower level maintenance costs discovered in CostEx, compared to maintenance and repair of facilities

	WBS Level			
	4	5	6	7
Buried Maintenance Element Example	Counterterrorism and Counterproliferation	National Technical Nuclear Forensics	Disposition and Forensic Evidence Analysis Team	**Facility Maintenance**
Baseline Maintenance Element	**Maintenance and Repair of Facilities**			

We identified 46 such unique elements across the CostEx WBS, some unique to specific sites and specific years. Each of these elements is explicitly listed as facility maintenance but is not categorized under "Maintenance and Repair of Facilities." It is unclear why CostEx captures these costs in this manner, perhaps because of the sometimes complex nature of the NNSA's funding structure, but we would expect that FIMS would include the maintenance cost for an asset regardless of where it is being stored in a WBS.

There are several elements in CostEx we took note of and captured that should *not* be considered maintenance costs in FIMS, but we figured it could be possible that they were regardless. The following are the elements:

- **"Programmatic Equipment/Personal Property Maintenance":** Annual actual maintenance in FIMS should only be capturing maintenance costs associated with real property (i.e., the asset itself and not the programmatic equipment contained by the asset).
- **"Weapons Maintenance":** Costs associated with maintaining weapons systems. Again, the weapons systems are not part of the buildings, so their maintenance costs should not be assigned to a building.
- **"Recapitalization":** This is a tricky one, as definitions of the line between recapitalization and maintenance can vary from site to site and even person to person. But in general, recapitalization projects require discrete funding lines in the budget and have their own WBS buckets that are fully separate from maintenance, so hopefully FIMS is not lumping recapitalization costs into its annual actual maintenance column.

And one final wrinkle. Within "Maintenance and Repair of Facilities," there are subelements for the Roofing Asset Management Program (RAMP) and the Cooling and Heating Asset Management Program (CHAMP). Many of the costs for RAMP/CHAMP are assigned to one NNSA site, but the subelements to that cost state that the activity is taking place at another NNSA site. See **Table 3** for an example of this. Since the asset that is receiving those maintenance dollars is at the latter site, it would make sense that those costs should be re-assigned to the latter site to properly compare the cost in FIMS, assuming that FIMS is tracking the total maintenance cost for the asset, regardless of which site's funding paid for it.

Table 3: Example of CHAMP execution at Site B but tagged to Site A

Site	WBS Level 4	WBS Level 5	WBS Level 6
Site A	Maintenance and Repair of Facilities	CHAMP Execution Portfolio	CHAMP Execution at Site B

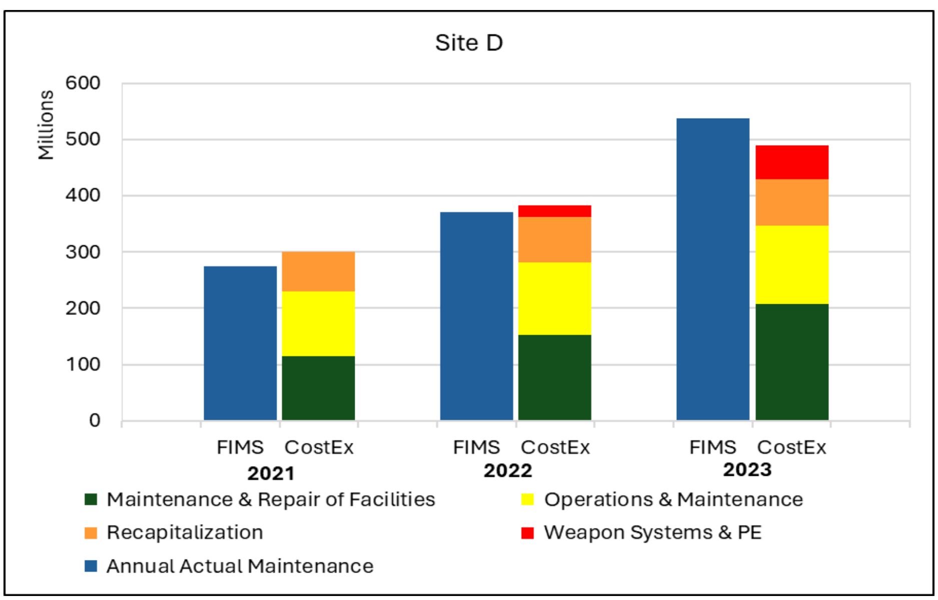
Great, so now we've looked through every little nook and cranny in the CostEx WBS and identified anything that could possibly be construed as a maintenance cost, giving us hundreds of discrete costs for each year at each site.

These costs include the following:

- The elements that FIMS ***should be including*** as facilities maintenance costs:
    - "Maintenance and Repair of Facilities"
        - Including RAMP/CHAMP costs moved to the site where execution takes place.
    - Facilities maintenance costs as child elements of other WBS elements.
- The elements that FIMS ***might be including*** as facilities maintenance costs:
    - "Operations and Maintenance"
- The elements that FIMS ***probably should not be including*** as facilities maintenance costs:
    - "Recapitalization"
- The elements that FIMS ***definitely should not be including*** as facilities maintenance costs:
    - "Programmatic Equipment/Personal Property Maintenance"
    - "Weapons System Maintenance"

Including *all* of these elements makes the CostEx total much higher than the FIMS total at every site and every year (see Appendix F: FIMS versus CostEx Maintenance Comparison Charts), except one year at Site D, as seen below in **Figure 13.** This makes sense given we are now including all of the elements we identified as "probably should not include" and "definitely should not include." But what about 2023 at Site D? How is it possible that the FIMS total is still higher than the CostEx total, even after including all of these elements? It should not be possible. We have to investigate further, but 2023 at Site D suggests a data error or wildly different definitions of facility maintenance between FIMS and CostEx.

Figure 13: Site D Comparison Between FIMS and CostEx



But let's come back to 2023 in a bit. For all the other years and sites, the CostEx total is greater than the FIMS total, meaning that there must be some subset of the CostEx elements that is equal to the FIMS total. We have already determined the hierarchy of costs that FIMS should and should not be including, as we have shown stacked up in **Figure 13** for Site D. By our logic, in 2021, Site D's FIMS total should include all the CostEx "Maintenance and Repair of Facilities," the other "Facility Maintenance" child elements, "Operations and Maintenance," and some subset of "Recapitalization." Site D had 62 recapitalization elements in 2021, which is a bit too many to parse through by hand, so instead, we can run a minimization function to determine the subset of elements that will equal the FIMS total. But there is no exact match. However, we were able to get within $14, which could be a rounding error but we'll take it.

How about for 2022? Refer back to **Figure 13** and see that now we need to include all of "Recapitalization" in addition to all of the previously mentioned elements. This time, we have to subset the equipment and weapons maintenance costs. Well, that's not good. These are costs that *definitely should not* be included in FIMS. Either FIMS is now including costs it should not be, or the data are flawed, and these comparisons are meaningless. Either way, there are only four discrete elements under equipment/weapons maintenance for 2022, and by our step function logic, we can only get within $8 million of the FIMS total. Not exactly a great match. So what if we throw out this step function logic and run the minimization function on every discrete cost, regardless of bucket? As you would expect, we can again get within a rounding error, $8, but now all logic is gone. The elements returned by this function are a Frankenstein's Monster of different costs, *excluding* a bunch of elements blatantly labeled as "Facility Maintenance" and *including* the equipment/weapons maintenance elements. This is not good validation. Just because we can get the costs in FIMS and CostEx to be almost equal by throwing out logic, this in no way validates the costs in FIMS or CostEx.

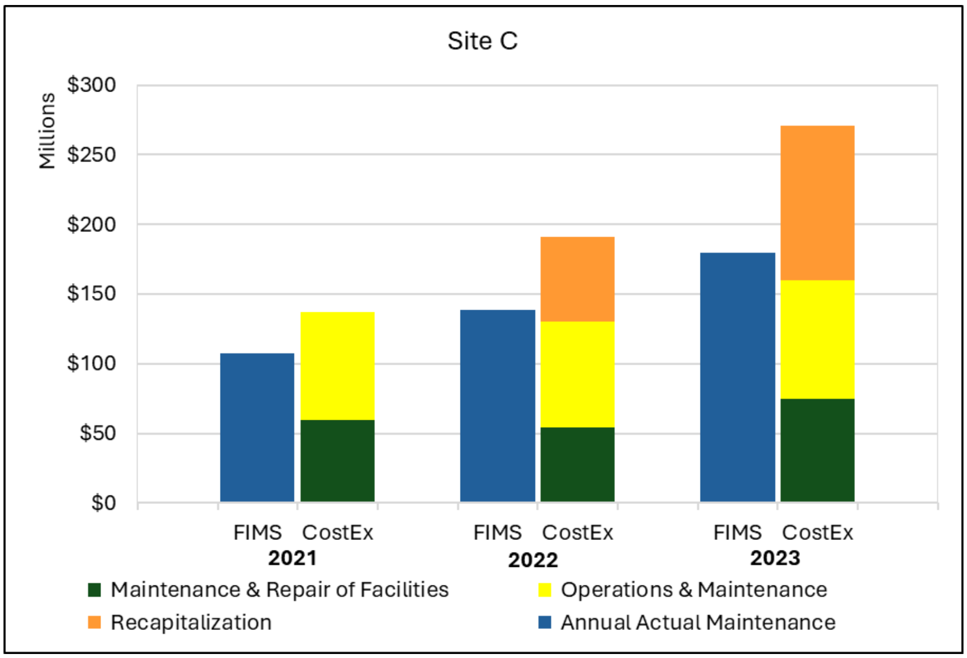
Looking at the bigger picture, in 2023 there is no subset of CostEx elements that can equal FIMS, because the FIMS total is greater than the CostEx total. The subset of elements in 2021 and 2022 that get closest to FIMS are completely inconsistent with each other. The subset of elements that by our logic should be included in FIMS are hundreds of millions of dollars off from what FIMS says. But as we said previously, Site D is our worst-case scenario. What about the other sites?

The answer: not much better. Once again, there was not a single site nor a single year that we were able to achieve, by hand or with the help of functions, through any permutation of elements, logically, hierarchically, or randomly, an exact match between FIMS and CostEx. There were several additional potential rounding errors, but not a single FIMS = CostEx = True. But like with the utilities, three groups emerged.

The first group was seen above in Site F/K in **Figure 12,** in which the CostEx "Maintenance and Repair of Facilities" bucket alone is above the FIMS annual actual maintenance total. Of the seven sites analyzed, only one other site joins Site F/K in this group (see Appendix F: FIMS versus CostEx Maintenance Comparison Charts). While still not equal in their magnitudes between FIMS and CostEx, the FIMS total appears to be a subset of the costs that we identified as definitely should be included in FIMS and nothing else, in each of the three years analyzed. Furthermore, the percent difference between FIMS and CostEx "Maintenance and Repair of Facilities" stays relatively constant for both sites among years. This could suggest there is a consistent subset that represents the FIMS cost. Unfortunately, that subset is not evident in CostEx, as the minimization function returns a completely different set of elements every year.

The second group includes three sites (see Appendix F: FIMS versus CostEx Maintenance Comparison Charts), including Site C in **Figure 14**. These are our middle ground sites. To align with FIMS, we need to include the "Operations and Maintenance" and sometimes a subset of "Recapitalization." These sites each have two out of three years where the same elements are included, and a roughly equal percentage of the subset element is needed to align to FIMS in those two years. Once again, this suggests a small level of consistency in methodology, even if we are unable to derive the subset that makes up that consistent methodology. And even if there is any consistency, it would be consistency in including elements that likely should not be considered facilities maintenance.

Figure 14: Site C FIMS versus CostEx comparison



The third group includes the previously discussed Site D and one other site, Site L, seen in Appendix F: FIMS versus CostEx Maintenance Comparison Charts. These are the only two sites that tripped the threshold of needing to include equipment/weapons maintenance. However, Site L is not nearly as bad at Site D, as this threshold is only tripped in 2021, so CostEx can still be subset to roughly equal FIMS in 2022 and 2023 using the recapitalization bucket, and both years are consistent in their percentages of recapitalization required to match FIMS.

We again find ourselves in a situation where two sources of data that should be showing the same values are unable to validate each other without further investigation, creating more questions than they answer. These questions include:

1) Have we actually captured all of the CostEx costs that are considered facility maintenance, or are we still missing elements?

2) Why isn't facility maintenance fully centralized in CostEx in the first place?
3) Do FIMS administrators even use their sites' accounting systems to calculate annual actual maintenance for FIMS?
    a. If they do, what are we missing?
    b. If they don't, what are they using? And why does it differ from the ledger that is reported to the government?

Inevitably, putting this information and questions in front of CostEx SMEs and FIMS administrators directly was our best path forward. Their answers can be summarized as follows:

1) It is possible that there are other maintenance costs hidden in CostEx. As already seen, facility maintenance can be funded from sources other than Maintenance & Repair of Facilities, appearing under other WBS elements. These are not the hidden costs. The hidden costs would have no textual reference to maintenance. They could come from any available funding source, including those that were not originally intended to be spent on maintenance. But if a need arises, they may be spent on maintenance and never receive a WBS reference. Conversely by this logic, it is also possible that some of the Maintenance & Repair of Facilities costs were not actually spent on maintenance and repair of facilities. There is no way to identify if these elements exist in any given year and where they are without having an intimate knowledge of a site's accounting practices. But given the discrepancies with FIMS, and if we assume that the FIMS values are correct, then this implies that hidden costs are a common occurrence.
2) The above largely explains why maintenance costs are not centralized in CostEx. Because the system is broken out by funding source and is primarily a tool to track spending against funding, it becomes difficult to aggregate specific activities, such as maintenance, that can come from multiple funding sources, especially when they are not always explicitly delineated in the WBS.
3) About a third of the sites do use their accounting systems to calculate annual actual maintenance. Another third uses their site's Computerized Maintenance Management System (CMMS). The remaining third said "I'm not sure. They email me a number every year and I enter that number into FIMS."
    a. The third that do use their accounting system are using it from the native format, prior to being converted to the CostEx WBS. No FIMS administrators had any familiarity with CostEx. As such, we are missing the specific methodology that these sites are using to map their charge codes to maintenance costs, which is clearly different from the CostEx mapping and may or may not include hidden costs.
    b. For the third using a CMMS, these systems are likely funding agnostic, just tracking the cost of maintenance activities. That may make this source the most straightforward, but a site's CMMS should still be traceable against the accounting system/CostEx, and again, it is clear that it is not.

Given these answers, it is possible that the FIMS costs represent the true maintenance costs, inclusive of any hidden costs and untethered from funding source. And because of the complex nature of accounting systems and tracking funding to costs to activities, it is too complicated to use CostEx as a validating source. On the other hand, we have evidence that FIMS' utilities costs are unreliable, so we have a healthy skepticism that the FIMS maintenance costs are true costs. Maybe there are no hidden costs, and we are conducting a futile exercise of trying to align a combination of CostEx elements to a

FIMS number that is wrong. So how do we know what to trust? With an inability to use the data itself to determine either source's validity, we will assess each source's data collection and validation process to attempt to amplify our trust in the data.

5 Trust Me Bro: Your Concerns are Valid

The CostEx data validation process is fairly simple. Sites upload their financial data twice. Once in the native format and once mapped to the CostEx standard WBS. The set of accounting codes that map to specific CostEx WBS elements is determined at the beginning of each fiscal year. If the total cost of each mapped WBS element in CostEx matches the total of all of the codes mapped to that element in the native format, then the data will successfully upload to CostEx. If there is any misalignment, the data do not publish. And of course, if any accounting codes are attributed to a WBS element other than the one explicitly stated in the mapping, this will also trip the validation rules. This ensures that the mapping cannot be altered after it is published, and that costs in the native format always match CostEx. (Reference 18)

That said, the accounting codes in the native format can only provide a finite level of detail. In addition to site and date, this is usually just the overarching mission that is being funded. Luckily for us, there are codes that map directly to the "Maintenance and Repair of Facilities" WBS element. Great! We can fully trace how "Maintenance and Repair of Facilities" is derived in CostEx and have trust in that data. The same can be said for the other elements at that level, including "Operations and Maintenance" and "Recapitalization."

But here's the catch. All of the costs in the child WBS elements that encompass "Maintenance and Repair of Facilities" are at a lower level than what can be gleaned from the native format accounting systems. This means that none of these lower-level costs are validated. For example, if a site spends $100M on maintenance and repair of facilities, we can validate that it did in fact spend that $100M on maintenance and repair of facilities. But we cannot validate what any of that $100M was spent on. If CostEx states that $99M was spent on Maintenance Cost A and $1M on Maintenance Cost B, but the true value was $50M on each, we would have no way of knowing. As long as the sum of the child elements equals the $100M that we can validate, it's not a problem for CostEx. The system simply trusts the accounting/financial SMEs to correctly allocate these lower-level costs.

Now if we were only dealing with the total of the "Maintenance and Repair of Facilities" element, this wouldn't matter at all. We have validated costs at this level for every site and every year. However, we identified dozens of facility maintenance elements at lower levels and outside of "Maintenance and Repair of Facilities," and lower-level costs within "Maintenance and Repair of Facilities" that might be attributed to the wrong site. Now that we know that these lower-level costs are not validated and might not always be true values, coupled with the potential of hidden costs (which also may or may not be true values), it makes sense that our subsetting adventure was unsuccessful. There are simply too many variables. We have uncertainty around both the elements to include and the accuracy of any of the lower-level elements. If all of the lower-level costs were true values, then we could run the minimization function on all of CostEx and attempt to find the hidden costs. But given the uncertainty of the accuracy of all the lower-level costs (and the accuracy of the FIMS total), it is an exercise in futility to attempt to validate FIMS using CostEx. And in general, given all of this information, it would not be advisable to use CostEx for any cost estimating efforts that require data below what CostEx can validate on its own or that can be validated with an outside source.

Now what about FIMS? We were invited to take a multi-day training on how the FIMS data validation is conducted. To FIMS personnel's credit, the process is well-documented and in-depth. Much of the process hinges on being able to back up any piece of data in FIMS with a primary source document, and much of the training centered around what should and should not be considered a valid primary source document. A random spreadsheet with tabulations? No. A facility as-built drawing? Great. If any calculations were made, the methodology must be well-documented and replicable by an outside auditor. This is a great process that produces an excellent paper trail – in theory.

In practice, every piece of information in FIMS is a single point of failure controlled by and only understood by a SME at each site. FIMS personnel considers actual annual maintenance to be one of their most important and highly scrutinized data elements, but not a single one of the DOE or NNSA Headquarters FIMS administrators that conduct the site audits could identify an example of a primary source document for annual actual maintenance. And as noted above, even a third of the site-level FIMS administrators could not identify the primary source document, stating that they just enter the information that they are given. Even among those that did know their primary source documents for maintenance, not a single site-level administrator could explain, even in high-level terms, how maintenance costs were tabulated. Only the SME knows. So, this means that there is not one person in the entire data validation process that is giving any scrutiny to the costs provided by the SME. All the audit is doing is making sure that a number from a document was successfully entered into the database, with no analysis of the accuracy of that number.

Because of this, the quality of FIMS data at a given site is largely just a function of the quality of the SMEs providing the data to the administrators, whose primary role is just to wrangle the SMEs and input data. This leaves FIMS wide open to turnover and knowledge transfer issues when a SME leaves and is not replaced with someone with the same level of knowledge, and the same level of relationship with the FIMS administrator to understand what data and quality they are required to provide. It also doesn't help when SMEs work in a silo rather than working with a representative from another data source, like the Sustainability Dashboard or their accounting staff. This means each site representative is duplicating work while unaware of the other representatives' mission and policies that link them together. The data quality issues that commonly arise from this type of practice have previously been discussed in the presentation "Return on Investment Metrics: An Army Perspective" (Reference 13). The FIMS administrators openly acknowledge that this is a problem, and in nearly all our utility graphs that we identified a potential change in methodology, the FIMS administrator for that site could either identify SME turnover or his or her own start date in the year in which we identified the change.

This brings us to the next big shortcoming in the FIMS data validation process. Incorrect data are *never* corrected. Yes, you read that right. Never. About half of all Headquarters-conducted FIMS audits result in at least one corrective action plan for the site being audited, but the site is not allowed to correct the incorrect data. Rather, they are expected to correct the issue moving forward only. This also explains why we see major shifts in data trends for the utilities data. It was being reported incorrectly, a corrective action plan was issued, and it was fixed in subsequent years. This may rectify the issue, but for analysts like us looking to use the data for trend analysis and escalation, any data that had a previous issue are not reliable or usable. And incorrect data in previous years just stays there, with no note, no highlight, no flag to tell anyone that a certain field was issued a corrective action plan.

So, the only way to find out about the bad data is to explore the data like we did and start a dialogue with the FIMS administrators to understand what is going on. This is simply not good data management. Perhaps FIMS personnel was not aware that there were offices attempting to use their historic data for analysis, and we are an edge case for them, but any good future planning decisions that are made with FIMS should be taking the historic data into account. In its current form, without full knowledge of the history of corrective action plans, this is an unreliable endeavor.

Furthermore, the FIMS administrators only audit each site once every five years. In the intervening four years, the sites conduct a self-audit. According to the FIMS administrators, the self-audits consistently receive higher data quality scores and result in fewer corrective action plans, suggesting that except for the one in five years when Headquarters shows up, the data validation is treated as a check the box activity with minimal oversight. While this may vary from site to site, this creates reasonable doubt that four out of five years of any site's FIMS receives the same level of scrutiny and unbiased review. Even when the Headquarters FIMS administrators conduct their audit, they audit to a 90 percent confidence, meaning that any individual datapoint can be 10 percent different between the number in FIMS and the number in the primary source document before it is flagged. Corrective action plans are not issued until the deviation is greater than 20 percent. So even when the audit uncovers issues, they must be large issues for anything to happen. And for a corrective action plan to be issued, the administrators must be able to confirm that there is a discrepancy between the number in FIMS and the number in the primary source document. The FIMS administrators noted many cases in which a SME is not available during the in-person audit. As noted previously, the site administrators struggle to speak to methodologies or source documents themselves, so the element that the missing SME is responsible for is just skipped over. This is not a suggestion that site SMEs are purposely avoiding the auditors, but not being available for a once-every-five-years process certainly can hinder the process of a corrective action plan being issued for that data element.

Very specifically to our focus area of utilities, these issues cast doubt on the accuracy of any data in FIMS and can explain the data error and change in methodology patterns found in the electricity data. But not the multiplier pattern. Utility costs are very specifically not one of the categories that are given a lot of scrutiny in the FIMS audit, so it is likely that the source documentation is not as high-quality and not as heavily reviewed as other columns. If it were, it would be immediately obvious at a site using a multiplier that its value in FIMS is significantly higher than the raw utility bill that should be used as the primary source document. If the utility bill were not the primary source, it would immediately raise questions. Or if a site were upfront about using a multiplier, it would be immediately obvious in its methodology documentation. This was clearly not the case. The Headquarters FIMS administrators explicitly told us that using multipliers is not an acceptable practice, and they were not aware of anyone using the practice until we showed them the FIMS versus DOE Sustainability comparison charts. Since the sites were very open with us about using a multiplier, this suggests that FIMS is simply not auditing the utility costs to the same level of rigor as other columns.

But what about annual actual maintenance? This is allegedly one of the most scrutinized columns. The answer is simple. If we can get in contact with the SMEs at each site, and those SMEs can provide the primary source documentation and methodology that produced that annual actual maintenance costs for FIMS, and the numbers match and the methodology makes sense, proving that the FIMS validation process is functioning, then we will have validated data. But until we can ensure that documentation exists and is accurate, we cannot move forward with producing any CERs from FIMS.

6 Making Things Better, and Why Any of This Matters

You may be thinking at this point, “great, if I ever find myself working for the DOE, I know to be careful with FIMS and CostEx. But I don’t, so why should this matter to me?” Great question. Let’s zoom out a bit. The GAO has published numerous reports (Reference 9) highlighting inadequate real property asset management across the Federal government, which resulted in the Federal Property Management Reform Act of 2016 (Reference 15). This law requires all Federal agencies to submit data on their real property assets to the FRPP. But as of 2020, two-thirds of the addresses in the FRPP were incorrect (Reference 9), demonstrating how much the government struggles with this law. To address these shortcomings, all agencies are being required to adopt a FIMS-equivalent system, with the same data validation rules and policies. So, everyone that works with or for any Federal agency that owns or leases property and conducts cost analysis on those properties - get ready to experience (and hopefully avoid) the same pitfalls that we encountered. But perhaps that is still too niche, so let’s zoom out some more.

The topics discussed here, at their core, are data validation best practices that can be applied to any dataset. You can have an in-depth validation process with audits and oversight like FIMS has, but you must be able to assess the accuracy of the data beyond the word of a SME, benchmark against analogous data, conduct trend analysis of historic data, and consult multiple sources. That’s all we did. Compare the sites against one another and themselves in previous years, and anomalies appear. You do not have to be a SME in maintenance or utilities to see that a bar or a line does not follow a trend or does not match a benchmark. The FIMS administrators could be more than administrators and reduce their reliance on trusting SMEs if they simply conducted some of the routine data visualization that we demonstrate in this paper. As can anyone with any dataset.

If you are in the position to influence the data collection and validation process in your organization, ensure that the data reflect the needs of the business decisions that are being made with them. A database is useless if it is not being used for decision making, and inputting and validating data into a database that does not drive decisions is nothing more than a regulatory box check. Sometimes simply understanding the downstream impacts of how your data are being used and not used are enough to motivate the database administrators and SMEs to put more effort into the database. As the users of data, we have the responsibility to communicate our needs to the people collecting and maintaining the data.

There should be no bigger takeaway from this paper than our big four lessons learned when validating data:

1) Slow down.
2) Trust nothing.
3) Compare everything.
4) Get primary sources.

This means having a healthy skepticism of any data that you did not personally collect and taking the time to intimately understand the data you are working with. When we use someone else's data, we are adopting all the assumptions they made and all their methodology. If we then make inferences based on that data without fully knowing the data, then we are making inferences we ourselves do not fully understand and cannot fully defend. This can lead to unforeseen events and risk realization that would have been avoidable, if we had just slowed down and taken our time up front. Take that extra time to visualize and compare data against themselves and other sources. Pull the threads and keep asking questions until you get to the source. It may seem tedious, and it should lead to uncomfortable conversations with data owners, but validating data empowers us to create trust in our data foundations, confidence in our estimates, and defensibility in our decisions.

APPENDIX A: ACRONYMS

Acronym	Definition
AFFECT	Assisting Federal Facilities with Energy Conservation Technologies
CAEF	Cost Analysis Estimating Framework
CBS	Corporate Business Systems
CER	Cost Estimating Relationship
CEQ	Council for Environmental Quality
CF-40	Office of Corporate Business Systems
CHAMP	Cooling and Heating Asset Management Program
CMMS	Computerized Maintenance Management System
CostEx	Cost Execution
DOE	Department of Energy
EIER	Energy Intensity Estimating Relationship
E.O	Executive Order
FEMP	Federal Energy Management Program
FI	Financial Integration
FIMS	Facilities Information Management System
FRPP	Federal Real Property Profile
FY	Fiscal Year
GAO	Government Accountability Office
GSF	Gross Square Footage
kWh	Kilowatt-Hour
LCCE	Life-Cycle Cost Estimate
LPS	Laboratory, Plant, and Site
NA-911	NNSA Office of infrastructure Planning and Integration
NA-MB-1.4	NNSA Office of Business Systems and Integration
NA-MB-90,PA&E	NNSA Office of Programming, Analysis, and Evaluation
NDAA	National Defense Authorization Act
NNSA	National Nuclear Security Administration
NSE	Nuclear Security Enterprise
MA-50	DOE Office of Asset Management
M&O	Management and Operating
O&M	Operations and Maintenance
O&S	Operations and Support
OMB	Office of Management and Budget
OSF	Other Structures and Facilities
POC	Point of contact
PPBE	Planning, Programming, Budgeting, and Evaluation
RAMP	Roofing Asset Management Program

Acronym	Definition
SER	Schedule Estimating Relationship
SME	Subject Matter Expert
STARS	Standard Accounting and Reporting System
SWBS	Standard Work Breakdown Structure
WBS	Work Breakdown Structure

APPENDIX B: REFERENCES

1) GAO-20-195G, *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs*, guide, Government Accountability Office, dated March 2020.
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7) LBNL-2001637, "2024 United States Data Center Energy Usage Report," report, Lawrence Berkeley National Laboratory, dated December 2024.
8) DOE/GO-102024-6200, "Federal Energy Management Program," PDF, Department of Energy, dated March 2024.
9) GAO-23-106203, "*High-Risk Series: Efforts Made to Achieve Progress Need to Be Maintained and Expanded to Fully Address All Areas,"* PDF, Government Accountability Office, dated April 2023.
10) "All in the Hierarchy: Meta-Estimators to Standardize Work Breakdown Structures," technical paper, National Nuclear Security Administration, dated February 2023.
11) Expanding the Range of Your Data: A Small Ships Case Study, Technomics, Incorporated, International Cost Estimating and Analysis Association 2017 Professional Development and Training Workshop, dated June 2017.
12) "Diamonds in the Rough: How to Normalize Cost Accounting Data," presentation, International Cost Estimating and Analysis Association 2018 Professional Development and Training Workshop, dated 2018.
13) "Return on Investment Metrics: An Army Perspective," presentation, 2010 International Society of Parametric Analysts and the Society of Cost Estimating and Analysis Joint Annual Conference and Training Workshop, dated 2010.
14) Executive Order 13327, "Federal Real Property Real Assessment Management," order, dated February 4, 2004.

15) U.S. Congress, House of Representatives, Federal Property Management Reform Act of 2016, 114th Congress, 2nd session, passed December 16, 2016.

16) U.S. Congress, House of Representatives, The Federal Assets Sale and Transfer Act of 2016, 114th Congress, 2nd session, passed December 16, 2016.

17) "Schedule Estimating Relationship (SER) Development Using Missile and Radar Dataset," paper, Naval Center for Cost Analysis, International Cost Estimating and Analysis Association 2019 Professional Development and Training Workshop, dated 2019.

18) *Costs of Execution User's Guide*, Rev 4, National Nuclear Security Administration, dated October 16, 2020.

APPENDIX C: DATABASE BACKGROUND INFORMATION

C.1. DOE Sustainability Dashboard

The DOE Sustainability dashboard is the primary tool for collecting sustainability related data at DOE. DOE is required to meet sustainability goals mandated by statute and related Executive Orders (E.O.), such as goals for energy and water use. Each year, DOE tracks performance and reports progress towards these goals by providing annual reports to the OMB, White House Council for Environmental Quality (CEQ), and Congress. The Dashboard maintains historical data sets for each DOE site and national laboratory and collects current year data. The Dashboard features analytical figures to provide DOE sustainability personnel with tools for managing sustainability at their site or within their program. The dashboard is currently managed by the Office of Management.

To fulfill federal sustainability reporting requirements, the Sustainability Performance Office issues annual guidance to DOE sites and National Laboratories for site-level sustainability reporting. Examples include submitting Site Sustainability Plans annually. Basic facility information in the DOE sustainability dashboard is uploaded from the FIMS database, linking the two databases together. If a building in FIMS is labeled “sustainable,” then specific fields such as operating hours, energy usage and water usage are submitted from FIMS. Otherwise, site representatives are expected to work with accounting offices at their site to verify, validate and record their usages and costs in the dashboard.

C.2. Federal Energy Management Program

The Office of Federal Energy Management Programs (FEMP) is a program developed to help federal agencies meet their 2035 and 2050 carbon reduction and other sustainability goals. FEMP builds federal agencies’ capacity to meet those goals by supplying agencies with the information, tools, and assistance they need to meet and track their energy-related requirements and goals. FEMP also supports agencies build capacity through administering the Assisting Federal Facilities with Energy Conservation Technologies (AFFECT) Grant Program. FEMP is an existing program under the Office of Energy and Renewable Energy and is moving to the new Office of Federal Energy Management Programs.

The mission of FEMP is to work with critical stakeholders to accomplish energy change within organizations. The program brings expertise from different levels project and policy implementation to enable federal agencies to meet energy-related goals and to provide energy leadership. The program also provides agencies with training and technical assistance to help them comply with federal laws and requirements and improve performance on sustainability and energy scorecards. Other activities include offering agencies guidance on facility and fleet compliance and reporting, collecting and publishing annual performance data, providing information on awards, and convening interagency working groups. The information found in FEMP can be used to track energy usage for different facilities across the labs, plants and sites and translate to costs for CER development.

C.3. Cost Execution

Cost Execution (CostEx) CostEx is one of the data collection tools, part of a suite of tools that make up Financial Integration (FI), that aligns with National Defense Authorization Act (NDAA) requirements, managed by The National Nuclear Security Administration (NNSA) Office of Business Systems and Integration (NA-MB 1.4). The team collaboratively interacts with NNSA Programs, Field Offices, and NNSA and Non-NNSA Management and Operating (M&O) contractors to implement the Financial Integration project. Starting in Fiscal Year (FY) 2018, for the first time, NNSA M&O contractors reported direct and indirect costs in a standard and consistent format across NNSA's programs. As a result, during FYs 2018 and 2019, NNSA successfully completed six of seven Government Accountability Office (GAO) identified requirements to improve financial reporting and cost comparability across the Nuclear Security Enterprise (NSE). FI cost collection improves financial management oversight in alignment with Planning, Programming, Budgeting, and Evaluation (PPBE) procedures, and provides senior NNSA leadership with information to make decisions for future programming and budgeting.

M&Os are directed to follow The CostEx Common WBS Level Breakdown structure, an example of which is seen below in Table 15. The NA-MB 1.4 office collects and updates data from M&Os on a monthly basis. CostEx provides a more user friendly and effective way for program managers and cost estimators to view data submitted to STARS and the M&Os.

C.4. Standard Accounting and Reporting System

The Standard Accounting and Reporting System (STARS) managed and operated by the Office of Corporate Business Systems (CF-40) provides the Department with a comprehensive and responsive financial management system that is the foundation for linking budget formulation, budget execution, financial accounting, financial reporting, cost accounting, and performance measurement.

The system processes Departmental accounting information, including general ledger, purchasing, accounts payable, accounts receivable, and fixed assets. The system also includes budget execution functionality associated with recording appropriations, apportionments, allotments, allocations, and provides funds control for commitments, obligations, costs, and payments.

STARS is operated and maintained by the Office of Corporate Business Systems (CF-40) as part of the Corporate Business Systems (CBS) program. The CBS program consolidates and streamlines DOE business systems by integrating management information related to financial and cost accounting, travel, payroll, budget formulation and execution, procurement and contracts management, facilities management, human resources, and research and development

Table 4: CostEx WBS Example

OEA	Secretary of the Department of Energy
OEB	NNSA - Under Secretary for Nuclear Security
OEB.000	Federal Salaries & Expenses (Administrator's Office)
OEB.010	Weapons Activities
OEB.010.000	WA Program Office
OEB.010.001	Directed Stockpile Work
OEB.010.001.001	Life Extension Programs and Major Alterations
OEB.010.001.001.001	B61 LEP
OEB.010.001.001.002	W76 LEP
OEB.010.001.001.003	W78/88-1 LEP Dev & Prod
OEB.010.001.001.004	W88 Alt 370 Dev & Prod
OEB.010.001.001.007	W80-4 Life Extension Program
OEB.010.001.001.008	W87-1 Warhead
OEB.010.001.001.009	W93
OEB.010.002	Research & Development, Test and Engineering
OEB.010.003	Secure Transportation Asset (STA)
OEB.010.004	Infrastructure & Operations (formerly RTBF)
OEB.020	Defense Nuclear Nonproliferation
OEB.020.021	Global Material Security
OEB.020.021.001	International Nuclear Security
OEB.020.021.002	Domestic Radiological Security
OEB.020.021.003	International Radiological Security
OEB.020.021.004	Nuclear Smuggling Detection & Deterrence
OEB.020.021.005	International Contributions
OEB.020.022	Defense Nuclear Nonproliferation Research & Development
OEB.020.022.001	Proliferation Detection
OEB.020.022.002	Nuclear Detonation Detection
OEB.020.022.003	Nonproliferation Fuels Development
OEB.020.022.004	Nonproliferation Stewardship Program
OEB.020.023	Material Management & Minimization
OEB.020.023.001	Conversion
OEB.020.023.002	Nuclear Material Removal
OEB.020.023.003	Material Disposition
OEB.020.023.004	Laboratory & Partnership Support
OEB.020.023.005	Nonproliferation Construction
OEB.020.023.005.001	99-D-143 MOX
OEB.020.023.005.002	18-D-150 Surplus Plutonium Disposition Project
OEB.020.023.005.003	22-D-XXX LANL Project
OEB.020.024	Nonproliferation & Arms Control
OEB.030	Naval Reactors (NA-30)
OEB.040	Emergency Operations (NA-40)

APPENDIX D: CAEF STANDARD 2.0 WORK BREAKDOWN STRUCTURE

Table 5: Work Breakdown Structure Dictionary

WBS	Title	Level	Definition
2	Operations and Support	1	Costs incurred once the capability is operating.
2.1	Mission O&S	2	O&S costs directly attributable to the mission .
2.1.1	Direct Labor	3	Fully burdened salaries for staff directly working the mission process.
2.1.2	Transportation	3	Moving material, components, products, et cetera from one site to another.
2.1.3	Mission Facilities Maintenance	3	Repairs to equipment and infrastructure components, can be planned/preventative or unplanned.
2.1.4	Recapitalization	3	Fully replacing equipment at the end of its useful life.
2.1.5	Mission Material	3	Procurement of raw materials for use in the process.
2.2	Site O&S	2	Activities that take place at the site housing the mission that also support other site missions. A portion of the total expenditure for each of these areas is allocated to (paid for) by the mission.
2.2.1	Indirect Labor	3	Allocated fully burdened salaries for staff supporting the mission.
2.2.2	Site Maintenance	3	Allocated costs to repair facilities that house multiple missions (office, storage, etc.), site infrastructure (roads, utilities, etc.), and general site features (landscaping, snow removal, etc.).
2.2.3	Site Recapitalization	3	Allocated costs to replace standard equipment in facilities that house multiple missions (office, storage, site utilities, etc.).
2.2.4	Waste Management	3	Allocated cost to handle, store, and transport waste streams (uncontaminated, low level, radiological, etc.) resulting from mission activities.
2.2.5	Utilities	3	Allocated usage fees for needed utility services.
2.2.6	Site Material	3	Allocated cost to procure raw materials/products for use by the site (printer paper, food services, vehicles, etc.).
2.2.7	Other Shared Services	3	Other allocated costs not mentioned above.

APPENDIX E: ELECTRICITY COMPARISON CHARTS

All costs shown in the following figures are in current year fiscal dollars.

E.1. Discrepancy 1 – Change in Reporting Practices

Figure 15: Discrepancy 1 – Change in reporting practices at Site A

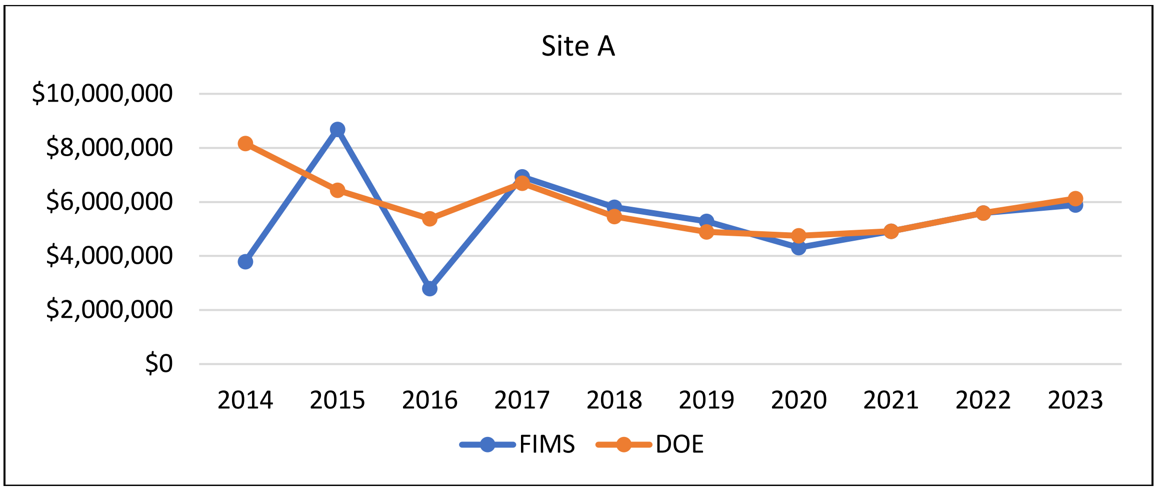


Figure 16: Discrepancy 1 – Change in reporting practices at Site H

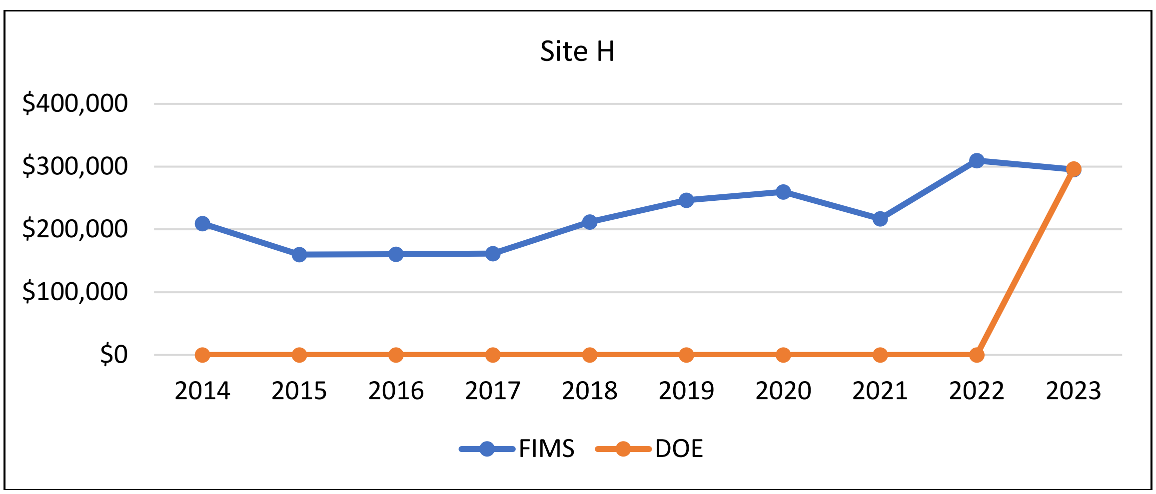


Figure 17: Discrepancy 1 – Change in reporting practices at Site K

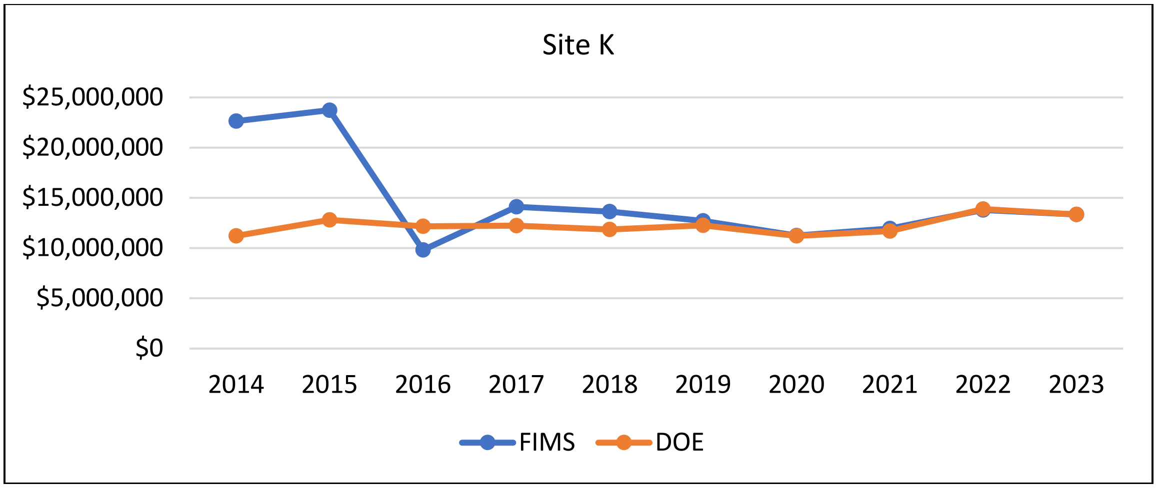
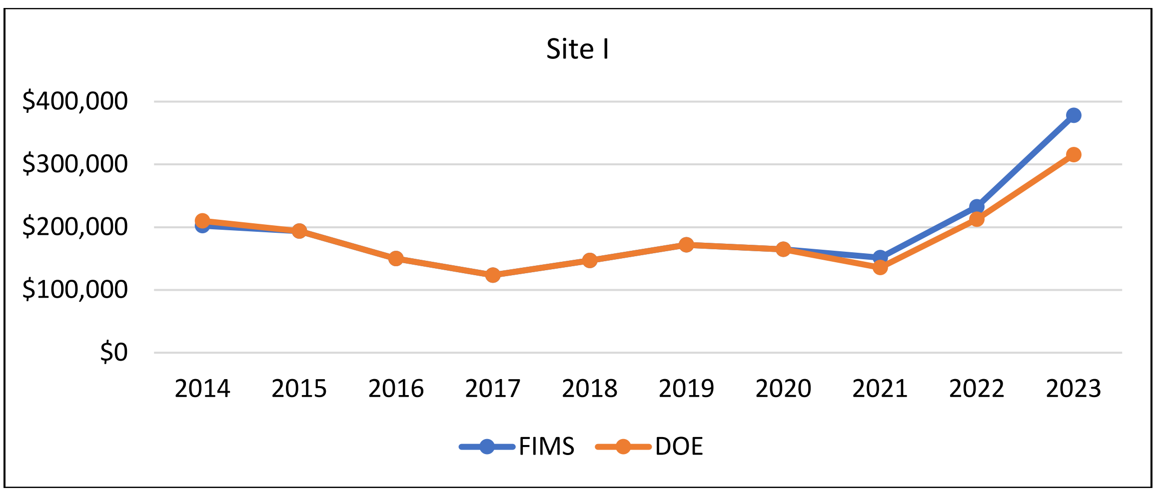


Figure 18: Discrepancy 1 – Change in reporting practices at Site I



E.2. Discrepancy 2 – Data Errors

Figure 19: Discrepancy 2 – Data errors at Site E

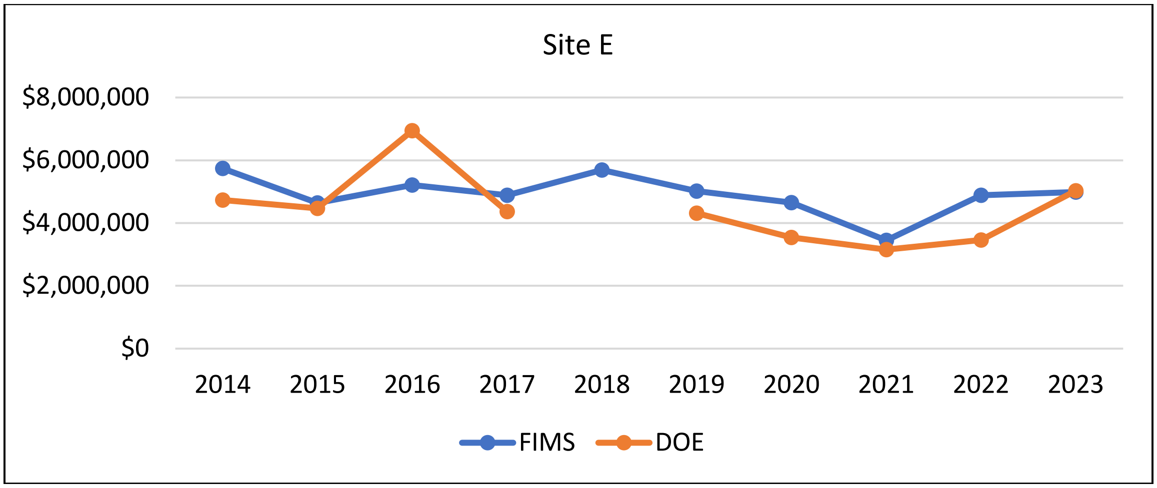


Figure 20: Discrepancy 2 – Data errors at Site G

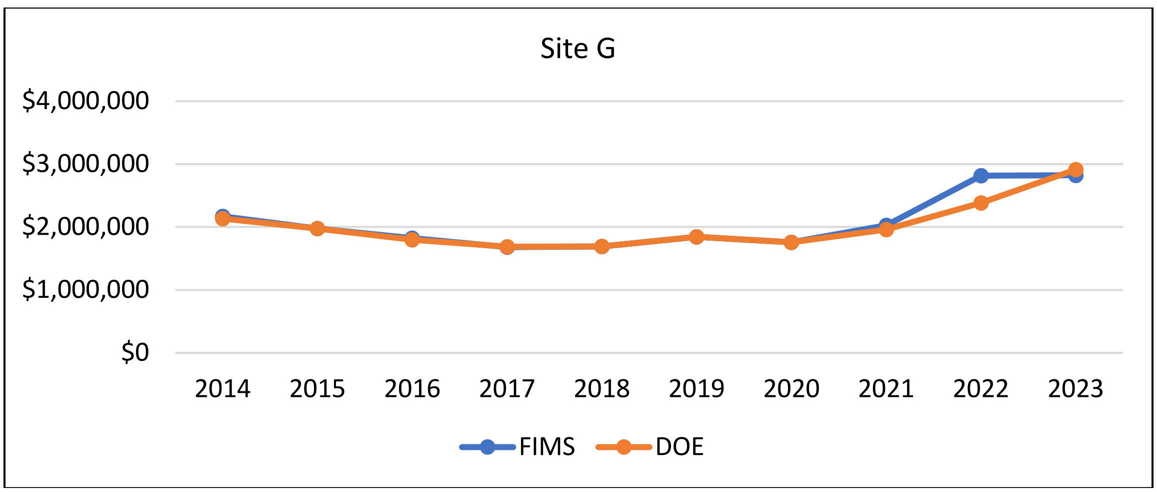
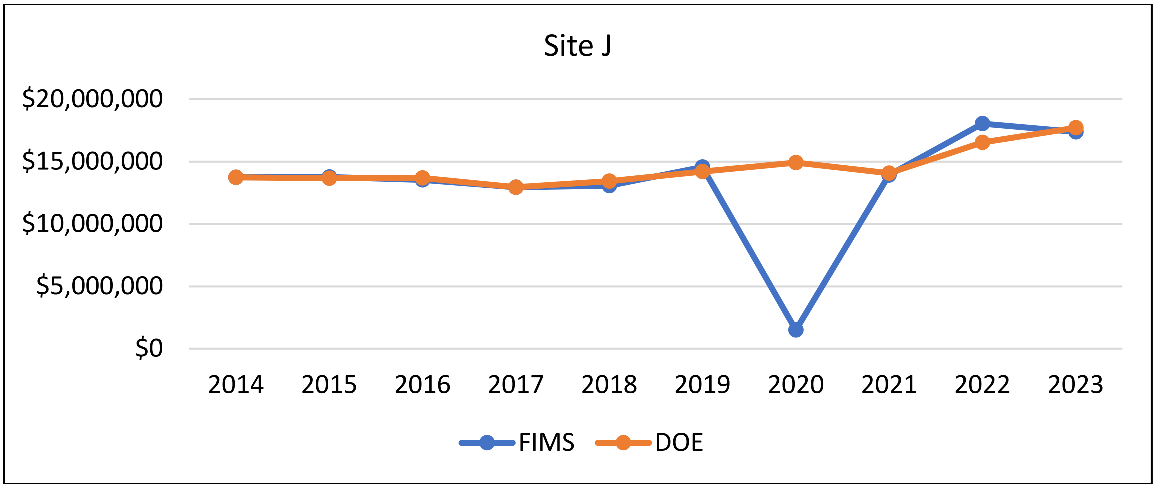


Figure 21: Discrepancy 2 – Data errors at Site J



E.3. Discrepancy 3 – Multipliers

Figure 22: Discrepancy 3 – Multipliers at Site B

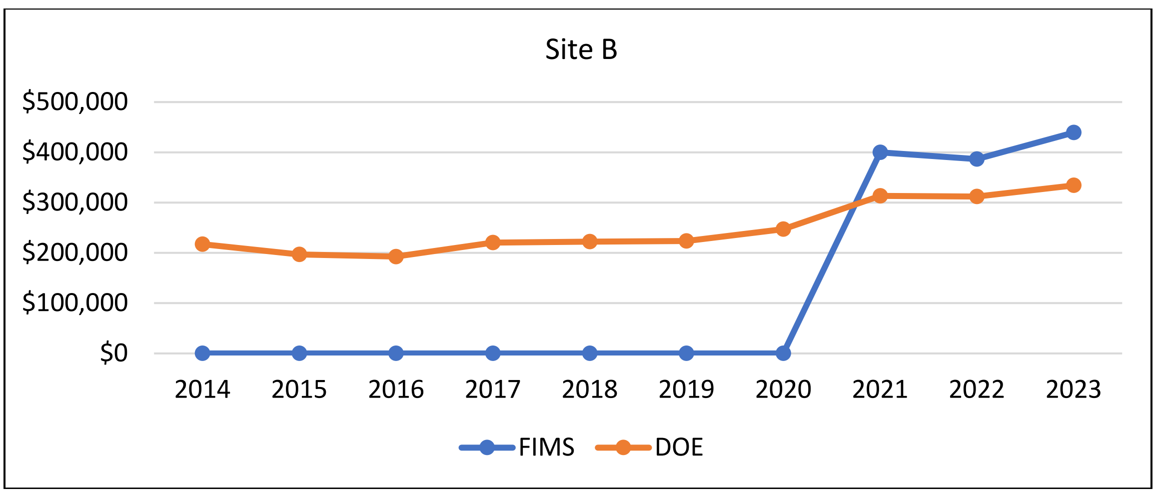


Figure 23: Discrepancy 3 – Multipliers at Site C

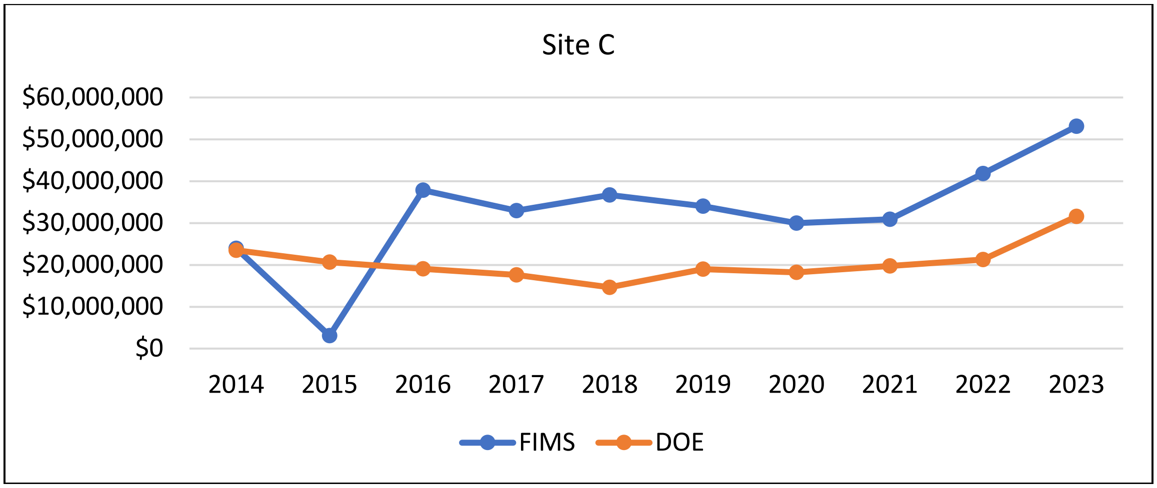


Figure 24: Discrepancy 3 – Multipliers at Site D

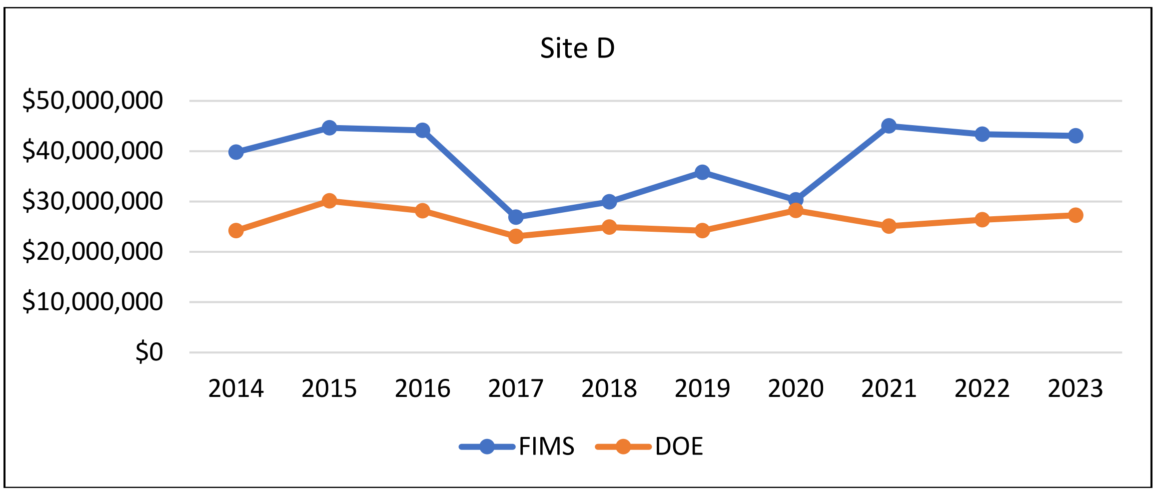
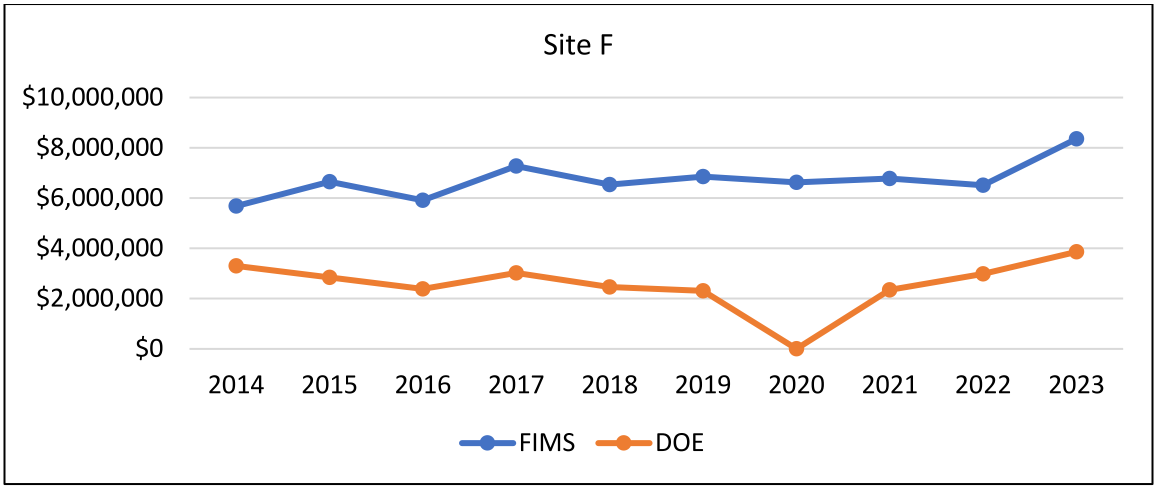


Figure 25: Discrepancy 3 – Multipliers at Site F



APPENDIX F: FIMS VERSUS COSTEX MAINTENANCE COMPARISON CHARTS

All costs shown in the figures below are in current fiscal year $M.

F.1. Pattern 1

Pattern 1 shows that FIMS annual actual maintenance is less than CostEx maintenance and repair of facilities.

Figure 26: Pattern 1 – Maintenance and repair costs, Site A

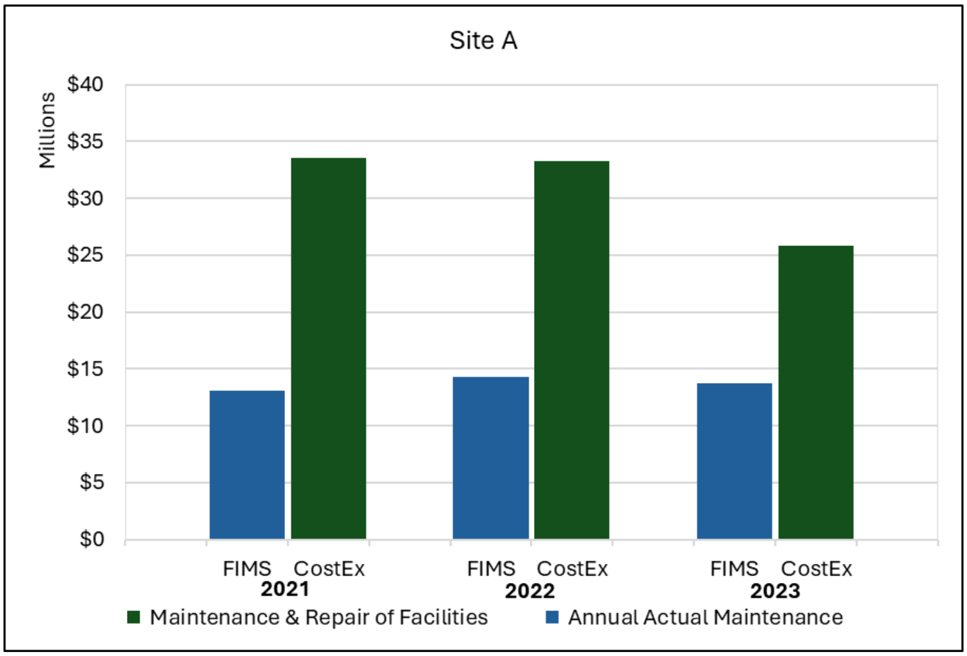
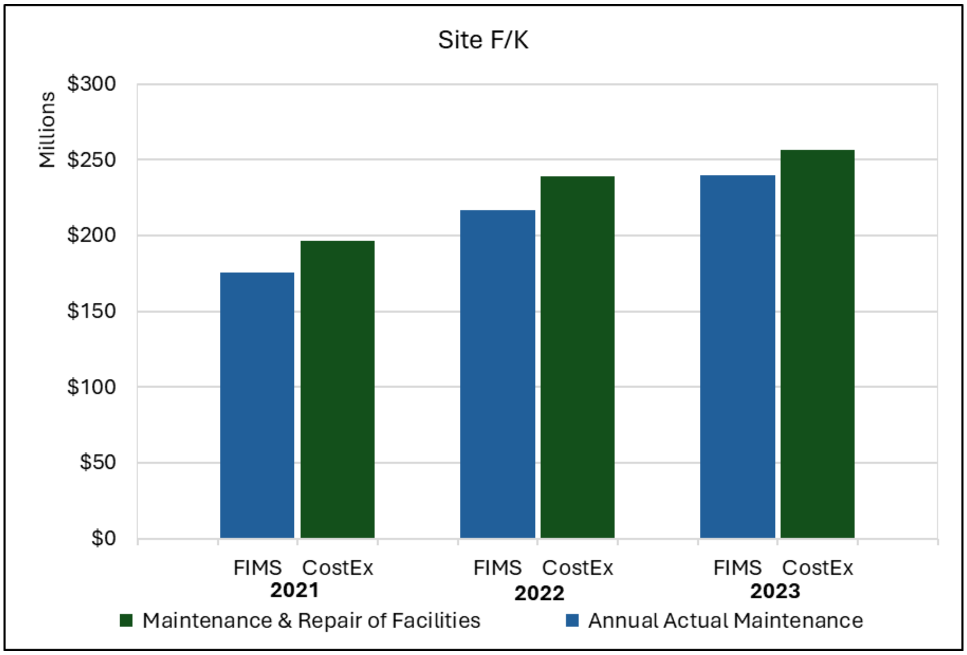


Figure 27: Pattern 1 – Maintenance and repair costs, Site F/K



F.2. Pattern 2

Pattern 2 shows that aligning with FIMS annual actual maintenance requires some use of CostEx operations and maintenance and recapitalization.

Figure 28: Pattern 2 – Annual actual maintenance costs, Site C

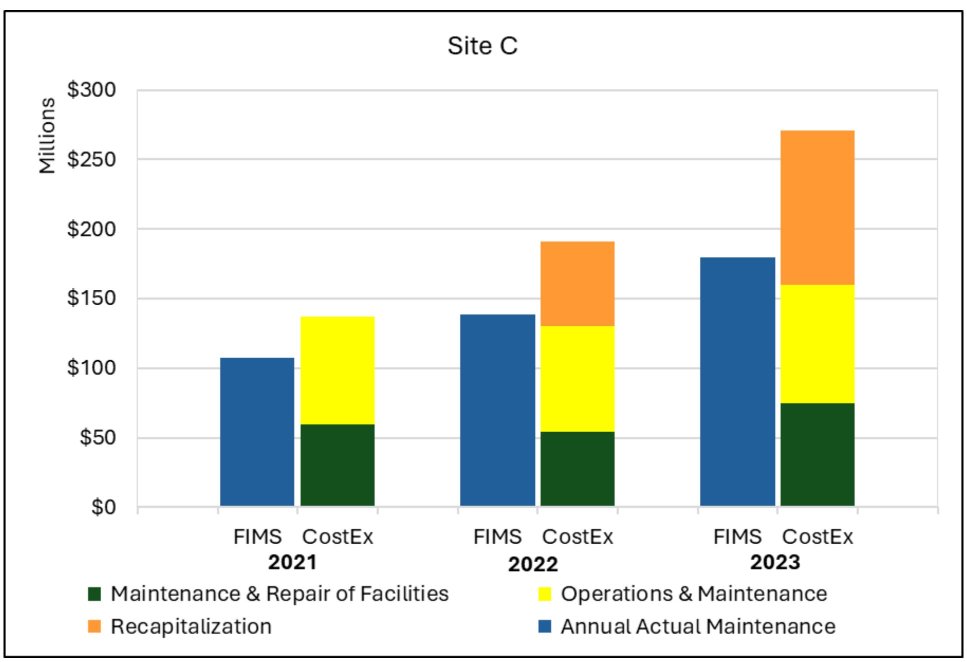
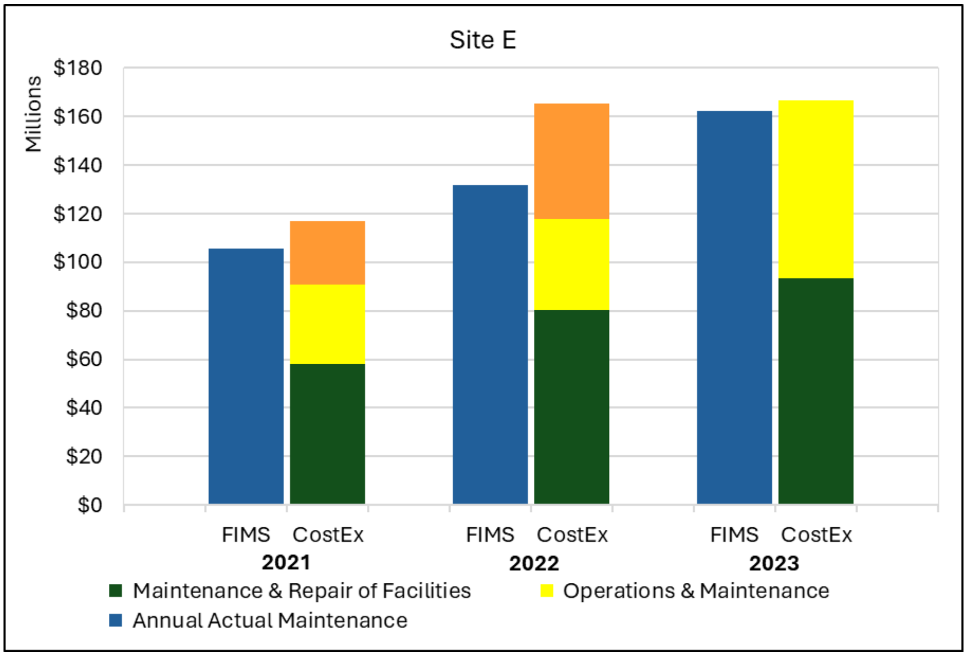


Figure 29: Pattern 2 – Annual actual maintenance costs, Site E



F.3. Pattern 3

Pattern 3 shows that aligning with FIMS annual actual maintenance requires some use of CostEx equipment and weapons maintenance.

Figure 30: Pattern 3 – Annual actual maintenance, Site D

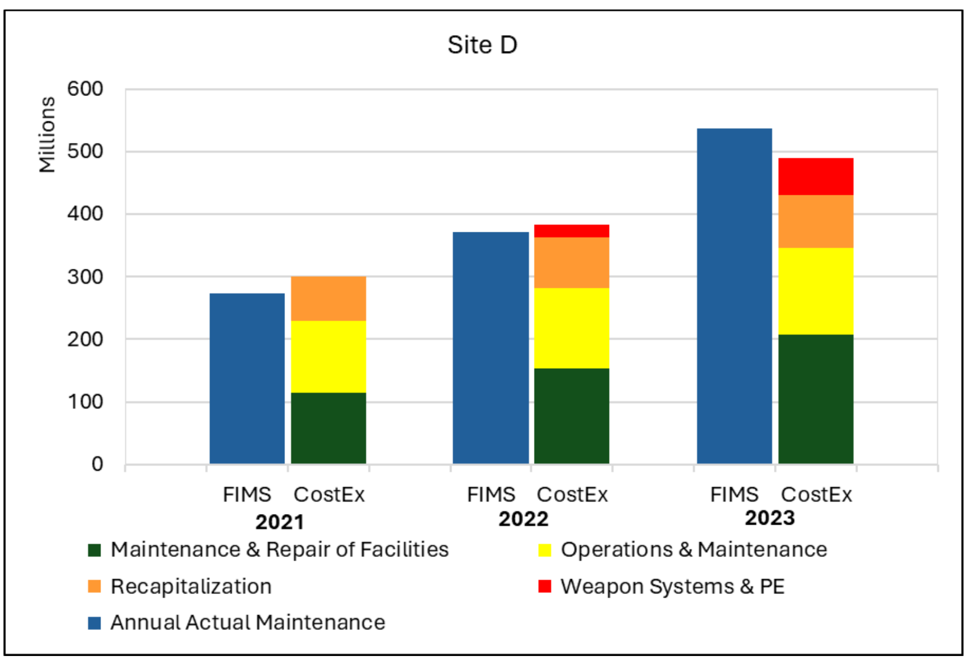
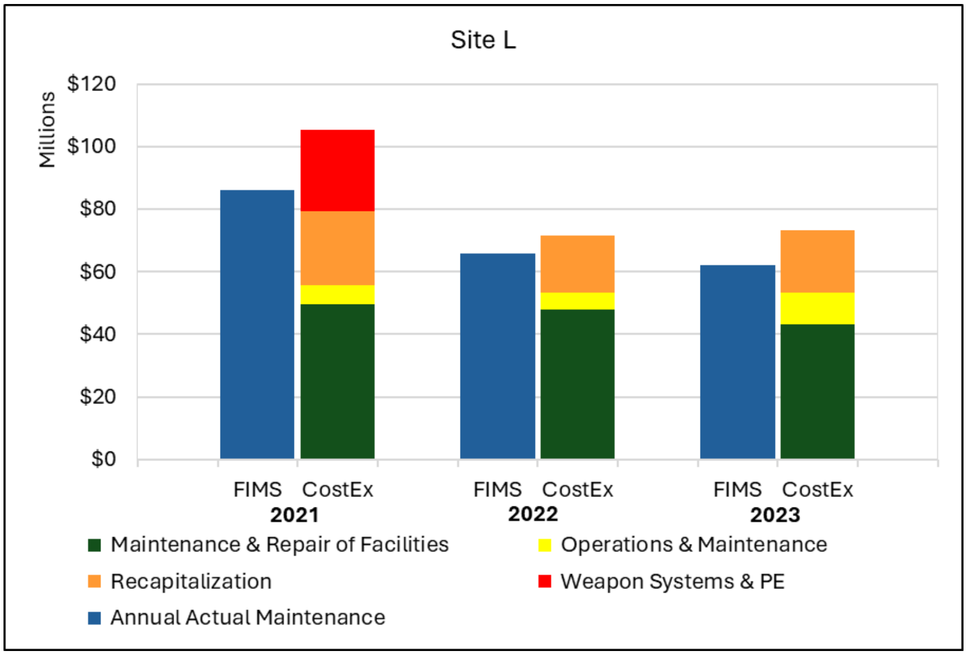


Figure 31: Pattern 3 – Annual actual maintenance, Site L



APPENDIX G: FIMS DATA DEFINITIONS

All of the following definitions can be found in the FIMS User Guide (Reference 6).

- **Repair needs:** The estimated cost to restore all deficiencies identified, for a real property asset during a condition assessment survey, to a state substantially equivalent to the most recently configured capacity, efficiency, or capability as required by the mission. The needs originate from the real property asset, not necessarily management. Repair needs will always equal or exceed deferred maintenance; the difference between the two depends on each noted deficiency's optimum period and acceptability to management.
- **Deferred maintenance:** Maintenance that was not performed when it should have been or was scheduled to be and which, therefore, is put off or delayed for a future period. Maintenance costs and work *do not* include the following: regularly scheduled janitorial work such as cleaning and preserving facilities and equipment; work performed in relocating or installing partitions, office furniture, and other associated activities; work usually associated with the removal, moving, and placement of equipment; work aimed at expanding the capacity of an asset or otherwise upgrading it to serve needs different from or significantly greater than those originally intended; improvement work performed directly by in-house workers or in support of construction contractors accomplishing an improvement; work performed on special projects not directly in support of maintenance or construction.
- **Annual required maintenance:** Include estimated, fully burdened costs for predictive, preventive, and corrective maintenance or surveillance and maintenance for which the budget year (two years beyond the current fiscal year, displayed on the O&M/condition window) is the optimum period of accomplishment.
- **Annual actual maintenance:** The actual, burdened costs of all maintenance and repair activities in a given fiscal year for a building, real property trailer or other structures and facilities (OSF).
- **Hours of operation per week:** This field is initially system defaulted to 60 hours per week. This is an approximation of the lights on hours for a building that operates a single shift, five days per week. This field should be updated if the hours of operation differ substantially from the norm. Setting the hours of operation to zero for an asset will cause zero to be allocated to all asset-level Operating Cost components for that asset. Reference the allocation topic in the "Operating Cost" definition.
- **Total operating cost:** Calculated total of the asset-level operating cost – electricity, water/sewer, gas, central heating, central cooling, pest control, refuse, recycle, snow removal, janitorial, and grounds.
- **Total operating and maintenance cost:** Calculated total of the asset-level operating cost – electricity, water/sewer, gas, central heating, central cooling, pest control, refuse, recycle, snow removal, janitorial, and grounds plus the annual actual maintenance.
- **Operating Cost:** Operating cost includes the following:
    - Utilities (include plant operations and purchase of energy).

- Cleaning and/or janitorial costs (includes pest control, refuse collection, and disposal to include recycle operations).
- Roads/grounds expenses (includes grounds maintenance, landscaping and snow and ice removal from roads, piers, and airfields).

Sites need to accomplish the following:

- Populate site-level costs for each operating cost component (e.g., electricity, gas, refuse). The site-level costs must include operating cost for all ownerships (e.g., DOE-owned, DOE-leased, contractor-leased).
- Update the hours of operation per week for buildings and trailers that operate other than normal operating hours.
- Ensure asset-level operating costs are populated where available.

The allocation routine will be run at fiscal year-end and the system will generate values for reporting of asset-level operating costs where they are not populated by the site. These asset-level operating costs are required for reporting annually to the FRPP.

Asset-level operating costs that are allocated by FIMS at year-end are designated on the "O&M/Condition" window with an asterisk (*) to the left of the "Operating Cost" value.

Each component of operating cost *must* be entered at the site level (total cost at the site for each component). If a component cost does not exist at the site level, a zero should be entered for that site-level component cost.

NOTE: The site-level total *should not be decremented* to account for consumption entered at the asset level. The site-level costs must include operating cost for all ownerships (e.g., DOE-owned, DOE-leased, contractor-leased).

NOTE: Site-level totals *will* include costs attributable to programmatic assets. In many cases, programmatic assets will consume large amounts of utilities (especially electricity). The allocation model accommodates this by requiring an actual or calculated cost to be entered at the asset level (e.g., OSF 3000).

Data fields are available at the asset level for sites to use if they have actual asset-level costs or engineering estimates. If a DOE-owned building or trailer asset-level component cost does not exist, leave the field blank for that asset-level component cost for it to receive an allocation (see below). Enter a zero into an asset-level component cost field to prevent a cost from being allocated to that component for the asset.

NOTE: Cost are only allocated to DOE-owned buildings and trailers. No allocations are made to OSFs. The allocation will populate OSFs with zero if no asset-level operating cost values have been entered by the site.

At fiscal year-end for each operating cost component, the following will occur:

- FIMS will sum up the manually entered asset-level costs.
- That will be subtracted from the total cost entered at the site level.
- Then the remainder will be allocated, on the basis of GSF (and hour of operation per week in the case of utilities), among DOE-owned buildings and trailers where no manual entry was made at the asset level.

The allocation for utility costs (e.g., electric, water/sewer, gas, central heating, and central cooling) will be further refined by **Hours of Operation per Week**. This field defaults to 60 hours per week and needs to be changed only if the hours of operation differ substantially. Setting the hours of operation to zero for an asset will cause zero to be allocated to all asset-level operating cost components for that asset.

For a fully serviced lease, operating and maintenance cost is defined as total contract cost which correspond to the **Annual Rent**. For these types of leases, **Annual Actual Maintenance** and the asset-level **Operating Cost** fields should be reported as zero.

For a non-fully serviced lease, **Annual Rent** is reported while any additional maintenance or operating contracts should be reported in the respective **Annual Actual Maintenance** and/or asset-level **Operating Cost** fields.

- For non-DOE-owned assets located outside the site perimeter (offsite), operating costs are expected to be input at the asset level. Non-DOE-owned assets do not receive an asset-level allocation at fiscal year-end and are defaulted to zero by the allocation process if no asset-level entry is made.