DECEMBER | 2020


# ESTIMATING WITH AND PRICING OF PREFABRICATION

Commissioned by ELECTRI International. Conducted by MCA Inc.
Researchers: Dr. Meik Daneshgari, Dr. Heather Moore

ELECTRI INTERNATIONAL
Research and Education for the Electrical Construction Industry

# Contents



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# Acknowledgements

The authors acknowledge the guidance and feedback received from Task Force members and the support ELECTRI International provided in distributing the survey. The authors extend their thanks to survey participants and to the MCA team members for their support in this research project.

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Thank you to Dr. Perry Daneshgari and Philip Nimmo, both with MCA, Inc., for their assistance in preparing this report.

This ELECTRI International research project has been conducted under the auspices of the Research Center.

Center for RESEARCH

Cover photo courtesy of Miller Electric Company, Jacksonville, FL.

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# Executive Summary

Many contractors are hesitant to start or expand their use of prefab. Recent changes and disruptions in the industry emphasized the importance of prefabrication for electrical contractors to increase productivity and improve their ability to price their estimates with prefab in order to stay competitive.

The main focus of prefab is not building faster. It is risk mitigation, higher predictability of cost, quality of work, and profits. Research shows that most contractors do not have a practical way to track and quantify the benefits from using prefab. This leaves business owners, estimators, and project managers with little confidence and knowledge about the cost-saving potentials of prefab and they struggle to account for prefabrication when bidding potential work.

Prefabrication as a means of Externalizing Work® describes any activity or work moved away from the final point of installation to be performed in a controlled, hence safer, and more productive off-site environment with the objective to reduce the number of on-site manipulations for final completion and installation.

*Effective application of prefabrication requires:*

- Company leadership, vision, and culture focused on "Prefab-Thinking" and "Prefab-Building"
- Prefabrication doesn't require a physical location or different labor
- Proper prefab identification very early in the project lifecycle
- Proper classification of Prefab: Common-Among-All (Type 1), Type-of-Work-Specific (Type 2), and Build-To-Order/Project-Specific (Type 3)
- Different types of prefab are provided through different means, carry different risk, and need different pricing

The research results, based upon interviews with and assessments of electrical contractors, show that:

- Industry-wide level of prefab usage averages less than 5%
- Leadership and vision regarding prefab are more important for achieving higher usage of prefab than the differences across contractors of different company size might suggest
- To increase prefab usage, contractors need to go beyond building prefab items, contractors need to think how to build and complete projects with prefab
- Improvements in productivity, wage rates, and safety are the most important factors for prefab usage

- At the current prefab usage rate of 5%, the safety and planning impacts due to prefab are negligible

The Excel-based **Prefabrication Calculator,** developed as an outcome of this research, will help:

- Make the cost saving potentials from Externalizing Work using vendor/manufacturer services and Simple Prefab (Type 1 and Type 2 Prefab) visible to electrical contractors
- Translate the total savings into an equivalent composite rate as a practical method for "pricing" estimates with prefab (see Case Study on page 26)

# Rationale, Scope and Deliverables

Prefabrication (Prefab) has become the "norm," attracting significant attention in the construction industry. The recent disruptions and outbreak of COVID-19 have affected the way contractors perform their work. The disruptions likely act as catalysts and incentives for contractors to start or increase moving work away from the actual point of installation to a controlled, safer and more productive off-site environment (Externalizing Work® through Prefabrication).

To date, a large number of contractors do not have ways to quantify the net benefits of prefab. Business owners, estimators and project managers have little confidence in or knowledge about the potential cost saving of prefab, and therefore struggle to reliably price and estimate potential work with prefab. Recent developments in the construction industry show that prefab is becoming more important for electrical contractors to retain and increase productivity and competitiveness, particularly in recent times with drastic disruptions such as the current pandemic.

Historically, MCA, Inc. has not advocated to "price with prefab" for a few reasons including:

1. Prefab was a competitive advantage when only a few contractors were doing it
2. There was no means of measuring the cost or benefit of prefab
3. Even if reasons #1 and #2 are satisfied, contractors lack a reliable prefabrication process that can ensures consistent quality output and guaranteed profitability. However, the impact of prefab should be measured and accounted for by a reduction in project composite rate.

Prefabrication does not require a prefab shop, and prefab is more than just building and manufacturing prefab assemblies. "Prefab-Thinking" is key. Prefab is about improving and structuring the construction of a project by moving as much work away from the job site as possible to reduce the number of manipulation on-site for final installation. The major challenge is the change in the mindset of contractors on how to plan, structure, and manage their construction projects.

As of 2020, the industry has moved beyond reason #1 above, and this research provides insight into reason #2. In a collaboration later this year, the National Electrical Contractors Association (NECA) and MCA will provide the first *National Electrical Installation Standard™ (NEIS™)* for Processes in Prefabrication, which should help with reason #3.

**ELECTRI International commissioned this research with the following three main objectives:**

1. Identify and evaluate contractors' current practices for pricing and accounting for prefab
2. Determine the relevant cost and benefit factors of prefab from a contractor's perspective
3. Develop recommended practices, models, and strategies for electrical contractors on ways to determine, reliably and sustainably, the value and cost savings of prefab

The objective of this research project is to help contractors move forward from where they stand, no matter how much prefab they are doing, by providing a means to quantify the net benefits of Externalizing Work® and by shaping a common understanding about prefab. This research introduces a "simple" model to determine the net value (cost and benefits) of prefabrication to help NECA contractors "price" their estimates with prefab by understanding the aggregate composite rate (crew mix) impact of prefab.

Addressing questions related to pricing and selling individual prefab components or the determination of individual cost drivers for establishing and operating a prefab shop are beyond the scope of this initiative. The calculator provided as part of this research will serve as a starting point that can be applied immediately with minimal inputs, and can then be built and expanded upon in future research projects to address more complex and specific questions. Having a simple and practical way to quantify the cost advantage of prefab will help to price and account for prefab during the estimating phase. This will provide an immediate competitive advantage for NECA contractors to win more work and help meet a long-term necessity in this industry.

Interest in this topic is the result of decades of work, relying on information and experience in a collaboration between ELECTRI International, MCA, Inc. (the researcher), and electrical contractors across the U.S. and Canada. The objective is to build on the same foundation for this research to help members catch up, get ahead, and stay ahead by having the means of estimating and pricing with prefab. In the same spirit, the data sources used for this research are a combination of primary sources and MCA, Inc. research and industry information from more than 500 electrical contractors compiled over three decades.

This research project utilized a survey to gather and validate current practices of electrical contractors regarding prefab. In addition, the research team relied on collected data, experience, and practices from ELECTRI Council members, ELECTRI research, as well as industry-wide information from union and non-union contractors collected in JPAC® (an application of ASTM E2691 Standard Practice for Job Productivity Measurement and an expansion of the 2003 ELECTRI research on "The Impact of Variation on Profits") as the sources for developing the model for estimating and pricing with prefab. The collected data in JPAC® was used as a source to identify and quantify the industry-level of prefabrication, and to provide benchmark estimates for on-site and prefab productivity.[1]

The research team followed an outlined work plan by conducting and taking to account personal observations, individual interviews, and responses from a survey among NECA contractors. The team also relied upon internal data, case studies, and experience as outlined above, along with direction from the ELECTRI Task Force members who helped guide the team and the research. The initiative's final products include this report, training, and education materials to be presented by NECA and MCA, Inc., and the Excel-based Prefabrication Calculator for estimating with and pricing of prefabricated and externalized work.

1 The JPAC® database includes over $3 billion of construction projects (by contract value) spanning back to 1997. The current database used (from year 2013 forward) represents data from $1.5 billion in project value and over 8 million manhours of work spanning across 35 U.S. states and Ontario, Canada.

# Research Project

## 2.1 Externalizing Work® through Prefabrication

Any work or activity performed off-site and moved away from the final point of installation that reduces the number of manipulations for final installation or effort spent on the construction site is considered Externalizing Work, which includes prefabrication. In a traditional sense, most contractors think about prefabrication in terms of the manufacturing and assembly process of tangible material that is ready for final installation. Prefabrication in the sense of Externalizing Work is more than just having a prefab shop that is building prefab assemblies. Prefabrication is any work performed prior and away from the point of installation. It requires a different way of thinking and a change in the contractor's mindset and perspective. The focus of prefabrication is on risk reduction, not necessarily centered around installing faster or building cheaper. Prefab provides savings in the installation outcome (quality), efficiency improvements as well as structure on how a project is built and completed.

An integral part of a sustainable prefab approach that will result in more work for a company is to initiate and establish the mindset change of "How to Build," and actively work with project managers, foremen, and skilled field labor to understand and practice *"Prefab-Thinking"* and *"Prefab-Building."* After prefab has been initiated, many contractors run into operational and business problems with keeping the prefab shop busy and productive over time. This is particularly true for contractors who skip initial and continuous training, education, exposure, and experience in "Prefab-Thinking" and the process of building with prefab.

The reasoning for this is that the traditional mindset of "On-site Building" and on-site operations will make prefab suffer due to on-site labor hoarding in an attempt to keep field on-site labor busy, thereby preventing a contractor from leveraging the potentials. To avoid this from happening, a contractor's business model needs to incorporate the knowledge, skill, and experience from the field into the prefabrication process in order to contribute to the company's overall success.

An important step for a contractor to expand the company's current use of prefab and to follow the path of prefab evolution towards Externalizing Work (see **Table 1**, *next page*) is to realize is that every construction installation task can be broken down into three separate phases:

1. **Prepare:** Preparation, transportation and distribution of
   - Labor (understanding the plans and schedule)
   - Tools (setting and powering up)
   - Material (receiving, moving, unpacking, fabrication, assembly, etc.)
2. **Install:** The actual installation task
3. **Put away:** Return workers, tools, material to the next task's appropriate location(s)

*Table 1 – Evolution of prefabrication (Daneshgari & Moore, 2020)*

| Type | Description | Examples | % of Work Done Offsite | Level of Supply Chain Integration |
|---|---|---|---|---|
| **Prefabrication** | Building sub-assemblies away from the installation location | • Ductwork<br>• Bathroom plumbing carriers<br>• Fully assembled fixtures | 3–5% | None |
| **Modular Construction** | Combining subassemblies into cross-trade integrated final assemblies | • Hospital headwalls<br>• Ceiling MEP racking systems | 7–10% | Low (across trades) |
| **Externalizing Work®** | Any work not needing to be done onsite is done away from the jobsite | • Only final assemblies delivered (no parts are manipulated onsite)<br>• No movement of individual tools or materials done onsite | 30–50% | Moderate (involving vendors) |
| **Megacenter** (full Industrialization of Construction®) | All trades work in production setting offsite to build and integrate assemblies; the "job site" is only final erection and connections | • Broad Group Buildings in China (3 stories per day build offsite)<br>• Marriott Hotels (built in Poland, assembled in U.S.) | 70%+ | Full (Logistics-Centric Model) |

In a traditional mindset, these three activities are often hard to distinguish from one another as they are all seen collectively as "part of the work." Prefabrication tasks are not any different. Prefab work can be separated into the same three general phases. The only difference is to replace "install" with "make" and "prepare" with "assemble." Unless these three phases are not understood separately, the work cannot be segregated, measured, and prefab opportunities identified (Daneshgari & Moore, 2015, 2017, and 2020).

**Risk mitigation** through higher predictability of labor cost, quality of work, and profits is the main reason for doing prefab. The total risk of a project is reduced through moving work away from the point of installation by lowering the three forms of associated risk:

1. **Technical risk:** Lowered by reducing unnecessary, non-value-added proliferation of components, means, and methods.
2. **Business risk:** Reduced by leveling production, economies of scale, and lower schedule uncertainty.
3. **Integration risk:** Reduced by having material, labor, and tools available on the job site when, where, and how they are needed for the final installation.

To manage the risk and work of any project, both must first be identified. A Work Breakdown Structure (WBSTM) is a powerful starting point to make tacit knowledge of skilled-trade work visible and explicit and therefore manageable. The main focus of a WBSTM is the work only—not duration, time, hours, or cost codes. It should reflect how the project is getting built and should be developed based on the work it will take to fulfill the contractual obligations, requiring input from multiple project stakeholders.

Maximizing prefabrication comes from true Externalizing Work by reducing risk—not just from fabricating widgets for installation. Once project work and risks are visible and understood, the WBS can be used to identify the work and evaluate the risk to determine *who* does *what, when,* and *where* (see "Work Cube" in Daneshgari & Moore, 2015 and **Figure 2**, *next page*).

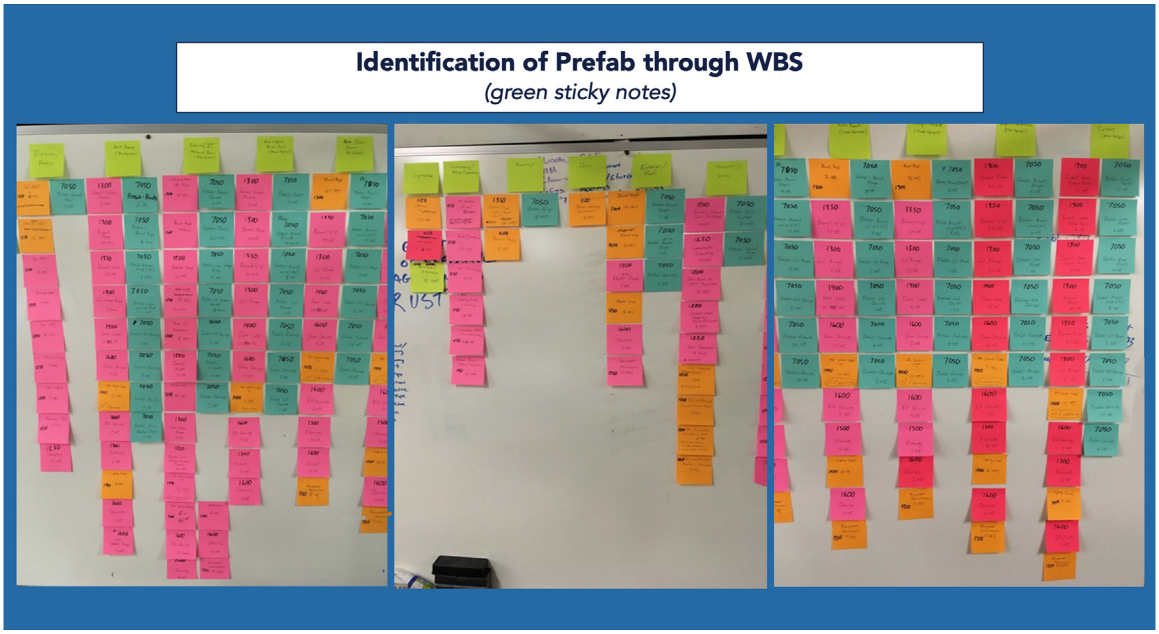



***Figure 2** – Work Breakdown Structure and prefab identification (©MCA Inc.)*

The scope and amount of electrical prefabrication might differ across different types and segments of construction projects because prefabrication is usually determined by most electrical contractors based on the repetitiveness of work and similarity of assemblies. Repetitiveness is one criterion that electrical contractors can use to identify prefabrication opportunities. However, the threshold of required repetition level for every prefab assembly and component is determined through experience and trials by each electrical contractor.

Work completed away from the final point of installation can be considered prefab if performed in a separate and controlled environment away from the final point of installation. Advantages of a prefab work area generally include:

- Savings from reduced cost and effort due to less material handling, fewer material returns, less wasted material, improved labor efficiency, and ultimately improved labor productivity
- Consistency of production
- Increased reliability and predictability
- Improved safety
- Manpower flexibility or buffer
- Decoupling of the sequence of work from the sequence of time on the project

A good place to start looking for prefab opportunities is non-installation work and activities (preparation, pre-assemblies, etc.), repetitive work and assemblies, or any work that requires special equipment that is time-consuming and expensive to mobilize/demobilize to and from the job site to perform the work on-site. In line with findings by Simonian and Korman (2013) as well as Siddiqi and Woldemichael (2018), this research team found that the most frequent prefabricated assemblies in the electrical industry are:

1. Receptacle assemblies/Device boxes
2. Temporary power supply units
3. Light fixtures
4. Pre-Cut cable/Cutting and spool wires
5. Conduit bending

## 2.2 Three Types of Prefab

In addition to the general definition and understanding of prefabrication as a means of Externalizing Work, prefabrication can be further segregated into the following three main prefab categories to help contractors distinguish and standardize prefab and to train and guide labor for the identification of prefab opportunities on construction projects.

1. ***Common-Among-All Items*** are those that are generally simple, uncomplicated sub-assemblies or assemblies that can be built without restriction to a specific job or specification. The assembly effort is predictable (by unit) and correlates with the quantity produced, which allows standard assembly units to be developed for these items. The same drawing sheet and assembly instructions can be used to produce identical products without a specific quantity, date, or job-related information needed. These offer an excellent place for smaller contractors to begin prefabrication, as most of these items do not require an established, full-blown prefab shop.

   Some common prefab items can also be drawn and ordered from vendors, manufacturers, or other specialized firms using a unique part number, or SKU when and for any job they are needed. **Figure 3** illustrates a variety of examples for simple


*Figure 3 – Examples of common prefab items (Type 1) (©MCA Inc.)*

*Figure 4* – *Examples of work-specific items (©MCA Inc.)*


common prefab items, including boxes, wall mounts, MC whips, pre-punched J-boxes, standard 90-degree feeder conduit bends, preassembly of in-wall and ceiling boxes, bracket pre-assembly, receptacle pre-assembly with pigtails, etc. An increasing number of electrical suppliers and manufacturers are beginning to offer these "Build for Stock"/"Hold for Release" types of simple prefab, involving a Make-vs.-Buy decision for contractors.

***2. Type-of-Work-Specific Items*** are assemblies and applications specific to a type of work, such as schools, hospitals, airports, hotels, etc., which are similar across jobs but vary in ways that make them not interchangeable. Examples of these include services such as unboxing, whipping, lamping, and crating light fixtures, area- or room-specific kitting/packaging, wiring, and speed pulls, (see **Figure 4**). The key here is to recognize that the assembly instructions and work steps are identical, only the components change.

This work includes a one-time arrangement for basic planning, setup, and layout within the job, then ongoing production. For example, you cannot build up a supply of crated fixtures for which you have no idea if/when they will be requested. Not all jobs use the same fixtures, but all fixtures require unboxing, whipping, lamping, etc. A work-specific prefab item also includes planning, ordering, and purchasing the materials. Other preparation activates such as kitting, labeling, and onsite inventory management are also included.

***3. Build-to-Order/Project-Specific Items*** are also referred to as "one-offs," "prototypes" or "snowflakes" and consist of assemblies that are custom designed and built for a specific application. Where cable hangers or conduit supports may be simple common prefab items, an entire raceway system can be built up from a BIM drawing but it will be unique for the project and will only have one place that it fits (see **Figure 5**, *next page*). Much like a jigsaw puzzle, these types of prefab require a plan for the finished product because each piece is built to fill a specific place in the system. Build-to-Order

*Figure 5* – *Examples of build-to-order items (Type 3) (©MCA Inc.)*


items require the most planning, coordination, and most lead time. Mastering Build-To-Order prefab, however, also offers the greatest risk reduction and benefits, more than any of the other prefab types.

## 2.3 Prefab Survey to Validate and Verify the Model Structure

Over the last 20 years, MCA Inc. has had the opportunity to work with more than 500 contractors across the nation. During this unique exposure to the industry, MCA has been able to collect valuable and extensive data that shows and measures the usage and benefit of prefabrication across companies and projects. MCA has offered to share and use the data for this research project to benefit ELECTRI, NECA contractors, and this research project. Additionally, literature searches, including insights and data from ENR, ELECTRICAL CONTRACTOR magazine and many other organizations, have helped establish current industry practices as far as usage and measurement are concerned.

A survey on prefab usage, tracking, and prefab measurement among electrical contractors was conducted to uphold the existing data's prognosis and to achieve deliverables 1 and 2 for this research project (see **Appendix A** for the questionnaire). The survey was also used to determine and verify the cost and value factors of prefab most relevant to electrical contractors and which need to be taken into account in the prefab calculator model.

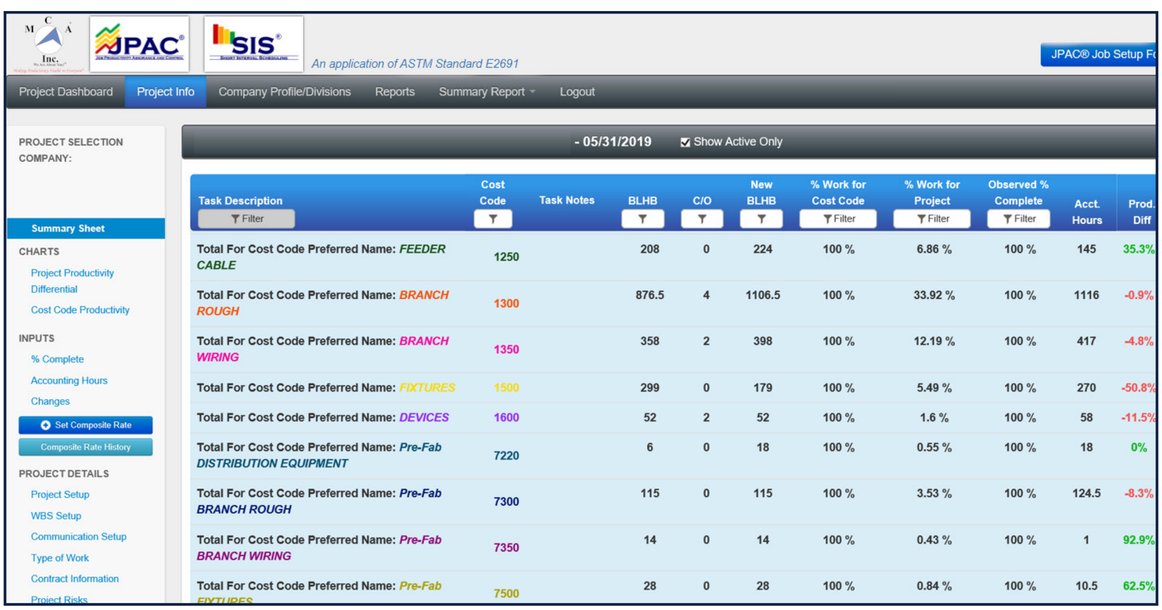
The overlying message from the survey results is that most union contractors are trying to implement some form of prefabrication but seem to have very little ability to determine what prefab is, how to determine what portion of their work is being prefabricated, and to reliably quantify, measure and make the impact (costs and savings) of prefab visible to their business operations. Further, survey responses suggest that contractors either did not have information to share about prefabrication or those that do feel it is providing them with a competitive advantage and they prefer not to respond or share their proprietary information.

The survey results show that the predominant level of prefabrication usage among union electrical contractors is still limited. An overwhelming number of contractors (both smaller as well as larger) reported performing less than 5% of their work through prefab if at all. The survey results are consistent with Said (2015) who reported that the vast majority of surveyed union electrical contractors either do not have a prefab shop or prefab covers less than 5% of their work volume using prefab—totaling about 69% of survey responses.

The survey results on prefab usage among electrical contractors are further supported by MCA's JPAC® dataset covering electrical construction projects and prefab usage (see example in **Figure 6**) from about 1,175 individual projects and Work Breakdown Structures since 2013. The source includes union and non-union contractors from 35 U.S. states and Ontario, Canada, representing about $1.5bn project value and more than 8.1 million labor hours. This dataset indicates about 1.5% industry-wide prefab usage across all covered projects, and an average of 4.2% prefab usage among projects that have prefab work specified in their project WBS™ (see **Figure 7**, *next page*). Hence, the research team concludes that the survey results are both very telling and representative of the electrical industry. Compared to other studies, MCA's data and the survey results might even suggest an improvement and increase in prefab usage among union electrical contractors over the past 5 years. Detailed survey results can be found in **Appendix B**.

Actual observations, assessments, and interviews with individual companies, such as United Electric, Atlanta, GA, revealed that company size is not necessarily indicative for prefab usage but rather it is company philosophy and leadership that determine higher or lower use of prefabrication (see Section 2.1). United Electric has been very successful in implementing and using prefab across its projects and is expanding the size of its prefab shop as this report is written. This is consistent with collected data and information from other conducted assessments and observations.

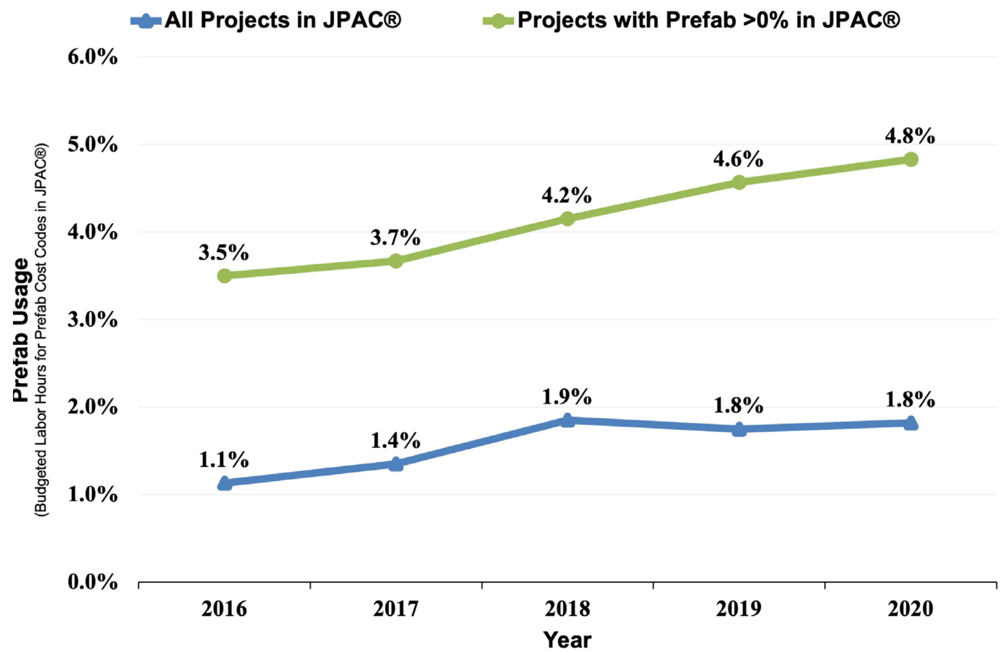
About 35% of the survey participants are performing less than $50 million in annual revenue while nearly 60% of responding companies reported more than $100 million in annual revenue.




| Task Description | Cost Code | Task Notes | BLHB | C/O | New BLHB | % Work for Cost Code | % Work for Project | Observed % Complete | Acct. Hours | Prod. Diff |
|---|---|---|---|---|---|---|---|---|---|---|
| Total For Cost Code Preferred Name: *FEEDER CABLE* | 1250 | | 208 | 0 | 224 | 100 % | 6.86 % | 100 % | 145 | 35.3% |
| Total For Cost Code Preferred Name: *BRANCH ROUGH* | 1300 | | 876.5 | 4 | 1106.5 | 100 % | 33.92 % | 100 % | 1116 | -0.9% |
| Total For Cost Code Preferred Name: *BRANCH WIRING* | 1350 | | 358 | 2 | 398 | 100 % | 12.19 % | 100 % | 417 | -4.8% |
| Total For Cost Code Preferred Name: *FIXTURES* | 1500 | | 299 | 0 | 179 | 100 % | 5.49 % | 100 % | 270 | -50.8% |
| Total For Cost Code Preferred Name: *DEVICES* | 1600 | | 52 | 2 | 52 | 100 % | 1.6 % | 100 % | 58 | -11.5% |
| Total For Cost Code Preferred Name: *Pre-Fab DISTRIBUTION EQUIPMENT* | 7220 | | 6 | 0 | 18 | 100 % | 0.55 % | 100 % | 18 | 0% |
| Total For Cost Code Preferred Name: *Pre-Fab BRANCH ROUGH* | 7300 | | 115 | 0 | 115 | 100 % | 3.53 % | 100 % | 124.5 | -8.3% |
| Total For Cost Code Preferred Name: *Pre-Fab BRANCH WIRING* | 7350 | | 14 | 0 | 14 | 100 % | 0.43 % | 100 % | 1 | 92.9% |
| Total For Cost Code Preferred Name: *Pre-Fab FIXTURES* | 7500 | | 28 | 0 | 28 | 100 % | 0.84 % | 100 % | 10.5 | 62.5% |

***Figure 6*** *– Example WBS™ of an electrical construction project translated into JPAC® for production and productivity tracing (including prefab) (©MCA Inc.)*

*Figure 7* – Prefab usage of projects covered in MCA's JPAC® database (©MCA Inc.)




More than 80% of contractors reported having invested in the physical space, plant, and equipment for in-house, centralized prefabrication. Again, prefabrication as a process and means of Externalizing Work does not require this investment to establish a prefab shop and to begin using prefab. The vast majority of contractors who engage in prefabrication use their prefab shop due to economies of scale, easier sharing or tools and equipment, larger production capacity, and the opportunity to leverage training and supervision effectively of both work and workers.

Effectively operating a prefab shop requires common processes across all jobs, for planning and coordinating work, providing greater lead time to ensure availability of installation-ready assemblies at the time needed, handling, packaging, and labeling costs that are not present with job-specific on-site prefabrication, in addition to investments in the facility and people to manage the shop. The single biggest inhibitor of widespread and immediate use of prefabrication or any type of Externalized Work is confidence in and exposure to the savings. Knowing what to measure, where to measure, and how to measure the impact eludes most contractors. The survey reveals that almost 30% of contractors do not track any prefab related cost. From the remaining 70%, all respondents report tracking labor hours and/or cost. About 70% track material while less than one third say they track safety-related information on their prefab activities.

The reasons contractors want to use prefabrication in their business model for project delivery are to lower risk and increase productivity, predictability and, ultimately, profits. Along these lines, the survey results indicate contractors would agree that productivity improvements through prefab offered from reduced technical and integration risk are the greatest benefit and motivator for prefabrication, followed by wage and safety aspects linked directly to the reduction of business risk.

On the contrary side, surveyed contractors view the highest cost aspect associated with prefab to be planning and coordination effort. Planning effort, as well as financial benefits from improved safety, do not follow a simple linear pattern with increasing prefab. While additional planning effort and safety improvements are important factors to consider in particular at higher levels of prefab usage and for Build-To-Order Prefab Items, data from hundreds of projects tracked in MCA's database JPAC using prefab reveals that planning effort and safety improvements are not significant impact factors, and offset each other at the current industry-wide prefab usage of approx. 4-5%.

## 2.4 Developing the Model to Determine the Value of Prefab

This section introduces a "simple" model to determine the net value (cost and benefits) of prefabrication to help contractors "price" their estimates with prefab by understanding the aggregate composite rate (crew mix) impact of prefab. This then helps contractors move forward from where they stand, no matter how much prefab they are doing, by providing a means to quantify the net benefits of Externalizing Work through vendor services as well as prefab.

The developed Prefabrication Calculator won't address issues on determining specific costs for pricing of individual prefab components or quantify individual cost components and drivers for establishing and operating a prefab shop as this is likely highly specific to the operational strengths, processes, procedures, tools used, and experience of individual contractors.[2] While this calculator model might not address these topics directly and to their full extend, the calculator will serve contractors as a starting point that can be applied immediately with minimal inputs, and can be built upon and expanded in future research projects to address these more complex and specific questions.

The research team started to build the prefab calculator by using the information collected from the survey as well as available data JPAC and additional literature. While it is hard to create a tool that captures all tangible as well as intangible savings and cost effects associated with prefab, the team used the survey responses from electrical contractors to determine the prefab cost and benefit factors most important to electrical contractors (see the end of Section 2.3) to put together a tool that allows evaluating not only the value from a company's prefab activities but also other categories of Externalized Work such as services, material or assemblies provided by vendors or manufacturers. Consistent with responses reported by other studies, such as the 2017 FMI/BIM Forum Prefabrication Survey, this survey's results also emphasize that improvements in productivity and differences in wage rates due to prefab are among the impact factors of highest interest to electrical contractors, and hence, should be incorporated in the prefab calculator.

**Figure 8** *(next page)* depicts an overview of the calculator model, which follows a 3-level structure to account for different types of Externalizing Work regardless of who is doing the work. A sample illustration of the available calculator is included in **Appendix C** and the case study/sample job following this chapter illustrates and explains its usage.

The calculator model has three components to capture the net benefits and composite rate impact of Externalizing Work:

2 Said (2015) provides some recommendations regarding the initial assets/investment needed to start up a prefab shop for an electrical contractor. He suggests to acquire the following equipment: 1. Assembly workbenches with replaceable cover/tops; 2. Storage bins to stack and organize basic material and components; 3. Electric hand tools (screwdrivers, saws, etc.); 4. Wire spool racks; and 5. Wire cutting and stripping machine.

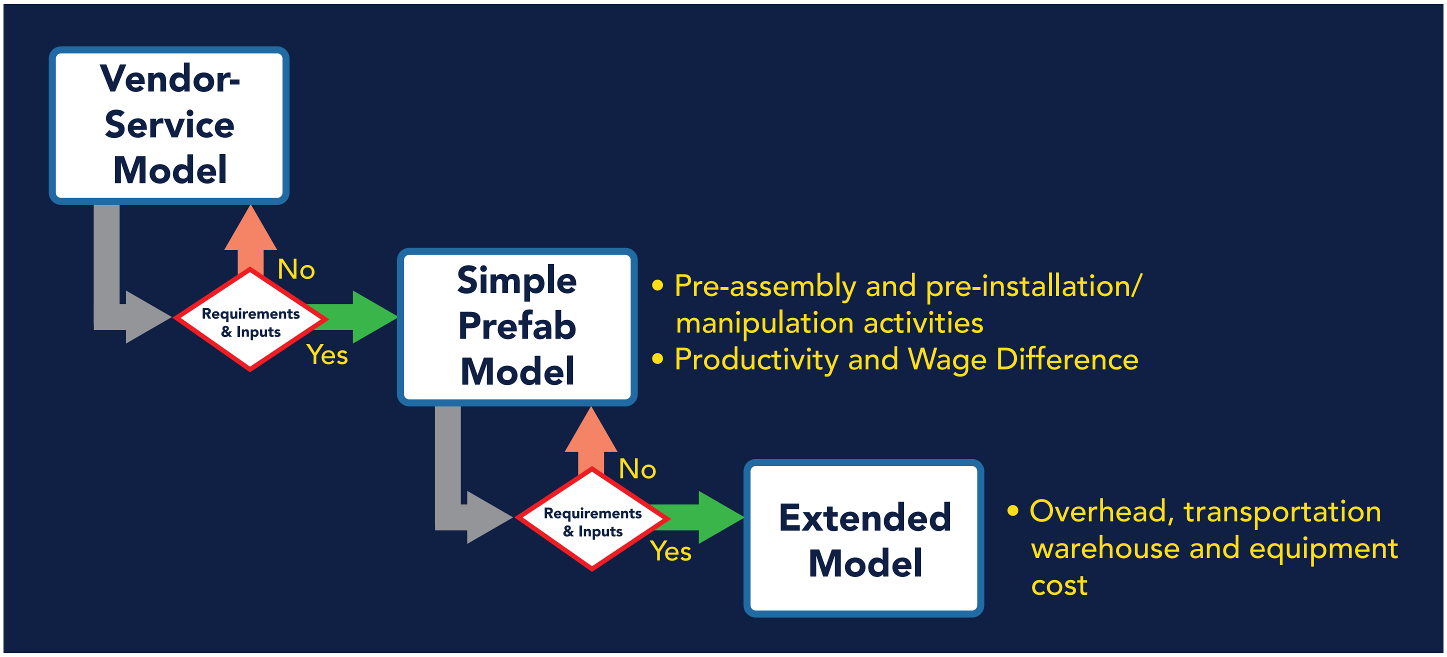



***Figure 8** – Prefab model structure (©MCA Inc.)*

1. **Vendor and Manufacturer Services**
2. **Simple Prefab**
3. **Extended Model**

To calculate the labor savings and composite rate impact of prefab, the calculator requires some inputs. As most of the input parameters are specific to a specific business and vary across contractors, projects, and geographic locations, the calculator requires a few company- and project-specific input factors, such as labor costs, labor productivity, vendor service charges, the wage rate in the prefab shop as well as the equivalent on-site effort (hours) needed to complete the work and activities that have been identified to be moved away from the job site and to prefab (prefab budget). These inputs are needed to best align the calculator with the particular business, business environment, and project specifics. **Table 2** *(page 23)* provides an overview and explanation of the different input factors, definitions, measurement, as well as the requirements for the three different models of the prefab calculator.

## *1. Vendor and Manufacturer Service Mode*

The first step of Externalizing Work is to increase Vendor/Manufacturer partnership and involvement. It is good practice to start small using available third-party services and material to evaluate vendor prefab services or standard material purchase decisions. Doing this typically requires very little or even no upfront cost or investment by the contractor for a prefabrication facility. However, it needs investment and commitment into a mutual and reliable contractor-vendor partnership. To achieve this and to use the Vendor-Service Model of the calculator, contractors need to:

- Identify activities/tasks and the involved effort that can be outsourced to vendors (see WBS™)
- Identify any opportunities for using common, standardized material to reduce material variation
- Gather quotes for the requested services and price differences on standardized material

With the above information and the calculator at hand, electrical contractors can evaluate the cost savings and labor benefits from available services, pre-assemblies, or standard material from vendors and manufacturers. However, from MCA's work experience with distributors and electrical contractors over many years, it is most likely that contractors will find it hard to compete with their prefab operations against the specialization and economies of scale from vendors providing material management services, pre-assemblies, and from manufacturers producing standardized materials.

### *2. Simple Prefab Model*

This part of the calculator can be used separately or in addition to the vendor-service model. Electrical contractors can use the Simple Prefab Model to determine the labor cost savings from simple prefab, which mainly consists of lower risk Type 1 Prefab (Common Items) as well as Type 2 Prefab (Type-of-Work-Specific Items) that require limited or almost no additional planning and coordination, compared to highly complex Build-To-Order (Type 3) Prefab.

For the Simple-Prefab Calculator to best align with the specific contractor, project, and type of prefab specific characteristics, contractors need to determine:

- Prefab-Budget - the on-site equivalent effort measured in hours
- On-site Labor Productivity and Prefab Labor Productivity
- The average composite rate for labor used on-site and for prefab

- **Determine the Prefab-Budget:** Contractors need to identify prefab opportunities by breaking down the work in a structured, standardized way, like a WBS (see Section 2.1), identifying all activities from the WBS that can be taken off-site using prefab, and determining the field on-site effort (hours) for all individual activities and work. The sum of the determined on-site effort of all activities and work that will be prefabricated and completed off-site will serve as the number of available hours for prefab, i.e., the Prefab Budget.

  As an example, assume a company has identified fixture unboxing, pre-assembly, and packaging disposal to be performed off-site and away from the final point of installation. Next, assume it takes electricians an average of 30 minutes to prepare and pre-assemble a specific type of fixture on-site with a total of 20 of these fixtures to install for this project. The prefab budget for the unboxing and preparation work would total 600 minutes (30 minutes each * 20 fixtures) equals 10 hours.

- **Determine Labor Productivity:** The Simple Prefab Model requires information about labor productivity, in particular the average on-site labor productivity and the average prefab labor productivity which should ideally be determined by each contractor individually. Although there are different definitions and ways to measure productivity in construction, labor productivity is measured as the effectiveness of production: How effective was labor in production? How effectively did labor get to final installation? Productivity and effectiveness of installation should not be confused with or equated to the speed of installation. Productivity is measured as the percentage of productive time (installation time and time spent on any other value-added activity) relative to the total shift time. In other words, productivity is the ratio of useful hours to total hours spent.[3]

*Table 2 – Overview, Definitions, and Explanations of Prefab Calculator Input Parameters*

| Model | Requirements | Input Parameter | Description | Measurement |
|---|---|---|---|---|
| *Vendor-Service Model* | Understanding and separation of the three phases of work:<br>1) Preparation<br>2) Installation<br>3) Put away | **Pricing Structure** | Flat fee or per unit pricing for vendor service. | Per unit can be any count or length measure. |
| | | **On-Site Time Measurement** | How is the equivalent effort on-site measured and entered? | Time as total time or, if available, as time per unit. |
| | | **Equivalent Time on-site** | Field labor time needed to perform the same work on-site that is outsourced to the vendor. Can be entered either as a total for the service or as per unit measurement. | In hours (either as total time or per unit). |
| *Simple Prefab* | Additionally:<br>• Segregation of Work and Labor<br>• Identification of own prefab opportunities | **Field Labor Composite Rate** | Fully-burdened wage rate per hour for the field crew. | Total wage rate including benefits, fringes, etc. |
| | | **Field-/Prefab-Productivity** | Effectiveness of production. The average amount of time labor spends on installation, assembly, or any other value-transfer activities relative to the total time spent. | The average percentage of time spent on installation, assembly, or any other value-transfer activities not including auxiliary activities and waste, such as wait time, material movement. |
| | | **Prefab Labor Composite Rate** | Fully-burdened wage rate per hour for the prefab crew. | Total wage rate including all benefits, fringes, etc. |
| | | **Prefab Hours Budget** | Equivalent effort in hours for the work moved away from the job site, and to be completed in a controlled environment/ prefab shop. | The number of hours (effort) needed to complete the work or activity on-site, typically taken from WBS™. |
| *Extended Model* | Additionally:<br>Prefab shop with established cost tracking process and procedures | **Overhead Cost** | Average fraction of total cost for overhead. | As a percentage of total prefab cost. |
| | | **Packaging & Transportation Cost** | The cost associated with packaging and transportation of prefab. | As a percentage of total prefab cost. |
| | | **Warehousing & Equipment Cost** | Warehouse and equipment cost related to prefab. | As a percentage of total prefab cost. |

3 For example, labor on-site spends on average a total of 307 min on non-productive activities during a full 8hr-shift (640min), the non-productivity percentage can be calculated as 48% (288/640). The remaining time is productive time, and therefore average labor productivity on-site is about 52% (100% - 48%).

Labor productivity can be measured using ASTM E2691-20 Standard Practice for Job Productivity Measurement. MCA's Job Productivity and Control (JPAC®) is based on an application of ASTM 2691 and previous ELECTRI research on 'The Impact of Variation on Profits," which offers an easy way to measure company-, project- and activity-specific productivity to help determine contractor-specific on-site and prefab productivity. It further allows contractors to track job site and prefab production (see Daneshgari and Moore, 2015 and 2017). For alternative metrics and tools to measure productivity in construction, see Huang, Champman, and Butry (2009).

Previous research and studies[4] as well as MCA's JPAC database[5] provide the following reference points and benchmarks for on-site and prefab productivity that give electrical contractors a starting point:

> The average on-site productivity ranges between 45% and 60%. In other words, 40% to 55% of the time on-site is spent on non-productive activities and, therefore, is considered lost productivity.
>
> JPAC data and investigations show that the average productivity in a controlled work area can increase to approximately 70% to 80% when there is a significant reduction of wasted time on material movement, material handling, searching for equipment and material, higher tool uptime, etc. Such reductions immediately translate into higher labor productivity.

It is essential for contractors to determine and quantify their own on-site and prefab productivity. It is important to note that the difference between on-site and prefab labor productivity does not solely determine the net benefit of prefab. The benefits of prefab are the result of a combination of both: The productivity difference as well as the level of productivity.

- **Determine Labor and Prefab Composite Rates:** Finally, the last two parameters for the Simple-Prefab Model are the average fully-burdened crew composite/wage rates for on-site and prefab labor.

Using the collected information and inputs detailed above plus additional, basic, project-specific information (required fields in the calculator highlighted in yellow) that can be gathered from the project's contract, the calculator will provide an estimate or target value for the labor savings available to the electrical contractor from vendor services and simple prefab activities.

Based on specific input parameters, the Simple Prefab calculator will provide a total dollar amount of labor cost savings. The Prefabrication Calculator will show how the savings translate into an adjusted labor composite rate for the project. Further, it will break down

4 An EC&M Article in 2017 ("How To Make A Good Estimate Even Better") states that "Studies have shown that on most construction sites, productive labor stands at about 50% – 65%.

5 See page 18 of this report for a detailed description of the data and information covered in the JPAC® database.

total labor cost savings into cost savings due to improved productivity and cost savings due to labor wage rate differences between prefab and on-site. The calculated savings are not guaranteed but do provide contractors a quantitative reference point of the additional profit through labor savings. The provided Excel spreadsheet also offers contractors the opportunity to easily create different case scenarios by altering input parameters, such as labor and/or prefab productivity. As contractors gain more experience with prefab, and the more that prefab processes and procedures improve and become standardized, the higher and more reliable the calculated value from prefab will be.

### *3. Extended Model*

Many contractors are concerned about incorporating the impact of overhead, packaging, transportation, warehousing, and equipment cost associated with operating a prefab shop. The extended model of the calculator allows contractors with established, reliable, and standardized prefab processes to factor in the additional costs (as a percentage of their total prefab cost). This extended model is most applicable to complex and large-scale prefab activities that are well beyond getting started with and using simple prefab.

If a prefab shop has been established, and a standard prefab process is in place, and the cost structure of the prefab operations is tracked, then the extended model of the calculator can be used to account for these additional cost factors to translate the net benefit of the prefab operations into an aggregate labor composite rate impact to "price" estimates with prefab. Without prefab as a standardized and reliable process within the electrical contractor's operations ("Prefab Thinking") and without frequent and consistent prefab usage by field labor ('Prefab-Building"), determining and providing common percentages for overhead, equipment, transportation, and packaging cost can be misleading and will set unrealistic targets rather than providing guidance.

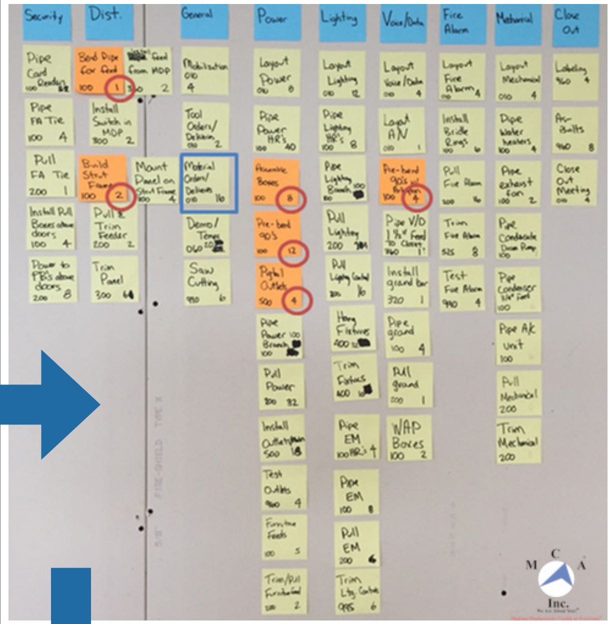
Further, the documented current industry-wide prefab usage among electrical contractors also indicates that if such cost percentages are provided, these numbers are likely to suffer from low information tracking and data availability issues (as indicated by this research's survey), data inconsistency, and hence high variation, as well as dependencies/biases related to the sample of surveyed (typically larger) contractors.

## 2.3 Case Study Project

*1. Project Characteristics (Estimate)*

- Total Revenue: $165,400
- Labor Cost: $ 64,720
- Total Labor Hours: 809 hrs
  - o Direct Field Hours: 750 hrs
  - o Indirect Hours: 59 hrs
- Field Composite Rate = $80.00
- Material & Equipment Cost: $71,911
- Costs for Subs: $0
- Other Cost: $7,191

*2. Project Work Breakdown Structure (WBS™) with Prefab Identification*




*3. Identification of Vendor Services*

1) Unboxing 20 Fixtures
   - Estimated on-site effort of 0.25hrs/fixture
   - Vendor offered unboxing service and putting on light fixture charts for $300 flat fee
2) Vendor-Partner offered material delivery and on-site movement service at no additional charge
   ➔ Reduction of on-site material handling and movement by approx. 8 hrs of the total identified on-site effort (see blue box in WBS™).

   ➔ *Outsourced On-Site Effort = 13hrs*

*4. Simple Prefab Identification and Prefab Budget Calculation*

| **Identified Prefab** (see orange sticky notes) | **On-Site Effort From WBS™** |
|---|---|
| "Bend Pipe for Feed" | 1 hr |
| "Build Strut Frame" | 2 hrs |
| "Assemble Boxes" | 8 hrs |
| "Pre-bend 90s" (Power) | 12 hrs |
| "Pigtail Outlets" | 4 hrs |
| "Pre-bend 90s" (Voice/Data) | 4 hrs |
| **TOTAL Prefab Budget** | **31 hrs** |

➔ *Prefab Usage = 31hrs/737hrs = 4.2%*

*5. On-Site and Prefab Labor Productivity and Composite Rates*

The electrical contractor performed all prefab in a separate work area in the back of the shop with minimal preparation. The area was equipped with two work benches, electrical tools, conduit bender, and bins for the material and assemblies.

Since the contractor had no history and data about the company's labor productivity, **the average on-site and prefab labor productivity rates of 50% and 75%** were used, respectively.

Field Composite Rate = $80.00 Prefab Composite Rate = $55.00

Required Field
Calculated Field

**Prefabrication Savings Calculator**

| Project Information | | |
|---|---|---|
| Project Number - Name | Office Expansion | |
| Total Contract Value | $ 165,400.00 | |
| Estimated Total Labor Hours | 809 | |
| Estimated Field Labor Hours | 750 | |
| Estimated Indirect Labor Hours | 59 | 7% |
| Total Labor Cost | $ 64,720.00 | 45% |
| Total Material & Equipment Cost | $ 71,911.00 | 50% |
| Total Costs for Subs | $ - | 0% |
| Other Cost | $ 7,191.00 | 5% |
| Estimated Total Cost | $ 143,822.00 | 87% |
| Estimated Profit | $ 21,578.00 | 13% |
| Field Labor Composite Rate ($/hr) | $ 80.00 | |
| Total Field Labor Cost | $ 60,000.00 | |
| Field Labor Productivity (average) | 50% | |

| Simple Prefab | |
|---|---|
| Prefab Hours Budget | 31 |
| % Prefab | 4.2% |
| Prefab Shop Labor Wage Rate ($/hr) | $ 55.00 |
| Prefab Shop Labor Productivity (average) | 75% |

| Extended Model (Use only if you have an established prefab shop) | |
|---|---|
| Overhead Cost (%) | |
| Packaging & Transportation Cost (%) | |
| Warehouse and Equipment Cost (%) | |

Vendor Prefab-Services

| # | Type of Service | Pricing Structure | Service Fee | Cost per Unit | Units | On-site Time Measurement | Equivalent Time on-site (in hours) | Units |
|---|---|---|---|---|---|---|---|---|
| 1 | Unboxing Fixtures | Flat fee | $ 300.00 | | | Per Unit | 0.25 hours | 20 |
| 2 | Material Delivery & Movement | Flat fee | $ - | | | Total | 8.00 hours | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | |
| 12 | | | | | | | | |
| 13 | | | | | | | | |
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| 15 | | | | | | | | |
| 16 | | | | | | | | |
| 17 | | | | | | | | |
| 18 | | | | | | | | |
| 19 | | | | | | | | |
| 20 | | | | | | | | |
| | Total Cost for Vendor Prefab Services | | $ 300.00 | | | Total Equivalent Time (in h) | 13.0 h | |

| Labor Cost Savings through Prefab | Amount | % change |
|---|---|---|
| Through Vendor Prefab-Services | $740.00 | -1.2% |
| Through Simple Prefab | $1,343.33 | -2.3% |
| *From Productivity Improvement* | $826.67 | 62% |
| *From Wage Difference* | $516.67 | 38% |
| After accounting for additional cost | $1,343.33 | -2.3% |
| **Total Labor Savings** | **$2,083.33** | **-3.5%** |

| Field Labor Composite Rate Adjusted (Simple Prefab only) |
|---|
| $78.18 |
| **Field Labor Composite Rate (Extended Model)** |
| $78.18 |
| **Total Adjusted Labor Composite Rate (incl. Vendor Services)** |
| $77.22 |

## 6. *Output of the Prefab Calculator*

- Using 4.2% of prefab on this project translates into approx. -2.3% reduction of labor cost
- Aggregate composite rate (crew mix) impact of prefab on is a reduction from $80.00 to $78.18
- Aggregate composite rate (crew mix) impact incl. vendor services and prefab is a reduction from $80.00 to $72.22
- Project profit increases to $22,921 and profit margin rises to 13.9% (+ 0.9)
- About 60% of the savings are due to higher productivity, while 40% is due to a lower prefab composite rate

## 7. *Prefab Usage Scenarios and Impact Analysis:*

| % Prefab | 10% | 15% | 20% |
|---|---|---|---|
| **Composite Rate** | **$ 75.65** (-$ 4.45) | **$ 73.53** (-$ 6.47) | **$ 71.36** (-$ 8.64) |
| **Profit (Margin)** | **$ 25,524** (15.4%) | **$ 27,084** (16.4%) | **$ 28,688** (17.3%) |

# Conclusion

As noted throughout this report, recent changes and disruptions in the industry emphasize the importance of prefabrication for electrical contractors to retain and increase productivity and for their ability to price their estimates with prefab to stay competitive. Many contractors are hesitant to start using or expanding prefab as most lack a practical way to quantify the benefits from Externalizing Work®, consequently struggling with bidding and pricing their work with prefabrication.

Prefabrication as a means of Externalizing Work describes any activity or work moved away from the final point of installation to be performed in a controlled, therefore safer, and more productive, off-site environment. The objective is to reduce the number of manipulations for final completion and installation on-site. To get started with and use prefab effectively, neither a separate physical location such as a prefab shop nor different labor is required. The main rationale for using prefab is the mitigation of technical, integration, and business risk, higher predictability of cost, quality of work, and finally profits. Prefab is not as much about building faster. The three different types of prefab, i.e., Common-among-all (Type 1), Type-of-Work-Specific (Type 2), and Build-To-Order/ Project-Specific (Type 3), are provided through different means, carry different risk, provide different benefits and costs, and therefore require different pricing.

Survey results from NECA contractors and data from a large proprietary dataset covering more than 1,175 union and non-union electrical construction projects show that the industry-wide level of prefab usage among electrical contractors averages less than 5%.  While variation in the use of prefab among larger and smaller contractors was observed in the survey, interviews and assessments of small and large electrical contractors show that the use of prefabrication is less a matter of company size than it is of leadership, vision and culture regarding "Prefab Thinking" and "Prefab Building" along with initiatives of continuous education, training, and experience on prefab identification and building with prefab. To increase and enhance the use of prefab, contractors need to start building with prefab, which is more and beyond building prefab assemblies.

Improvements in productivity, composite rate, and safety constitute the most important and critical factors for union and non-union contractors for evaluating the benefits of prefabrication. While safety improvements and planning due to prefab usage are important determinants, they do not represent significant factors at current levels of prefab usage among electrical contractors. The total impact and benefits that come with increasing prefab usage should be measured and accounted for by a reduction in the project composite rate. Using contractors' responses and work experience with electrical contractors from over three decades, the researchers developed an Excel-based Prefabrication Calculator to help electrical contractors:

- make the cost savings/profit increase potentials from using prefabrication visible
- translate the aggregate labor savings from project-specific individual levels of prefab usage into an equivalent composite rate impact to help contractors in "pricing" their estimates with prefab

The developed Prefabrication Calculator will provide a quantitative reference point and practical way to determine the cost and profit impact of increasing prefab usage. Contractors will have to develop and establish their individual and proven process for prefabrication along standardized procedures. This will enable contractors to measure and track the relevant information within their companies. This data can then be used to determine their individual costs and benefits from their prefab operations and be translated into company-specific models on how to estimate and price work with prefab.

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# Appendix A: Survey Form

ELECTRI INTERNATIONAL
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### *2020 ELECTRI International Research Project*
### *"Estimating with and Pricing of Prefab for Electrical Contractors"*

Date created: May 1st, 2020

Take survey online https://www.surveymonkey.com/r/686CTNZ or return completed form and related attachments to Dr. Meik Daneshgari at mdaneshgari@mca.net **latest by June 15th, 2020**.

Please be assured that all information provided will be kept strictly confidential, and will only be used for the purpose of this research project.

**1) Company and Contact Information**

| | | | |
|---|---|---|---|
| **Company Name** | ☐ | **Your Name** | ☐ |
| **Company Position** | ☐ | **Phone** | ☐ |
| **MWBE Certified?** | ☐ Yes ☐ No | **E-Mail** | ☐ |
| **Type of Company** | ☐ Electrical Contractor ☐ Distributor ☐ Manufacturer<br>☐ Other, please specify: | | |
| **City** | ☐ | **State** | ☐ |
| **Company Size** (by annual revenue) | ☐ < $5 million ☐ $5 - $10 million ☐ $10 - $25 million ☐ $25 - $50 million<br>☐ $50 - $100 million ☐ $100 - $200 million ☐ > $200 million | | |

**2) Questions**

a) **Do you operate your own prefab shop?** ☐ Yes ☐ No

b) **Do you purchase any prefabricated or preassembled material?**
- ☐ Yes, from distributors
- ☐ Yes, from manufactures
- ☐ Yes, from electrical fabricators
- ☐ No, I only use my own prefab
- ☐ No, I do all assemblies onsite

c) **What percentage of your project work is accomplished using prefabrication?**
(Work completed through your own prefab activities or by purchasing prefabricated material)
☐ 0 - 5% ☐ 5 - 10% ☐ 10 - 20% ☐ 20 - 30% ☐ 30 - 40% ☐ > 40%

ELECTRI Prefabrication Research Questionnaire Page 1 of 3
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**d) Do you track and measure the effectiveness of your prefabrication activities?**
Please select the suitable categories for what you track within your company.
Please provide some details and explain what you are tracking, and how you measure it?
How do you validate your measurements?

☐ Labor Measurement:

☐ Material Measurement:

☐ Equipment/Tools Measurement:

☐ Risk/Safety Measurement:

☐ Other:

Measurement:

☐ Other:

Measurement:

**e) From your experience, which of the following benefits/saving from prefabrication do you consider most important?** (Multi-Selection)

- ☐ Wage difference
- ☐ Productivity difference
- ☐ Lower installation time
- ☐ Safety improvement
- ☐ Schedule savings
- ☐ Lower purchasing cost
- ☐ Less mobilization
- ☐ Less waste (e.g., motion, waiting, material handling, etc.)
- ☐ Other, please specify:

**Do you account for the selected items when bidding work? If yes, how? If no, why not?**

*<u>Example</u>: X% prefab, Y% lower wage rate of prefab labor → Adjustment of direct labor cost by Z%*

**f) From your experience, which of the following do you consider the most substantial costs of prefabrication? Do you account for these when pricing your work?** (Multi-Selection)

- ☐ Internal planning & coordination
- ☐ External coordination
- ☐ Transportation & logistics
- ☐ CAD/BIM requirements
- ☐ Packaging/Staging
- ☐ Reduced flexibility
- ☐ Other, please specify:

**Do you account for the selected items when bidding work? If yes, how? If no, why not?**

*<u>Example</u>: Higher planning effort for doing X% of prefab → Increase of indirect labor cost by Y%*

# Appendix B: Survey Results

## Survey Responses—Distribution

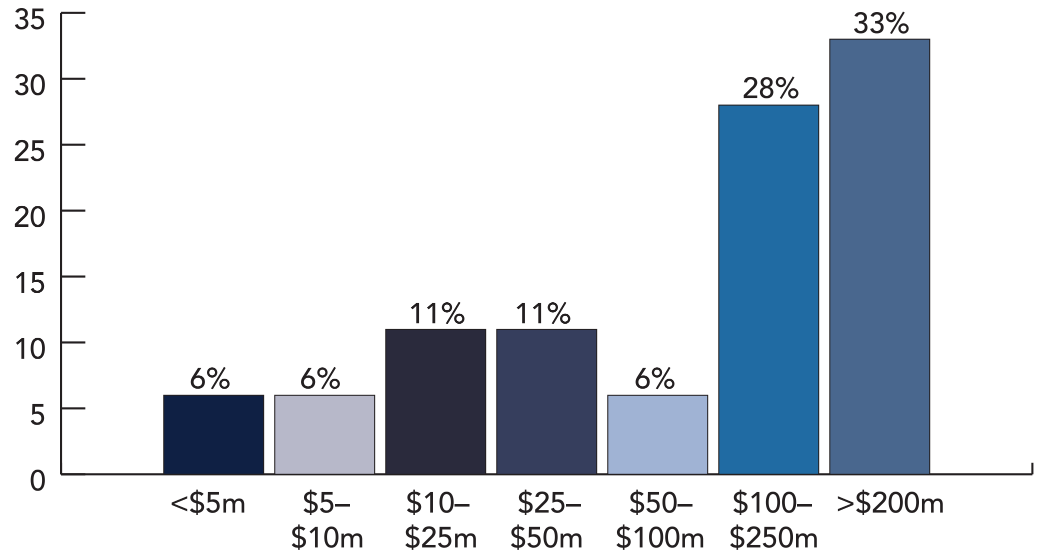


***Figure B-1*** *– Company size distribution (©MCA Inc.)*

## Survey Responses—Percent Prefab

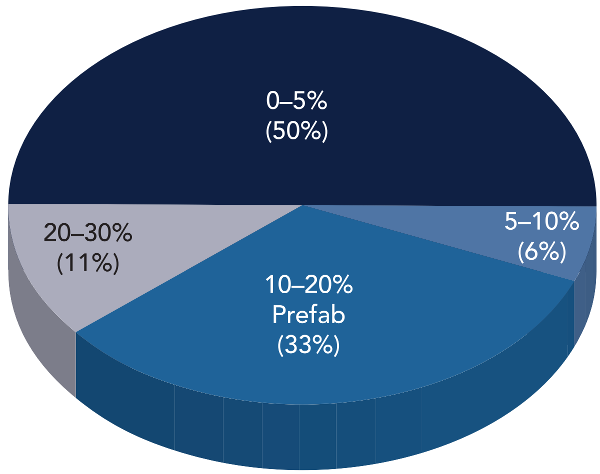


***Figure B-2*** *– Reported percent of prefabrication (©MCA Inc.)*

## Survey Responses—Prefab Shop

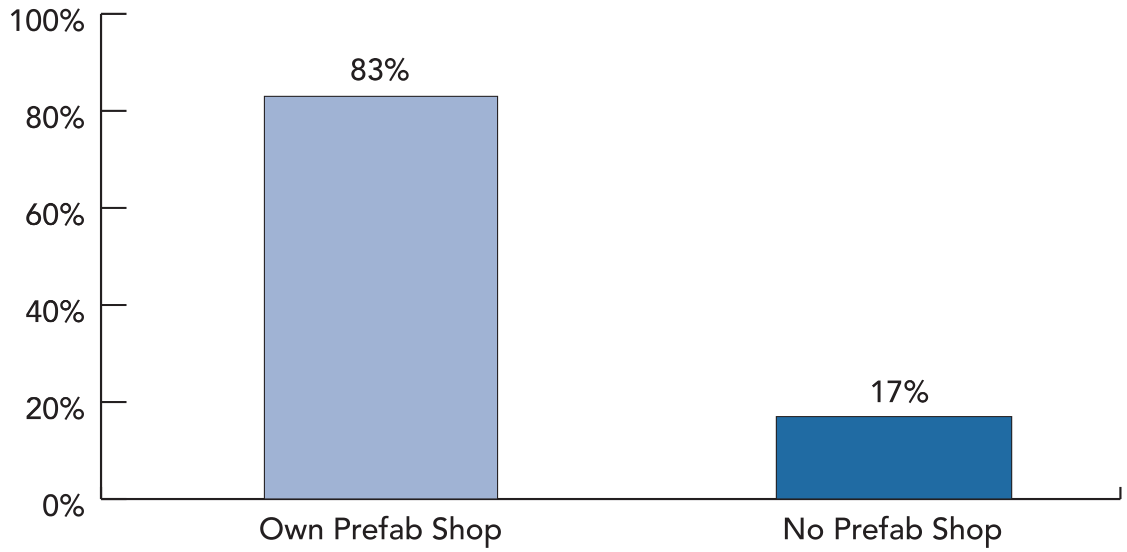


***Figure B-3*** *– Survey responses on operating prefab shop (©MCA Inc.)*

## Survey Responses—Prefab Tracking

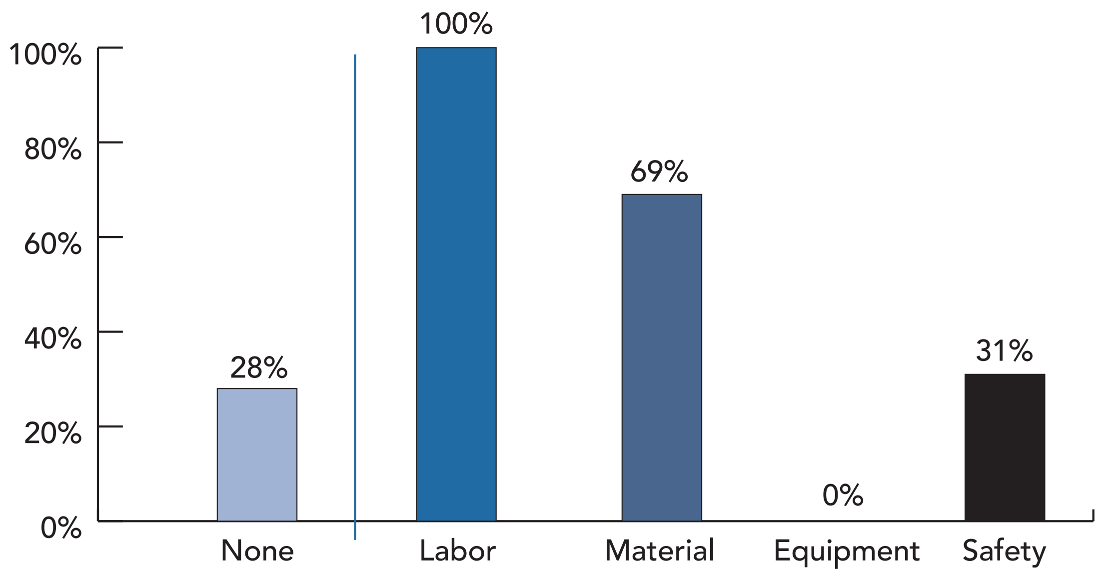


***Figure B-4*** *– Categories of prefab tracking (©MCA Inc.)*

## Survey Responses—Potential Benefits

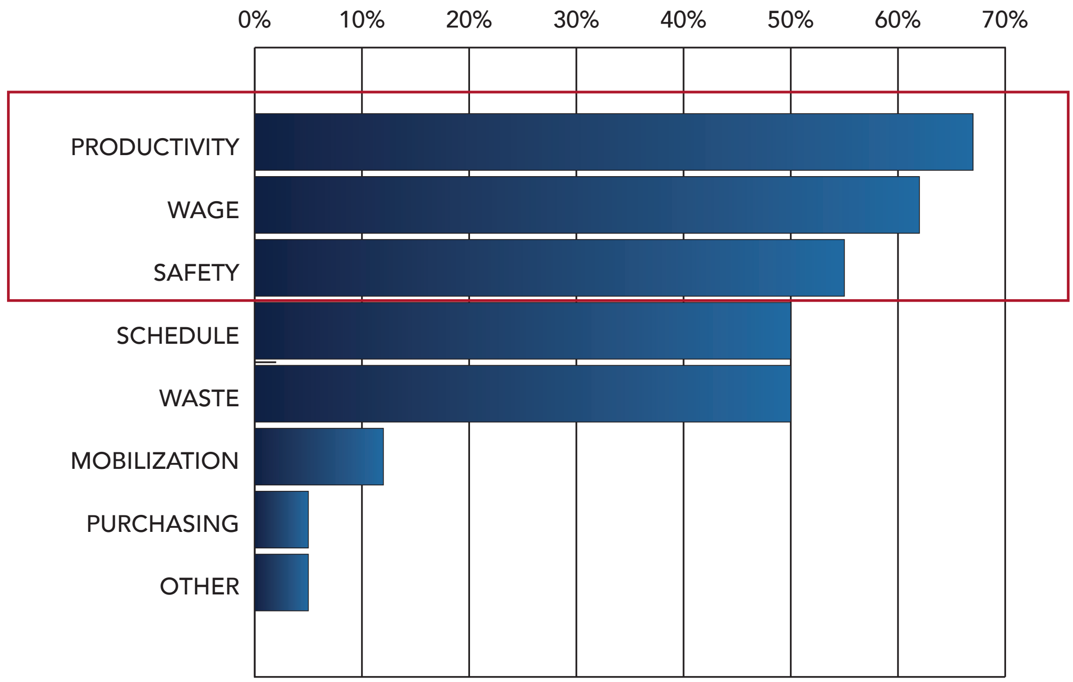


***Figure B-5** – Benefits of prefab from contractors' perspective (©MCA Inc.)*

## Survey Responses—Potential Cost

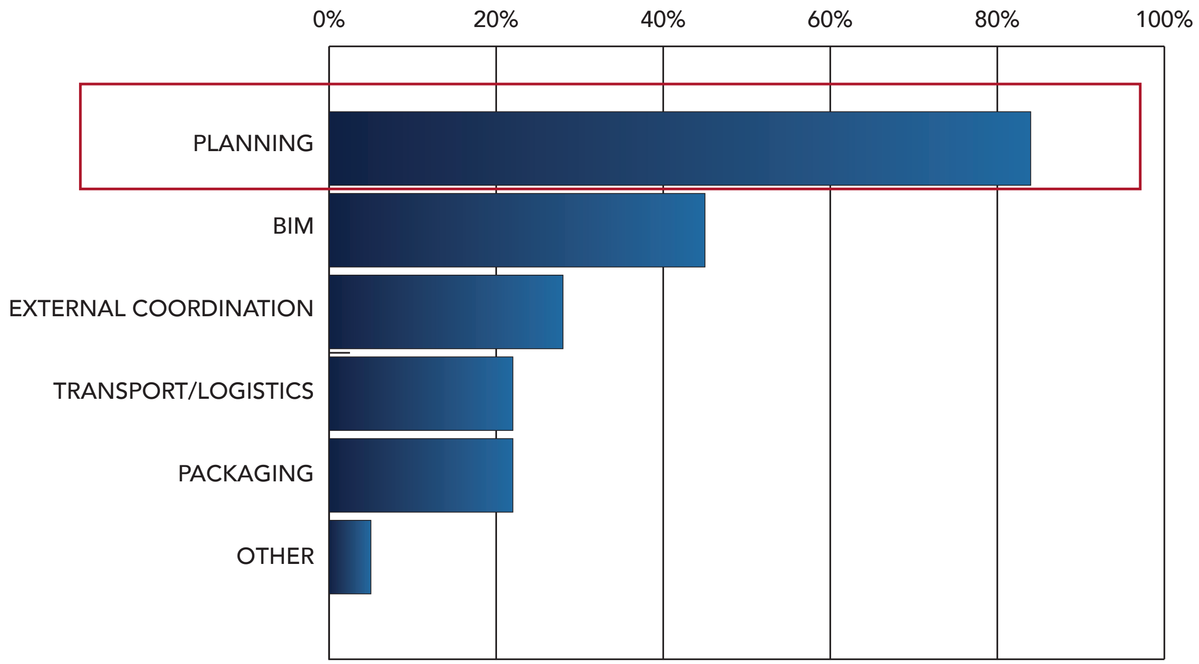


***Figure B-6** – Costs of prefab from contractors' perspective (©MCA Inc.)*

# Appendix C: Prefabrication Calculator

| | |
|---|---|
| (yellow) | Required Field |
| (blank) | Calculated Field |

**Prefabrication Savings Calculator**

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| Project Information | |
|---|---|
| Project Number - Name | |
| Total Contract Value | |
| Estimated Total Labor Hours | |
| Estimated Field Labor Hours | |
| Estimated Indirect Labor Hours | |
| Total Labor Cost | |
| Total Material & Equipment Cost | |
| Total Costs for Subs | |
| Other Cost | |
| Estimated Total Cost | |
| Estimated Profit | |
| Field Labor Composite Rate ($/hr) | |
| Total Field Labor Cost | |
| Field Labor Productivity (average) | |

| Simple Prefab | |
|---|---|
| Prefab Hours Budget | |
| % Prefab | |
| Prefab Shop Labor Wage Rate ($/hr) | |
| Prefab Shop Labor Productivity (average) | |

| Extended Model (Use only if you have an established prefab shop) | |
|---|---|
| Overhead Cost (%) | |
| Packaging & Transportation Cost (%) | |
| Warehouse and Equipment Cost (%) | |

**Vendor Prefab-Services**

| # | Type of Service | Pricing Structure | Service Fee | Cost per Unit | Units | On-site Time Measurement | Equivalent Time on-site (in hours) | Units |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | |
| 12 | | | | | | | | |
| 13 | | | | | | | | |
| 14 | | | | | | | | |
| 15 | | | | | | | | |
| 16 | | | | | | | | |
| 17 | | | | | | | | |
| 18 | | | | | | | | |
| 19 | | | | | | | | |
| 20 | | | | | | | | |
| | Total Cost for Vendor Prefab Services | | $ - | | | Total Equivalent Time (in h) | 0.0 h | |

| Labor Cost Savings through Prefab | Amount | % change |
|---|---|---|
| Through Vendor Prefab-Services | $0.00 | |
| Through Simple Prefab | $0.00 | |
| *From Productivity Improvement* | $0.00 | |
| *From Wage Difference* | $0.00 | |
| After accounting for additional cost | $0.00 | |
| **Total Labor Savings** | **$0.00** | |

| |
|---|
| Field Labor Composite Rate Adjusted (Simple Prefab only) |
| |
| Field Labor Composite Rate (Extended Model) |
| |
| Total Adjusted Labor Composite Rate (incl. Vendor Services) |
| |

# About the Authors

**Dr. Meik Daneshgari,** Director of Research at MCA, Inc., holds a Ph.D. in Finance and a Master's degree in Industrial Engineering from the Karlsruhe Institute of Technology in Germany. He earned a Bachelor's degree in Industrial Engineering with a specialty in mechanical engineering from Otto-von-Guericke-University Magdeburg, Germany. Daneshgari has experience working with the construction and automotive industries applying his strong knowledge and skills in financial analysis and statistical and empirical data analysis. Working with MCA, Inc., he now applies his knowledge and data analytics skills to helping electrical contractors across the country on data-driven business and process improvement and productivity measurement.

**Heather Moore Ph.D.** is Vice President of Operations for MCA Inc. where she specializes in process design and operations research. Her experience includes working with the construction industry, and she currently engages with contractors and distributors across the country on process improvement and productivity measurement. Moore has taught numerous classes for the construction industry and has contributed to several research projects for ELECTRI, MCAA, NHF and NAW. Moore was a contributor to the ASTM Standard E2691 and is now Vice Chair of ASTM Subcommittee E06.81 on Building Economics.

Dr. Moore holds a Ph.D. in Construction Management, Michigan State University and an MBA and a B.S.E. in Industrial and Operations Engineering, University of Michigan. She has co-authored four books on the Industrialization of Construction® and the future of the industry and is also co-author of the industry's "Prefabrication Handbook."


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Index Number # F3439