

BES501955 | BES681752

Laying the Groundwork in Revit for the Best MEP Data Platform

Jacob Elliott, EI
Cator, Ruma and Associates

Learning Objectives

- Link mechanical and electrical elements in a Revit model
- Leverage the Revit API to improve coordination of mechanical and electrical systems
- Move coordination workflows into Revit from other platforms
- Extend a custom coordination platform to use Autodesk Forge and Power BI

Description

Change orders are frustrating and expensive. Preventable change orders are even more frustrating. For an MEP (mechanical, electrical, and plumbing) firm, uncoordinated equipment is a huge source of preventable change orders and RFIs. Revit software doesn't natively allow users to link mechanical and electrical equipment for coordination. Coordinating mechanical and electrical requirements in an MEP design requires a lot of data to flow between team members. Historically, our firm used PDF cutsheets, spreadsheets, and emails. But this data is static and can't take advantage of our parametric families. We've created a Revit add-in that displays real-time data from both disciplines, side by side. This allows us to flag problems automatically and prevent mismatches in construction documents. In this session, we'll discuss the methodology we used to create this coordination tool, and how it prevents expensive change orders, keeps projects on schedule, and can be extended to integrate with Autodesk Forge and Microsoft Power BI.

Speaker

Jacob Elliott is a mechanical engineer-turned-software engineer who develops software for Cator, Ruma and Associates of Denver, CO. His main focus is two areas: (1) MEP engineering and design automation in Revit and (2) a web-based analytics platform for building automation systems. For the past four years, Jacob has developed a suite of custom Revit tools for Cator Ruma that is focused on improving quality and efficiency of MEP designs. More recently, he has created custom visualization and analytics dashboards for clients to view building automation system data.

Link Mechanical and Electrical Elements in a Revit Model

Linking elements between disciplines is what makes comparison of values possible. Our technique for linking elements is an extension of the technique demonstrated by Andrew Duncan in AU 2017.¹ This technique is intended to be as flexible as possible in allowing users to specify the unique needs of all their equipment. By storing the element ID in a parameter, we can reuse the value for lookups at any point.

Associate Elements to Equipment Instance

The first level of association required is on the family instance level. To make this association, we store the element ID of one element in an integer-based shared parameter. We have accomplished this using a Revit Addin with a WPF interface, but it can also be done in Dynamo if needed.

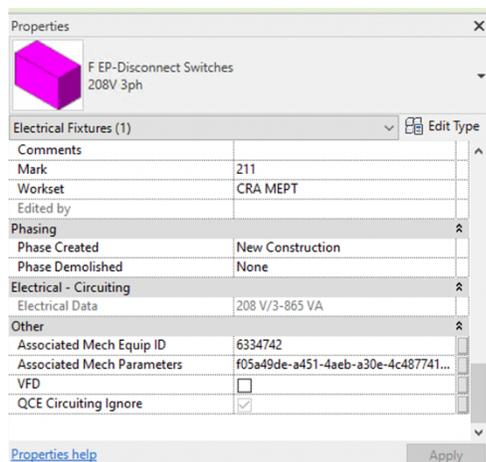


Figure 1: Mech Equip ID parameter stores the ID of an associated mechanical equipment instance.

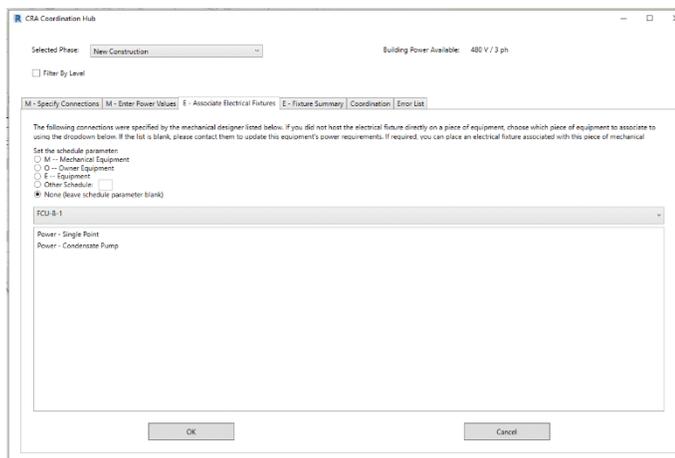


Figure 2: Custom interface for allowing users to associate equipment using a dropdown

This association can be completed one of two ways:

- Electrical element is hosted directly to mechanical element. The relevant element ID is automatically populated.
- Electrical element is hosted somewhere near the mechanical element. The user chooses which connection(s) to associate.

Associate Elements to Connection Point

The second level of association allows the association of an electrical fixture with a specific point of connection on a mechanical equipment instance. This allows flexibility to coordinate families that have one item to coordinate (single point connection) or many items to coordinate (e.g., custom air handling units).

¹ <https://www.autodesk.com/autodesk-university/class/Creating-Even-Smarter-MEP-Families-and-Workflows-Revit-and-Dynamo-2017>

This association is similar to the previous association. Rather than a single element ID, we store parameter GUIDs in a comma-separated list. Again, populated in two different ways:

- Mechanical specifies single point of connection. Connection is automatically selected.
- Mechanical specifies multiple points of connection. Select one or more items from list.

Leverage the Revit API to Improve Coordination of Mechanical and Electrical Systems

We have created a Revit addin that uses our specific shared parameters and the associations we have made between mechanical and electrical elements to surface comparisons between disciplines.

Standardize Power Parameters

Standardizing power parameters is a critical part of interacting with this power data in a predictable way. For our firm, we opted to create a “curated” list of the different points of connection that may be required for all mechanical equipment families. This means that (in theory) the user has all the potential options available in each family, but not *extra* options.

Our firm opted to use a set of (6) parameters:

Template	Example
Power - [parameter name] (Yes/No)	Power - SA Fan (Yes/No)
Power - [parameter name] Quantity	Power - SA Fan Quantity
Power - [parameter name] Voltage	Power - SA Fan Voltage
Power - [parameter name] Phases	Power - SA Fan Phases
Power - [parameter name] Value	Power - SA Fan Value
Power - [parameter name] Unit	Power - SA Fan Unit

The Power Value, Voltage, and Phases parameters store exactly what they say. The others require a little explanation:

- **Power - [parameter name] (Yes/No):** This value is for describing whether a specific connection point needs to be coordinated with electrical. This is also the “index” parameter used by the addin code to look up the related 5 parameters. That allows the association to store one parameter instead of six.
- **Power - [parameter name] Quantity:** This is for storing information about a point that gets repeated multiple times. For example, an air handler fan wall that needs multiple disconnects/VFDs instead of being wired together.
- **Power - [parameter name] Unit:** This is a controversial approach that was right for our situation but may not be right for yours. We have used a power shared parameter for storing these values in the past but had some issues with forced conversions and lack of flexibility. Because of that, our power value parameter is stored as a number and the unit is

stored separately. This means that in any schedule, a column can have multiple units used instead of just one. We can have large lab exhaust fans (HP) and small restroom exhaust fans (W) listed in the same schedule.

Monitor Equipment Additions to Database

Automatically triggering the Coordination Hub popups helps drive user engagement with the tool and helps users understand what is expected and when. All the operations done by the Coordination hub can be triggered manually at any time, but a combination of automatic and manual is helpful.

When to Automate Coordination Processes

We automate a popup in three key situations:

- **Mechanical equipment is placed:** trigger the Specify Connections tab. This is helpful because specifying connections is what populated the electrical association list. Without these connections specified, the electrical tab's list will be empty.
- **Electrical Fixtures are placed:** trigger the Associate Electrical Fixtures tab. Again, this encourages the user to finalize any associations the Coordination Hub needs for making comparisons. Also defaults the designation of the electrical element to match mechanical.
- **Schedule parameter changed on some electrical elements:** J-boxes and receptacles often NOT associated with mechanical equipment. In the case of these families, we track the schedule parameter. If it gets modified to equal "M" (mechanical equipment), the Coordination Hub appears just like when a disconnect is placed. Otherwise, nothing happens. We wouldn't want every receptacle placed in a building to cause a popup.

To automatically run the Coordination Hub in these instances, you'll need to create and implement an Updater² and specify all the triggers to use.

Move coordination workflows into Revit from other platforms

Every firm has their own coordination processes, but the goal is always to make sure mechanical and electrical designs are using the same information. We have used different formats for collecting and coordinating this information; all of them required duplication of work to communicate between disciplines.

- **Standardized Excel spreadsheet:** Mechanical engineer sits down and takes a pass at listing all the equipment that needs coordination, plus all the power information required

² <https://www.revitapidocs.com/2023/4cdaf502-fc25-8f18-7618-8448cce33d11.htm>

by the electrical team. When the team has enough time to do this thoroughly, it can be extremely effective. However, any changes to equipment require the process to start over.

- **Revit Schedule:** A Revit schedule of mechanical equipment helps the coordination process by providing a list of everything that needs to be coordinated. However, this still required extra (duplicate) data entry and doesn't have a way to connect/compare data between disciplines

Mechanical Process



Electrical Process



Figure 3: An overview of the coordination process.

The design of the Coordination Hub is centered around allowing users to easily make associations between elements and compare data between disciplines. However, this process was heavily influenced by one requirement from the engineers: each discipline needed to maintain their own data. As a person using this tool, it needed to be easy to edit your own data and difficult to accidentally make changes to the opposite discipline's data. Because the electrical elements are circuited, automatically propagating changes from mechanical to electrical was not an option. There would be potentially huge downstream consequences to panels and other power distribution equipment. For that reason, the coordination tab is a mostly read-only place to find and discuss inconsistencies. To make changes, the users need to go back to their respective tabs. Keeping automation from getting in the way of engineering was critical.

Mechanical Workflow

Below is a screenshot showing the screen presented to the mechanical user automatically once they place a mechanical equipment family in the Revit model.

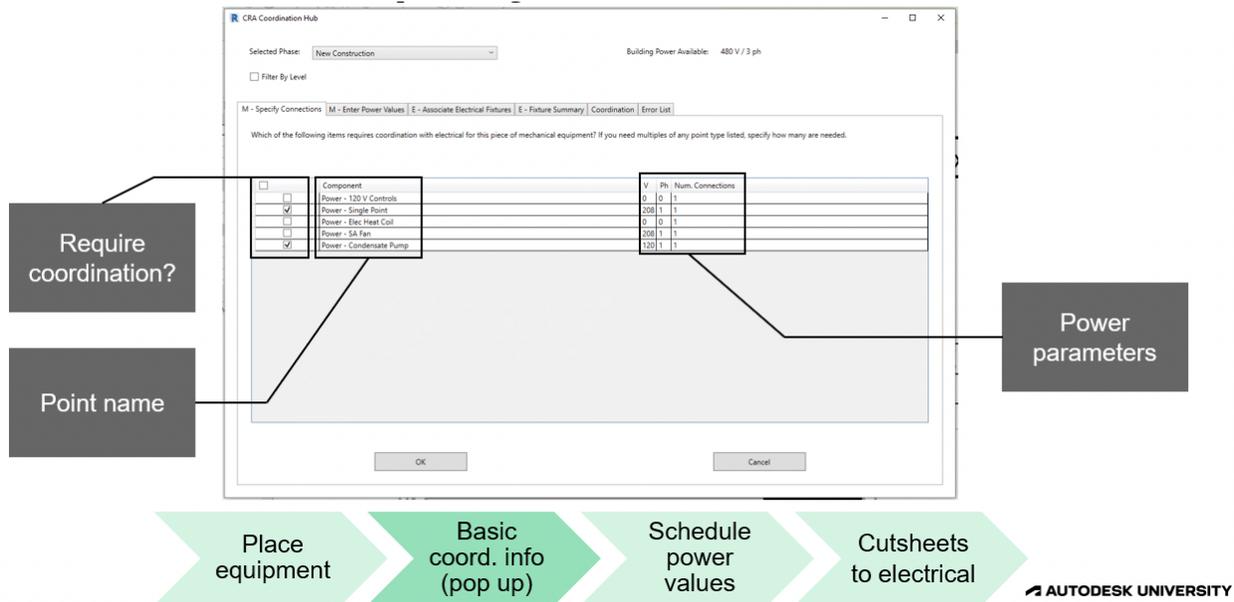
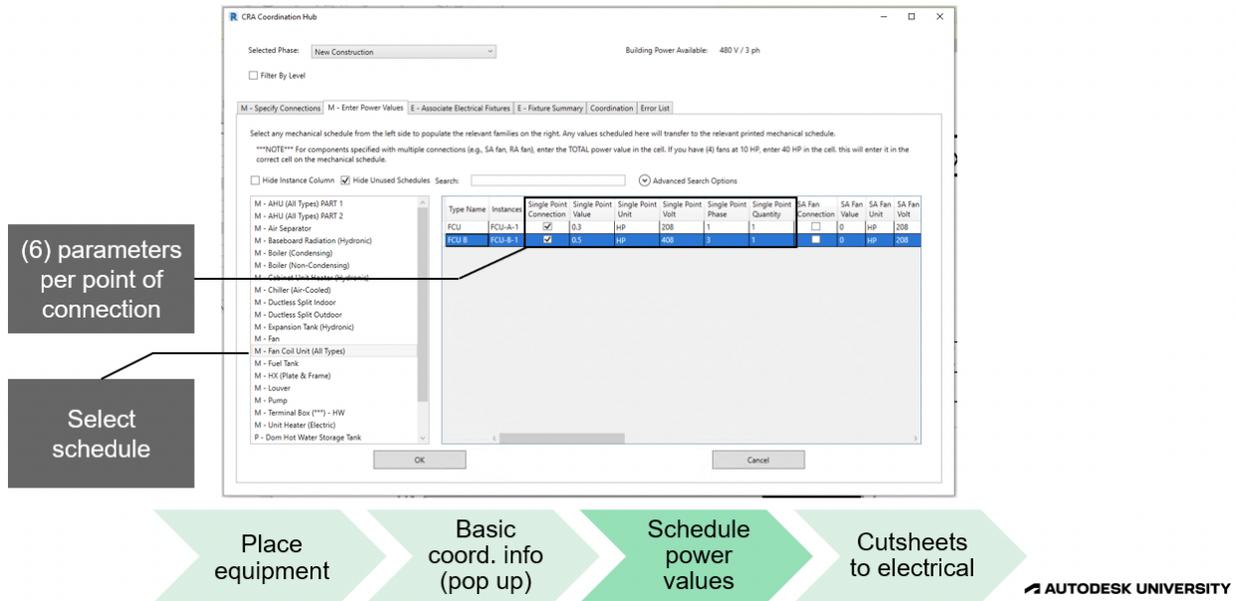


Figure 4: First step in the mechanical designer's coordination workflow

This tab has three key areas:

- **Point name:** These items are prepopulated for each family. They should cover all the potential connection points required.
- **Coordination required:** Specify which connection points need to be coordinated with electrical. In many cases, the only item checked will be Single Point.
- **Power parameters:** Inputs for voltage, phases, and quantity. This information is intended to be very basic (and maybe an educated guess to start). The user is NOT asked for motor sizes, etc. at this point because they may or may not have an actual selection done.

The next step in the mechanical process is inputting power values from an equipment selection. This step is not triggered automatically but rather on-demand by the user whenever the information is available.



(6) parameters per point of connection

Select schedule

Type Name	Instances	Single Point Connection	Single Point Value	Single Point Unit	Single Point Volt	Single Point Phase	Single Point Quantity	SA Fan Connection	SA Fan Value	SA Fan Unit	SA Fan Volt
FCU	FCU-A-1	<input checked="" type="checkbox"/>	0.3	HP	208	1	1	<input type="checkbox"/>	0	HP	208
FCU	FCU-E-1	<input checked="" type="checkbox"/>	0.5	HP	480	3	1	<input type="checkbox"/>	0	HP	208

Place equipment → Basic coord. info (pop up) → Schedule power values → Cutsheets to electrical

Figure 5: The "Enter Power Values" tab of the Coordination Hub

Key areas on this tab:

- Schedule selection:** The organization of this tab mimics our firm's Revit schedules. The schedule list is pulled from the Revit schedule list and filters the equipment the same way the actual schedules do (we use a text parameter). This means updating/adding a new schedule on an individual project will be reflected here too.
- Power parameters:** This is where the user fills out the data from the equipment selection. This data then appears both in the mechanical schedules and the Coordination Hub's coordination tab.

Electrical Workflow

The electrical workflow is similar to the mechanical workflow. When a user places an electrical fixture, they are presented with this tab of the Coordination Hub:

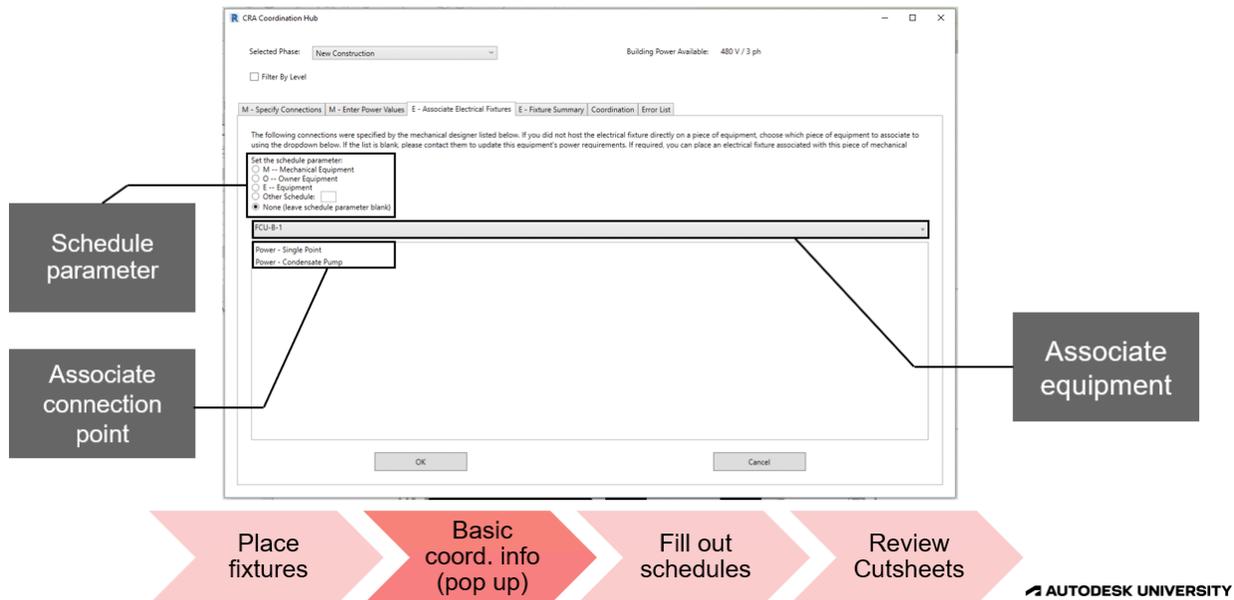


Figure 6: The "Associate Electrical Fixtures" tab of the Coordination Hub

Key areas on this tab:

- **Schedule parameter:** We use a text parameter to sort disconnects, junction boxes, and receptacles into the correct Revit schedule. This section provides radio buttons for easy selection of common schedule values as well as the option to enter a custom value.
- **Equipment association:** This is where the user selects the mechanical family instance associated with this electrical family instance.
- **Connection Point Association:** This is where the user selects a specific point of connection to associate to (single point, supply fan, electric heating coil, etc.)

Coordination Workflow

Once both disciplines have completed their respective workflows, users can review the coordination tab. The main feature of this tab is a data grid that flags potential coordination issues.

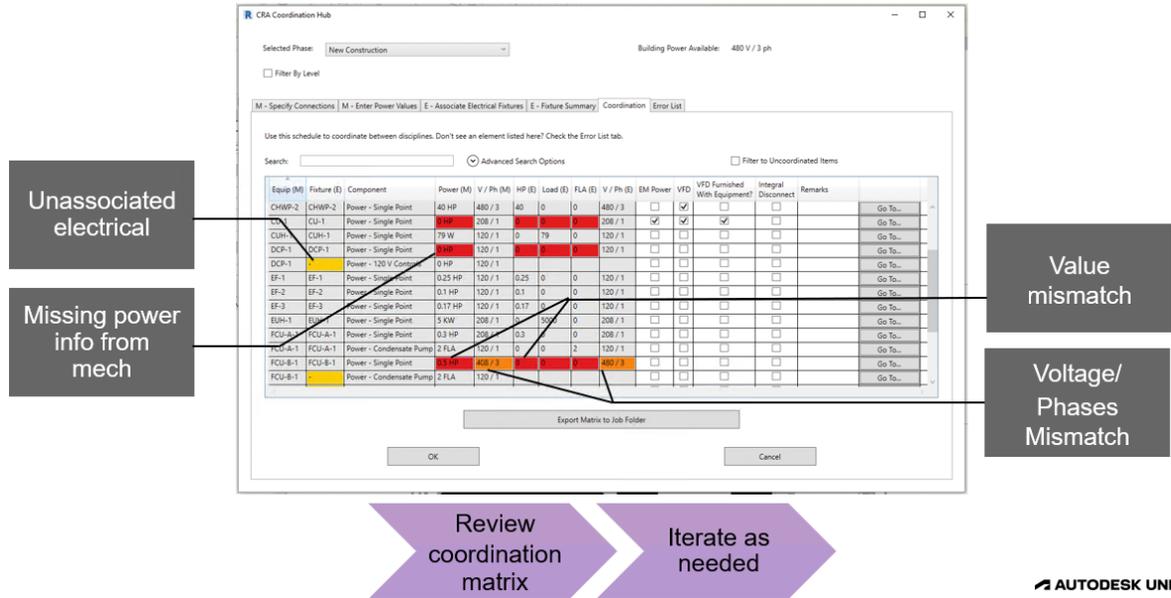


Figure 7: The Coordination tab of the Coordination Hub

This tab contains read-only data showing power values from both disciplines, but it also includes (editable) checkboxes for commonly missed coordination items. Based on the information in this tab, team members can discuss and reconcile any differences shown.

Extend a Custom Coordination Platform to Use Autodesk Forge and Power BI

The data available in the Coordination Hub is extremely useful. Because of this, we wanted to extend its capabilities and make the data more accessible. This includes making the data available to non-Revit users and providing high-level analysis of the data. We have worked through two different solutions to this idea.

The Original Approach: Coordination Hub + Forge + Power BI

Forge is a powerful way of extracting data from Revit models, so we expected it to be a good fit for extending the Coordination Hub. It has a connection available to BIM360, so the process we expected was something like this:



Figure 8: Data flow for extending the Coordination Hub

However, the first step is a problem in our case. If the models you need are part of another firm’s account, a Forge app would need to be approved account-wide for that other firm. Not practical for our firm – all our BIM360 models live on other accounts. If you are building this for a firm that mostly works on your own account, the Forge approach would work well. However, we moved on to a slightly different approach

The Modified Approach: Coordination Hub + Revit Addin + Power BI

The new plan for making this data available outside of Revit is to use a Revit addin. By running an external application on each Revit user’s computer, we can export the data silently in the background without interrupting workflows. The logic behind the export would be nearly identical (CSV export). If someone has the model open for edits, an external application can periodically export data to a central location. This means the export can occur no matter where the model is hosted.

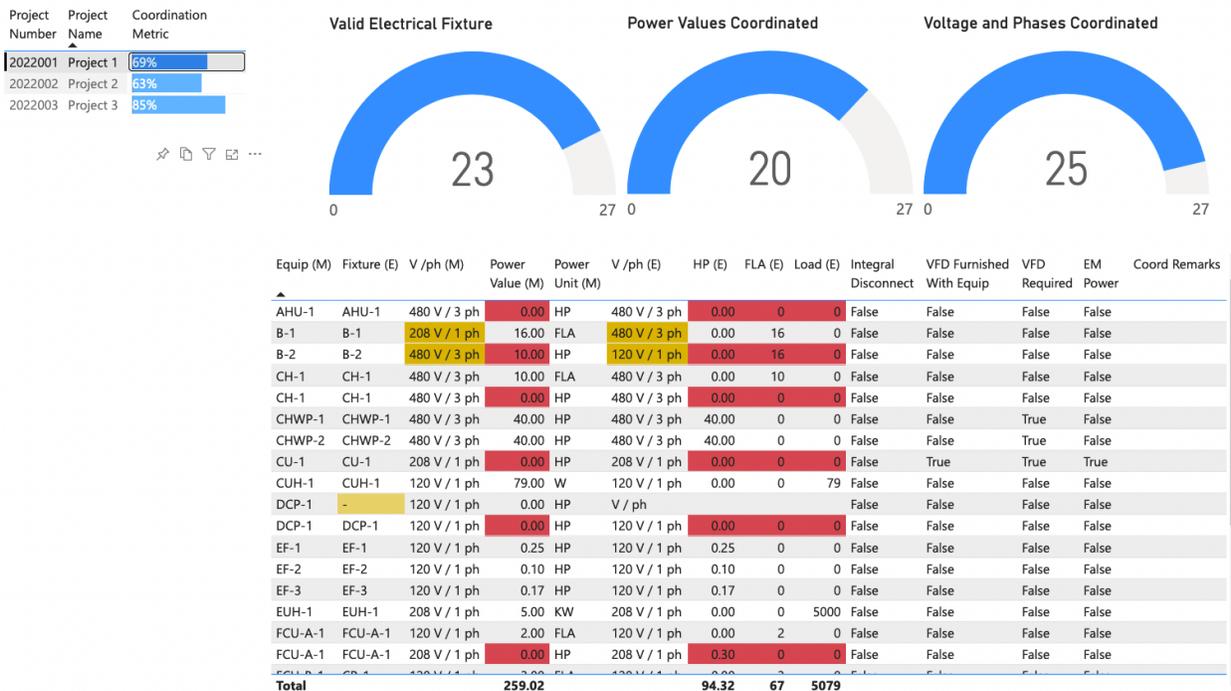


Figure 9: Power BI Dashboard Proof of Concept

What Does this Dashboard Achieve?

The Power BI dashboard provides two key benefits:

1. Gives Non-Revit users access the same data available to the Revit users. Project managers who are not involved in the day-to-day drafting efforts can easily gain insight into how their projects are coordinated.
2. Allows for summarization of coordination efforts and high-level metrics. Power BI provides powerful and relatively straightforward ways to summarize data. The gauges and bar charts give the user a quick understanding of the state of multiple jobs at once.

Plans for Extension

The proof-of-concept seen above currently uses a manually triggered export from the Coordination Hub. The first task will be to convert the export portion of the code to the external application discussed above.

Staffing integration is also a potential area for expansion. By integrating with our external staffing software (SQL Server-based), the user will be able to filter down the project list to only their projects. This makes the at-a-glance features more powerful.

Once this data is out of Revit, the possibilities are endless. You can do anything from company-wide metrics to trending coordination over time.

Conclusion

The Coordination Hub is designed to augment the coordination process. Data input and communication is streamlined to keep everybody up to date on changes. It will not replace the exchange of final cut sheets, but it does provide quick insight into what needs attention in the model.