Hybrid MEP Design and Documentation

Many MEP engineering firms are challenged when implementing building information modeling (BIM) on building projects for the first time. This white paper provides guidance on how to leverage Autodesk's core MEP engineering products and supporting solutions to better deliver an MEP BIM project.

Hybrid design and documentation for MEP engineers is a method of using a combination of 2D, 3D, and BIM solutions to efficiently and effectively deliver project requirements. To understand how best to integrate the benefits of a model-based design approach, it is important to have a basic familiarity of the toolset available to help deliver a BIM project. This document highlights Autodesk products that are used in MEP design workflows, including:

- Autodesk® Revit® MEP
- AutoCAD® MEP
- AutoCAD®
- Autodesk® Ecotect™ Analysis
- Autodesk® Navisworks®

Autodesk Solutions for MEP Projects

Autodesk Revit MEP software is purpose-built BIM software for MEP engineering. Mechanical, electrical and plumbing engineers and designers can use design models created with Autodesk® Revit® Architecture, linked into Revit MEP for the creation of intelligent building systems. Revit MEP also provides design analysis tools and documentation capabilities. The software is best applied early in the design process and is most suitable for creating construction documents for small retail, office, and education market projects. Revit MEP can also be used for documentation production on larger projects that have the flexibility to use annotated 3D and isometric model views rather than traditional 2D annotated line drawings.

AutoCAD MEP is the version of AutoCAD software for MEP designers and drafters providing MEP-specific drafting automation and documentation tools. AutoCAD MEP provides feature-rich functionality for producing construction documents more efficiently than traditional drafting. Designers and drafters can work in a familiar AutoCAD environment to create 2D coordinated drawings and object models.

Autodesk®

AutoCAD software is designed to drive projects from concept to completion with powerful documentation tools. The software's automation, management and editing tools minimize repetitive tasks and help speed a project's time to completion. Twenty five years of continuous innovation has made AutoCAD nearly synonymous with documentation.

Autodesk® Ecotect™ Analysis software is a comprehensive, concept-to-detail sustainable design analysis tool, providing a wide range of simulation and analysis functionality through desktop and web-service platforms.

Autodesk Navisworks solutions enable project design and building professionals to unite their contributions into a single, synchronized design model. By helping team members to more reliably share, combine, review, and revise detailed 3D design models of different sizes or formats, Navisworks is primarily utilized by contractors for timelining projects and analyzing constructability of the models created by the various design team members, but it is also used by engineers and architects to help check their own designs.

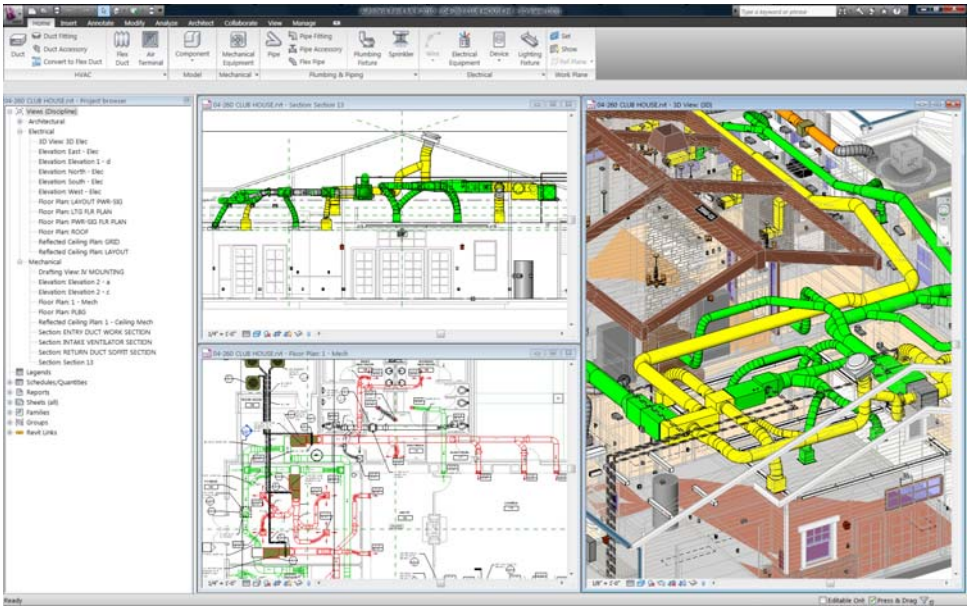

Figure 1

Autodesk Revit MEP is purpose-built BIM software for MEP engineering.

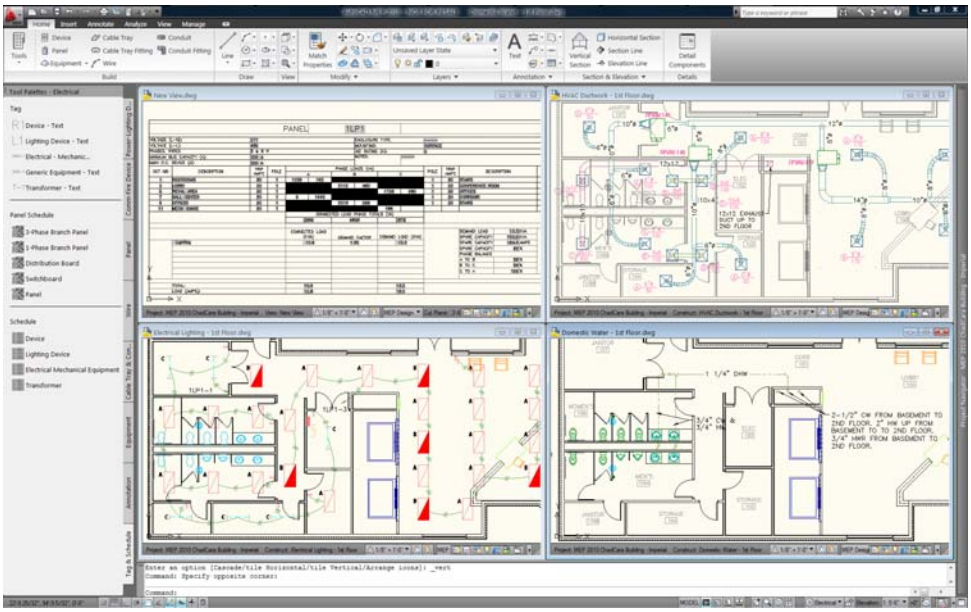

Figure 2

AutoCAD MEP is the AutoCAD object-oriented software providing MEP specific drafting automation and documentation tools.

Hybrid Design and Documentation: Ask Yourself

A good starting point for understanding the hybrid design and documentation method is to walk through the typical phases of the MEP design process and ask yourself, 'what am I trying to accomplish?' Once you have defined the expectations for each phase, you can then map your decision points against the supporting Autodesk solutions noted above. This method enables you to select the best tools for the specific tasks you are seeking to accomplish in your MEP design process.

Let's take a deeper look at the tasks and tools that can be utilized during each design phase, followed by examples that illustrate the use of the hybrid design and documentation process.

Conceptual Engineering Design

Conceptual engineering design requires a holistic view of the project—to fully understand the energy requirements of the whole building. By using the architect's Revit Architecture model, Revit MEP may be employed to thermally zone the building.

The thermal zoning allows the HVAC engineer to compute heating and cooling loads using a variety of mechanisms including: leveraging the tools that are a part of the Revit MEP software such as the heating and cooling load calculation tool; or exporting the Revit-based design models via enhanced gbXML export format and then using that file in analysis software such as Trane TRACE™ or Carrier HAP. In addition, that gbXML file can be used for carbon footprint evaluations using the Green Building Studio web-based service available with subscription of Autodesk Ecotect Analysis.

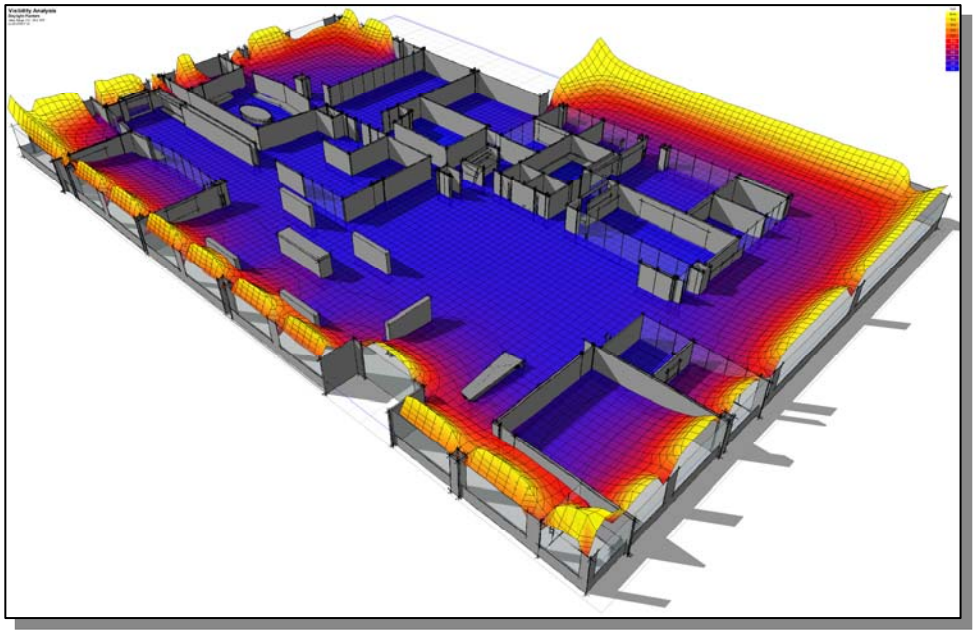

Figure 3

Once the thermal zones for a building are modeled in Autodesk Revit MEP, Autodesk Ecotect Analysis can be used for conceptual building performance analysis.

The ability to leverage the architect's design model for energy modeling and analysis can help provide an efficiency gain, with some Autodesk customers reporting a 50 percent time savings just for the geometry creation. Tools like these help architects, engineers and designers to consider and employ sustainable design strategies.

For example, in California—which has one of the most stringent energy codes in the world and the largest number of certified green buildings—a study found that when a design team uses whole building energy analysis while designing a building they save on average

an additional 20% more energy than the maximum allowed by the California energy code[1]. A similar study found that only 10% of new buildings underwent this type of whole building energy analysis in 2005[2].

From the results of the heating and cooling load analysis, the HVAC engineer can make preliminary equipment selections, which are the basis for identifying the approximate required space in each of the major mechanical equipment rooms. Within Revit MEP, the designer can place mechanical equipment components directly from the Revit MEP Content Library or quickly mockup generic parts that represent the approximate overall length, width, and height of the required equipment. In addition, the designer can use Autodesk® Seek web service to search for additional content. Autodesk Seek is a web service that allows engineers and designers to search for and find manufacturer-specific or generic building products and associated design content such as 3D models, 2D drawings, and specifications.

The electrical engineer can use the same spaces created by the mechanical engineer during the zoning process to establish an approximate total power requirements based on total building area. Using a similar workflow as the mechanical engineer, the electrical designer can place major electrical equipment. All the electrical and mechanical equipment in the model can be quickly scheduled for interdisciplinary coordination—making sure the electrical designer is aware of the major mechanical units. Furthermore, these schedules may be used for a preliminary cost analysis of the installed MEP systems.

Before the creation of any drawings, the engineer has already captured an extensive amount of information from the architectural model and placed preliminary equipment that can be shared with both the architect and the structural engineer. This information provides the extended design team with valuable up-front information that can be used to adjust equipment rooms, plan for structural reinforcement, and plan for major penetrations.

At this point, it may be easier and quicker to use the drafting functionality in AutoCAD to begin developing schematic diagrams for mechanical systems as well as electrical riser diagrams. The software's automation, management and editing tools minimize repetitive tasks and help to increase drafting productivity.

Example

An MEP engineering firm is working with an architect on a 500,000 square-foot multi-story, multi-use building. The firm has several years of experience using AutoCAD and AutoCAD MEP for the creation of construction documents—and even coordinated 3D models. For this project, the firm wanted to explore the energy analysis benefits of using Revit MEP, and also be as efficient as possible while creating their final deliverables. The firm's designers used the linked Revit-based architectural model in Revit MEP to zone the building for energy analysis and to place components in the model representing the major mechanical equipment. This helped the overall project team identify any significant space and structural planning issues early in the project.

[1] "Final Report 2003 Building Efficiency Assessment Study - An Evaluation of the Savings By Design Program," RLW Analytics, http://www.calmac.org/publications/BEA_2003_Final_Report__080105_.pdf, Table 16, page 21.

[2] "NRNC Market Characterization and Program Activities Tracking Report, 2005," Itron, Inc., *http://www.calmac.org/publications/MCPAT_Report_2005_-_Final.pdf*, table 1.3 page 1-4 & table 3.8 page 3-12.

Preliminary Design

During preliminary design, the MEP design team identifies major duct and pipe routing—planning where they need chases and horizontal distribution By using a model-based design approach with BIM at the core, MEP engineers and designers using Revit MEP can leverage the Revit-based design models provided by the architect and structural engineers to coordinate their design within the context of the overall building.

Revit Architecture and Autodesk® Revit® Structure models are provided to the MEP design team for this phase of design. The updated architectural model may also be used to help refine the heating and cooling load calculations, which may result in adjustments to the major mechanical components.

The architectural and structural designs have gone through iterations to provide the preliminary space and support required for the major MEP components. In this phase, the major duct and pipe routes are added to the model to help both identify the chase requirements and see where these major MEP duct and pipe components may clash with architectural or structural components. The configuration of major equipment rooms begins to take shape and consideration is made for the routing of ductwork to and from each equipment room.

Connection locations to external building services (such as fire protection water, waste, storm drainage, communication, and power utilities) are identified. Provisions for accommodating these services and their primary distribution are communicated to the architectural and structural teams via the design model.

Example
Continuing with our multi-use/multi-story example, the project is now in the next major phase of design. Using Revit MEP, the MEP design team routes the major ductwork and piping through chases and in interstitial space, referencing the linked architectural and structural Revit design models to help avoid interferences. The resulting Revit MEP model is shared with the architect and structural engineer to facilitate cross-discipline coordination and collaboration.

Pre Design Development

At this point in the design process, the design team has used the Revit-based design models to help identify and resolve many of the major coordination issues. By utilizing the Revit Architecture model, the MEP design team has been able to more quickly provide feedback on the energy impacts of the architectural design. Based on this collaborative effort, the extended design team has been able to analyze the environmental impacts of the building orientation and construction.

Now the design team needs to make decisions about what systems need to be modeled (vs. drawn) and why. This is the point where the question '*what am I trying to accomplish*?' becomes particularly important. Are you trying to expedite the development of construction documents? Are you trying to coordinate with architecture, structure and other building systems? Do you want to leverage the Revit Architecture model to more quickly adjust to design changes? Or do you want to maximize the value that BIM can bring to your project? Each goal requires an understanding of the technology and how to apply it to achieve the desired results. The decisions made at this juncture lead to the different scenarios presented below and will impact the methods by which design development and documentation occur.

Project goal: Expedite the development of construction documents

Suggested tools:

- ***AutoCAD MEP, using 2D views exported from Autodesk Revit MEP***

In this scenario, the primary concern of the MEP organization is the productivity of their MEP production staff. Two-dimensional views are exported from the Revit MEP conceptual models in DWG format. These files are then used as underlays for the creation of the MEP construction documents using AutoCAD MEP.

To a large extent, the team is using the traditional, familiar AutoCAD functionality. In addition, the production staff may find some benefit in the MEP-specific tools of AutoCAD MEP. For example, the modeling of domestic hot and cold water systems, along with waste and vent piping within plumbing walls, can be very time consuming and provides limited benefit to the extended design team. However, using the Plumbing Line functionality of the AutoCAD MEP software helps to expedite these drafting tasks.

Project goal: Coordinate with architecture, structure and other building systems

Suggested tools:

- ***AutoCAD MEP, using 2D views exported from Autodesk Revit MEP***
- ***Autodesk Navisworks for clash detection***

The organizations who fit this scenario are concerned about cross-discipline project coordination as well as productivity, and are comfortable with using AutoCAD MEP to define elevations of ducts, pipes, and other MEP elements.

The preliminary Revit MEP design is exported to DWG as a design underlay. 2D views from the Revit Architecture model are also used as underlays for plotting. 3D horizontal slices of each level of the Revit Architecture and Revit Structure models are exported to DWG formats as solids and utilized as design references in the AutoCAD environment.

This facilitates coordination and provides the ability to check for interferences in AutoCAD MEP on a per level basis. Navisworks helps with final physical design coordination, where the Revit Architecture and Structure models are aggregated with the AutoCAD MEP final design deliverables for clash detection.

Project goal: Use the Revit Architecture model to help adjust to design changes

Suggested tools:

- ***Autodesk Revit MEP for design and documentation production***
- ***AutoCAD and AutoCAD MEP for supplemental documentation production***
- ***Autodesk Navisworks forclash detection***

In this scenario, the MEP firm wants to do as much as possible in Revit MEP. The firm's documentation standards are flexible and its engineers are focused on the design and modeling effort, while finding new ways to convey design requirements. Revit MEP is used to create some of the construction documentation based on views (both 2D and 3D) of the underlying design model. For this documentation effort, less emphasis is placed on traditional symbology.

With this approach, designers also learn the fundamentals of using Revit-based software to create custom content, such as specific air handling unit configurations, specialized equipment, etc. Certain aspects of the design details are still drafted using AutoCAD or AutoCAD MEP, such as the linework that represents small diameter piping for domestic water, waste, and vent. Other documentation that is not directly derived from the modeling effort (such as riser diagrams, schematic flow diagrams, typical details, and some schedules) are created directly with AutoCAD.

Project goal: Maximize the value that BIM can bring to your project

Suggested tools:

- ***Autodesk Revit MEP for design and documentation production***
- ***Autodesk Navisworks for clash detection***

This final scenario is for those organizations that have multiple project experience with Revit MEP using the hybrid design and documentation scenarios described above. These organizations now want to use Revit MEP to create all their project deliverables. Most likely, some aspects of the design will still be drafted, but in this case using Revit MEP linework tools.

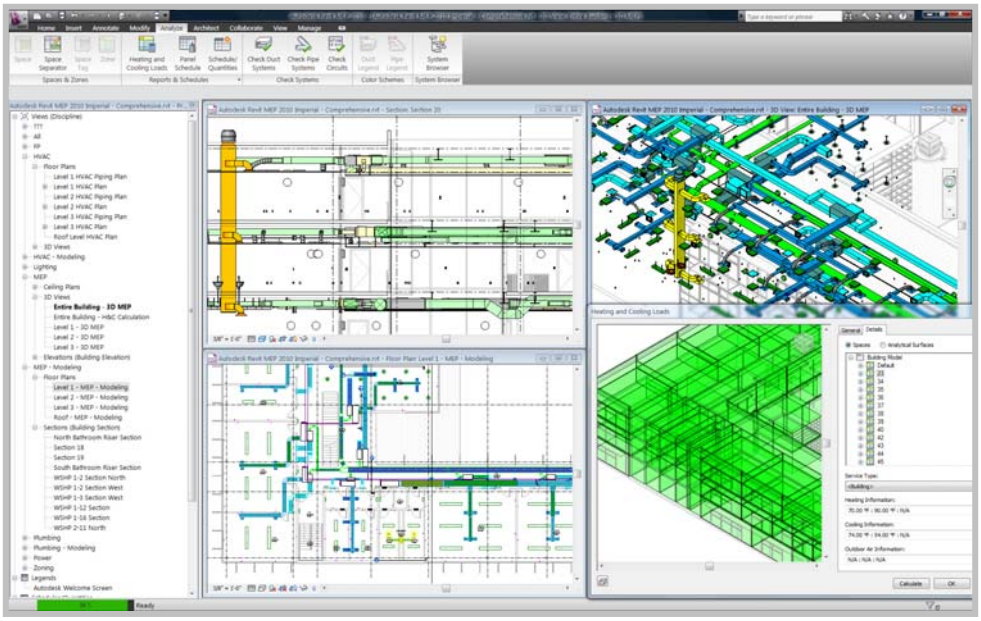

Figure 4

For design development, some firms choose to use AutoCAD MEP whereas others use Autodesk Revit MEP (shown here) based on the firm's specific goals for a project.

Design Development Phase

As the MEP design develops, pipe and duct are routed to all final termination points. This helps identify any additional architectural and structural coordination issues that may require additional design iteration by those disciplines. The equipment in the major mechanical rooms are interconnected with pipe and duct per the systems design requirements to ensurepatial requirements will be met. For these design efforts, some firms will choose to use AutoCAD MEP whereas others will use Revit MEP—based on the goals for the project outlined in the section above.

In this phase, the actual documents that will eventually be issued also start to take shape and—like the design tools—the tools used to create the documentation vary based on the selection process outlined above. Annotation symbols and tags are placed to display information embedded within the MEP objects, such as duct size, or circuit number. As the design iterates, these annotation elements adjust and update accordingly.

Example
On our multi-use/multi-story example, the MEP engineering firm was contracted to provide the design on some of the tenant uses within the retail and office portions of the project. To help expedite the creation of the design, the base building duct, the hydronic water, the main domestic water distribution and main sanitary piping were all modeled using Revit MEP.

For documentation production, each floor of the Revit MEP model was exported to the familiar DWG format and those drawings were then developed and detailed in AutoCAD MEP, since the design staff were very comfortable with an AutoCAD MEP workflow. However, the MEP design team determined that they did *not* need to model the plumbing, lighting and power systems in Revit MEP, so AutoCAD MEP was used for that entire design/documentation effort.

Additionally, the team assembled an aggregated model in Navisworks—comprised of the Revit-based architectural, structural and MEP design models as well as the AutoCAD MEP drawings. Navisworks was then used for full building model visualization and clash detection.

Detailed Design Phase

In the detailed design phase, all final equipment selections are made, and equipment is placed, identified, and scheduled. All duct and pipe connections are made, and all lighting fixtures, receptacles, mechanical equipment, and other devices are circuited and annotated. Final physical coordination with architecture, structure, and other services is verified. Schedules are utilized to keep track of quantities for energy compliance reports and to facilitate connection coordination details between trades. The final result of the detailed design phase is construction documents. During this final phase, if Revit MEP has been used for design development, then a combination of Revit MEP and AutoCAD-based tools are used. If only AutoCAD MEP was used for design development, AutoCAD and AutoCAD MEP will be used for final documentation production.

Example
Our example multi-use/multi-story project is almost complete. The MEP engineering team has used only AutoCAD MEP for this detailed design phase. They have designed the base building duct, the hydronic water, the main domestic water distribution and main sanitary piping, lighting and power systems including circuiting and annotation, as well as the schedules in AutoCAD MEP. They have also designed and connected all the duct and pipe systems to the mains. In addition, the layout of the cable tray and conduit systems have been drafted in AutoCAD MEP. AutoCAD has been used to create all of the mechanical system schematics, electrical riser diagrams and plumbing riser diagrams.

Conclusion

BIM is rapidly being adopted by the building industry due to its many benefits for productivity, coordination, and building performance analysis. For most firms in the building services design industry, this means a transition in the traditional processes used to complete their designs. But implementing a BIM workflow does not have to be an ‘all or nothing’ proposition. Project teams should identify what aspects of their workflows would benefit most from the advantages of BIM. The expectations and requirements of the project client and owner must also be considered.

As the project team matures in its adoption of BIM methodologies, a critical success factor will be understanding what needs to be modeled in 3D and what should be just drafted. Early design stages tend to benefit from leveraging the Revit-based architectural model for energy analysis in Revit MEP. Preliminary design in Revit MEP helps engineers coordinate their design within the context of the overall building. For design development, an individual firm’s goals for a specific project dictate the use of one software tool versus another.

As the MEP team migrates to the BIM workflow, it is imperative that the tools are applied appropriately to help maintain productivity. Revit MEP may be used to create construction documentation where there is flexibility to challenge traditional line drawings. AutoCAD MEP may be used to help expedite drafting tasks of MEP systems. AutoCAD may be used to facilitate schematic documentation, non model-based details, and schedules. Navisworks provides the ‘glue’ to aggregate designs for comprehensive coordination and design review.

Using the hybrid design and documentation methods outlined in this whitepaper, MEP engineering firms can use AutoCAD MEP and Revit MEP in tandem—leveraging the strength of the individual tools to provide value throughout the design and documentation process.

Appendix – Hybrid MEP in Practice

Design West Engineering

Design West Engineering (*www.designwesteng.com*) is a full-service mechanical, electrical, plumbing (MEP) and energy engineering consulting firm based in San Bernardino, California. Design West was founded on the philosophies of second-to-none service, environmental sensibility, and a commitment to forward thinking. The firm specializes in a diversified range of building sectors including municipal, educational, green-building, medical, commercial, and residential.

A long time AutoCAD and AutoCAD MEP user, Design West adopted Revit MEP software in early 2006 to facilitate a new level of project collaboration with their BIM-based architectural clients and structural engineers, and to help transform their sustainable design practices from ad-hoc to technology-based. An accurate design model integrated with energy analysis tools greatly simplifies their building performance analysis, the proper sizing of their building systems, and the compliance calculations that are needed to meet building codes.

Design West's engineers have completed more than 15 major projects through construction documents in Revit MEP, starting with projects around 20,000 square feet and steadily increasing in size with one of their current BIM projects, a multi-building school campus, now encompassing approximately 410,000 square feet. Their steady pace of implementing BIM across the company and their continued reliance when appropriate on AutoCAD-based software has allowed them the time to learn all facets of the BIM software, and how to apply it to all MEP disciplines within their organization.

Glumac

Founded in 1971, Glumac (*www.glumac.com*) provides mechanical, electrical, and plumbing consulting engineering services for its clients in the commercial, healthcare, institutional, and advanced technology market sectors. With more than 220 employees in eight offices along the western coast of the United States, the company also provides sustainable design, information technology, and commissioning services—areas of expertise that are key to enhancing its core engineering capabilities. Glumac currently employs more than 80 LEED-accredited professionals and every project the firm undertakes is staffed with sustainable design experts.

Several years ago, Glumac made a strategic decision to adopt BIM to enable more rigorous building analysis and better informed decision making, and to optimize the coordination of their designs with related building disciplines. In 2006, the firm implemented Autodesk Revit MEP software to supplement its existing AutoCAD-based design platform.

Glumac uses the Revit MEP software—in conjunction with building energy analysis tools—to analyze potential savings of various green design approaches. To help streamline the analysis process, Glumac leverages the architect's Revit-based model to create the building geometry and then uses Revit MEP to modify the model—making it suitable for energy analysis. The Revit MEP model embodies the wealth of information necessary for multidiscipline design and coordination as well as the analyses required for sustainable design. Given the firm's focus on energy efficiency and sustainability, being able to leverage its Revit-based design model for energy modeling and analysis helps the firm deliver more cost-effective sustainable designs to its clients.

Dunham Associates

Founded in 1960, Minnesota-based Dunham Associates (*www.dunhameng.com*) is a mechanical and electrical consulting firm, providing engineering services to its clients across the country in aviation, commercial, education, healthcare, hospitality and retail sectors. With nearly 50 LEED accredited professionals on staff, the firm offers extensive knowledge and experience in the sustainable design of all types of facilities.

Dunham adopted BIM with Autodesk Revit MEP software in 2007 to coordinate its mechanical and electrical designs, to enhance project collaboration with its architectural and structural partners, and to help streamline its sustainable design workflows. To date, the firm has used Revit MEP to complete five projects through design and documentation and has more than 30 MEP engineers using the software. The firm also uses AutoCAD for drawing production on some of its projects, based on project size, staffing, client expectations, etc.

On its BIM projects, Dunham uses Revit MEP to coordinate its design across disciplines by linking the plumbing, electrical, and HVAC models, and also by leveraging models from architects and structural engineers created using Revit Architecture and Revit Structure. Through a collaborative BIM process, the extended design team can identify and resolve interferences and other issues early in the design phase—before they impact construction costs and schedules. When available, Dunham's engineers also use the architect's design model to streamline their energy calculations, helping them optimize building systems for maximum performance and efficiency. On many projects, the firm also uses Revit MEP, supplemented by AutoCAD, to create documentation. Beyond the traditional drawings, Dunham uses Revit MEP to automatically create 3D isometric drawings and shaded images of highly congested areas, that are incorporated into construction documents to more clearly communicate the engineering design during installation.

About Autodesk

Autodesk, Inc. is a world leader in 2D and 3D design software for the manufacturing, building and construction, and media and entertainment markets. Since its introduction of AutoCAD software in 1982, Autodesk has developed the broadest portfolio of state-of-the-art digital prototyping solutions to help customers experience their ideas before they are real. Fortune 1000 companies rely on Autodesk for the tools to visualize, simulate and analyze real-world performance early in the design process to save time and money, enhance quality and foster innovation.

For additional information about Autodesk, visit *http://www.autodesk.com*.

For more information about building information modeling please visit *http://www.autodesk.com/bim*.

For more information about Revit and the discipline-specific applications built on Revit visit *http://www.autodesk.com/revit*.

For more information about AutoCAD and the discipline-specific applications built on AutoCAD visit *http://www.autodesk.com/autocad.*

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