DAVID SCHEER: Well thanks for coming. Hope it's been a great day so far. [INAUDIBLE] thanks for coming to this one. I'm glad so many people are interested in zero energy. My name's David Scheer, I'm an architect and a product manager at Autodesk. And I get to work on special projects, which means mostly in the last year or so it's been daylighting analysis and solar analysis. Got my developer up front here, Liz, to thank for the tools.

So today we'll be talking about workflows for solar power design, particularly PV design, using the insight360 platform in Revit, Formit, and also some Dynamo automation. And I just found out, actually, that the handouts and everything are now available on the class site. They've been-- the links were messed up for a while. So if you want to download the handouts, and there's a lot of Dynamo scripts and sample models available there as well.

So what we're going to cover today is this idea that we've been working on of Agile Design. And we'll talk about that in a minute. And go over the insight360 PV and solar design tool set, and then walk you through a workflow for PV and solar energy design from concept design, all the way through full specifications.

So this is something that probably a lot of people who are here-- who are interested in renewables and energy efficient design have probably seen, the chart that tells us that the cost of design changes gets to be greater the farther along the design process we get. And the ability impact cost and performance is higher earlier in a project. So in the typical traditional model, analysis is often done later in the design process, as you're approaching the end of DD and construction documents, when you know a lot about the model. So an input driven process, that's the time where a lot of people are doing analysis. But it's also the time when it starts to get expensive to make changes based on those analysis results.

So the integrated model says that we should start doing analysis earlier in the project. Now we're finding that really the process of making better buildings is really similar to the process of making better software. And in software we have this similar dichotomy of the waterfall versus the agile process. And most software companies are now moving to agile development practices.

So in the waterfall process, it's really similar to that traditional model, where it's a serialized process. There's hand-offs, so the design team hands off to the engineering team. And finally, maybe the PV design crew gets going. And what that looks like in terms of software development terms, is this, discover, design, develop, test. So at the beginning we kind of discover what the project parameters are, design the whole thing up front, develop that design at the end. When we've finally got it fully designed and developed we can test it. And then that's when you really find out if you've made the right decisions during the design process, but by that time you're pretty late in the process.

So this is how that looks in the typical architectural design process. And this is a metaphor that's often used in software development for the waterfall process. So if we're designing a car, you would design the whole car up front, and then build up the pieces, and then finally put them together at the end. And as you're building up each of those pieces, you might have a wheel, but you really can't do anything with the wheel. You might have a chassis, you can't really do anything with a chassis. Finally, you get a car together at the end of the process, and hopefully everybody's happy with the outcome.

The agile process promotes, at each phase of the design process, going through a full iteration. So if we're developing a transportation device, we're first developing a simple transportation device where we can test that skateboard, get some feedback about how it works, develop a little bit better transportation device. And at each phase in design, we've got a useful product that we can actually test and make some decisions based on. So at each stage in the process, we've got some partial happiness, and by the end we've got a much better final product. So this is really what that looks like for the design, develop, test, and discover process, is there's a cycle at each phase, a full cycle in the process, at each phase in the development process.

So in applying that waterfall versus agile example to a zero energy building design process-- I taught a class on zero energy buildings for a few years. And what we would typically tell people is that first you want to define your goals. And of course, zero energy building, your goal is to reach zero energy. Then you want to optimize your passive design, so optimize the envelope and loads in the building. Then you optimize your active systems. And then finally in the end, when you know how much energy your building needs, you design the PV system to meet your targets. And hopefully you have enough space in your project to meet those targets.

In the agile process, we're going to do a full cycle at each phase of the process. So at the beginning we can really do some analysis, look at site shading, and really understand the PV energy potential of our site. And at the concept phase, we can assess concept design, and do a full PV design analysis workflow at the concept stage. And then by the time we get to building integration, we already know quite a bit about how the solar energy system's going to integrate with the building, and we can just start fleshing out the sizing and the panel siting. So at the end we can just put together the final system specifications based on what we already know about a good integrated building and PV design.

So just taking this to the full extent, what this ends up doing is really we're getting away from this concept schematic design, and we're just doing design. So you may be doing more detailed design as you go further along the process, but it's really just a complete cycle of design, design, design. We could even say that we're moving some of the construction documentation into that early design process, because we're starting to embed some decisions, some specifications, some performance numbers, into the early design process, that's typically figured out during the documentation phase.

So applying this to that cost versus ability to impact performance cycle, we're looking at something like this. So we're really doing analysis all long in the process. Emphasize maybe a little more at the beginning, but we're embedding analysis into the entire process. And really what that does is it builds intelligence into the model that we're working with. It builds intelligence into the design. So the design intelligence is really part of the modeling process. I like to call this the living model, so the model is alive through the whole process, and you're continually understanding more and more about itself.

So I'm going to quickly go over the tools that I'll be talking about today. And the handouts are available for each of these tools, that define each of the pieces I'll show right now. So insight360 is the new platform that we've just released a couple weeks ago, that finally wraps up all of our energy analysis, solar analysis, loads analysis, and lighting analysis into one integrated tool set for Revit 2016. And it's based on bringing together the authoring tools, Formit and Revit, to work through this insight360 environment, to provide information about the performance of your model.

At the highest level, it consists of a rollup-- a rollup widget that tells you, gives you basically a single number telling you how you're doing, color coded for the performance. That is integrated with more detailed information about individual factors of the building. So we have the building level information, we've got information underneath that layer about individual factors of the building, including loads, and tracking the history, and doing comparative analysis. I'll show you a little bit more about that in a minute. And these are all contained in a model and project organization system, where we can compare the individual design and form level as well.

So I'm going to start looking at a process that starts with conceptual design in Formit, which is a fairly new conceptual design tool that's also integrated with the Revit workflow. And starting in Formit for the solar analysis and the insight360 workflows, it's a pro subscription benefit. So you have to sign in. The first part of the process is to define your location. Location is going to give us weather information, it's going to give us solar intensity, solar geometry, all the stuff that we need to understand the performance of the building. And that location information is going to be used throughout the design process.

The solar analysis tool is accessed through the sun and shading tools in Formit. And clicking the solar analysis button will put you into a solar analysis mode. And the process is basically to select surfaces and then click Analyze, and the results will be generated automatically for annual, cumulative insulation and peak monthly insulation, which are two typical metrics needed for solar energy design or understanding energy loads on the building.

And a couple of the useful metrics at this level for early stage solar energy designs, we want to look at some of the potential energy falling on different services of the building where we might put solar panels. Understanding what these numbers are. So in this case we've got about 900 kilowatt hours per square meter on these surfaces. We can see in our scale that we've got a range from zero to about 950. So some of the numbers we're looking for for a decent performance so far are about 950. And we might try some other designs to get those numbers a little bit higher.

So here's a-- so now moving to Revit, we can either start in Formit, open the Formit model in Revit, or do conceptual design in Revit, or work with a detailed model in Revit. They both work with the same tool, the same engine. The process in Revit is the solar analysis tool is now built into the insight360 tool set on the analysis toolbar. Opening the solar analysis tool, we've built this with the idea that it's a helper tool that can be open any time. It's a place where the information about PV solar energy is going to be displayed. And you can have it open at any time, change the settings, it's always referencing whatever view you are operating in in Revit.

The basic process is to select the Study type. In this case, we're selecting a solar energy PV study type. And it's built so that really you can just select a Study type, and then update the results and get useful information right off the bat. So initially we automatically set it up to select all the roof services, and set up a typical PV panel type and coverage in a full annual solar simulation. So the settings, your initial settings, are displayed here. You can see we've selected about 1,900 square feet-- or square meters of roof area.

Or you can select your own services. And this is something that always confuses people, is when you're in the multiple service selection mode, you have to click Finish to be done. So don't forget that. After your analysis is set up and ready to analyze, you get this message. Whenever, basically, the analysis results are out of date, we'll hide them and show the message to update results. Just click the Update button.

And this is the results for insulation on the services of the model for full annual. And the results contained in the PV study type, the typical results that you might use to understand how well these services would do as services for PV panel. So the amount of energy production for the panel type that's selected, how much that energy-- what the value of that energy is annually for your electricity cost, and then the payback period, how long it would take to produce enough energy to pay for the installation of the system.

Same thing as Formit, the scale which is automatically set for whatever analysis type you want, uses the analysis display styles built in to Revit. And again we can see here the range of insulation we can get on these services. I'm looking at about 1,284, about 1,300 kilowatt hours per square meter. So that's getting into the good range. The best services are going to appear yellow.

And then some advanced settings. It's often a little difficult to find the ways to navigate through the analysis display styles and the different results settings, so we just made a little helper dialogue here where you can navigate through the different analysis results. In this case, cumulative and insulation, or PV energy, so you can kind of see how much energy is coming from per square meter on each part of the building. And then this is one I like a lot, is the payback period. And this is basically a way to filter out the services that are just not creating enough energy to be worthwhile for putting solar panels in those areas. So this is a way to really quickly see what areas on the building are a really good place to put solar panels.

And then some advanced settings where you can refine the types of PV panels you've selected. I'll talk about some of these other settings later, but basically if you enter information about your coverage, it's going to assume that the area is not fully covered with solar panels, because you need area for access around the edges and roof penetrations. The payback filter, so this total value will filter out the areas that don't have-- don't meet the payback minimum. And then if you enter information about the building energy, you will get feedback in the dialogue about what percentage of your building energy use is being met by-- if you put solar panels on all the selected surfaces.

So just walking through this again, what we would do in a typical process would be to do an initial analysis, maybe on all the potential areas to put panels, and then start paring that down to select the services that actually perform better. And then getting a little bit more refined information on how much energy you might really produce on this building.

So now I'm going to move to Dynamo. So the same engine that's used in insight360, in Revit, in Formit is also used in Dynamo. So it's going to be the same analysis engine, the same analysis results, as the Perez method, if anybody knows about the typical solar analysis engine. So Dynamo, the solar analysis node, is where this code is embedded. And the solar analysis node, of course, requires a time span.

Here we're going to define a full annual time study for solar analysis. That could be defined a couple ways, either taking the sun settings from the Revit model, which I always think is useful, because in the sun settings in the Revit model you can see the solar path diagram, and we can use that same data in the Dynamo simulation. Or you can just set hard coded dates and do all your work directly in Dynamo. And by the way, these graphs are available for download with the class, and they should work with any Revit model.

And then you can either visualize those results back with solar analysis in Revit, or use the built in Dynamo visualization capabilities to show the colorization on the model services. And here I just had a couple ways of defining the range of those colors, either from a fixed max and min, which is how they're set up in Revit and Formit, or taking the maximum and minimum results from the analysis. And what that looks like when you put it all together-- this is a fairly complicated one where I've built up some other sections to automate the construction of the layout of the panel system.

Here we've got the solar analysis node, and the time settings, the surface colorization, these nodes are set up for selecting shading and analysis services. This is all the PV information. This area over here is where all the settings are to automate the creation of the solar array. And then all the PV calculations. This is basically a re-creation of solar analysis for Revit in

Dynamo.

So the typical workflow, this is what I call the Agile solar power workflow. And remember, we're going to do an iteration at each phase of the design. Setting the location at the very beginning of the project-- setting the location at the beginning of the project, you basically know a lot about the solar energy available on your site. So that's really part of the solar analysis process.

Generate insight right at the beginning, which just kind of frames are our whole problem and gives us a lot of information about the project from a very early concept design. Opening up insight360 to explore the energy factors and the PV factors, and starting to set targets and expectations, and then using Formit or Revit to do more detailed work on individual surfaces of the model. And then optionally automating the process with Dynamo. And then just iterate through that at each phase in the design. That's really a push button process for any model in Formit or Revit.

So I'm going to go through a workflow. I've got a bunch of slides here and they're all canned, so I'm going to go pretty fast. But the slide deck's available for download if you have any more questions. So the first cycle, the first iteration, or the first sprint would be just looking at site potential. So setting the location, of course. And one thing I like to do is just do some generic forms in the site. In this case I've done a bunch of different tilted surfaces in Formit.

And here we can see the range of potential insulation we can get-- potential insulation that we can get on the site. So we have up to 1,500 kilowatt hours per square meter. So that's about the maximum I can expect on any surface. We can also do this in Revit, using solar analysis for Revit. And it gets a little more useful here because I'm actually getting some feedback about my total on the surfaces. So I could try some different orientations and see what the difference is going to be on those different orientations.

One thing I've always found interesting is that looking at the results for just a flat surface, like an area where you might put PV panels, you can look at this number here, but 11,200 kilowatt hours per year. If I put the same area tilted optimally to the latitude tilt, I'm not getting all that much difference, because you're getting overshadowing, you've got some wasted space. So really, doing conceptual analysis is getting you within 15-20% of what your final design PV performance might be. So doing conceptual analysis of solar for solar energy design is actually a valid process.

So next iteration. Looking at some concept designs. I'm going to show you a little bit of the insight360 workflow, to kind of frame what our energy needs are going to be. So starting in Formit, the-- running the insight is going to be from the insight360 button. Select the Generate Insights, and that's-- the reason we call it Generate Insights rather than Do An Energy Analysis is because it's doing a lot more than energy analysis now. It's running the energy analysis, it's running a whole bunch of simulations, it's also doing a solar energy analysis and it's doing a loads analysis. So there's a lot of information that comes out of it besides the energy analysis.

Now when that's finished, viewing the insight will take you to the insight360 page. And I'm not going to go into this in depth right now, because we've got another demonstration tomorrow afternoon on insight360. But I wanted to take you through the parts that apply to solar energy workflow. So insight360 basically consists of that roll up number, this is basically your overall-- your most likely performance of your building. And that can be viewed in EUI or energy cost. That number also shows up on the potential energy range chart. And that's going to show your design potential.

In this early stage in the project, where we don't have much of the building defined, you can see that what we did is we built the form, and we just pushed the button. We didn't define all the input and then run an energy analysis. We just pushed the button. So really our results are very uncertain. And you probably can't see it here, but the range of our building performance is going to be from $4 to $84. So it's a huge range. And we're just admitting that we-- you know, you haven't given us a lot of information, so we're not sure yet, but we could still provide some useful workflows. And on this chart we've also got a couple benchmarks, ASHRAE 90.1 and Architecture 2030, so you kind of see how you're doing compared to some typical benchmarks.

And then the factor widgets. Now this is the useful part, especially at this stage of the design, where these factor widgets, if you flip those over, they're going to start to tell you what the sensitivity of the building is to each of these design parameters. Because we've run a ton of options already, so you can see how your building might perform if you select different variations. And is all based on just one energy simulation. I mean, one button click.

The way I like to use the tool is-- this is basically, you can see the top part is what I showed in the last slide. I like to just zoom out so I can see all these factors, flip them all over, and right away, you can start to see what parts of your building are more sensitive than other parts. So just to go through this quickly, because we'll talk about this more tomorrow, the process I generally use for solar energy design is-- remember that old traditional process I mentioned is reduce your loads-- set your targets, reduce your loads, optimize your HVAC system, and then design your PV system. You could do that all in a single iteration here.

So what I'm doing is going through each of these factors, and just dragging this range to something that I think I might target for my building. And you can see here that you get some feedback very quickly about the impact of changing your lighting design, for instance, to the overall energy use of the building. And of course, this is going to affect your solar energy targets. And each time you do an iteration, that's going to show up as a decision a point in history. And you see we're starting to reduce the uncertainty, because we're starting to refine the building a little bit more. Yeah?

AUDIENCE: I'm sorry, quick question.

DAVID SCHEER: Sure.

AUDIENCE: [INAUDIBLE] used to have this feature where you could look at multiple iterations next to one another.

DAVID SCHEER: Right.

AUDIENCE: [INAUDIBLE] trend line [INAUDIBLE] ability to [INAUDIBLE] multiple iterations?

DAVID SCHEER: Yeah, I have a couple slides that show a couple compare options. Yeah, it's not the same way, but probably a more useful way, actually. So continuing in the process, this is basically a very early design building. I've decided on-- I've decided a bunch of settings on parameters, so I've really made some initial design decisions. This is where I'm talking about how you're starting to maybe build some construction documentation into the early design process, because I'm actually documenting my decisions here.

Now you can see that all these are not all set to one single decision, because I'm not really sure, for instance, what HVAC system I'm going to use. I'm not sure what my lighting power density is. So I'm leaving a range and some uncertainty at certain points. But I'm still getting some feedback about how my building is doing, and all those decisions show up in history.

So now I can again review how well I'm doing. And what this single number tells you is basically the mean of all the options that you have left still on the table. So it's really the most likely energy use you're going to take, if you make-- if you take an average of all your decisions. But you still have this design potential, so your building could perform anywhere from $5.50 to $13 per square foot-- or per square meter. And again we're starting to get-- now you can see we're in the yellow, we're between Architecture 2030 and ASHRAE 90.1. And we're within range of Architecture 2030, and maybe we're even within range of our zero energy target.

Now down at the bottom of this window, in all the panels we have the link to the 2030 palette, which is a way to give you some additional information-- ideas for reducing energy, some other design ideas. Also down at the bottom of the screen are the PV widgets. So this is another thing we run every time a scenario-- every time a model is submitted, is we run a set of PV simulations. And we've run three parameters that we feel are the key parameters to early PV design. So the panel type you're going to choose, which of course affects the efficiency of the conversion of solar energy to electric energy, and it also affects the cost. So a higher efficiency panel is going to cost more per watt to install.

The payback limit, which again will filter out areas of the building that you may have selected that are not good for-- good candidates for solar panels. And then the surface coverage, which earlier in the design you're probably going to select big swaths of roof areas, and just say, well, maybe only going to cover about 60% of that. Later in the process you might be selecting individual panels, and you'd put that to 90 or 100%. So here I've got it at 0%, because I want to just work on getting the building energy.

And then just one other piece of feedback before I start working on the panels. We can visualize where the energy is appearing on the model surfaces. This is going to be a scale from good performance to poor performance. You can see some of these roof areas have been knocked out by the payback filter. Some of these areas are going to be better candidates for solar panels. So you can get some spatial design ideas right off the bat. And then some detailed feedback, if you really want to dig in and get into some advanced information.

So what I would get this phase is usually select the surface coverage earlier in the design phase, choose about a 60% coverage. And I can see right there that between no PV panels and 60% coverage, I'm getting down pretty close to zero potential performance of my building. I've chosen a long 30 year payback right now, because I haven't really optimized my system yet. And this is really good enough for this phase of the design process. You can see all my different design decisions for PV panels on the history chart here, and where my performance is, and my range.

Now you can see the range here is down-- I think I've got that highlighted. Yes. So now I'm actually within range of getting to zero energy. So if I make all the really efficient decisions on my building at this point that I have still left on the table, I can get down to net positive. And again, maybe those decisions have affected the results on the models. You see some of these, some more of these areas have gotten knocked out for my panel selection.

So just looking back at the-- looking back into the Formit model, which is that same model that we're seeing in insight, I could start to maybe look at some more detailed design before I move on to refining this layout. So this is the same results that we're seeing on the insight model. I'm getting-- oh, OK, sorry about that. So here I have made changes to the model. You might've noticed I've tilted this roof a little bit more to the south, this one, tilted these a little bit more to the north.

Run another analysis, and I'm getting poorer performance here, of course, because it's more north facing, and a little bit better performance here. And then again running that through insight, another iteration in insight, and getting that feedback back on here. You can see that this building is actually performing a little bit better down-- I've got a narrower range and a little bit better mean performance.

And looking at some of these surfaces, some of these other surfaces are knocked out of the candidacy for PV panels. Comparing that to my other model. So this is where you're asking about the compare workflows. It's pretty fast to just cycle between these buildings. I'll review the rest of that now. So we've built in a compare so you can save different states from your history, from your design decisions, and compare all those different states of your model. So this could be a report of your energy efficiency decisions during the course of the project. And then going back up here to the project level, we have that same sort of compare at this level. So in this case we have different models that we built, from different concept models, to that one with really high roof tilts, moderate roof tilts, all the way to our detailed Revit model.

So now take it one step further. We know about all we could know about the model from just conceptual surfaces, and we want to move into a little bit more detailed workflow. So this is what I would call the building design integration phase. So the Formit model you can open up in Revit, and do the same sort of analyses. I'm just going to show these-- the same sort of analysis with SAR. Processes, open the solar tool again, choose the PV analysis, select the surfaces that you want to visualize. So you can see, very similar, well, same exact results as

Formit, but a little bit more information in this more detailed tool.

And then we can do things that we can't do in Formit, like select the parameters of the PV system. So you can see here I'm selecting a different PV panel type, so notice the numbers here in our potential energy production on a 16% panel, compared to a 20.5% efficient panel. And then at this stage, I would usually review through some of the other output parameters. So insulation on my services, and the payback period of these services, to understand really what services I want to look at in a little bit more detail.

And then comparing different PV panels, here's my payback with a 16% panel. And then adding things like escalation to the energy cost. It's something a lot of people don't consider, simple payback versus payback with real energy cost escalation. Here's the 3.5% energy cost escalation, which has been the average in California for the last 20 years. That reduced my pay back down to 16 to 25 years. Yeah?

AUDIENCE: Is there a method to [INAUDIBLE] clients [INAUDIBLE]?

DAVID SCHEER: Yeah, good question. Not right now, but I'll take that as another request, though. We've got plenty of those, including from myself. And well, talk with me later, and we'll talk about other ones you might want to consider, and where our assumptions might not meet your needs.

So at this stage, I've basically seen that some of my surfaces don't have good payback, they're not good candidates for solar panels. So I'm going to start to refine this design, look at a more realistic set of surfaces. Now I'm starting to get numbers here that are going to start telling me, OK, how much energy can I really produce on this building when I start making smart decisions?

Looking at the different output again, this is actually an example of the workflow that I think is pretty powerful. It's moving from a Formit mass model to starting to add detail services. In this case I've added some elemental roof surfaces, where I'm increasing the overhang on these roofs and getting some more realistic roof area. Adding some trees to the model, for instance, which are also of course considered as shading. And then same kind of process as Formit, generating insight from Revit, submits it to the same area. And now we're getting slightly more detailed model results, and that's also being added to the same project management environments so I can compare with my conceptual models. Yeah?

AUDIENCE: Is there a way Formit can take [INAUDIBLE]?

DAVID SCHEER: Yeah, I think right now you've just got to build some conceptual forms. I heard some people talking about it earlier today. But come down to the answer bar, there's some Formit people there that I think they figured out some ways to import some more complex shading geometry. But yeah, it will take that shading into account as well. So you see here I have run this detailed model here, and that's being added to my compare at the project level.

So now that we've got that conceptual design done and more information about the model from Revit, we can move on to some detailed design. And once we get the building fleshed out with some smart decisions about panel location, I can start refining the surfaces that I'm looking at, and start defining my panel layout and really optimizing the system. So here are those three surfaces that I've chosen to work with. I'm going to focus on this one here, and look at a panel layout on the surface.

So a typical panel layout, panels are about four by five feet, so I've just laid out a bunch of panels here. What I've done is created a little parametric parent object that has a panel tilt parameter. So I could just change that parameter and tilt the panel and re-run the solar analysis. I can do those iterations in just in a few seconds. So here's running through a few iterations. And what I'm looking at is what my total energy use is, and what my-- well, this is an old version actually, so payback period's not on there, but that would show up normally.

So you can see, energy use has-- energy production's gone down a little bit. Here I'm really getting out of range. Here I'm really about 10% below what my max is. So I figured out that basically about a 25% tilt is optimal for this surface. Now you'll find that it's-- typically people say that latitude tilt is the ideal for PV panels, but it's not always the case because of seasonal cloudiness and things like that. It actually usually turns out to be slightly different than latitude tilt. And you'll be able to see that here because it runs every hour of the year with clouds and everything in mind.

So then just cycling through my other metrics for performance. So you can see now that I've got this panel tilt down here, I've gotten by my energy production to about the maximum for this coverage, and I've got my payback. Remember before it was anywhere from 17 to 25, 30 years. Now I've got it really-- narrowed that range to about a 16 to 19 year payback. So that's a pretty good payback for a PV system, especially in Columbus, Ohio, where energy's pretty cheap.

So I'm just going to go through that same process with some Dynamo automation, with some simple Dynamo automation to some more complex automation. So at the simple level I'm going to use that parametric surface I created with the tilt parameter. And I've used just a really simple Dynamo node where I can add a slider bar to change the value of that tilt parameter. I've also made one so that I could control the height of the trees. Those trees at the entryway are basically intended to shade the south entryway, because there's very hot periods in the summer here. But I want to have them high enough to shade the entryway but not so high that they shade the PV system too much.

So I'm going to just run through a bunch of options with those parameters. And I'll just run a few without the solar analysis results, but so you can see as these sliders are moving, these panel tilts are changing. So this is just a really, basically as quick a process as I'm showing right here. And same thing with the tree heights. Try a few different tree heights. And I would run a solar analysis at each phase here. So here's basically the optimal that I've figured out.

And so again, I can then run a custom analysis on this ground area and make sure that I'm getting the proper shading to reduce my peak solar intensity on the entry surface as well. And again, my payback period, so now I'm within one year of 16 to 17 years. So I've really basically designed that to be about as optimal as I can.

So now I just want to show how this might be done to completely automate this process. So solar analysis in Revit is pretty quick, but laying out the PV system-- if we do solar analysis in Dynamo we can basically leverage all the other things you can do in Dynamo, to automatically lay out the panel system, automatically give feedback, automatically generate schedules, and things like that. So I'll just show you how that works. So this is that pretty complex looking re-creation of an automated panel layout analysis in Dynamo. And you can see the Revit model behind there. Basically the same ranges, same output, as we're getting in SAR.

And then let's just compare that workflow. So in-- here's what I would come up with with the manual process. And really this only takes a couple, three hours to do this in SAR, but with Dynamo I could run through a lot more iterations. So this is what I came up with manually. And I basically embedded all these decisions, all these potential decisions I can make into the Dynamo graph. So I embedded sliders for the array parameters, so for the distance spacing from the edges; the spacing from the bottom, the top; the distance between the rows so I can reduce overshadowing. The project parameters, like what solar panels are available, how much electricity cost and escalation is. And then my output results, which I can use to determine how well I'm doing with each of these settings.

So the process for this graph-- you can download this graph and use it, and it works well in any rectilinear surface right now. I didn't make it handle all surfaces, but you should be able to use it on any rectilinear surface. So this is basically the process. You can watch the sliders here, and the panel layout here, and the output here. Just running through a few different options. I've change the spacing of the panels so I can fit more panels on the roof. I'm creating more energy, but my payback period is going up a little bit. Here we've got a lot more panels, so it's going to be more expensive, but my payback period really hasn't increased all that much. But I'm getting a lot more energy.

So these are the sorts of design decisions you can make. And by embedding those design decisions into the Dynamo graph, I'm both documenting those decisions and making it easier for me to scan through those decisions. And then potentially I could even buildup optimization routines, kind of automatically figure those out for you. So here's what Dynamo came up with. I need to work on the spacing from the edges a little bit more, but we'll just call that good for now.

So running through that on another surface, just running it through a couple different spacings and tilt, and bringing those services automatically back into Revit. I've got a Revit model which basically documents those decisions I've made in Dynamo. So here's the results I got from Dynamo. And what I'd like to do now is just track back through all these different methods, different phases, different iterations, and show how well it works to refine the design from the beginning to end. And how it is really valid at each stage.

So here's the Dynamo solution. Actually, what we should note here is about $40-- about $7,600 worth of energy a year, and about a 19 and a half year payback. So here's the Revit model. So about $7,500. I don't have payback on-- actually, the payback is here. Yes, so payback is here, 13 to 19. So very similar results. And here's actually the results for my flat simple surfaces on the Formit model. And really if I apply my 60% coverage, that 12,000 number gets us right around that value of $7,500, $8,000 a year worth of PV energy. Now on these flat services, we have an optimize with panel tilt, and all that. So my payback periods getting a little bit longer. So those are the sorts of things that you optimize in detailed design.

So just in summary, what I'm talking about here is running iterations at all phases of the design process, running through the entire design process at all phases, maybe in a simpler way, with broader more uncertain results early on. But still valid results that give you information right at the beginning and very quickly to make good decisions early and continuously, so that the design intelligence is actually building up and becoming more accurate. And is embedded into the design process.

And the basic workflow, setting the location, that gives you your solar information. Generating the insight, reviewing insight, for understanding your targets and your basic potential, and then working in more detail in Formit and Revit. And then potentially automating and customizing the process with Dynamo. And then that's basically your iteration, that's your cycle, again and again and again.

So this is where you can download insight and all these tools. Dynamo's available on dynamobim with the pro subscription. It's web or mobile tool. And this will be on the downloads. So I'm going to go to the next page. Just remember to fill out your feedback forms. I'm supposed to remind you of that. And this basically has all the information I just gave you. And let me open it up for questions. I can't believe I made it. Any other questions? Yes, back there?

AUDIENCE: [INAUDIBLE]

DAVID SCHEER: Size limit? No, not that we-- have we found any model size limit? No. We've run some pretty-- it may take 45 minutes to run a long model-- I mean a large model in insight. The solar analysis is actually very fast. That's very optimized. So running iterations on that model just took a few seconds. And very large models, I've never seen anything take more than 15, 20, 30 seconds. Yeah?

AUDIENCE: You mentioned [INAUDIBLE] insulation [INAUDIBLE] based purely on [INAUDIBLE]?

DAVID SCHEER: Yes, it's based on the Perez calculation, which is a regression model that's generally used by most solar analysis tools, NREL and PV watts and stuff. It uses the direct normal and diffuse horizontal radiation and figures out the insulation coming-- or the solar intensity coming from different areas of the sky, the circumsolar, the solar disk, the horizon, et cetera. So it knows where it's coming from. So if there's a hill that's shading the direct sun, but you're still getting diffuse, you actually will get the shading of the correct type of solar intensity.

AUDIENCE: [INAUDIBLE]

DAVID SCHEER: It's baked in. And I can show you some validation tests we did later on if you come to the answer bar. Actually, if anybody wants to come to the answer bar, I'll be down there a lot tomorrow and we could walk through some of the Dynamo graphs. Oh, Expo Ultimate? OK, we'll be there too. Yeah?

AUDIENCE: [INAUDIBLE] done much [INAUDIBLE] grasshopper into this process, and where you would recommend [INAUDIBLE] cut out some or all of Formit or [INAUDIBLE]?

DAVID SCHEER: Yeah, I'm not the expert on that, but there are definitely some folks from the Formit and the Dynamo team here. They'll be at the answer bar. And yeah, ask them. They'll tell you about Rhynamo and imports from other tools. Yeah.

AUDIENCE: [INAUDIBLE] 2016 [INAUDIBLE]?

DAVID SCHEER: It is, yeah. We're only releasing it for Revit 2016. And actually solar analysis was in labs for 2015 but we're just releasing that for 2016 now. But that's one of the reasons I've made all those Dynamo graphs. Because it actually really recreates solar analysis for Revit, and you can use it in 2014, 2015. It's a pretty straightforward graph. It's a good way to kind of get going with Dynamo. Yeah?

AUDIENCE: [INAUDIBLE]

DAVID SCHEER: Yeah, I didn't-- last year, actually, I did one on the lighting analysis tool. That might be what you're talking about, where it slices through and shows you the daylighting results, yeah. Which is-- the reason I showed in that animation is because it's of course another important consideration when you're putting roof overhangs and PV panels on the site, is if you can do daylighting analysis in the same model, you can see the results of all your design decisions on different performance aspects. But look for my AU class last year, and that has the lighting analysis tool. And it's also on insight360. Yeah?

AUDIENCE: [INAUDIBLE] are there any [INAUDIBLE] algorithms [INAUDIBLE]?

DAVID SCHEER: Yeah, there actually is already a thing called Optimo out there, that was developed by--

AUDIENCE: [INAUDIBLE]

DAVID SCHEER: Yeah, exactly. I really wanted to do that for this class, but I didn't get to it. Yeah, that would be the next step. Basically that and also automatically generating schedules with your panel schedule. But those can definitely both be done. Look for Optimo. Yeah.

AUDIENCE: [INAUDIBLE]

DAVID SCHEER: So insight360 has a number of tools. They're each slightly different. So the energy analysis goes through Green Building Studio, which is part of Revit-- you get with a Revit subscription. The solar analysis actually will work for anyone. You don't need a subscription. The lighting analysis works-- there's a free level, and then more detailed analyses require Cloud Credits. So it's a little-- each one's a little bit different. And there's a loads analysis that also works off the energy analysis in energy plus, so that requires a subscription also. Any other questions? Great. All right, well, thanks a lot everybody. Come on down and talk about it more.