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Sandeep Ahuja and Patrick Chopson

PERFORMANCE-DRIVEN DESIGN

ECTURE

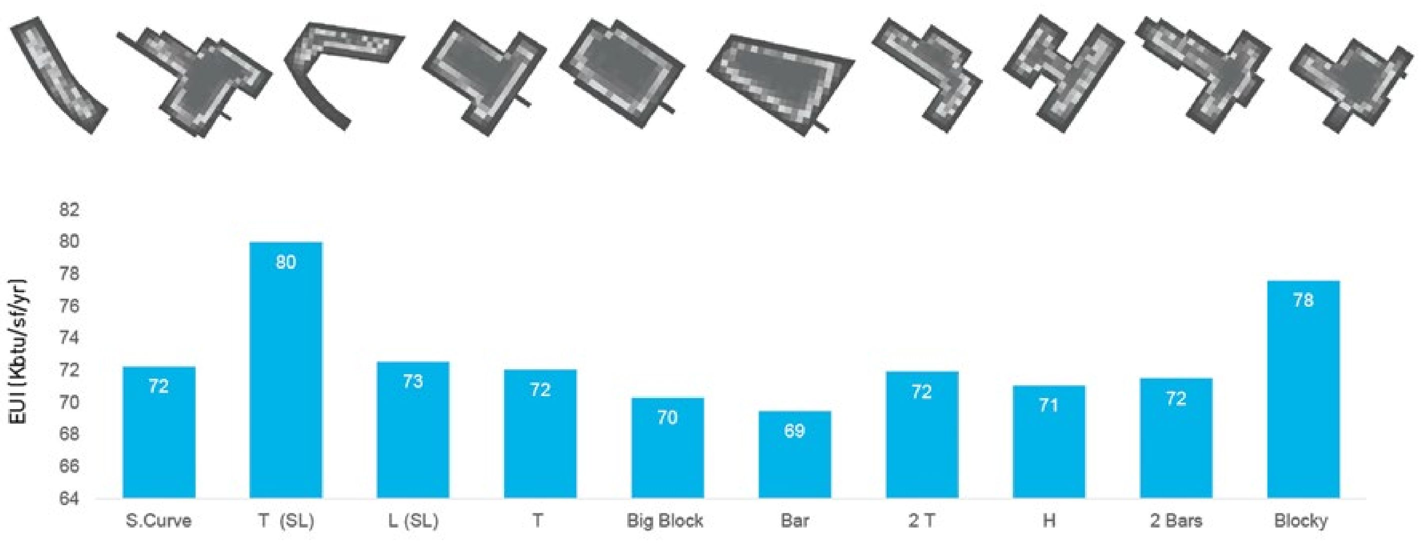
In the modern context it is important to be able to analyse building performance data at the initial stages of the design. This allows spaces to be optimised environmentally with fewer cost implications. **Sandeep Ahuja and Patrick Chopson**, founders of the Atlanta, Georgia firm Pattern r+d, have developed cove.tool software for the purpose.

The mounting effects of climate change on the environment are a powerful catalyst to articulate a new vision for architecture. If the profession is to become fact- and data-driven and responsible to the planet, alternatives to traditional practice must be found to foster innovation. Venture capital investment is lowering the barriers to entry for new types of startups that are building capabilities enabling the future of practice. Cove.tool is one such venture that has taken a non-traditional approach to the delivery of building energy analysis into the market.

During previous experience working in a large multinational architecture firm performing analysis on a wide range of high-profile projects, it became clear that architectural practices are unable to afford simulation on most projects.[1] Continuous simulation capabilities are needed during design iteration, since testing only a few options is like trying to navigate in the wilderness while infrequently checking a compass. However, relying on either in-house specialist teams or external consultants is too expensive for routine schematic phase analysis. An often-proposed alternative is to train architects to run their own simulations, but typical analysis packages are developed by researchers for use by specialists with years of experience, and require extensive knowledge of inputs and underlying science. Training all staff to use them would be cost prohibitive, and anyway the overheads and additional work would prevent them from running the necessary iterations. The best way to integrate rational decision-making into this aspect of design is to give architects tools to quickly and easily run models for themselves without needing specialised knowledge. The cost of human labour is the roadblock to data-driven design in traditional practice, not a lack of desire.

cove.tool, Massing studies for Campus Life Center, Emory University, Atlanta, Georgia, 2018

The impact of building massing on energy performance. Fast, accurate simulation makes evaluation of alternatives significantly easier for design decision making. Without the use of automation, a simple, iterative design study like this would take a skilled energy modeller 20 to 30 hours.



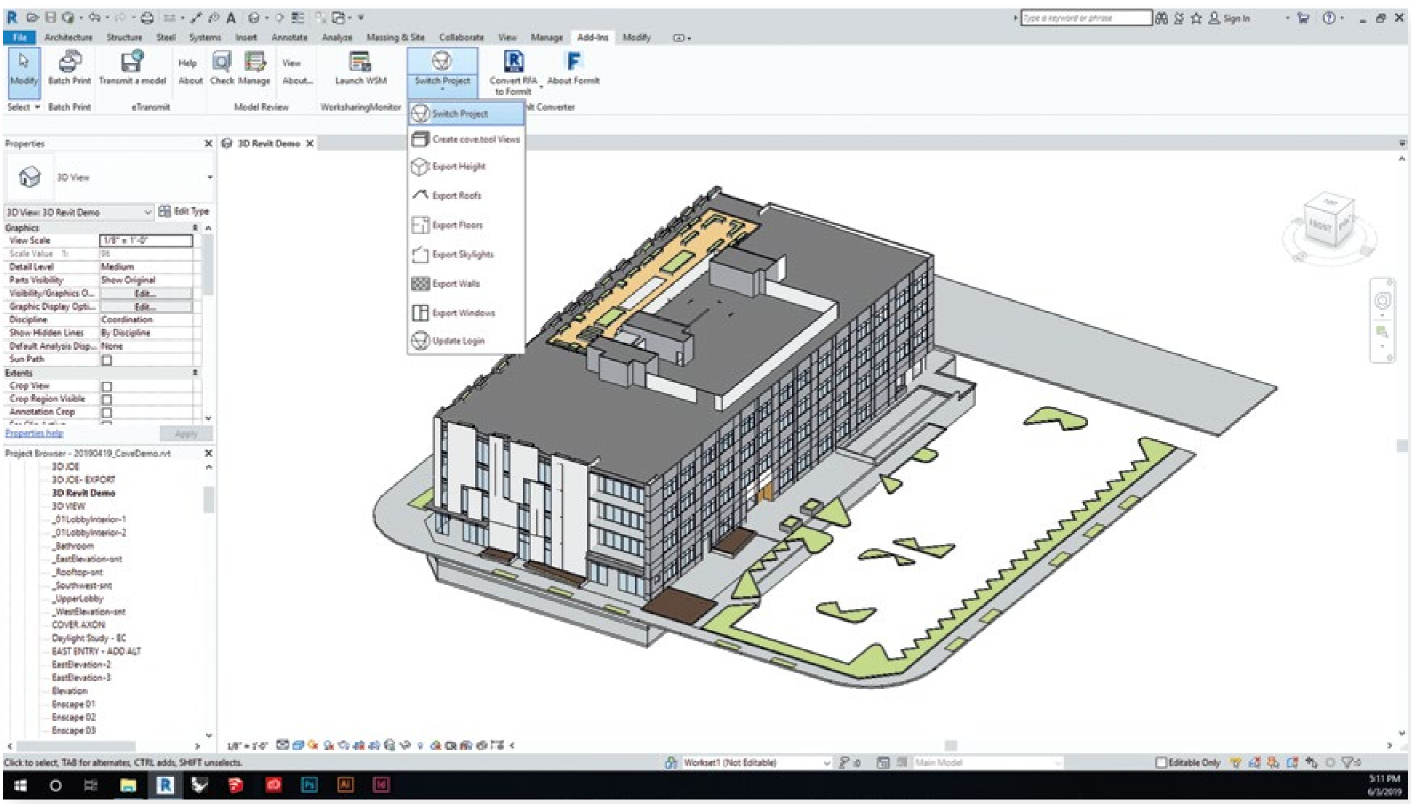
PLUGGING THE GAPS

The sustainability consulting practice Pattern r+d was launched in 2015 to respond to the challenges outlined above. While acquiring clients and consulting on projects, the firm immediately began automating each step of the consulting process, with the ultimate goal of eliminating the need for its services.

The team uncovered large gaps in the data flows between professions and at different stages of the design process. The engineers struggled to access the building geometry and run enough simulations for the architect. Contractors were unable to obtain pricing in the early stages or evaluate alternatives based on performance. Frustrated owners could not evaluate whether design proposals were either high performance or cost effective. At the centre of it all, architects tried their best to manage, but were ultimately overwhelmed by the volume of data. Each gap in the decision-making process added time and cost. Through this experience, Pattern r+d realised that in order to be effective, automation needs to be paired with a shared workspace.

In the process of automating workflows, it became clear that simulation tools often pursue meaningless accuracy improvements instead of speed and usability. All simulations are simplifications of reality and must produce repeatable, consistent guidance from the available information. Making too many detailed assumptions before the problem is well defined introduces uncertainty into the simulation. During the early design phase, the fewer assumptions entered into the model the more likely it is that the result will point the designer in the right direction. Along with fitting the complexity of the simulation to the decision to be made, speed is vital. If a result is 1 per cent more accurate but arrives a week later, it is useless. Low-resolution yet accurate simulations remove uncertainty and run faster than detailed models, making them more successful at guiding decision-making. Because the information to define additional parameters becomes more detailed as the project progresses, the software development of a large unified tool can proceed from low resolution to detailed compliance modelling. A philosophy of developing software from low- to high-resolution simulation is critical to bringing data-driven design to the profession.

Decision-making time and accuracy became a guiding principle for Pattern r+d's automation strategy. Instead of adopting detailed but computationally heavy simulation engines like EnergyPlus,[2] the firm uses an ultra-fast simulation method called ISO 13790.[3] Calibrating this engine with the engineer's modelling tools aligns all those involved around common benchmarking targets.



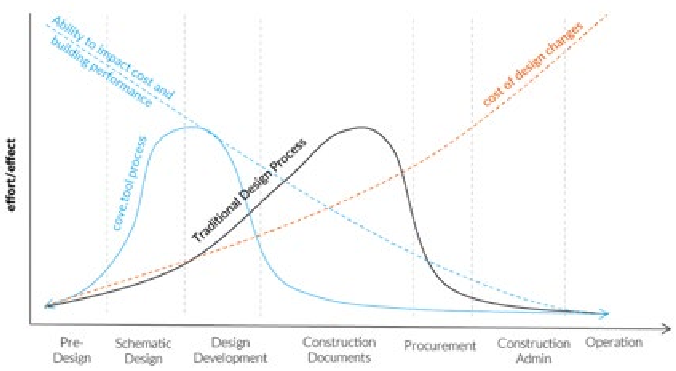
cove.tool, Revit plugin interface, 2019

The plugin enables users to rapidly send key information from their BIM model for automated analysis. Data transfer is typically the greatest impediment to implementation, hence the decision to allow the importing of open geometry.

UNIFIED MACHINE LEARNING

Architects make hundreds of design decisions each week and coordinate a web of multi-objective problems. Automating tasks as individual scripts is manageable only as long as the number of tasks remains small, as every design problem involves conflicting needs. Selecting a window product involves balancing HVAC systems, aesthetics, energy, daylight, glare, thermal comfort and cost. Faced with an explosion of data and options, many designers resign themselves to using the same glass as on their previous project or are swayed by the most recent salesperson's visit. Pattern r+d thus identified the need for a unified machine learning software for managing tradeoffs among the various scripts in the form of a simplified graphical user interface. Building upon decades of research at the Georgia Institute of Technology, the team began hacking together the first version of the cove.tool (cost versus energy) software platform.

Development of the tool was initially funded through the consulting business. With a strong focus on usability, the team began shaping the software into a robust user-friendly product. Even with limited features, it could be beta tested in the consulting practice. However, it soon became clear that venture capital would be necessary to launch a product that could scale. Armed with a working prototype, the cove.tool team entered a startup competition for funding, and won.



cove.tool, MacLeamy's Curve, 2019

MacLeamy's Curve highlights that current practice pushes performance analysis to later in the design phase when it is least economical to make any design changes. Cove.tool brings this analysis forward, to the earlier part of the design process when the opportunity to impact cost and performance is highest.

cove.tool, Baseline energy results, 2019

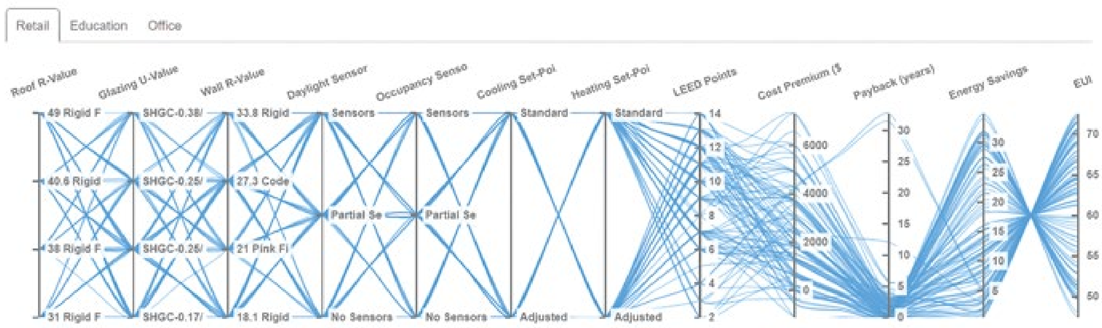
Snapshot from cove.tool showcasing a variety of building performance results that design teams can use to better inform their building process. Similar software tools, for building performance and other data-driven decisions, are starting to penetrate the industry. This study took Pattern r+d over 40 hours to prepare as part of their consulting practice. In cove.tool the analysis took just 10 minutes.

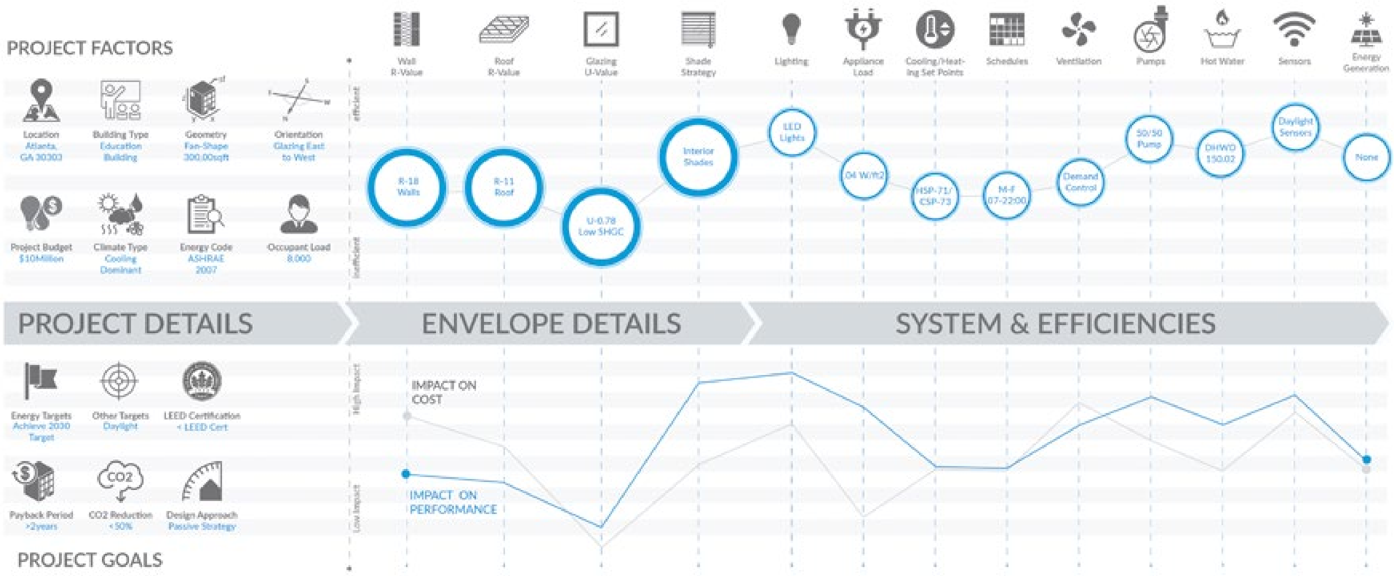
Duda|Paine Architects, Campus Life Center, Emory University, Atlanta, Georgia, 2019

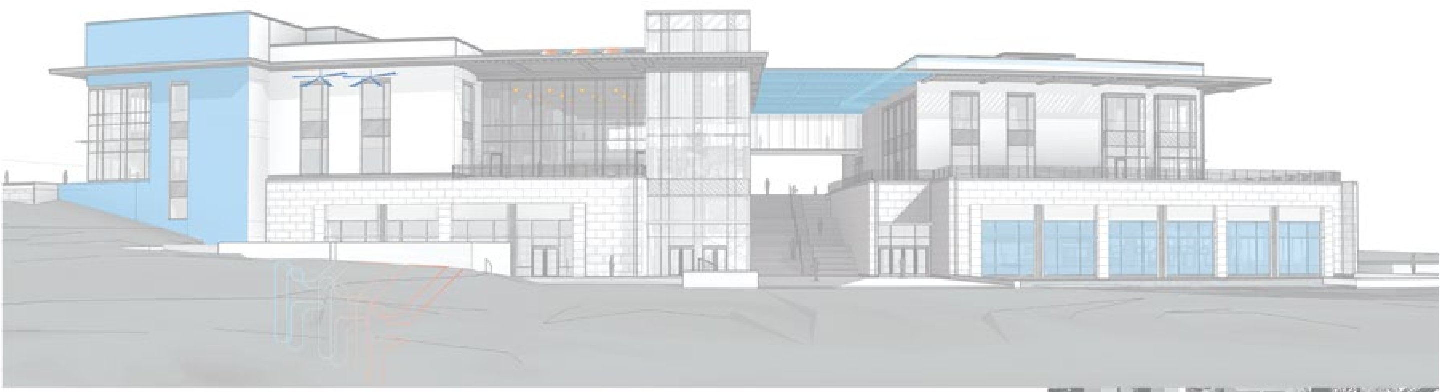
opposite: The architects worked in close collaboration with engineers IMEG and the university's capital planning and design group on the data-driven decision making for this high-performance centre. Using cove.tool, the design team was able to analyse over 3,000 design alternatives and select the optimal solution.

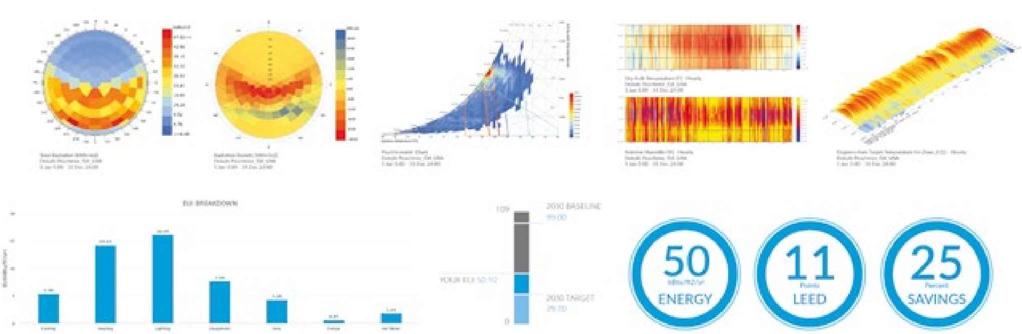
Cove.tool, Optimisation interface, 2019

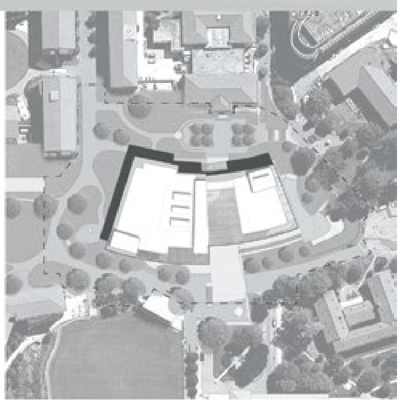
Parallel coordinates plots are useful for linking together bundles of decisions and their impacts. Multi-objective cost-versus-energy optimisation allows users to select the option that is optimal not just for performance, but cost too.



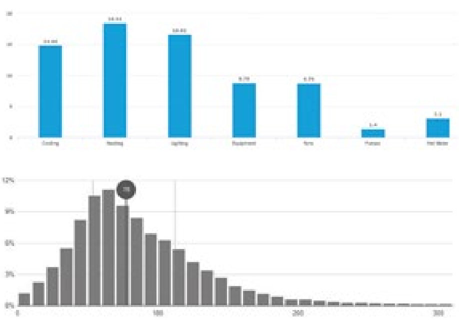


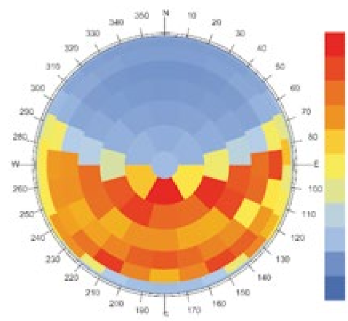


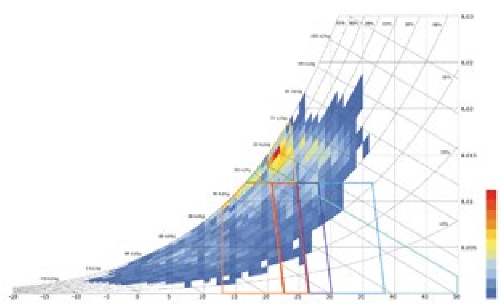


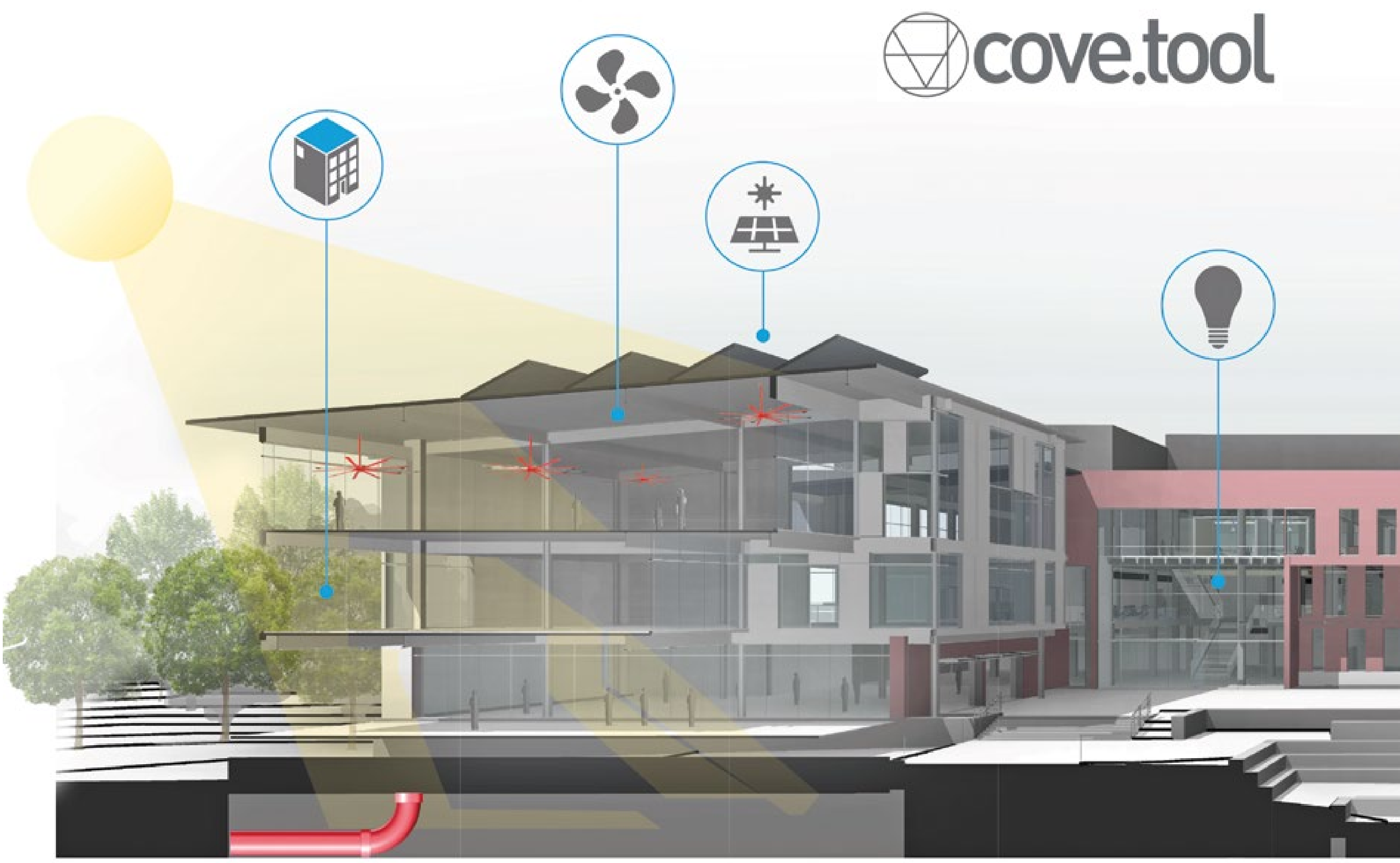


Data-driven, parametric and responsible, it is a paradigm for a modern architecture that reflects the needs and aspirations of the 21st century









This allowed cove.tool to scale up, making the software accessible to hundreds of firms. By enabling smarter, more accurate models to be built and tested quickly, a range of building alternatives can be explored and the best one identified. Cost is a motivating factor for most projects. The platform also simplifies the use of machine learning by giving algorithms a common scoring mechanism for each design alternative. Thousands of alternatives can be compared in a few seconds, allowing optimisation of cost-versus-energy tradeoffs. With a database of cost values from manufacturers integrated into this optimisation cycle, users can typically find systems that cost 2 to 3 per cent less while simultaneously being 40 per cent more efficient.

It was a conscious decision to address energy analysis first, since changing energy codes force architects to pursue aggressive targets. Additional scripts for analysing daylight, glare, thermal comfort and water usage, developed for previous consulting projects, are now rapidly being incorporated within the cove.tool platform. Each of these metrics can be linked back to the costing model and incrementally managed by the machine-learning approach. The ultimate goal is to incorporate every data point crucial in the design process and automate all the tedious work for generating and managing this data.

Changing a profession requires collective responsibility and collective empowerment. With buildings contributing 40 per cent of carbon emissions, architects need to find new ways to enable them to make better environmental performance decisions. Machine learning can be a critical part of this future. By managing the complex data flows between different analyses, consultants, contractors and owners, machine-learning software returns the decision-making power to the architect. Data-driven, parametric and responsible, it is a paradigm for a modern architecture that reflects the needs and aspirations of the 21st century. ⅅ

NOTES

1. American Institute of Architects (AIA), '2030 By the Numbers: The 2018 summary of the AIA 2020 Commitment', September 2019: http://content.aia.org/sites/default/files/2019-08/AIA_2030_BytheNumbers_2018.pdf.
2. Drury B Crawley *et al*, 'EnergyPlus: Energy Simulation Program', *ASHRAE Journal*, 42 (4), April 2000, pp 49–56.
3. ISO 13790: Thermal Performance of Buildings – Calculation of Energy Use for Space Heating and Cooling, 2003–08. Found at: www.iso.org/standard/41974.html.

Cooper Carry Architects, Campus Center, Georgia Institute of Technology, Atlanta, Georgia, 2020

The architects worked in close collaboration with engineers Newcomb & Boyd and the Georgia Institute of Technology capital planning and design group on the data-driven decision making for the high-performance centre. Cove.tool was used for the performance analysis to showcase optimal use of every construction dollar to reduce energy use intensity (EUI).