ANSYS

White Paper

Breakthrough Energy Innovation: Ambition and Urgency

• Climate change goals, customer sustainability expectations and pressure to reduce waste demand ambition and urgency from industry to deliver breakthrough energy innovation. More of the same is not an option.

• Aligning sustainability initiatives with a company's goals, mission and values is good for business. Industry leaders now holistically pursue growth along the dimensions of product innovation for regulatory purposes, product innovation to meet customer's "green" expectations, and process innovation to minimize waste and reduce time to market.

• The forces driving product and process innovation further compress the already fine margin for product performance and robustness; this in turn leads to increased product complexity in existing and disruptive products. Engineering simulation is the only practical way to address the unsustainable time and cost of physical testing requirements for these increasingly complex and often software-driven systems to deliver the real innovation breakthroughs that are required.

• Industry leaders address this complexity and deliver standout product quality and revenue performance by extending the use of engineering simulation from the component level to the subsystem and system level in an integrated cross-functional simulation platform.

• From startups to multinationals, businesses are seizing the opportunity to deliver break through energy innovation by using engineering simulation to explore the much wider design space that is presented by increased complexity and to tackle key engineering applications in the areas of advanced electrification, machine and fuel efficiency, aerodynamic design, effective lightweighting and thermal optimization.

• Companies do this with the support of a simulation platform that enables complete virtual prototypes, scalable solutions and an extensible ecosystem.

• Read more to find out how companies like General Motors, Pratt and Whitney, Whirlpool and others leverage engineering simulation to deliver breakthrough energy innovation with ambition and urgency.

Three Dimensions of Value Creation

There are three major forces compelling industry to urgently address sustainability and energy efficiency:

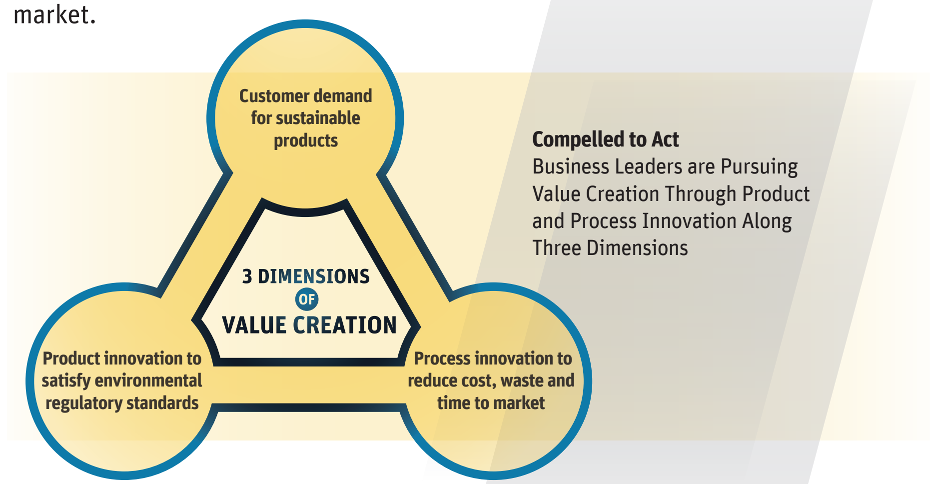
1. International climate change commitments, such as the “2-degree limit” agreement at the 21st Conference of Parties (COP21) in late 2015, cascade to the local business level and manifest themselves as clear environmental performance targets with severe financial penalties for those that fail.

2. Customer awareness and expectation of “green,” “environmentally friendly” or “circular economy” products continues to rise. From being a niche this is now rapidly becoming mainstream.

3. Operationally, pressure to grow continues unabated as do demands to simultaneously reduce product development costs, minimize waste and get to market faster. The investment community that can support growth shows a greater predilection for investing in companies that have sustainability as a significant part of their corporate strategy [1].

Industry leaders are acting with ambition and urgency. They now view these three related business forces as an opportunity for value creation [2]. According to McKinsey’s Global CEO Survey [3], 2014 was the first time that alignment with a company’s goals, mission or values ranked higher than both reputation and cost-cutting as reasons for organizations to address sustainability.

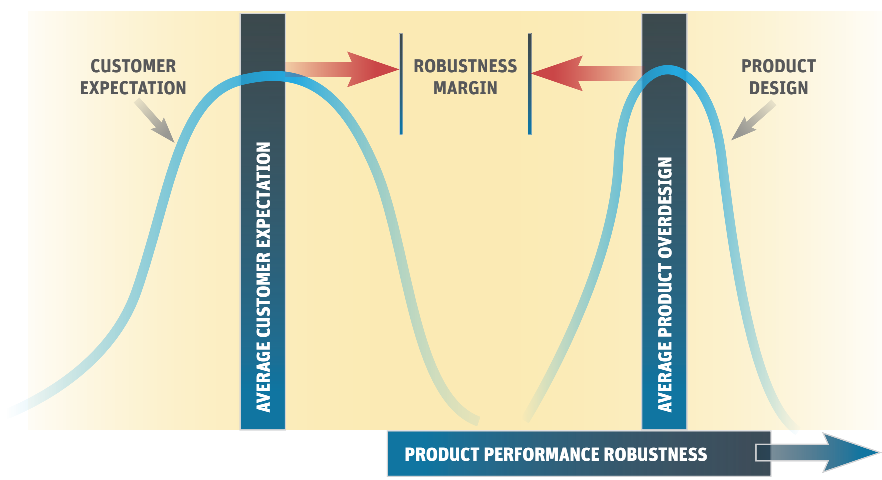
Today, innovative corporate sustainability initiatives are not just politics, they are good for business. Business leaders pursue value creation through product and process innovation along three dimensions: product innovation for regulatory purposes; product innovation to meet customer’s “green” expectations; and process innovation to minimize waste and reduce time to market.



Business leaders are pursuing value creation through product and process innovation along three dimensions.

Squeezing the Robustness Margin Demands Breakthrough Energy Innovation
The International Energy Agency (IEA) [4] identified significant opportunities for innovation in energy production, in part by boosting investment in renewable energy sources to $400 billion per year, and by improving energy efficiency across the transportation, industrial and residential sectors. The faster these technologies are brought to market, the more readily businesses will realize major savings in the cost of future mitigation measures. However, many products in these mature sectors are highly tuned for their intended purpose and leverage decades of operational experience. The margin for overdesign that exists between a product's actual performance and the robustness and the performance expected by the customer is already very fine.

To meet the aggressive regulatory goals and realize the value creation opportunities through product and process innovation, this already fine robustness margin must be compressed even more. For more disruptive innovation, a very wide design trade space exists as products do not have a history of operational experience and operate in different environments and include design variables outside of a traditional product's boundaries. Successfully squeezing the robustness margin of existing products or delivering disruptive technology requires breakthrough developments in technological solutions and in the way that these technologies are researched, designed, developed and manufactured. More of the same is not an option.



Customer and market expectations for performance and robustness continue to increase while sustainability initiatives drive down the margin for overdesign. Only with breakthroughs in technology and the means by which that technology is produced can we deliver what is needed.

Capturing Opportunity Through System Simulation: A Lesson from the Transportation Sector
In delivering breakthrough innovations, companies are developing ever more complex products [5].

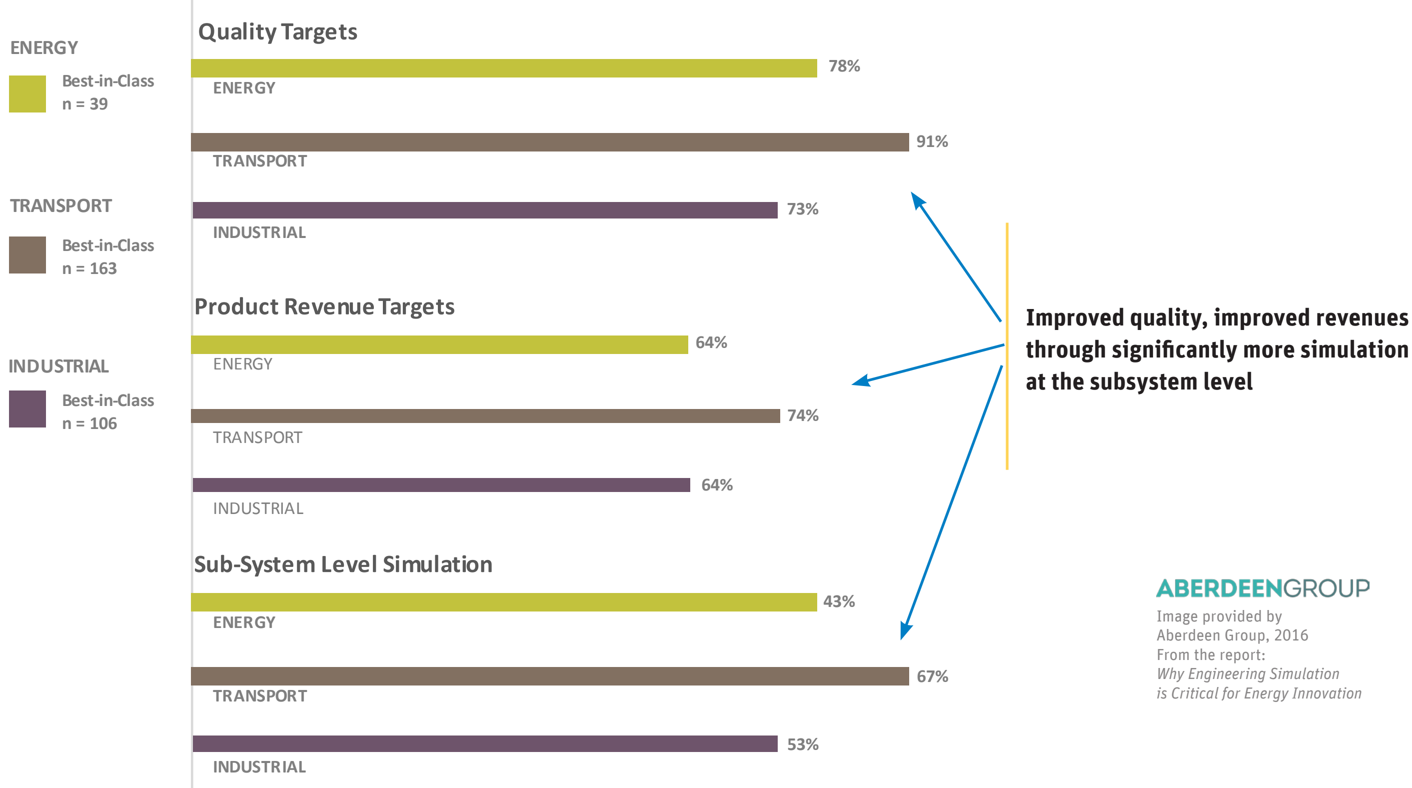
For example, in the automotive sector, emission control has led to a significant increase in both the software and hardware complexity of the engine control system and the extent of the interactions between the engine system and the exhaust aftertreatment.

This added complexity comes with a price. It requires exponentially more testing to explore the design trade space and system interdependencies, and to expose the potential product failure modes.

It is acknowledged that developing virtual validation and verification capabilities with engineering simulation is the only way to address the unsustainable time and cost of physical testing requirements for these increasingly complex, often software-driven systems [6].

Those who could potentially deliver breakthrough energy innovation in the energy production, transportation, industrial and residential sectors have used engineering simulation for many years as a standard part of the product development process. However, research has identified that the leaders in the transportation sector are significantly more successful at delivering products that meet quality and revenue targets than their counterparts in either the energy or industrial sectors [5]. So what are they doing differently?

One answer lies in how they are leveraging the power of engineering simulation during the design process. The standout difference identified [5] is that leaders in the transportation sector have deployed simulation beyond the component level and to the sub system level much more extensively and are therefore further along the journey to fully integrated multi-fidelity system level simulation.



Moving Beyond Component Level Simulation: A Key Product Quality and Revenue Differentiator for the Transportation Sector [5]

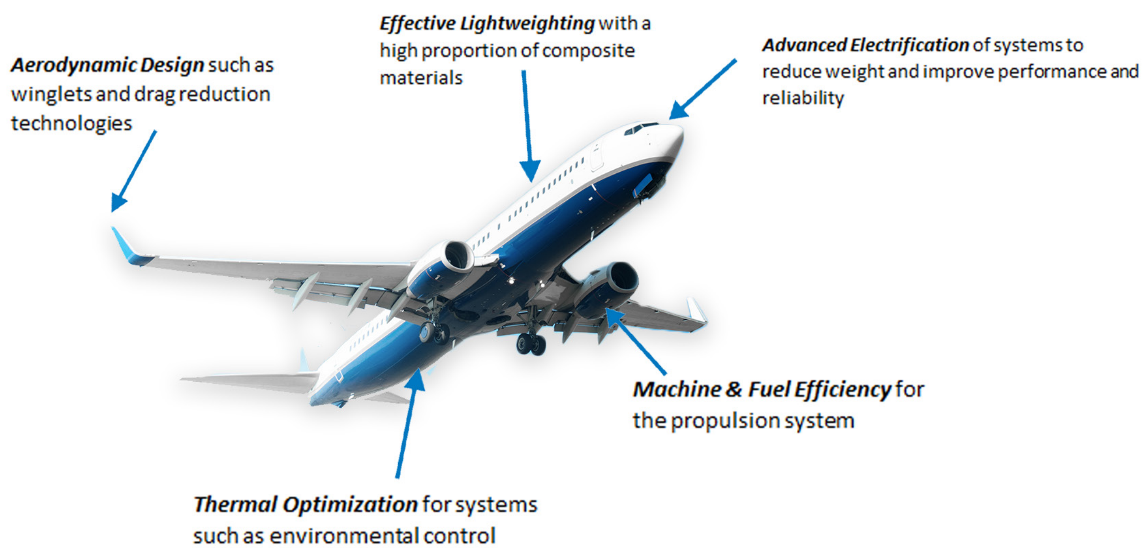
Practically speaking, this means that their engineering teams are capturing a greater degree of their product's behavior — such as the interaction of multiple physics or the behavior of a software-driven system — in a single simulation on a common platform, and are more readily able to address the challenges of product complexity and system interdependencies.

The increased use of engineering simulation decreases the number of physical prototypes required, reducing waste and cost as well as shortening the overall product development cycle.

Therefore, for those looking to deliver breakthrough energy innovation, integrated engineering simulation from the component to the system level is one of the key enablers of value creation along each of the three dimensions: product innovation for regulatory purposes, product innovation to meet customer's "green" expectations, and process innovation to minimize waste and reduce time to market

Five Engineering Applications: The Keys to Breakthrough Energy Innovation

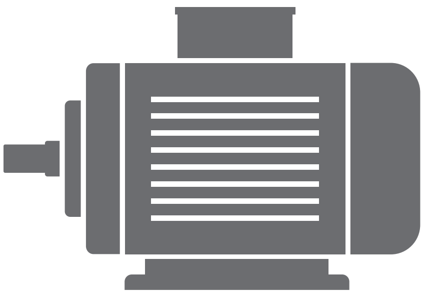
In recent years, significant breakthroughs have been made in the fuel efficiency of aircraft and the subsequent environmental impact of the aerospace industry. For example, the Airbus A350 and Boeing 787 Dreamliner claim between 20- and 25-percent improvement in fuel use when compared with other similarly sized aircraft. These breakthroughs can be summarized in five application areas: advanced electrification of systems to reduce weight, improve performance and reliability and reduce the dependency on combustion-related power generation; machine and fuel efficiency of the propulsion system; aerodynamic design improvement such as winglets and other drag-reduction technology; effective lightweighting through the integration of a high percentage of composite materials in the airframe; thermal optimization of non-propulsion energy-consuming systems such as environmental control, auxiliary power units, electronics cooling and anti/de-icing.



How the aerospace industry leveraged five key engineering applications that are common across industries to deliver breakthrough energy innovation

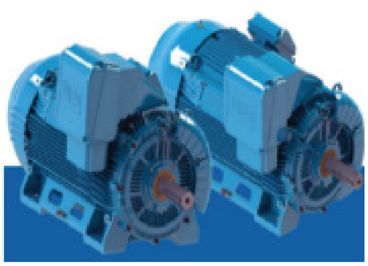
Not all products that can deliver breakthrough innovation are as complex as the latest generation passenger aircraft. However, a product development effort in any industry with the aim of delivering breakthrough energy innovation will require at least one of these five common applications.

Advanced Electrification



The advanced electrification initiative to replace traditional mechanical power functions with electromechanical systems, is impelled by the global need for greater power efficiency and the quest to make better-performing and more-appealing products. Electrically driven products are more convenient, more easily maintainable, lighter and have smaller footprints. In the automotive industry we see the rise of hybrid and electric vehicle technology and in aerospace the emergence of the more electric aircraft. In the USA alone over 40 million industrial machines convert electricity into useful work for manufacturing operations. Over a motor's lifetime, more than 97 percent of the total cost is accounted for by its power consumption and only 3 percent by the capital investment. Improving the performance of renewable energy technology is driving higher power density machines with better conversion which ultimately leads to reducing the energy cost across all industries while decreasing emissions.

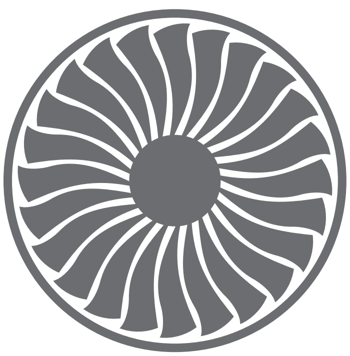
Case Study: WEG Reduce Induction Motor Simulation Computation Time by 70X



As product complexity increases, obtaining performance data across multiple design points becomes more and more challenging. This was the case for WEG, which offers a complete range of electronic products and systems and whose strategic vision is to provide complete and efficient solutions. When strategizing its business initiatives to attain high efficiency and energy savings, engineers at WEG combined ANSYS Maxwell simulations of their induction motor with a high performance computing infrastructure. This enabled WEG to reduce the computation time for a given design by a factor of 70 from almost 15 days when compared with non HPC simulation approaches.
Read more here.

Case Study: Reducing Battery Costs/kWh by 75 Percent with General Motors
Electric Vehicle (EV) Everywhere is the umbrella effort of the U.S Department of Energy (DOE) to increase the adoption and use of plug-in electric vehicles. A key goal of the challenge is to reduce battery cost from $500/kWh in 2012 to $125/kWh in 2022 – a 75 percent reduction in a decade. As part of this grand challenge General Motors led a team working under a program administered by the U.S Department of Energy's (DOE) National Renewable Energy Laboratory, known as the Computer Aided Engineering for Electric Drive Vehicle Batteries (CAEBAT) project.

To power an electric vehicle it is necessary to connect many hundreds of battery cells together as part of a large battery pack system. However, to maintain reliability of the battery system in the vehicle, it is crucial to keep the temperature of the whole pack within the range 25 C to 35 C. Because of the wide range of external operating temperatures, the temperature uniformity of individual cells is maintained by a dedicated thermal management system. One of the objectives of the GM CAEBAT project has been development of battery pack design tools, which included leveraging and extending the capabilities of system-level simulation packages. Incorporating this kind of simulation into the process helps guide the overall pack design direction as automakers seek to meet the DOE's programmatic goals and address the demands of the growing electric vehicle consumer market. ANSYS simulation tools formed a key part of the CAEBAT project and more information can be found here.



Machine and Fuel Efficiency

Engineers looking to improve machine and fuel efficiency must not only optimize the performance of each component by itself, but also how components operate in tandem with many others in the system. For example, the pump, motor and load must all be matched in order to work at startup, throughout the operating cycle and at peak efficiency. The engineering challenge is to balance the complex — and often conflicting —tradeoffs that arise. For example, higher firing temperatures for thermal turbomachines or engines increase efficiency but also introduce emissions problems that must be solved. In many types of industrial equipment, such as crushers, mixers and blenders, excess power input leads to a waste of energy and often degrades the quality of the final product being produced. There are many opportunities to improve efficiency. The challenge is to do so without compromising essential attributes of the complete system such as durability, reliability, safety, cost, sustainability and performance.

Case Study: Magneti Marelli Powertrain Improve Fuel Economy by 5 Percent

Automobile manufacturers are adding turbochargers to cars to help improve fuel economy and reduce emissions. However, as turbochargers compress air, the temperature of the air increases. This leads to reduced density and limits the air mass that can be forced into the cylinder, which in turn affects combustion. Intercoolers are used to remove some of this heat, but efficiency integrating the intercooler and the intake manifold is challenging. Engineers at Magneti Marelli Powertrain S.p.A, used simulation early in the design process to save time and money by optimizing the design earlier in the design process. The company expects to achieve higher performance while creating fewer prototype iterations than would have been necessary using previous design methods. The current design delivers a substantial increase in heat exchange through the intercooler, reducing outlet temperature by 8 percent compared to the previous intercooler. The new design also reduces overall pressure loss to improve fuel economy by 5 percent. Read more here.

Case Study: Pratt and Whitney Reduce Carbon Emissions by 3000 Tons Per Plane

Pratt and Whitney's Pure Power® engine design represents one of the biggest advances in jet engines in the past 50 years. By introducing an innovative Geared Turbofan (GTF) engine design they were able to achieve over 15 percent improvement in fuel burn and annual per plane reduction in carbon emissions of over 3,000 metric tons. According to Al Brockett, former Vice President of Engineering Module Centers, the company could not have developed this product, or sold it to customers, without incorporating engineering simulation. Simulation helps to protect the multi-million dollar investment by ensuring that thousands of engineers and operations staff around the world work efficiently, integrating functionality whenever possible and minimizing costly rework. You can learn more about how simulation helped Pratt and Whitney deliver breakthrough innovation for aircraft engines here.

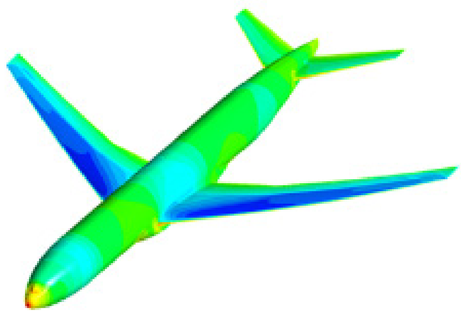
Aerodynamic Design

Of the energy spent on transportation, a significant portion is used by vehicles to overcome aerodynamic drag.

In the automotive sector, drag can account for as much as 22 percent of a typical highway truck's fuel. In recent years, stringent government regulations, such as the corporate average fuel economy (CAFE) norms for automobiles, and a strong consumer demand for cheaper, greener transportation has increased the urgency for aerodynamic improvements.

In the aerospace sector, airline operators work with very narrow profit margins, typically around 1 percent. Recent volatility in fuel price makes this business environment even more challenging. In parallel, the aerospace industry has committed to aggressive environmental targets, such as the CleanSky initiative with goals of a 50 percent reduction in CO_2 emissions and an 80 percent reduction in NO_x emissions by 2020. Consequently, the industry demands the most fuel-efficient aircraft possible from the aircraft OEMs and their suppliers.

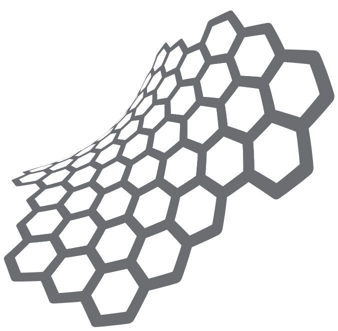
Clearly, improvements in aerodynamics can have a significant impact on the world's total transportation energy consumption and yield savings to operators.



Case Study: Accurate Prediction of Aircraft Aerodynamics
Over the lifecycle of an aircraft, even very small improvements in aerodynamic drag can have a significant impact. The aerospace industry therefore needs highly accurate predictions of drag during the design phase. This information is very difficult, time consuming and expensive to obtain through physical testing. To ensure that aerodynamic simulations keep pace with the needs of industry, the American Institute of Aeronautics and Astronautics (AIAA) runs a periodic and ongoing benchmark called the drag prediction workshop. ANSYS computational fluid dynamics tools consistently show strong agreement with experimental test data presented during the workshop and meets industry performance requirements.

Case Study: Piaggio Aero Improve Lift to Drag Ratio by One Percent in One-Tenth the Time
Piaggio Aero Industries needed to evaluate new wing designs much faster than their existing months-long process. By using ANSYS CFD and DesignXplorer, they were able to identify an optimal design that improved the lift-to-drag ratio by 1 percent and validate its robustness in just a few weeks, less than one tenth the time taken when they used conventional methods. Read more here.

Effective Lightweighting



The heavier an object, the more energy it takes to move it from one place to another. The transportation sector is therefore leading the way in making aircraft, trains and cars lighter as it seeks to reduce the cost of fuel and the environmental impact of transport without sacrificing safety and reliability. In engineering design, this is referred to as effective lightweighting.

There are two fundamental approaches to make designs lighter, both of which require significant engineering analysis.

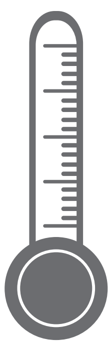
First, engineers can replace traditional materials such as steel or aluminum with lighter material alternatives, such as composites, ceramics or plastics. In addition to verifying the performance of these materials, development teams have to re-engineer how the part is manufactured. For example, substituting steel for plastic requires changing the manufacturing process from forging to injection molding. In the case of composites, engineers must specify the fiber orientation, stacking sequence and other attributes of the composite construction. Manufacturing composite materials presents additional problems due to curing, springback and residual stresses.

Secondly, the engineering teams might redesign the shape of a component to minimize excess material. Simple geometric modifications such as width, thickness, size and number of holes, are attractive because they have minimal impact on manufacturing. With the advent of additive manufacturing and 3-D printing, designers are now empowered to produce designs that could not previously be made using traditional manufacturing methods, thereby creating new opportunities for weight reduction.

Case Study: Reducing the Weight of a Monocoque by 20 Percent
KTM Technologies is a leader in selling solutions and supporting customers in economical, composite engineering via a holistic approach and is focused on people moving technologies. The first monocoque designs of the KTM X-Bow sports car were engineered without the use of ANSYS simulation tools. For the second generation design, simulation was used and the KTM team were able to reduce the monocoque's weight by 20 percent. Read more here.

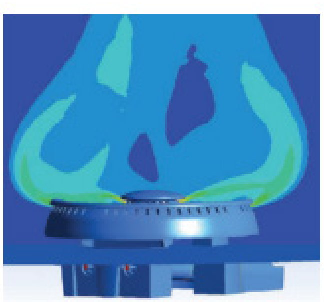
Case Study: Carbon Freight Develop 18 Percent Lighter Air Cargo Equipment-
New market entrant, The Carbon Freight Company, has a mission to build lighter and more durable air cargo equipment. According to Glenn Philen, CEO, "We believe that sustainable business practices and profitability must go hand in hand. Simulation from ANSYS enables us to innovate our solution and get our products to market faster with the confidence they will be right the first time."

Thermal Optimization



According to a OECD/IEA 2014 report, the production of heat accounts for more than 50 percent of global final energy consumption (FEC) today.

In addition to the more obvious opportunity to improve the heating and cooling of buildings and manufacturing processes, thermal optimization can also impact the efficiency of many products and manufacturing processes. For example, LED lights are sensitive to operating temperature and excess heat can affect both the quality of light being produced and its efficiency. Maintaining the correct die temperature of an LED can lead to higher efficiency, more light being produced at the same energy input and the need for fewer overall LEDs for the same lighting impact.



Case Study: Whirlpool Lowers Fuel Consumption and Reduces Development Time by 35 Percent
Whirlpool Brazil relies heavily on simulation to design gas burners for free-standing ranges, built-in ovens and cooktops. Simulation helps engineers to lower fuel consumption and cook time and reduce development time by predicting the performance of proposed burned designs prior to the prototype phase. Using ANSYS simulation software, the ability to much more quickly define and evaluate new design iterations has reduced the overall time required to develop a new cooktop model by 30 to 40 percent. Learn more about the Whirlpool story here.

Case Study: Nebia Manages Thermal Performance to Reduce Water Use by 70%

For many appliances, minimizing environmental impact translates into reducing the quantity of water used, hence the necessary energy to warm it up or cool it down to achieve the same quality of services. Nebia developed the concept of a "mist" shower that reduced water consumption by more than 70 percent. Because smaller droplets mean larger heat loss, the Nebia product development team combined its ANSYS thermal-loss simulation data with experiential information to achieve the right balance of water temperature, flow rates and directions, droplet patterns and sizes, and other characteristics to create the ideal shower experience more efficiently. By using ANSYS software, Nebia significantly compressed its R&D efforts by a factor 10 without compromising consumer thermal comfort. Learn more about the Nebia story.

The Benefits of a Platform for Simulation from the Component to the System

The data presented in this white paper shows that across industry sectors, businesses are leveraging simulation to pursue three dimensions of value creation for breakthrough energy innovation.

What stands out is that the best-in-class businesses are extending the use of simulation from the product component to the product subsystem and system level. To do this effectively requires both simulation technology and a simulation platform.

The combined ANSYS simulation technology and platform is unique. For detailed component design in individual engineering disciplines such as fluid dynamics, structural and mechanical analysis, electromagnetics and certified embedded software we provide the deepest set of simulation capabilities available. Our simulation platform, ANSYS Workbench, enables industry leaders to move from component-level simulation to the subsystem and system level by integrating these disciplines.

Research has shown that companies that consolidate on a simulation platform can expect a 20 percent increase in product cost targets hit, a 22 percent decrease in the length of development time and a 7 percent decrease in the total cost of software ownership over 12 months [7].

ANSYS Workbench is a single platform that unifies proven simulation technology, legacy tools and custom workflows to help companies transform their leading design concepts into innovative products. There are three key components that uniquely position ANSYS Workbench platform to extend the benefits of simulation to the full product lifecycle, from product ideation to product operations and maintenance:

Complete virtual prototypes: The ANSYS Workbench platform offers best-in-class, high-fidelity simulation across all disciplines, with a complete set of application-specific design and analysis tools to simulate the behavior of products in their actual working environments. While the use of smart chips and sensors capable of sensing and sharing information have greatly improved energy efficiency of present-day products, these intelligent systems have become increasingly complex because of more mechatronics, embedded software and sophisticated controls that mandate their close monitoring. The Workbench platform combines the latest advances in computer science with big data generated in real time to analyze "digital twins" of products while in-use. This enables timely detection of maintenance problems thereby reducing machine downtime and operational costs.

Scalable Solutions: Engineering enterprises continue to grow and leverage their distributed teams, and develop and share best practices to deliver breakthrough energy-efficient technologies. While this increases an enterprise's competitive advantage, it also increases process complexity. The Workbench environment offers collaborative services to manage such complexity by addressing the needs of multiple engineering teams located at multiple sites across the enterprise by connecting multitude of tools, enabling integration of engineering data and improving benefits from IT investments through effective IT governance. Workbench simulation solutions are carefully engineered to adapt to your IT infrastructure from desktop to cloud promising flexible and secure solutions to meet your enterprise's changing needs.

Extensible Ecosystem: The defining characteristic of the Workbench platform is its open framework, which enables experts to create customized workflows or download tested and ready-to-use "Apps" from ANSYS App store for wide adoption by non-expert users driving use of simulation throughout the product design process. This results in faster development and more reliable products than before. A vital additional benefit of the ANSYS open platform is access to an extensive network of ANSYS partners and software vendors, which accelerates development of world-class products and services.

To understand how simulation can help you pursue breakthrough energy innovation with ambition and urgency, ANSYS has developed a framework within which you can explore how simulation is used from the component to the system level in each of the five key application areas of advanced electrification, machine and fuel efficiency, aerodynamic design, effective lightweighting and thermal optimization. We encourage you to lean more by visiting ansys.com/energy.

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