SIEMENS

ENERGY AND UTILITIES

Siemens Energy

Leveraging model-based definition to accelerate adoption of a comprehensive digital twin

Products

NX, Teamcenter, Simcenter

Business challenges

Design and manufacture equipment to facilitate energy transition

Meet demanding manufacturability requirements

Maintain leadership position in competitive industry

Keys to success

Use NX for all design work

Employ model-based definition using PMI rule generation

Automate form tolerance definition for manufacturing

Re-use NX models in quality assurance

Results

Accelerated adoption of comprehensive digital twin

Enabled power companies to push energy turnaround and sustainability

Eliminated drawings from all product definition processes

Raised machine tool OEE from 65 to 85 percent, an increase of 31 percent

Reduced part machining time by 25 to 36 percent

Achieved nearly 26 percent CAx cost reduction

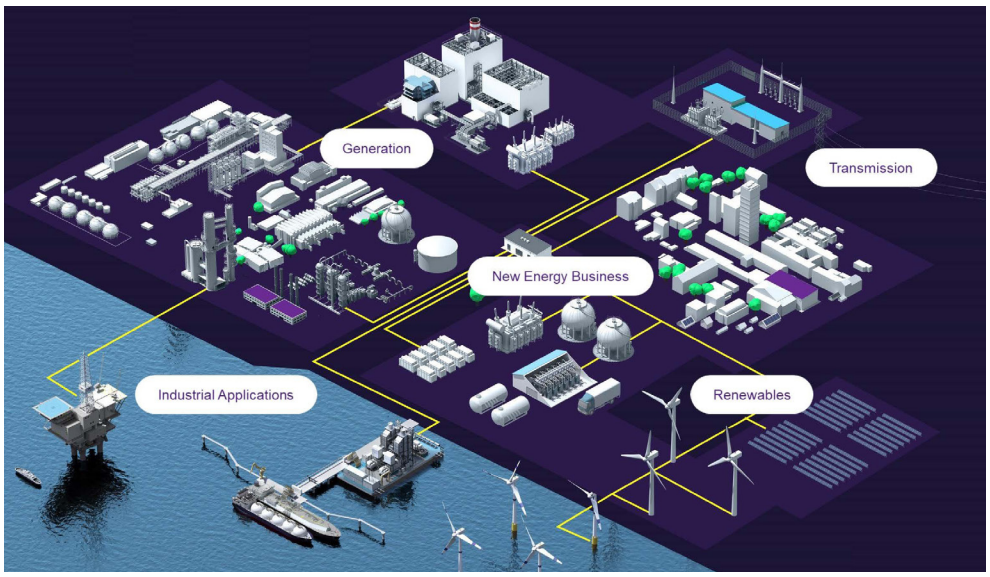
Siemens Energy uses NX, Teamcenter and Simcenter to help power companies push energy turnaround and sustainability

Leading the energy transformation

Using sustainable energy sources for electrification is considered a key factor in the world's efforts to harness global warming. While 770 million people were living without access to electricity in 2021, terminating the direct use of fossil energy for mobility/transport, heating and industrial production will result in a 50 percent increase in global electricity generation by 2040. Meeting the growing demand for electricity while protecting this planet's climate poses a formidable challenge for governments and power companies alike.

Making possible the energy transition to sustainability requires innovative solutions supporting decarbonization, grid stability and electrification. Siemens Energy AG is one of the world's leading energy technology companies, supplying a wide range of products, services and solutions. These include a broad portfolio of products, solutions and services for central and distributed electricity generation, hydrogen electrolysis and e-fuels refining, energy transmission and distribution as well as industrial applications.

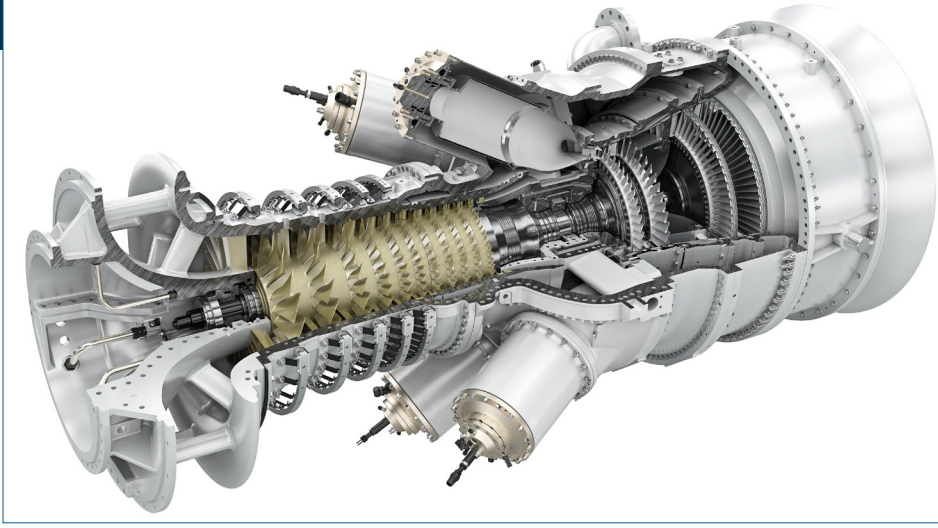
Siemens Energy is a major driver in transitioning to decarbonizing energy supplies. For example, the company designed and built cutting-edge gas turbine packages for combined heat and power plants ready to operate on various fuels. Initially fired with natural



Siemens Energy supplies a broad portfolio of products, solutions and services for central and distributed electricity generation, hydrogen electrolysis and e-fuels refining, energy transmission and distribution as well as industrial applications.

"Automatically creating dimension-driven form tolerances and surface properties led to design optimizations ensuring manufacturability and a favorable cost-to-performance ratio of the products. It also provided information directly usable in other areas such as quality assurance."

Falk Elsner
Model Based Manufacturing
Siemens Energy



The Siemens Energy portfolio includes gas and steam turbines fired with natural gas that can be converted to the combustion of green hydrogen produced by electrolysis using wind or solar energy. This will permit CO_2-free and climate-neutral plant operation.

gas, they can be converted to the combustion of green hydrogen produced by electrolysis using wind or solar energy. This will permit carbon dioxide (CO_2) free and climate-neutral plant operation.

Designing for a sustainable future

Siemens Energy designs, manufactures and supports products at numerous locations across several continents. It develops gas and steam turbines as well as process compressors in Germany, Sweden and the U.S.

Siemens Energy engineers use a variety of software from the Xcelerator portfolio, the comprehensive and integrated portfolio of software and services from Siemens Digital Industries Software. These include NX™ software for computer-aided design (CAD) and computer-aided manufacturing (CAM), Simcenter™ software for structural as well as computational fluid dynamics (CFD) simulation and the Teamcenter® portfolio for product lifecycle management (PLM).

Using these software products, Siemens Energy creates a comprehensive digital twin for an increasing number of products they make and draws a digital thread along its entire lifecycle, from ideation and manufacturing to its service life. Using these tools helped Siemens Energy raise machine tool overall equipment efficiency (OEE) from 65 to 85 percent, a 31 percent increase; reduce part machining time by 25 to 36 percent and achieve nearly 26 percent in computer-aided everything (CAx) cost reduction.

"NX Model Based Definition allows us to store, share and re-use every aspect resulting from the engineering process."

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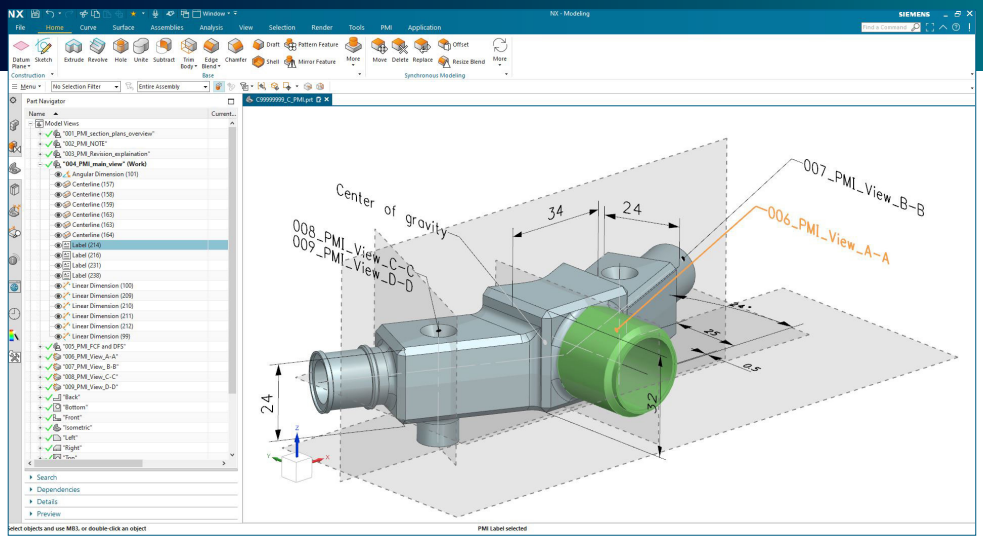


Siemens Energy turned to NX Model Based Definition using product manufacturing information embedded in the 3D models of components and assemblies rather than annotating 2D drawings.

"Using the PMIs embedded in the 3D models in the CAM process also yielded up to 26 percent CAx savings and increased the overall equipment efficiency of machine tools from 65 to 85 percent."

Falk Elsner
Model Based Manufacturing
Siemens Energy

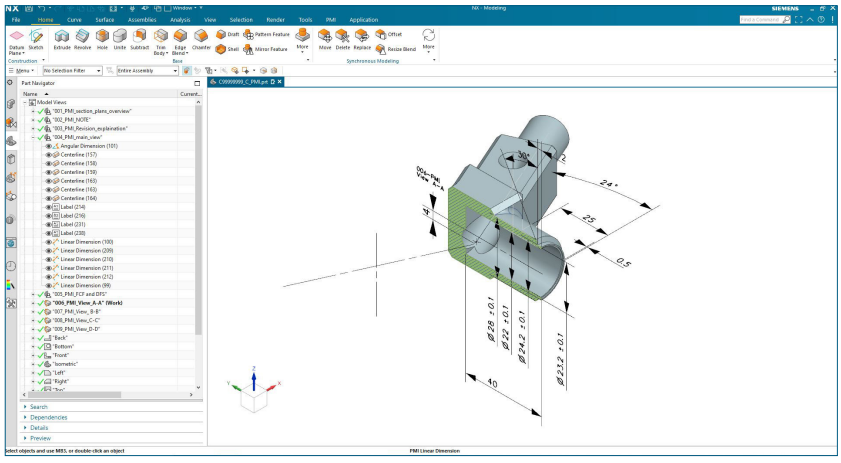
Siemens Energy pursues different approaches to the engineering process chain of its various product lines. They use the engineer-to-order (ETO) approach for smaller steam turbines, and the configured-to-order (CTO) for high-power gas and steam turbines. This also results in different ways to handle engineering bill-of-materials (EBOM). Some use the "single" approach, with a complete design unequivocally represented by a BOM. In the "double" approach, a part, assembly or complete product is represented by a number BOMs representing variants and configurations.

Concise and consistent manufacturing information

Siemens Energy uses manufacturing technologies including additive manufacturing (AM). However, the vast majority of components are machined using various machine tools. In addition to the 3D models of the components, manufacturing requires additional geometric information. This includes tolerances for form, orientation, location and run-out as well as surface finishing.

Traditionally, this information has been incorporated into 2D drawings that have been provided to manufacturers in addition to 3D models. "Although manufacturers are familiar with this well-established procedure, the need to separately handle a 3D model and a drawing contradicts our digitalization efforts," says Falk Elsner, head of model-based manufacturing for Siemens Energy. "We aim to provide manufacturing with comprehensive and consistent digital information all in one place."

During a conversion project for a particular type of compressor, Siemens Energy design and manufacturing engineers turned to using product manufacturing information (PMI) embedded in the 3D models of components and assemblies. These attributes included geometric dimensions and tolerances, 3D annotation (text) and dimensions, surface



The automatically created PMIs lock on to the boundary representation geometry of the 3D model to form a comprehensive GPS. The result can be exported in JT or STEP file formats for easy utilization in manufacturing, quality assurance or other downstream activities.

finish and material specifications. They used them to convey nongeometric attributes required for manufacturing as part of the 3D models created using NX and Teamcenter. Their aim was to eliminate 2D drawings altogether.

Using PMI to replace drawings

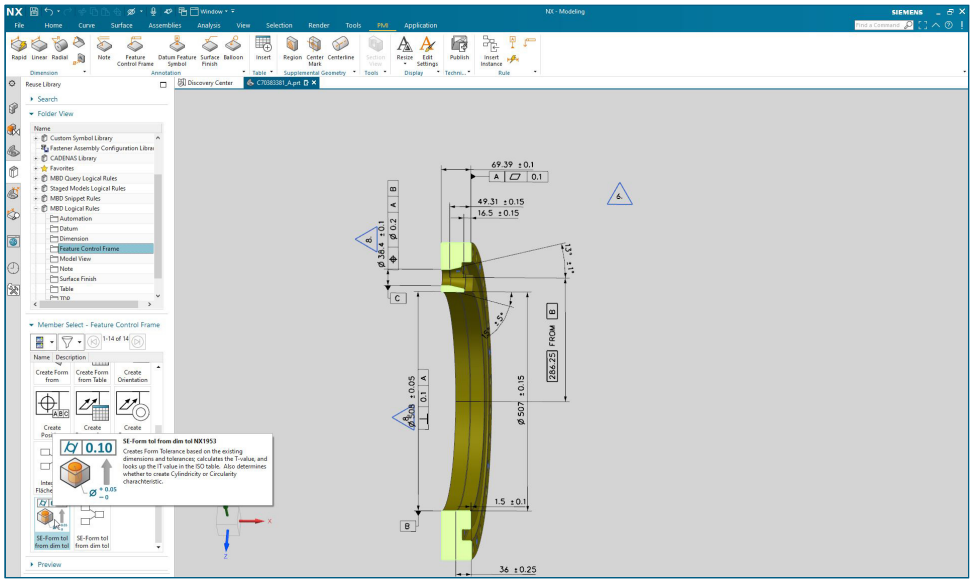
"In our initial effort to use PMIs to replace drawings, we found that the cost exceeded the benefit," Elsner recalls. This was mainly because the engineers had used PMI to directly replace former drawing features. "We learned that to unleash the benefits of using PMIs, we needed to change our product definition approach."

Still aiming to replace drawings with 3D models augmented with PMIs, Siemens Energy conducted a survey among users across the design and manufacturing departments as well as external contractors. Among other things, this revealed a strong desire to use PMIs within the framework of NX CAM. Using them in conjunction with feature-based machining (FBM) yields a considerable potential to reduce complexity, accelerate code generation and improve numeric control (NC) program quality. Another one of these was a PLM-integrated release strategy for products and product derivatives.

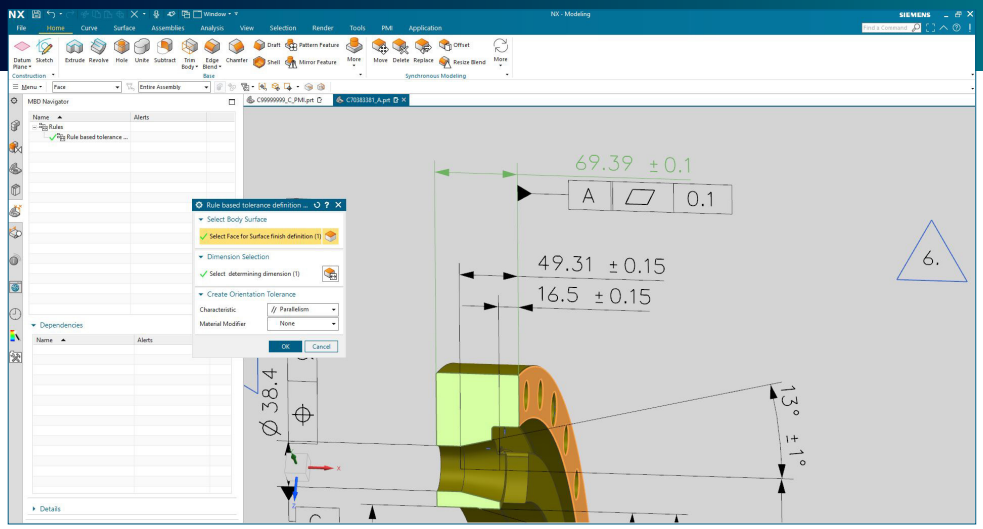
At the time, not all these requirements had been implemented in NX so Siemens Energy contacted Siemens Digital Industries Software. As a result, the scope of this software's PMI functionalities has been greatly extended. Current versions come with best-in-class comprehensive PMI capabilities.

Dimension-driven form tolerances

Turning to model-based design (MBD) to achieve a comprehensive digital twin was a key step in Siemens Energy's digitalization transformation. The aim was to eliminate copy-and-paste operations in the product definition phase of large parts and assemblies, which often comes with an unnecessarily strict specification of form tolerances and surface quality definitions. A prerequisite for this was introducing geometric product specification (GPS) in compliance with International Organization



The comprehensive MBD capabilities centering around automatic, rule-based PMI creation for GPS within NX allows companies to define, store and manage their own rules and standards using a built-in logic editor in a library.



Siemens Energy raised the overall equipment efficiency of machine tools from 65 to 85 percent by formulating parameters that were then implemented automatically upon selection from the library, eliminating copy-and-paste.

for Standardization (ISO) 14405. This replaces the envelope principle in tolerancing by the independence principle.

A German standard that is no longer used describes mathematical correlations between dimensional tolerances and form tolerances such as roundness, cylindricity, flatness and parallelism for plane-parallel surfaces. Siemens Energy used this correlation to implement a rule-based, automatic shape tolerance creation. This ensures the automatic definition of the largest possible shape tolerance or directional tolerance for parallelism. Siemens Energy engineers also used similar mechanisms to automatically derive and define surface quality requirements. These measures ensure optimum correlation between component size, tolerances and surface properties without requiring intervention by the designers.

“Automatically creating dimension-driven form tolerances and surface properties led to design optimizations, ensuring manufacturability and a favorable cost-to-performance ratio of the products,” Elsner confirms. “It also provided information directly usable in other areas such as quality assurance.”

Paperless product definition

Using the comprehensive MBD capabilities centering around automatic, rule-based PMI creation for GPS within NX, Siemens Energy eliminated drawings from its product definition processes. “It allows us to define, store and manage our own rules and standards using a built-in logic editor in a library,” Elsner points out. “NX helped us eliminate copy-and-paste by formulating parameters that are then implemented automatically.”

The automatically created PMIs lock on to the boundary representation (BREP) geometry of the 3D model to form a comprehensive GPS. The result can be exported in the JT™ data format or STEP file formats for easy utilization in manufacturing, quality assurance or other downstream activities. As using PMIs is not common practice among internal or external part manufacturers, Siemens Energy invested in supplier training to improve acceptance among contractors.

Solutions/Services

NX CAM
siemens.com/nxcam

Teamcenter
siemens.com/teamcenter

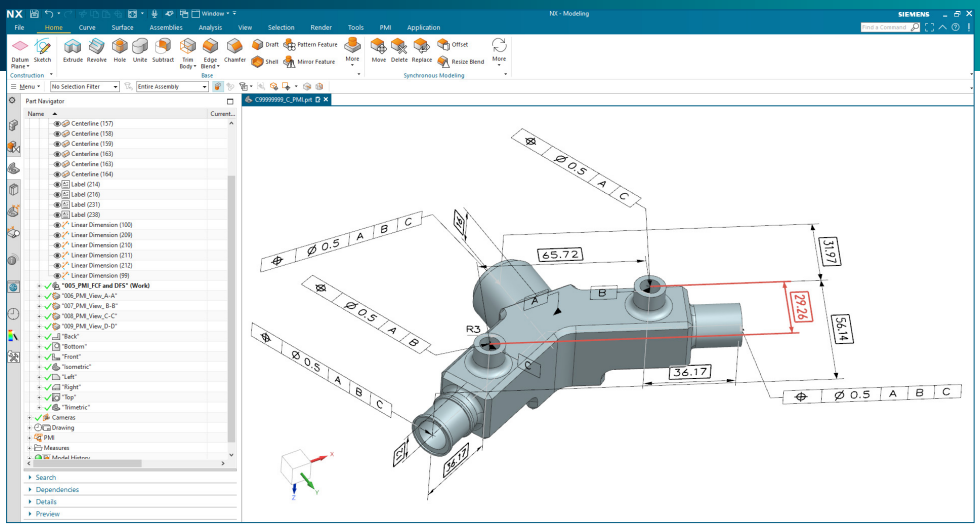
Simcenter STAR-CCM+
siemens.com/simcenterccm

Customer's primary business

Siemens Energy AG is a leading manufacturer of electricity generation, transmission and storage equipment. Based in Germany, it has 91,000 employees, annual revenues of €28.5 billion (FY 2021) and operates in more than 90 countries. One-sixth of the global electricity generation is based on Siemens Energy technology.
www.siemens-energy.com

Customer location

Munich
Germany



Program creation was accelerated by using NX in the CAM process to embed PMIs in the 3D models.

Creating a rule-defined PMI relieved Siemens Energy design engineers of unpopular and nonvalue-added tasks such as drawing annotations. When that was not possible, it shifted these activities from bureaucratic extra work to part of the natural flow.

"NX Model Based Definition allows us to store, share and re-use every aspect resulting from the engineering process," says Elsner.

Although GPS rule definition for automatic PMI creation takes as long as traditional methods, it helps eliminate errors and eases reacting to normative changes. "Using the PMIs embedded in the 3D models in the CAM process also yielded nearly 26 percent CAx savings and raised the overall equipment efficiency of machine tools from 65 to 85 percent."

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