Siemens Engineering Excellence & Design

Think tank for disruptive engineering methods and energy enterprise solutions
The industry faces various challenges, we bring in technological expertise, skilled labor and experience

Trends & Challenges

**TRENDS**
- Globalization
- Decarbonization
- Digitalization

**CHALLENGES**
- Sustainability
- Speed
- Technical Complexity
- Cost
- Skilled Labor
We are a trusted partner for our customers and support to outperform the industry standard

SEED in brief

Customer Focus
Value Orientation
Adaptability
Team

Power of People
Value Creation
Equipment
Network

WHAT

Consulting Services
• value orientation
• co-creation
• transformation
• economic analysis

Technology as a Service
• probabilistic analytics
• material engineering
• energy enterprise solutions
• additive manufacturing
• testing
• ...

VALUE

• Access to competencies
• Reduced cost ("flex loading")
• Provide access to broad network
• Benefit from our experience

• Access to
• Reduced cost
• Provide access to
• Benefit from our
test...
SEED offers network & global presence, technology & equipment and people & competence to co-create customer value

Customer value creation

**Our Competence**

For Your Value!

**Globalization**

Global Presence

14 locations

covering Europe, Americas, Asia

Regional Experts

understanding regional differences

Network

> 25 partners

with academia and companies

**Technical Complexity**

Digital Transformation

- probabilistic analytics
- IoT, 'big / smart data'
- 90+% connected products at GP

Design & Material Complexity

- new materials, sourcing
- >1,000 materials in database
- design for additive and 3D printing

Energy Enterprise Solutions

- energy as key factor for production
- decarbonization to impact industry

**Skilled Labor**

Experience

over 15 yrs

in probabilistic analytics

Value creation

> €20 mn/a

by increased life

Probabilistic

over 60 HC

for probabilistic analytics

**Network & Presence**

**Technology & Equipment**

**People & Competence**
SEED as a think tank for disruptive engineering methods and energy enterprise solutions

Customer value creation

Interdisciplinary, multi-cultural team and global network to academia and companies in Europe, Americas and Asia

Right tools and capability to identify, prioritize and implement customer use case

Track record of more than 80+ successfully implemented projects in Siemens

Apply digital technologies (Probabilistic Analytics) to turn data into value

Direct access to know-know for disruptive engineering solutions, products and process innovation around the globe

Broad competences & experience in mathematics, physics, materials science, mechanical engineering, data science
We provide a broad range of technology expertise

Technology as a Service

- Probabilistic Analytics
- Energy Enterprise Solutions
- Material Engineering
- Additive Manufacturing
- Testing
- Design Tools & Simulation
- Advanced Controls
- Plant Diagnostic & Data Management
- Sensors
- Power-to-X / Sector Coupling
- Energy Storage
- ...
Stepwise approach to co-create customer solution and to generate value

Customer co-creation

0. Problem Statement

Understand Problem
- Understand customer problem
- Challenge understanding
- Define stakeholders
- Clarify target

1. Research & Co-Define

Understand & Generate Insights
- Jointly look at information/data to better understand problem
- Research of similar problem (input of Siemens experience)
- Co-define next steps: workshop, team, project setup

2. Co-Creation

Generate Ideas & Develop Concepts
- Challenge definition
- Connect with similar solutions
- Perform co-creation session
- Collectively create solutions (minimum viable product)

3. Prototyping / Pilot

Prototype Concepts & Refine, Iterate
- Identify / create pilot
- Test minimum viable product
- Refine & iterate
- Define roadmap for implementation
Probabilistic analytics turns data into value by combining engineering, data science and computational modelling

Probabilistic analytics

Pro • ba • bi • li • stic
= related to probability

A • na • ly • tics
= art of analysis

Target
turn data into value
by predictive analytics and data science

Engineering + Data Science + Computational Modelling

Single value

Probabilistic

Fully quantified risks!
Probabilistic solutions are able to tackle the challenge to turn all data into useful business insights by customer co-creation.

Customer co-creation

### Data Collection
- Identify information needs, source and system interfaces
- Provide transparency about available data and data infrastructure
- Define and collect relevant data for analysis

### Data Assessment
- Check data quality and completeness
- Consider lack of knowledge
- Structure and assess relevant data (e.g. geometries)
- Analyze influence of data

### Modelling, Coding, Simulation
- Apply mathematical models and “domain models” (e.g. physical and logistic models)
- Consider field data
- Combine with methods of stochastics to quantify the underlying risks

### Evaluation & Decision-Making
- Interpret modelling results
- Derive possible improvement levers (e.g. characteristics of the product, material used, service concept)
- Recommend options for decision-taking & report
Probabilistic approach allows for improved risk assessment

Deterministic vs. probabilistic design

**Deterministic Approach**

- Uncertainties taken into account via *safety margins*
- Minimum life
- Average life
- Safety margin

**Probabilistic Approach**

- Consider uncertainties *explicitly*
- "Optimization problem"
- Probability of failure
- Time in service
- Conservative
- Non-conservative

---

No information about risk / reliabilities available

Single value

Identify design margins

Improve service concepts

Calibrate models based on field data
Probabilistic analytics – Turning all data into value

Data Assessment
- Temperatures, Geometries, Material Parameters

Modelling, Coding, Simulation

Evaluation, Decision-making
- Deterministic: single value, risk not quantified
- Probabilistic: + optimize design margins
  + improve service concepts
  + model calibration w/ field data
Probabilistic activities across the full value chain drive business value and sustainable utilization of natural resources

Probabilistic analytics

- fatigue (LCF, TMF)
- fracture mechanics
- structural dynamics (HCF)
- creep, oxidation, coating systems
- material properties
- service life extensions (e.g. rotor disks)

Lifting

- testing plans
- specifications and tolerance settings
- robust design (aero and mechanical)
- system optimization (power plant)
- statistical bid optimization
- business models and flexible pricing

Optimization

- functional safety
- field experience (operation and service)
- contingency calculation for field issues
- manufacturing deviations

Risk Modelling

Sustainable utilization

Add’l customer value

Cost savings

Engineering + Data Science + Computational Modelling
Probabilistic analytics @ Siemens: Proven track record since 2005

Competencies
of the probabilistic team

Global Network
with external and internal partners

Experiences
within power generation

Gas turbines
e.g. fatigue and fracture, materials, aero dynamic

Steam turbines
e.g. rotor and casing life, rotor dynamics

Generators
e.g. rotor lifting, geometry optimization, bidding

Power Plants
e.g. pipings, transformers, operational data

Coding / Scripting
Mathematical modelling
Simulation
High Performance Computing
Optimization
Data Science

Allianz
Center for Technology
Fraunhofer
IWM

SwRI
KIT

Technische Universität Darmstadt
Berufsakademie Wuppertal
Material engineering

Material = the matter from which a thing is or can be made

Engineering = branch of science and technology concerned with the design, building, and use of engines, machines, and structures

Target
Cost reduction while maintaining high quality

Engineering + Material Science + Material Test Labs
Material engineering ensures quality in supply chain management and manufacturing

Material engineering

**Concept**
- optimize material selection
- optimize material data generation
- perform failure analysis
- develop materials for product applications
- manufacturing support

**Application**
- gas and steam turbines
- generators
- plant components

**Network**
- Siemens Corporate Technology
- universities
- suppliers

**Competencies**
- material engineering
- design data
- failure analysis
- modelling
- material substitution
- know-how
- base materials
- joining
- coatings
- corrosion & oxidation
- non-destructive examination
- testing & investigation
- test concept
- mobile tests (e.g. small punch)
- in-house labs
SEED boosts savings through technical optimization by its broad competence

Customer offering – Examples

Potential Analysis

- Siemens Engineering Excellence & Design (SEED) combines Siemens inhouse knowledge and capabilities, a broad network and more than 3,000 R&D experts & engineers.
- To boost savings in technical optimization projects for industrial clients.

Analytics
- Expert Workshops
- Metallography
- Electron Microscopy Scan
- Economic Assessment
- Optical Microscopy
- Expert Workshops

Design
- Probabilistic Analytics
  - 3D Component Design & Printing
  - Advanced CAx
- Probabilistic- Compatible Property
  - Material Testing
- Additive Manufacturing
  - Residual Stress Measure

Selection
- Behavior Prediction
- Corrosion Resistance
- Material Substitute
  - Database
- Coating, Combustion
  - Minimal Specification

Productization
- Mechanical Properties
- Engineering Capacity
  - Hardness, Strength, Wear...
- Failure Analysis

Implementation

Savings Potential

Improved Design

Optimal Material

Fast Implementation
Technical and commercial optimization paves the way to an enhanced use of materials and maximized cost efficiency

Materials engineering

### Challenge
- **Availability**
  - Standards (ISO, ASTM, China etc.), alternative materials
- **Quality**
  - Deviation of chem. composition, mech. properties or production routes
- **Customer requirements**
  - Ensure required properties, minimize specification

### Solution
- **Database**
  - More than 1,000 materials available
- **Material testing and evaluation**
  - Internal and external labs
- **Global network**
  - Expert knowledge and many years of experience in materials engineering and testing

### Benefit
- **Cost reduction**
  - Global sourcing of required quality
- **Efficient production**
  - Higher design flexibility and cost efficient choice of materials and supplier base
Cost reduction for component of 66% realized

Material engineering

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Solution</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>High temperature</td>
<td><strong>Base material</strong> High Cr-steel provides adequate mechanical properties but insufficient oxidation resistance at given temperature range</td>
<td><strong>Cost Reduction</strong> Smart and efficient choice of base material and coating</td>
</tr>
<tr>
<td>Ni-base material</td>
<td><strong>Protection Measure</strong> PVD coating (6 µm thickness) provides efficient oxidation protection and allows Cr-steel to withstand high temperatures</td>
<td><strong>Efficient Production</strong> Higher design flexibility, efficient manufacturing processes</td>
</tr>
<tr>
<td>high temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>product costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>manufacturing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>solid particle erosion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coated Cr-steel instead of Ni-base alloy</td>
<td><strong>Coated Cr-steel instead of Ni-base alloy</strong></td>
<td></td>
</tr>
</tbody>
</table>
Material engineering to optimize material e.g. regarding cost, properties, sourcing, conformity to standards

Material engineering

Challenge in the field of material
- availability
- supplier
- material qualification
- production process
- sourcing issue
- standards
- design requirements
- manufacturing requirements

Material engineering process
- experience & know how
- databases, rules & standards

Material evaluation
- experience/know how
- check database & standards

Optimization & testing
- if no standard available
- if add’l data required

Improved material / process specified
- ~1,000 materials
- ~1,400 processes

Benefit
- adapted or new material
- availability
- ability to source
- conformity to standards
- global sourcing
- supplier qualification
- cost reduction

- global network
- testing option
- supplier qualification