Siemens generators are characterized by a long service life; in many power plants they have been in successful operation over several decades. However, the life of a generator is subject to normal ageing processes which manifest themselves differently depending on the generator model and its operating mode. For example, the insulation used in the rotor can exhibit pronounced signs of ageing on reaching its calculated service life due to thermal, mechanical and electrical stresses.

Global energy markets are also in a state of flux. The fraction of electric power from renewable energy sources is increasing in many locations. Conventional power plants are still needed to ensure a stable power supply. However, these must react to current conditions with more flexible operating modes. The technical requirements for the generator can thus also change over time.

Our solution
Rewinding your generator rotor can help increase the availability of your plant and enable adaptation to current market requirements. This can serve a variety of purposes:

• Rotor rewinding reestablishes the original condition of the generator rotor insulation following age-induced wear, thus lengthening service life.
• Your generator can also be adapted to new, more flexible operating modes and the associated technical requirements. This especially includes changes in operating modes with many startups and shutdowns, frequent turning gear operation in standby mode and fast load changes in the part load range, which stress the individual generator components to a considerably greater degree than previously and can result in accelerated ageing and unscheduled outages if such adaptations are not made.

• Furthermore, product or design changes can be implemented in the course of a rewind in order to account for new requirements such as uprating, more start/stop cycles or an improvement of previous characteristics.

We offer four concepts for rotor rewinding which are described in further detail below.

We also offer various scenarios for implementing a rewind as the objective of any modification is to keep standstill times and the resulting lost output as low as possible. For example, considerable time savings can be achieved with a rotor provided by Siemens at the time of the overhaul (see "Implementation scenarios").
Rewind concepts

A rotor rewind always involves the re-placement of the winding, including the entire winding insulation and spacers, thus resetting the "service life clock" for the insulation system. Either new or refurbished copper can be used. The preferable option depends on the planned operating mode, the available time window and budget, and the generator model. In both cases, as a minimum F-class materials are used in the insulation system. These materials are designed for higher temperatures and are more durable than those of the original design.

Every rewind also includes nondestructive testing after removal of the winding, electrical tests during fabrication and in the rotating condition, reassembly as well as balancing and overspeed testing.

In addition to the visual inspection, the quality of the brazed joints in the winding (depending on the design) is verified by a newly developed ultrasonic test method if required.

Over the course of the rewind, you can also benefit from the implementation of improved design features, depending on the requirements, the generator model, fact-finding inspection results and the history of the generator rotor. For example:

- Reinsulated J-straps with improved geometry
- Modified retaining ring shrink fit
- Improved pole crossover geometry
- Improved end winding design
- Use of inner-cooled transverse conductors in the rotor end winding

We offer four basic concepts for rotor rewinding. In addition to a standard rewind, you can select variants optimized with regards to cost, time or minimized risks. The following concepts are available depending on your requirements:

**Standard rewind**

The standard concept entails rewinding of the rotor with new copper coils as well as modernization by the implementation of an improved insulation system and of design changes (see figure 1).

**Re-insulation**

In this cost-optimized variant, the existing copper coils are refurbished and the insulation system is replaced. Additional modernization measures are optional. This variant is comparatively more time-intensive due to the refurbishment of the existing copper coils.

**Fast Rotor Rewind**

Siemens offers a time-optimized solution with the Fast Rotor Rewind. The shortest possible processing times of only around thirty days for rewinding enable the prevention of additional outage periods and associated lost output for the power plant. This is possible thanks to maximum utilization of manufacturing capacities and optimized processes with regard to planning, material procurement and fabrication. The overall standstill period can be reduced by up to ten weeks (not including transport times) compared with a standard rewind.

Possible design improvements are shown in figure 1. However, the actual scope of services which can be implemented within the time window provided by the customer must be reviewed individually for each case based on the generator model.

**Rewind including requalification**

This risk-minimized variant includes rewinding of the rotor with new copper coils and is characterized by extensive modernization measures. The scope of supply includes all of the available design improvements as a standard (see figure 1).

Special emphasis is placed here on requalification of the rotor by means of additional nondestructive testing using the most advanced ultrasonic and eddy current test methods. Rotor testing in the rotating condition is performed in the balancing and overspeed facility at an elevated overspeed of 120%, and additional electrical tests are performed (e.g. also before disassembly).

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**Fig. 1: Example scope of the four rewind concepts**

<table>
<thead>
<tr>
<th>Standard rewind</th>
<th>Re-insulation</th>
<th>Fast Rotor Rewind</th>
<th>Rewind incl. requalification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incoming inspection</td>
<td>with checklist</td>
<td>with checklist</td>
<td>reduced checklist</td>
</tr>
<tr>
<td>Rewind with ...</td>
<td>... new coils</td>
<td>... refurbished coils</td>
<td>... new coils</td>
</tr>
<tr>
<td>Improved J-strap design</td>
<td>✓</td>
<td>optional</td>
<td>✓</td>
</tr>
<tr>
<td>Modified retaining ring shrink fit</td>
<td>optional</td>
<td>optional</td>
<td>optional</td>
</tr>
<tr>
<td>Improved pole crossover geometry</td>
<td>✓</td>
<td>optional</td>
<td>✓</td>
</tr>
<tr>
<td>Nondestructive testing</td>
<td>Magnetic-particle/ dye-penetrant testing</td>
<td>Magnetic-particle/ dye-penetrant testing</td>
<td>Magnetic-particle/ dye-penetrant testing</td>
</tr>
<tr>
<td>Balancing and overspeed test</td>
<td>Balancing &amp; 110% overspeed test</td>
<td>Balancing &amp; 110% overspeed test</td>
<td>Balancing &amp; 110% overspeed test</td>
</tr>
<tr>
<td>Electrical tests</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
Implementation scenarios

Depending on the selected concept and the generator model, the performance of a conventional rotor rewind for which the original rotor is shipped to and rewound at the Siemens workshop usually takes around fourteen weeks (approx. four weeks for a Fast Rotor Rewind) starting from the arrival at the Siemens shop. For the overall time required, the duration of rotor removal and reinstallation as well as the time required for transport from the power plant to the Siemens workshop and back must also be taken into account.

This scenario is therefore suitable for customers who can accept the associated standstill times, have short transport times due to their proximity to the Siemens plant or are focused only on re-insulation of the rotor (see figure 2).

However, if the shortest possible standstill times are desired, it is expedient to acquire a rotor provided by Siemens at the start of the overhaul which can be installed immediately after removal of the original rotor. This eliminates extended standstill times due to transport as well as refurbishment of the existing rotor and any additional work associated with any findings that may be made.

The following scenarios are possible in this context:

**Use of a newly fabricated rotor**

In this case you receive a newly fabricated rotor which is supplied directly to the power plant. This scenario has the lowest risk with the shortest possible standstill period, as the new rotor is available immediately after removal of the old rotor (see figure 3). The removed rotor could also be refurbished by rewinding and would then be optionally available to you for future use in the power plant as a flexible spare rotor.

We can offer a long-term storage and transport container for protected storage of this rewound replacement rotor on the premises of the power plant.

This scenario is especially interesting for customers with several generators of the same model and/or very high demands on the availability of their systems. The higher cost for the acquisition of a new rotor quickly pays off through maximum availability and, if the optional spare rotor is selected, through increased flexibility in the event of a fault.

**Use of a rewound, requalified rotor (“seed rotor”)**

In this scenario, you receive a rewound and completely requalified rotor in exchange for your previous rotor at the start of the overhaul (see figure 4). In comparison to a new rotor, a requalified rotor is more cost-effective. In addition, with this scenario in comparison to a standard rewind the total duration of an overhaul can also be reduced about one-third. However, prerequisite for this is that a rotor of the same model is available at Siemens.

As an OEM (original equipment manufacturer), we have access to all original drawings, specifications, engineering calculations and manufacturing records for your Siemens generator and can therefore ensure complete electrical and mechanical interchangeability.
Your benefits
No matter what rewind concept you choose, common to all is that the electrical and mechanical integrity of the rotor winding is retained or restored. This extends service life and improves rotor availability and reliability. The risk of unscheduled outages can be reduced.

Rewinding can also serve to adapt the rotor to the new more flexible operating requirements and, depending on the implemented design changes, increase its output capacity.

The implementation scenarios with a rotor provided by Siemens at the start of an overhaul offer the ideal long-term solution for maximum availability of your power plant by minimizing standstill times and implementing state-of-the-art technology. This is possible because transport and processing times at the manufacturing plant are eliminated in both cases.

Our experienced service team is ready to assist you in deciding which solution is the right one for you. With our experts in engineering and those in manufacturing right “next door”, we can plan for every eventuality and thus offer the optimum service for your generator.

References
Within the last 16 years the global Siemens manufacturing network has successfully completed more than 250 rotor rewrings.

A Fast Rotor Rewind was completed for a hydrogen-cooled 153 MVA generator in the impressive time of only 20 days.

Since October 2010, the implementation scenario with a rewound, requalified generator rotor (“seed rotor” concept – see figure 4) has already been successfully implemented eight times.