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Siemens Steam Turbine Generator Packages for Advanced Nuclear Power Plants

Olaf Bernstrauch (Speaker)
Package Frame Owner
Steam Turbine & Generators for NPP

Dietmar Struken
Product Line Marketing Steam Turbines

Dr. Reinhard Kloster
Manager Nuclear ST Platform Development

Wolfgang Menapace
Head of Sales Steam Turbines, Worldwide

Atomexpo Moskau,
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Siemens Steam Turbines and Generators in NPP

Our strength & expertise

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Profound competence in designing & manufacturing Steam Turbines and Generators

- Since 1969 Siemens has built steam turbines and generators for 27 NPP with approx. 30 GW
- Siemens has performed upgrades of steam turbines and generators for 63 nuclear power plants over the last decades
  Example: Borssele improvement of +35 MW achieved in 35 days
- Siemens designed & delivered the steam turbine generator package for the *Olkiluoto 3 project in Finland*.
  EPR / ~1,700 MW class
- 2009 Siemens designs the steam turbine generator packages and delivers major steam turbine parts for the *Yang Jiang project in China*.
  CPR1000 / 6 x 1,100 MW class
- Total fleet >130units with more than 120 GW (incl. Parsons and Westinghouse)

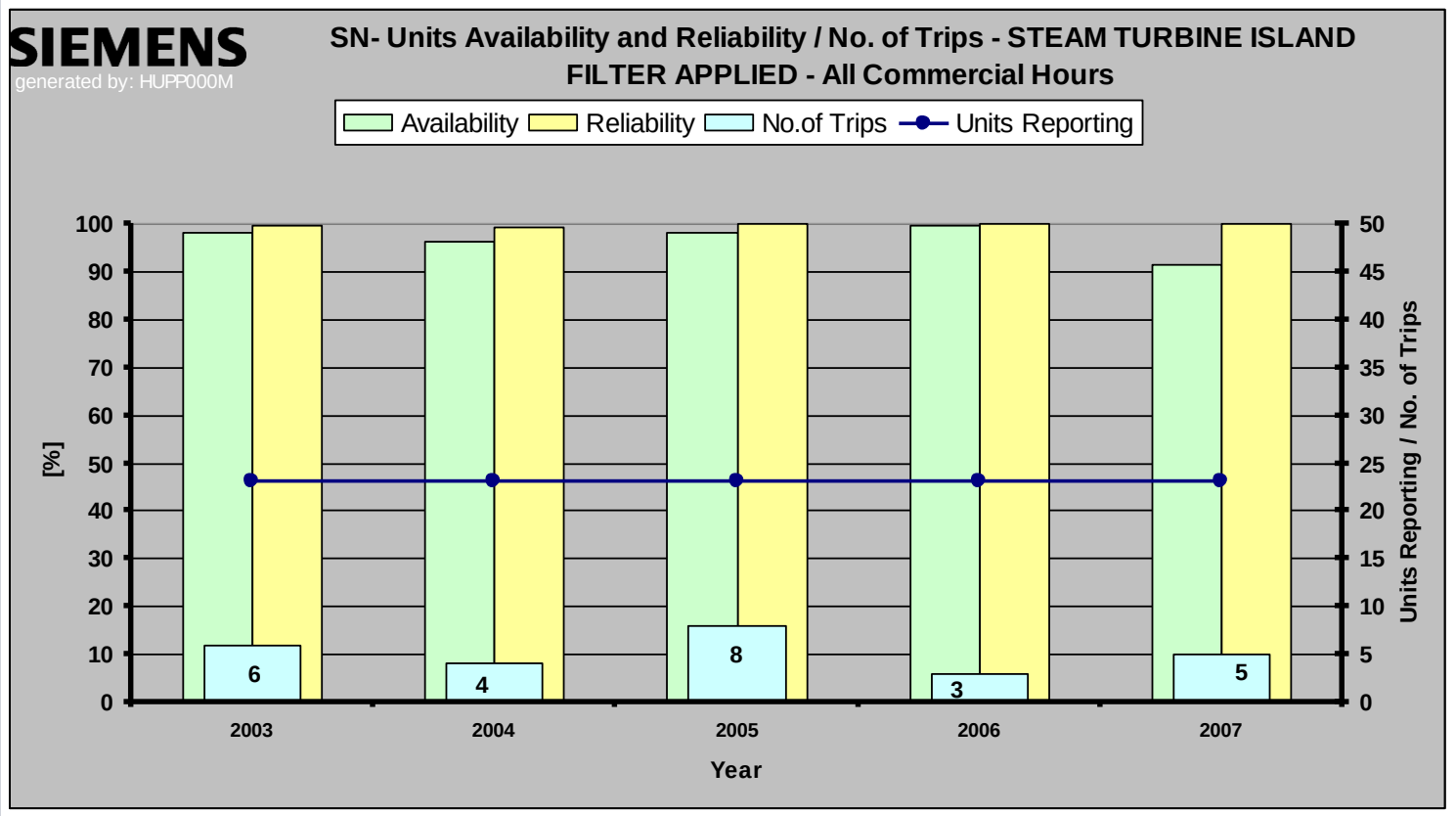
NPP (Reactor type: EPR)

Largest LP rotor (half speed design)

Siemens Steam Turbine and Generator Packages

Availability / Reliability

Outstanding Reliability of more than 99.7 % for Siemens Steam Turbine Generator Packages



Siemens steam turbines and generators for nuclear power plants have been setting global standards in terms availability (>98%), reliability (>99,7%) and service friendliness.

Siemens Steam Turbine and Generator Packages

Modules for 50Hz application

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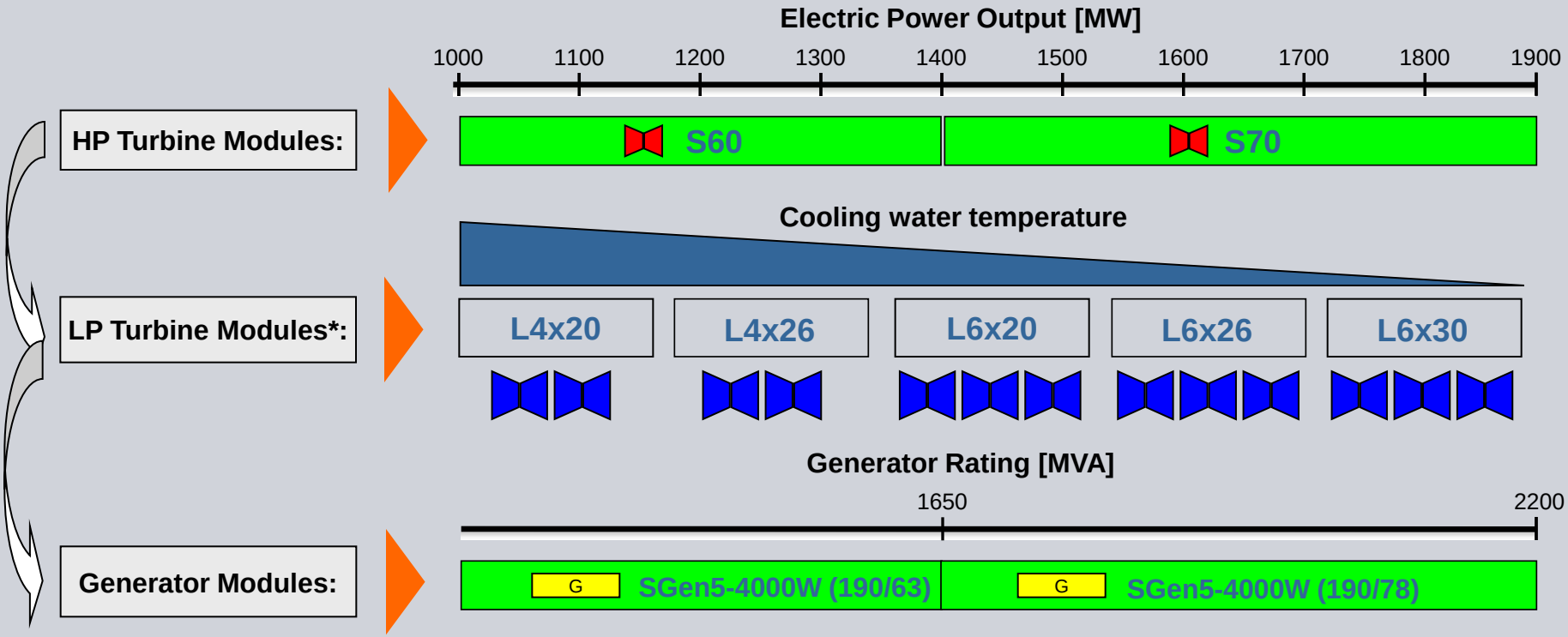
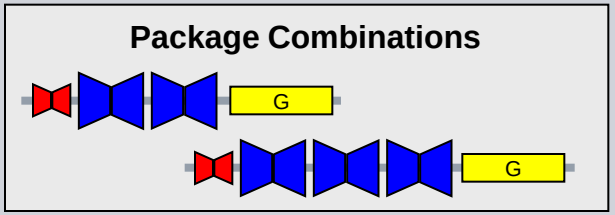
Modular approach allows high flexibility and broad range of application





* Half-speed LP turbine modules are derived from full-speed turbine modules by scaling.

SST-9000 Series Half-Speed HP-Turbine

Features of High Pressure Turbine

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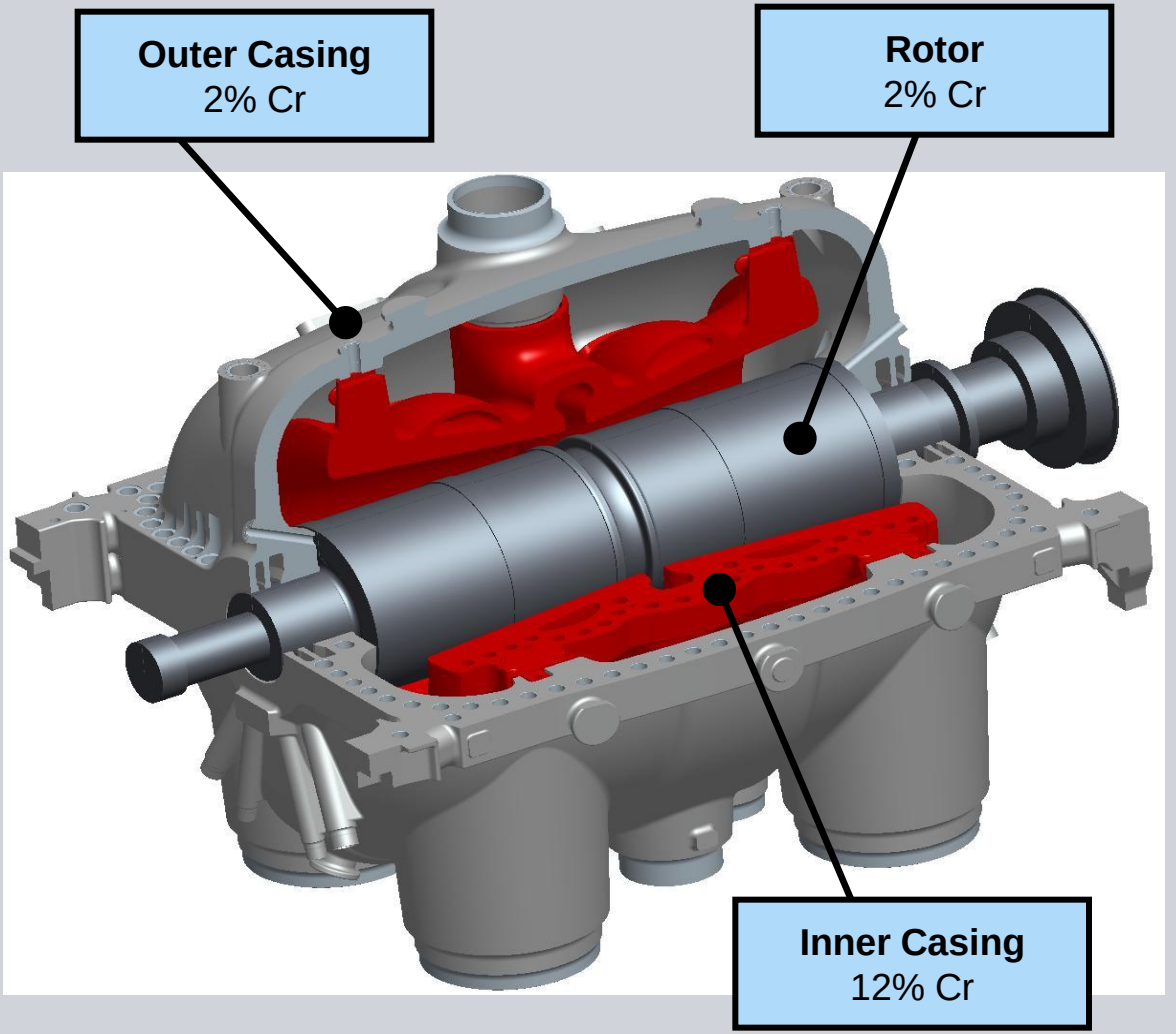
Reliable and high performance design of Siemens nuclear HP turbines

Design Features

- Double shell design with horizontally split inner and outer casing
- Double flow steam path
- Forged mono-block shaft
- High chrome inner casing
- Advanced blade design
- Full arc admission
- Optional diagonal inlet stage

Main Steam Parameters: 75 bar / 290°C



SST-9000 Series Half-Speed LP-Turbine

Design Features / Stress Corrosion Cracking (SCC)

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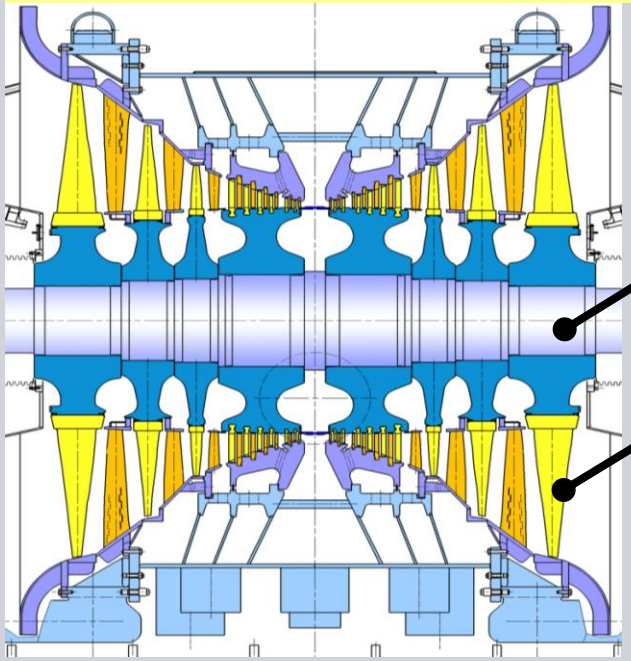
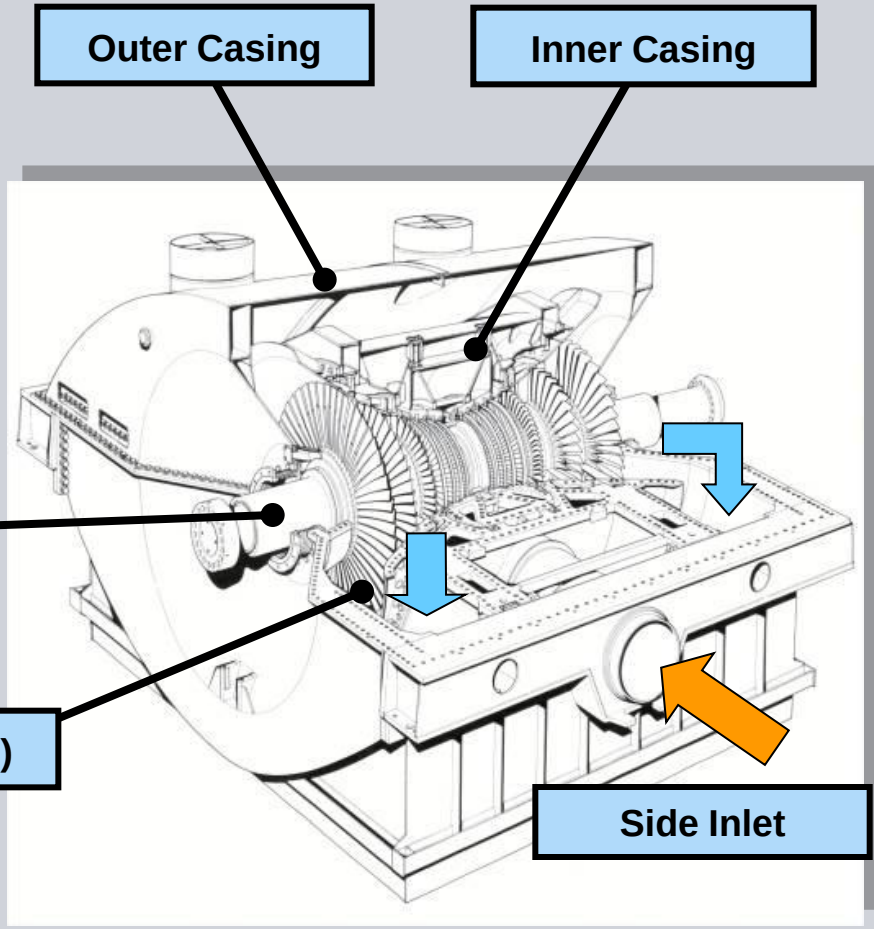
The most proven technology: No replacement of rotors or disks due to SCC

- Double Flow and Double Shell Casing Concept
- Erosion Corrosion Protection
- Advanced 3D Blades (3DV, 3DS)
- LRB Exhaust Area up to 30 m^2 (LRB 1,830 mm)
- Shrunk on Disk Rotor (>2.75 million fleet OH, >40 million disk OH, in operation up to 225,000 OH, >660 disk inspections





Avoidance of Stress Corrosion Cracking

Shrunk-on disk design

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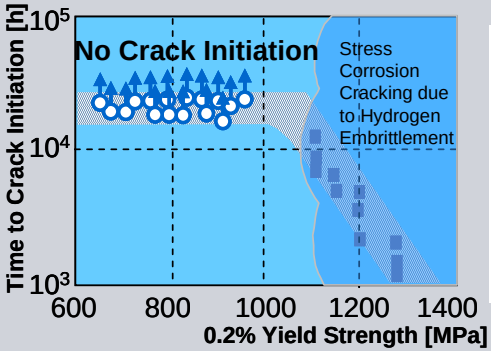
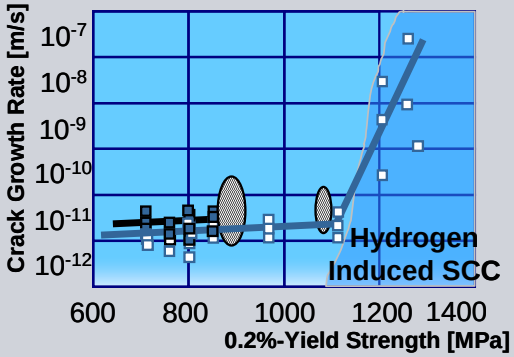
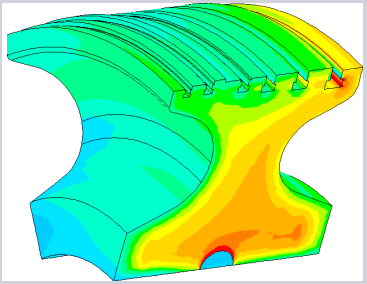
SIEMENS developed the technologies and processes to avoid SCC

Material Know How

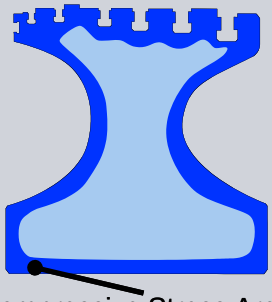




Engineering



Heat Treatment

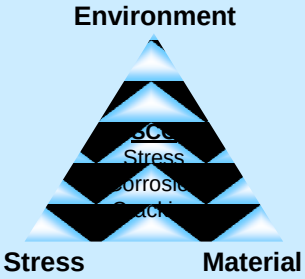


Quality Assurance

Manufacturing

Siemens Measures

- Low Yield Strength Material
- Lower Operating Stresses
- Compressive Residual Stresses
- Lower Stress Concentrations



Alternative half speed LP Rotor Design Concepts

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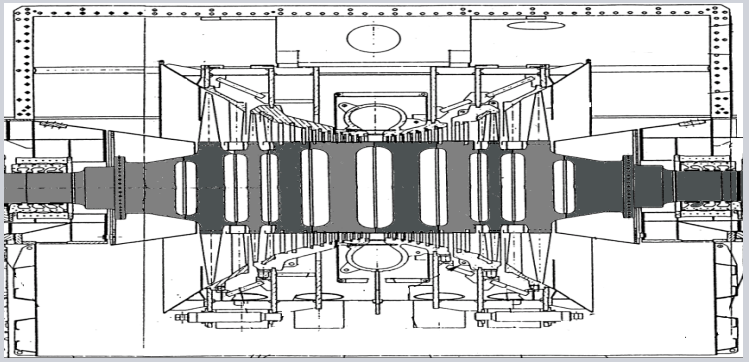
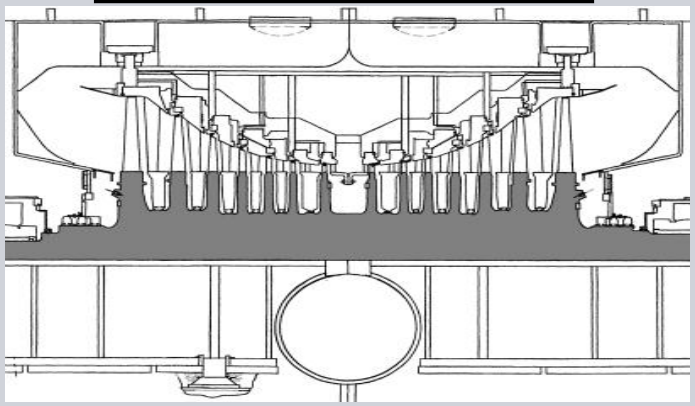
Disadvantages of alternative rotor design concepts compared to shrunk-on disk design

Welded Disk Rotor



- Inhomogeneous material properties in weld area
  → **reduced fracture toughness**
- Material weakening at blade groove nearby weld area
  → **crack starter at blade grooves**

Monoblock Rotor



- Stress concentration at shaft grooves
  → **Susceptible to SCC**
- Inhomogeneous material properties due to big forging diameters
  → **unpredictable material behaviour**
- Big initial voids and cracks due to large Forging size
  → **Crack starter at rotor center**

Shrink-fit Process

LP Rotor for Olkiluoto 3

Manufacturing of shrunk-on disc rotors is a Siemens key knowledge area

Low Pressure Turbine

Droplet Impact Erosion Protection

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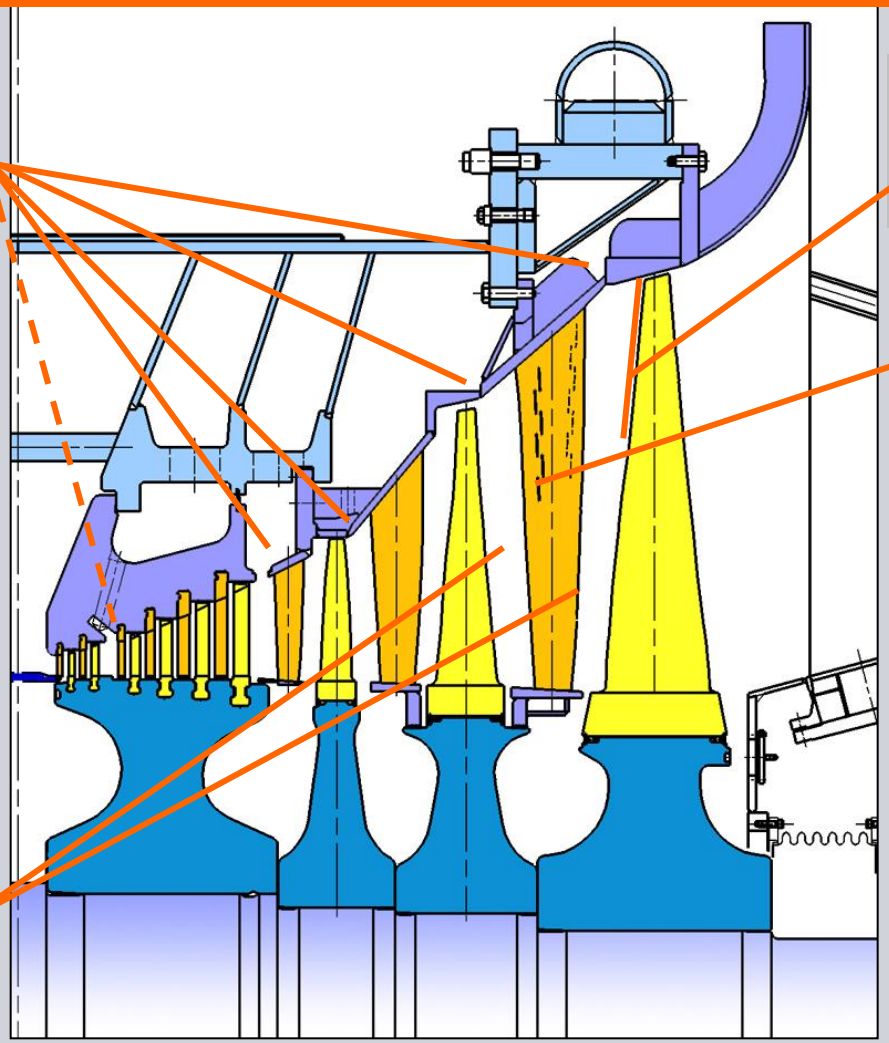
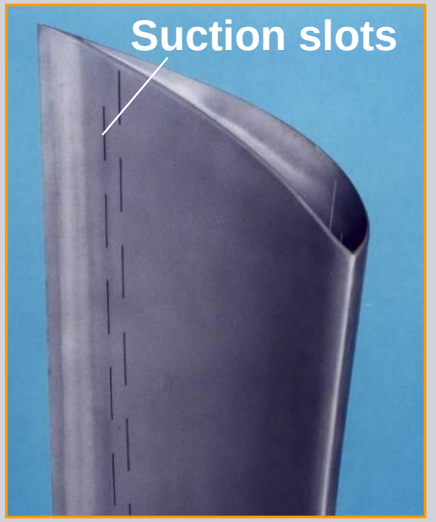
Effective and proven measures against droplet erosion available

Reduction of water by:
- **Extraction slots/drainage**



Active protection by
Leading-edge hardening
(flame or laser hardening)

Reduction of water by:
- **hollow stator blade with suction slots**
- **or heating of blade**



Small droplets by
- **axial gap design**
- **thin trailing edge**

Siemens Generators

Product Portfolio

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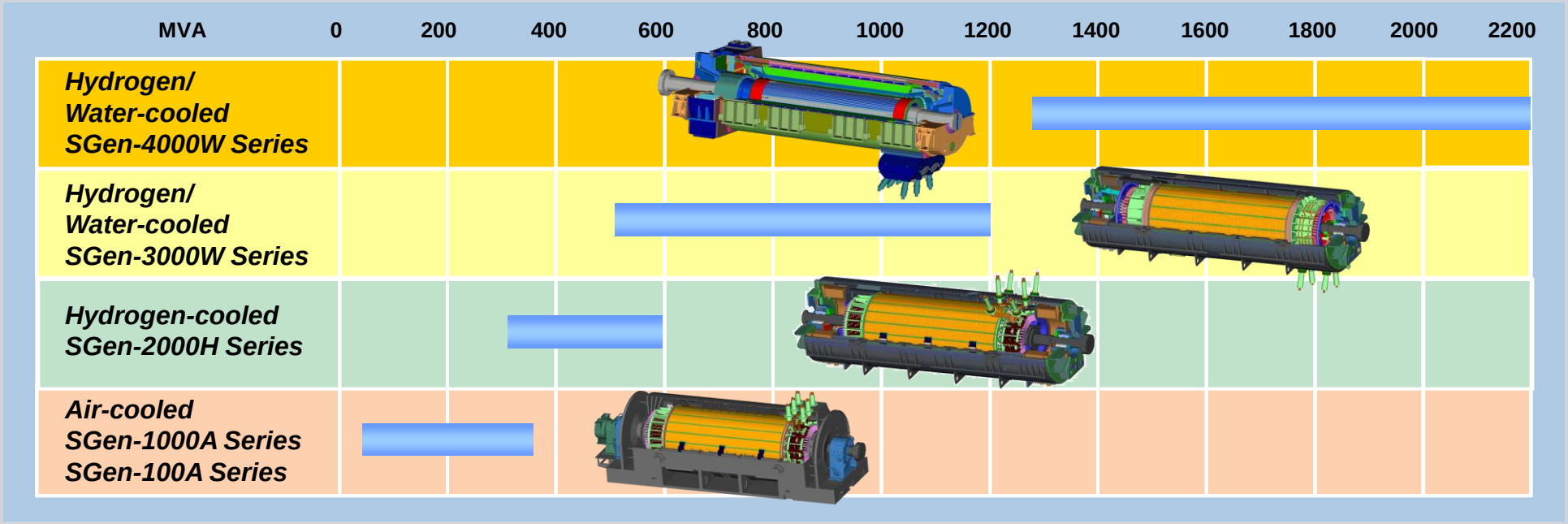
Siemens product portfolio for 50 and 60 Hz (2 and 4 pole)



- Siemens is one of the leading suppliers of power generators for industrial and power plan applications from 50 MVA through 2,200 MVA
- Current Siemens fleet includes:
  - Air cooled: more than 640 units
  - H2 cooled: more than 57 units
  - Water cooled: more than 100 units

Siemens Water Cooled Generators

SGen5-4000W

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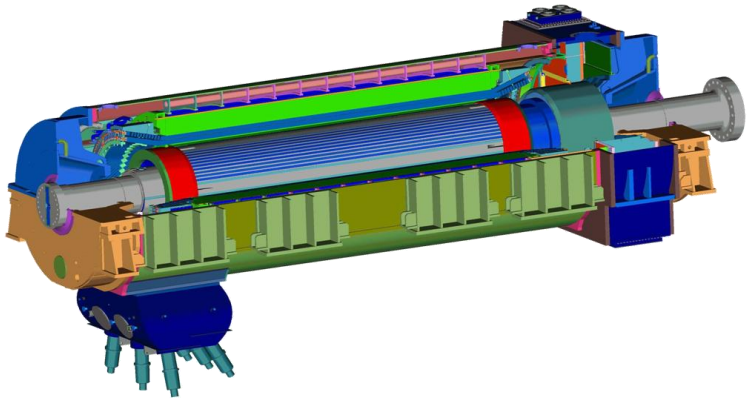
State of the art design features for SGen5-4000W generator

Frequency / Speed:	50 Hz, 1,500 rpm
Rated Line Voltage:	27 kV
Rated Capability:	1,300 to 2,200 MVA (4-pole)
Design:	IEC and ANSI standards
Thermal class:	Insulation class F
Cooling method:	Stator winding; direct/axially water-cooled Stator core; direct/axially hydrogen-cooled Rotor winding; direct/axially hydrogen-cooled
Excitation:	Brushless
Power Factor:	From 0.85 lagging to 0.95 leading
Efficiency:	Max. Efficiency up to 98.98% (Olkiluoto 3 shop test)



World's largest power generator SGen5-4000W

Generator for Olkiluoto 3

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Innovative generator design for highest power output and best efficiencies

Rating	*Nominal*	*Max*
MVA	1,992	2,191
MW	1,793	1,972
Power Factor	0.90	0.90
Terminal Voltage kV	27	27
Stator Current Amps	42,596	46,851
Efficiency	98.98 %	
Total Weight	900 tons	
Total Length	16.8 meters	

- Unit shipped in 2008 to Olkiluoto
- Unit installed at Site in 2009
- All customer's challenging requirements met

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Thank you for your attention!

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