Council of Enviro Excellence

5th NATIONAL POWER-GEN ENERGY EFFICIENCY AWARDS-2026

5TH NATIONAL POWER-GEN ENERGY EFFICIENCY

SUMMIT AND AWARDS 2025

Enhancing Efficiency in Indian Thermal Power Plants

SUSTAINABLE EFFICIENCY GAINS - MODERN RETROFITTING APPROACHES FOR STEAM TURBINES IN INDIA

MR. SAURABH VERMA

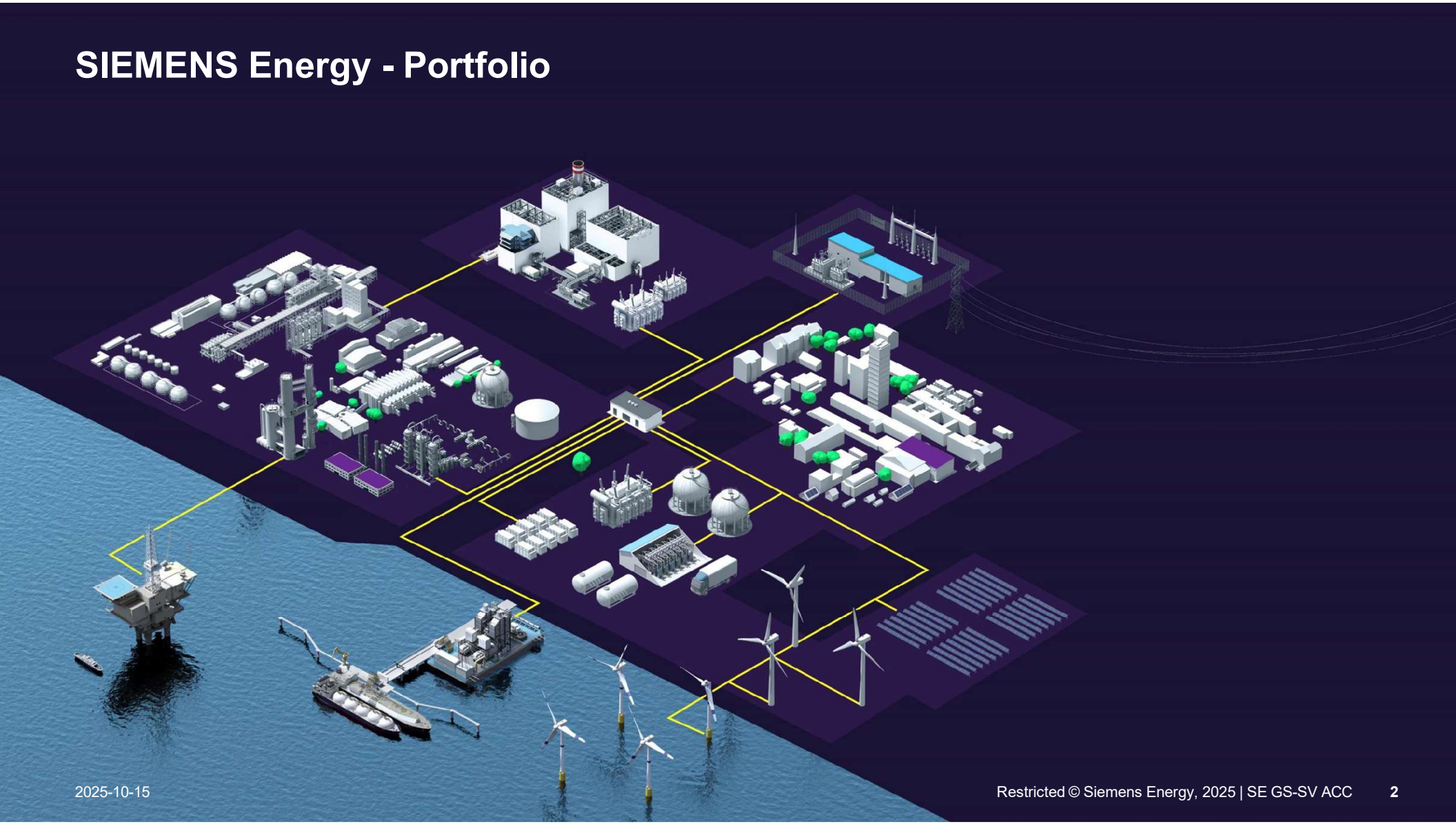
SIEMENS Solutions for *Thermal Performance Improvements with R&M and Module Upgrades*

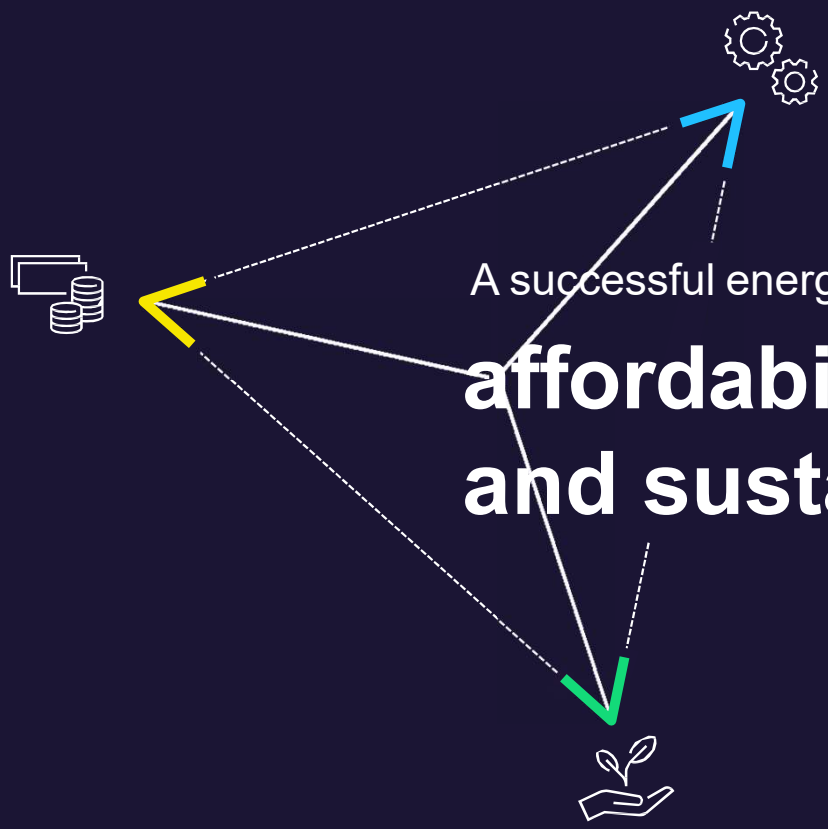
Theme
"Optimizing the Capital & Operational Expenditures"

5th National Power-Gen Energy Eff Sumit & Award

23rd Mar 2026

SIEMENS Energy - Portfolio

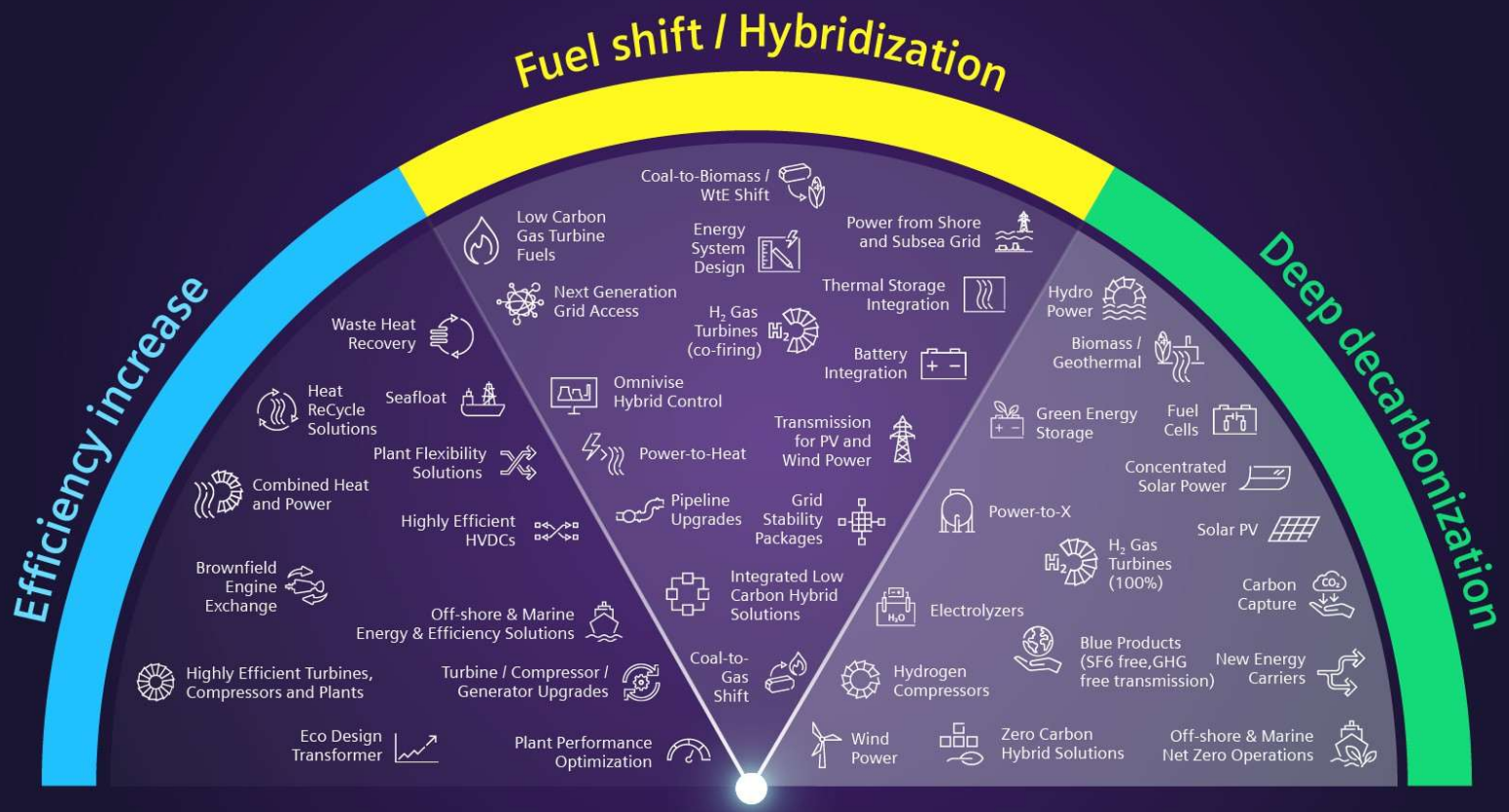




A successful energy transition requires balancing

affordability, reliability, and sustainability.

Siemens Energy is partner and shaper of the energy transition worldwide



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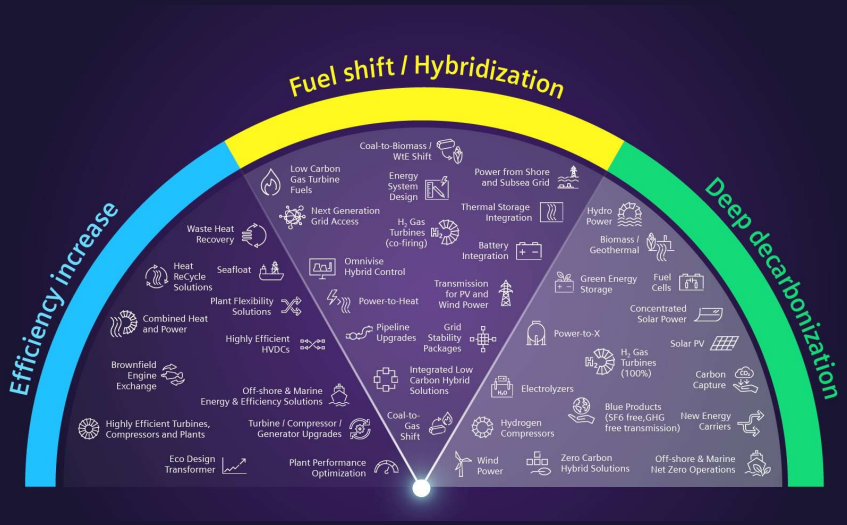
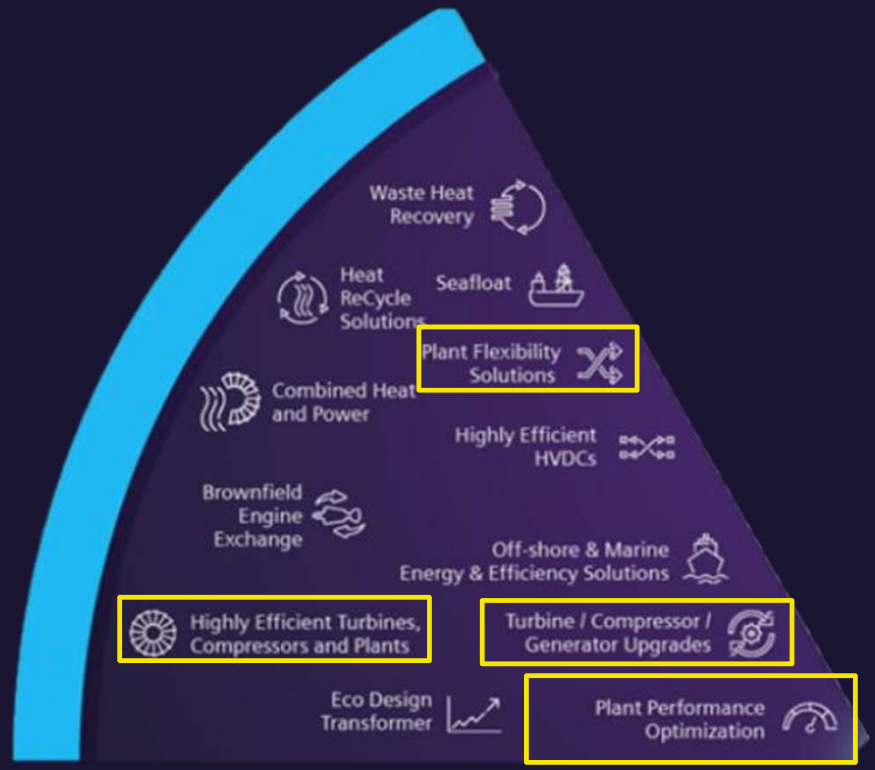
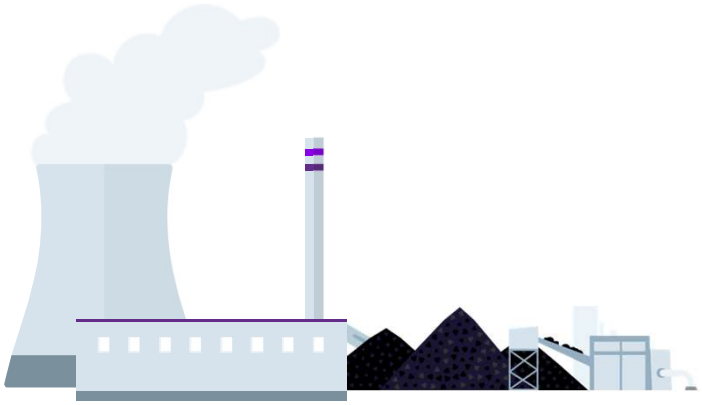
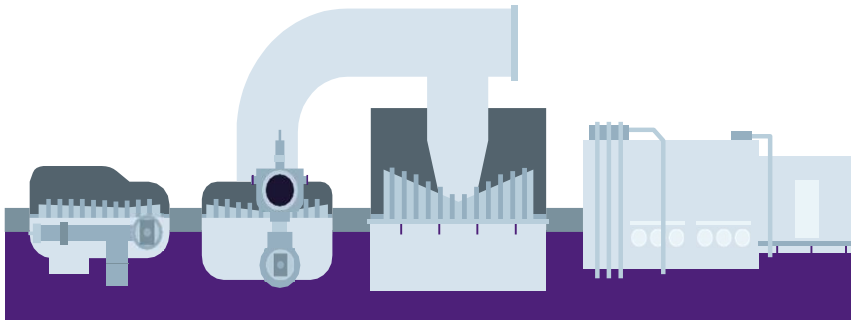




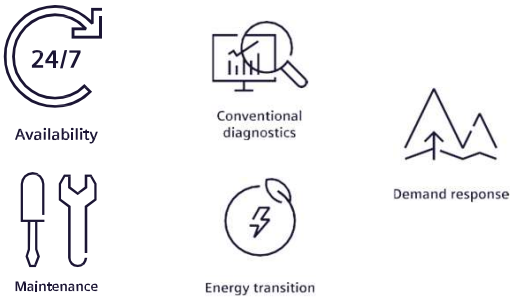
Siemens Energy is OEM and owner of KWU ST technology

Steam Power Plants – Coal Fired → Utility Steam Turbine

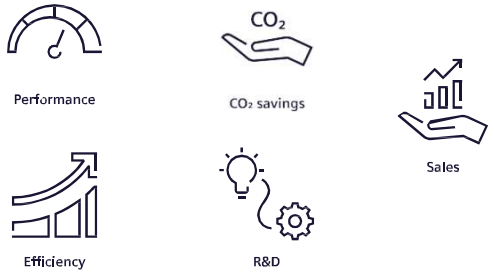




Challenges



Requirements

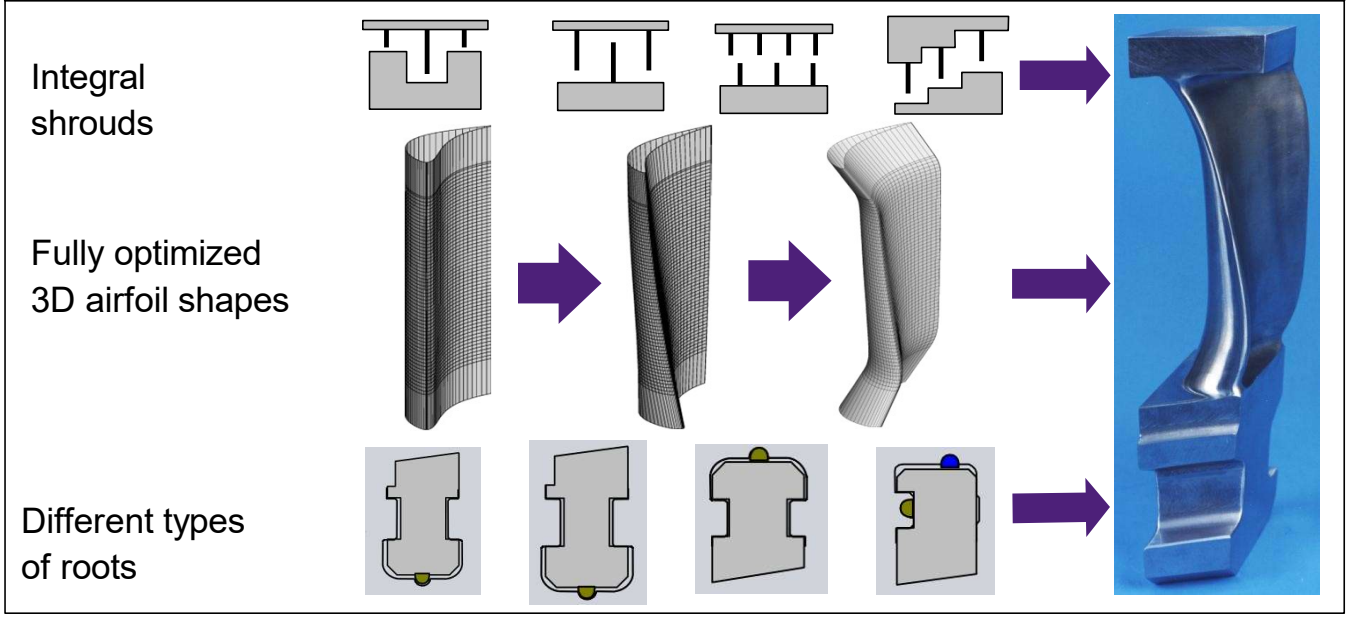


Blading Technology

State-of-the-art 3DS ™ Drum Stage Blading

SIEMENS energy

"Best Fit" combinations of shrouds, airfoils and blade roots



Advanced Features

- Advanced 3D Airfoils (Tapered, twisted & bowed airfoils)
- Integral shroud blading
- Advanced blade root design
- Optimized sealing
- Optimized blade axial clearances
- **Minimized profile, secondary and tip losses in blade stage**

T, T2 & T4 blade profiles — 1990 — T4X & F-blade profiles — 2000 — WP01 wide pitch profiles — 2010 — WP02 & WP03 wide pitch profiles, Hybrid Seals — 2020 — New "SBPF" blade profiles — 2023

Ever Evolving Innovative 3DV ™ Blade Design Technology

Sealing Features & Technologies
Abradable coating sealing

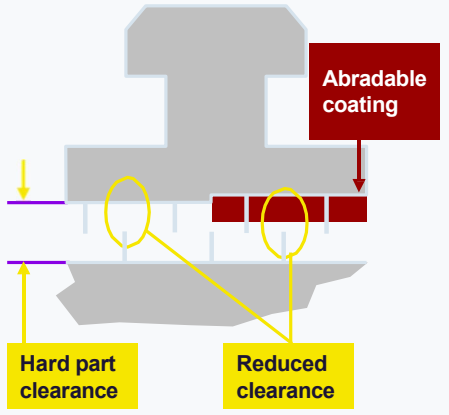
SIEMENS energy

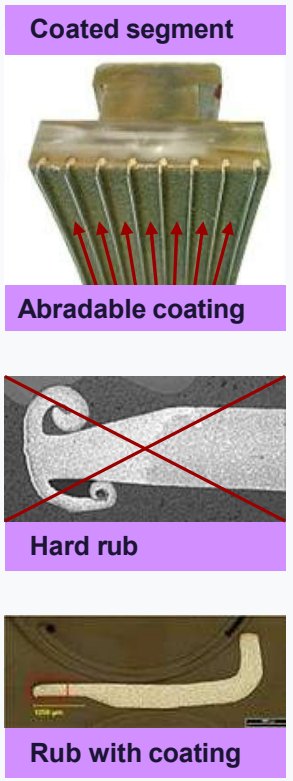
Design features

- Coating applied to standard seal segments (thickness ~0.6 mm)
- Reduced leakage flow due to reduced clearances (about 20% less)
- Fin cuts groove into coating without damage to fin or significant heating
- Suitable for large pressure drops
- Increased clearance between hard parts for additional operating safety

Customer benefits

- Increased efficiency and power output (~0.3%)
- Increased operational safety
- Proven and sustainable design





Advanced sealings with minimum leakage & > 15 years of operational experience

Blading Technology

State-of-the-art LP End Stage Blades

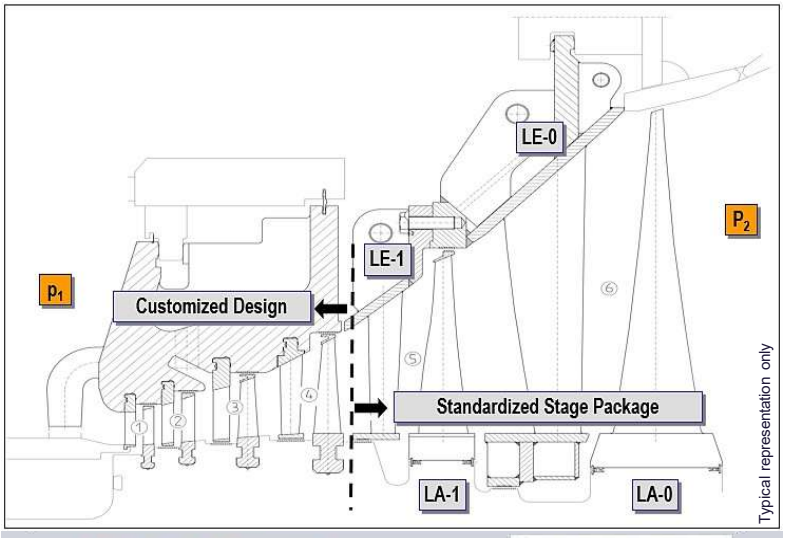
SIEMENS energy

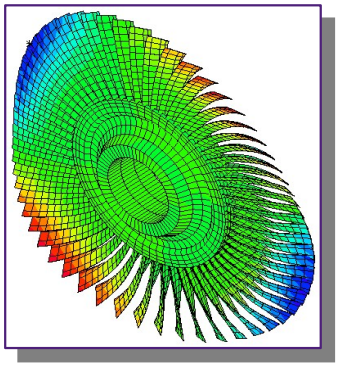
LP Blading Design Features

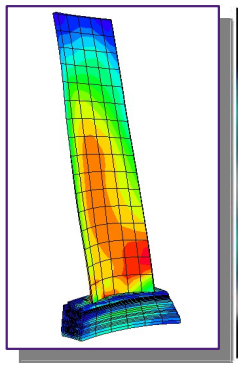
- State-of-the-art fully 3D design
- Optimized last stage blade size
- Optimized LP exhaust area
- New shrouded/free-standing Last Stage Blade with Trans- and Supersonic Tip Sections, 3D-Flow Design
- Stage De-wetting, Hardening of La-0, Suction Slot in Le-0

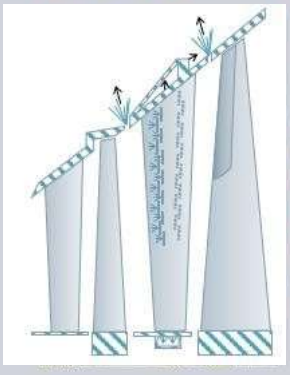
Customer benefits

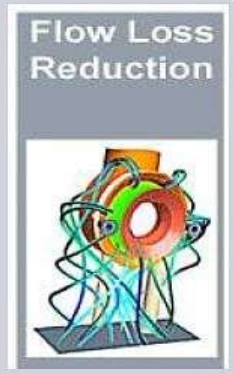
- Improved blade efficiency by advanced 3D blade design
- Increased efficiency by Advanced shrouded* rotating blades
- Reduced exhaust losses









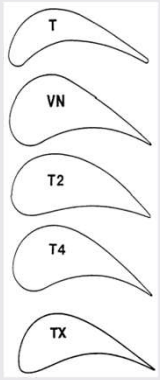


* Wherever shrouds are applicable

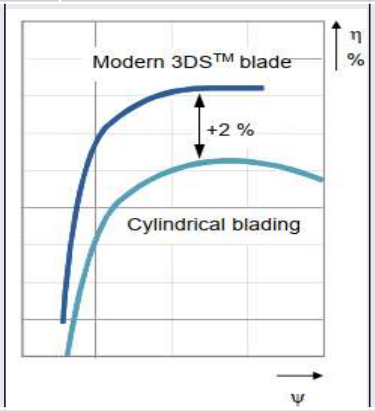
Steam Turbine Modernization
What "SIEMENS" can offer?

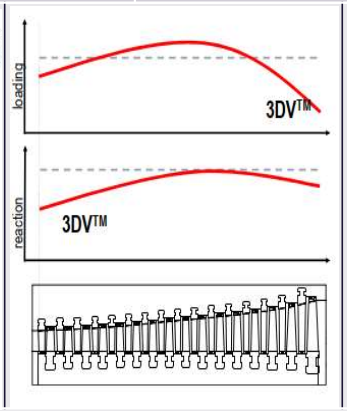
Component	Existing	SIEMENS Offering	Improvement results in	Overall Impact in Heat Rate
Steam Path and LP Turbine Last Stage Blades (LSB)	T2 Series Cylindrical Blades in blade path	3DS™ blades with 3DV™ technology + LSB 5m² backend with higher reliability and strengthen fir tree root (higher erosion protection standards)	Blades with minimum secondary loss profile – higher steam path efficiency	~ 1.0 % to 3 %

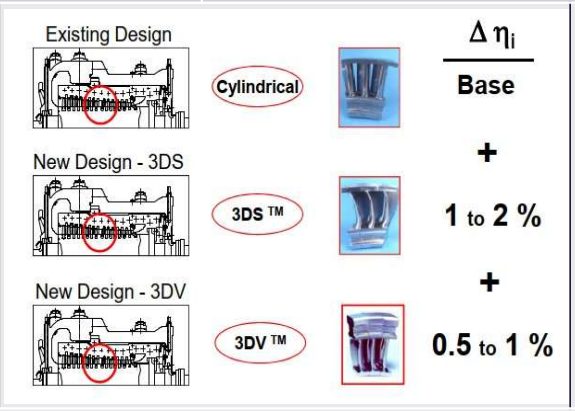
Siemens KWU Blade History



3DS™ Blading Late 1990's

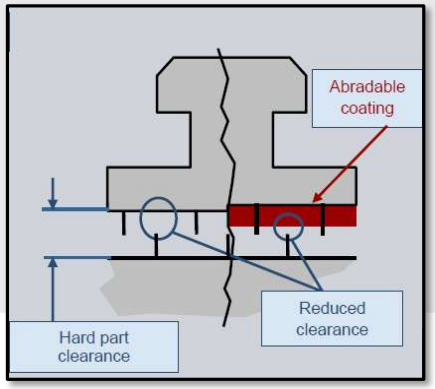


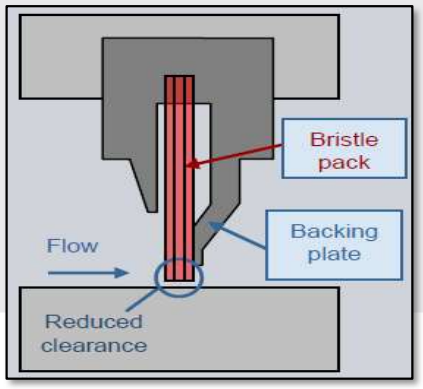


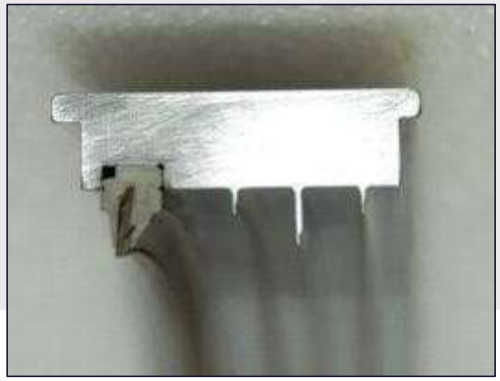


Steam Turbine Modernization
What "SIEMENS" can offer?

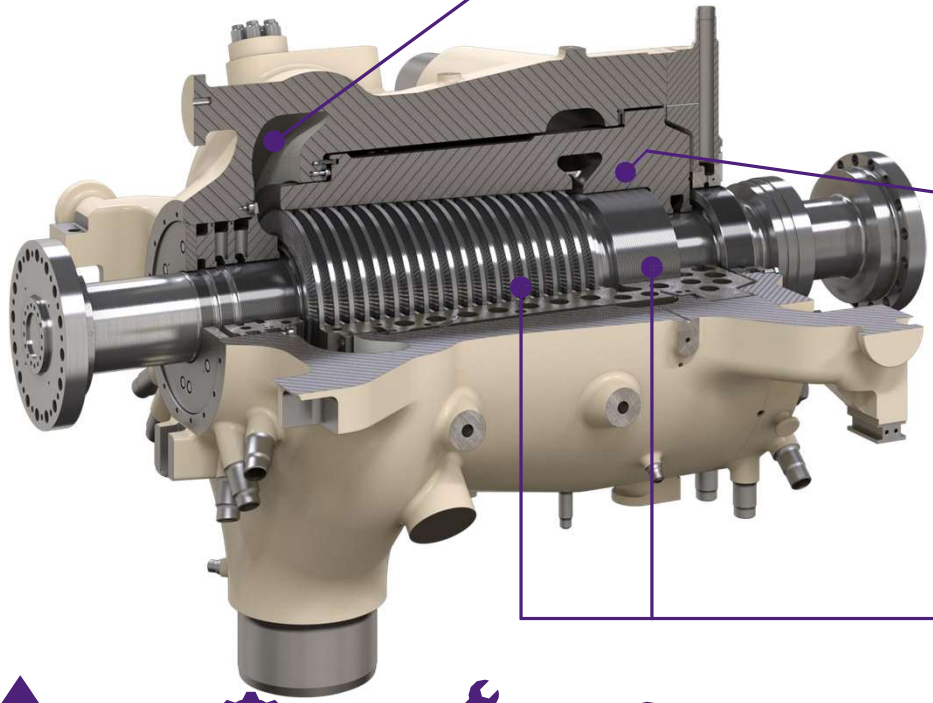
Component	Existing	SIEMENS Offering	Improvement results in	Overall Impact in Heat Rate
Seals	Standard Seals and Seal segments with standard clearances	Abradable coatings for interstage and balance piston with reduced clearances (w/ labyrinths and S-S seals) + Brush-seals for bladepath	Abradable Seals: Obtaining sustainable reductions in leakage flow of approximately 20% compared to uncoated segments Brush Seals: 50% reduction in leakage flow which can be achieved compared to conventional labyrinth seals	**~ 0.2% to 0.4%**







HP MODULE



Outer Casing Rework / New Supply

- Design / Refurbished with Rotational Symmetry
- Machined exhaust flow contour optimization
- Seal Ring optimized designed for lower leakages

Inner Casing

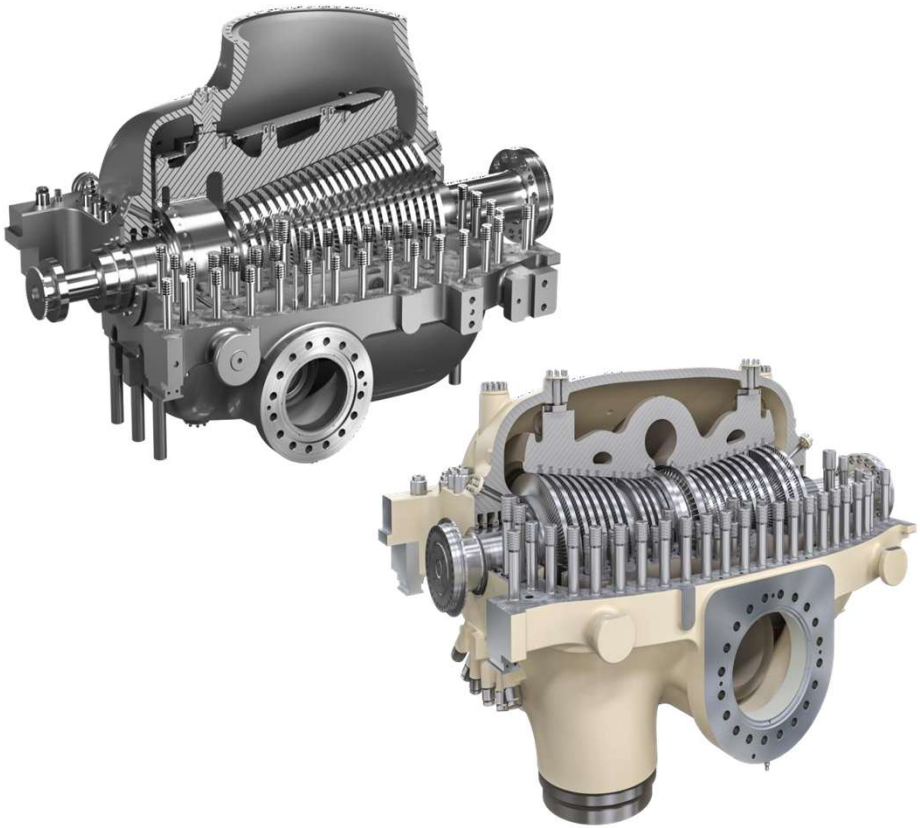
- Design with Rotational Symmetry
- Low ovalization → Minimum tip flow losses
- ***Low distortions during ramp up/down*** and creep. ***Ideal for flexibilization*** and future ready design
- Optimized inlet and exhaust flow contours.
- Leakage free design

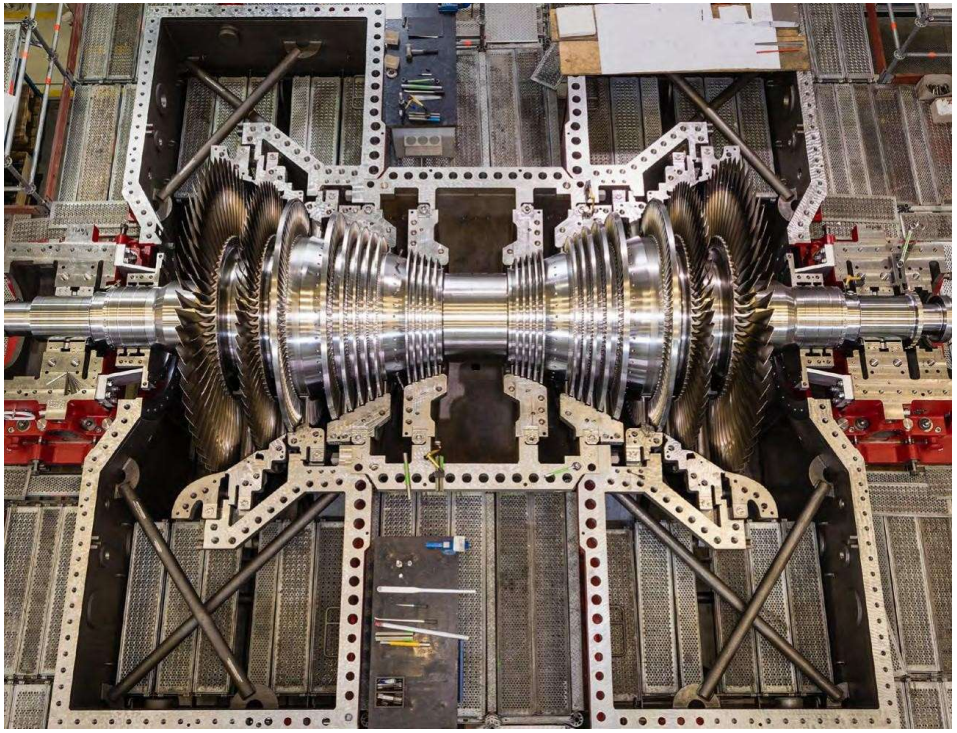
Bladed Rotors with Seals

- State-of-art 3DS/3DV technology
- Advanced technologies for max performance

Performance
New Design Feature
Lifetime Extension
Shorter Outage
Flexibility

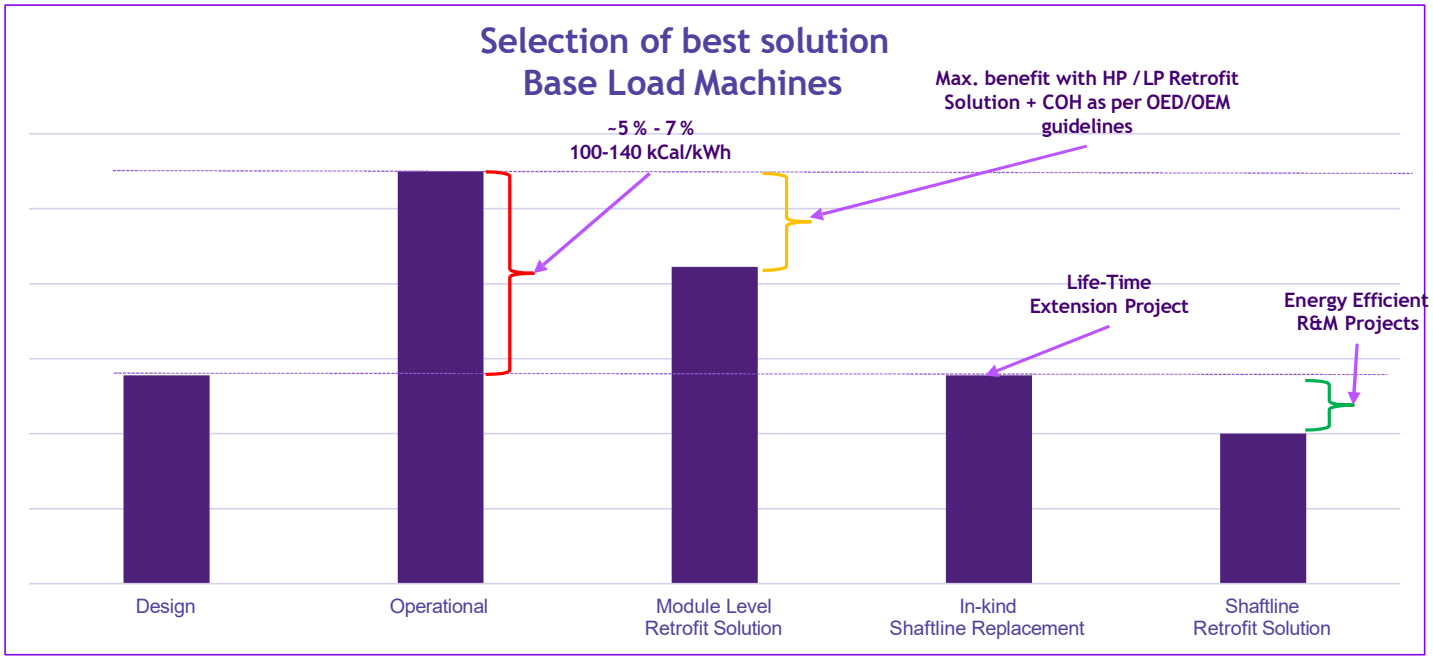
IP MODULE / LP MODULE





Steam Turbine Modernization

Selection of "BEST" Solution



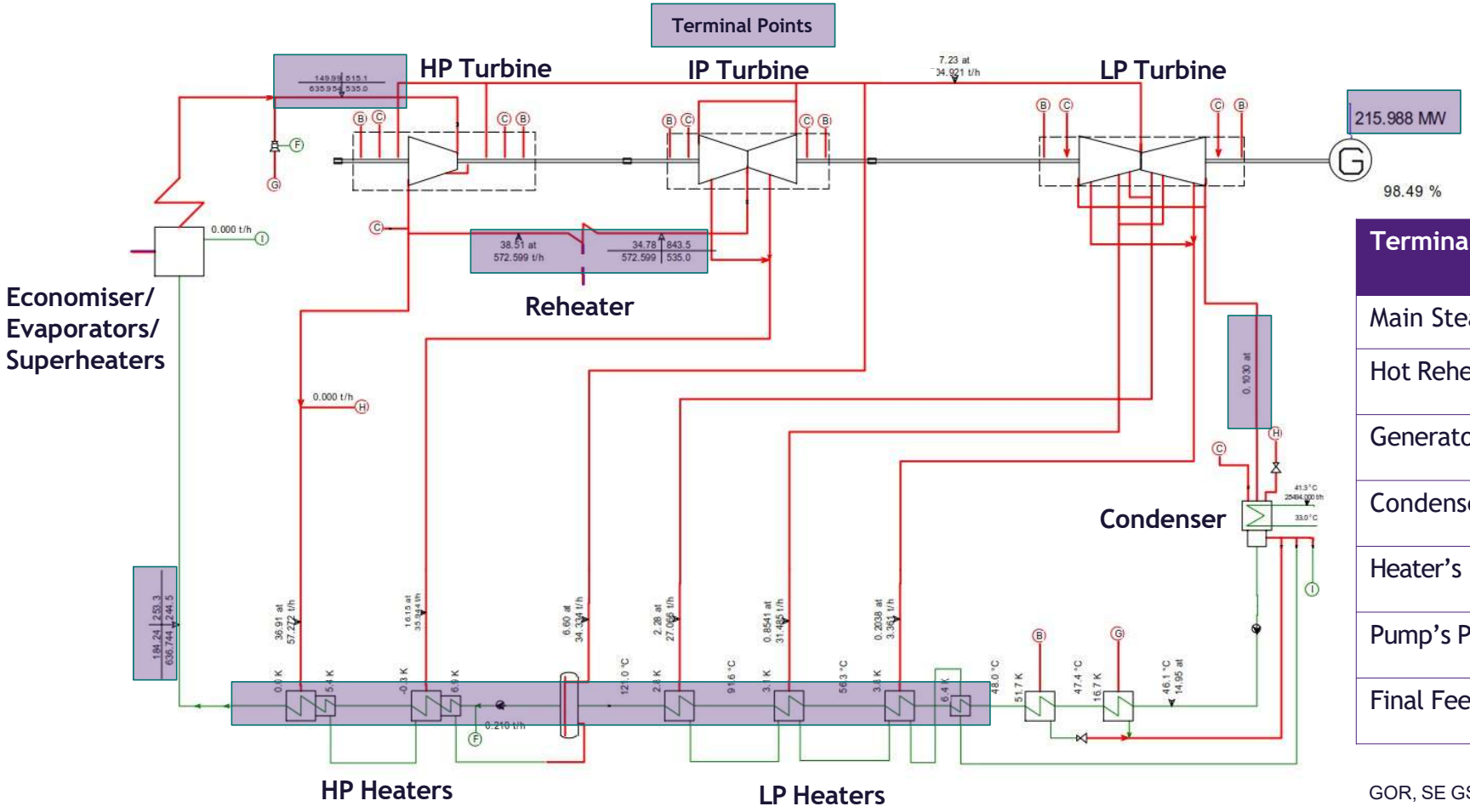
5%-7% Plant Level Degradation

Steam Turbine contributions ranges from 2%-3%

hence when planning for shaft line retrofit solutions, for achieving maximum benefits beyond design, boundaries upgradation should also be evaluated

- ***Module Level Retrofit Solution along with COH*** – Limitations in CAPEX but strive for Efficient Module
- ***In-Kind Replacement*** – Technological Advancement won't come into picture – Lifetime Extension Project
- ***Shaft-Line Retrofit Solution*** – Capturing new technological advancement + best in class efficiency – Energy Efficient R&M Project

Steam Turbine Modernization
Terminal Points for Performance



Terminal Points
Main Steam Conditions
Hot Reheat Steam Conditions
Generator Output
Condenser Backpressure
Heater's Performance
Pump's Performance
Final Feedwater Temperature

Steam Turbine Modernization
Improvement in boundary conditions

Component	Existing	Gain from boundary conditions	Ideal Approach
Better boundary conditions	Vacuum @ 0.1172 ata (36 deg C CW inlet)	Improvised condenser boundary conditions -> Lower Vacuum -> Efficient steam turbine performance -> ***Heat Rate Gain***	***Vacuum - 0.1172 ata @ 36 deg C*** ↓ ***Vacuum - 0.1033 ata @ 33 deg C***
	Final Feedwater Temperatures	Elevated final feedwater temperature -> optimal expansion + elevated final feedwater temperature -> ***Heat Rate Gain***	***HP Module Efficiency Gain*** ↓ ***Top Heater Performance Improvement***
	Better reheater dP	Lower existing reheater circuit dP -> better IP module boundary and design conditions -> ***Heat Rate Gain***	***Efficient IP Module*** ↓ ***Lesser Steam Flow/Resistance -> Better RH dP***
	Better pump performance	Improvised pump performance -> better work output (delta H) across pump and help in optimizing extraction flows -> ***Heat Rate Gain***	***Reduced Work Done Across Pump*** ↓ ***Better heater performance***

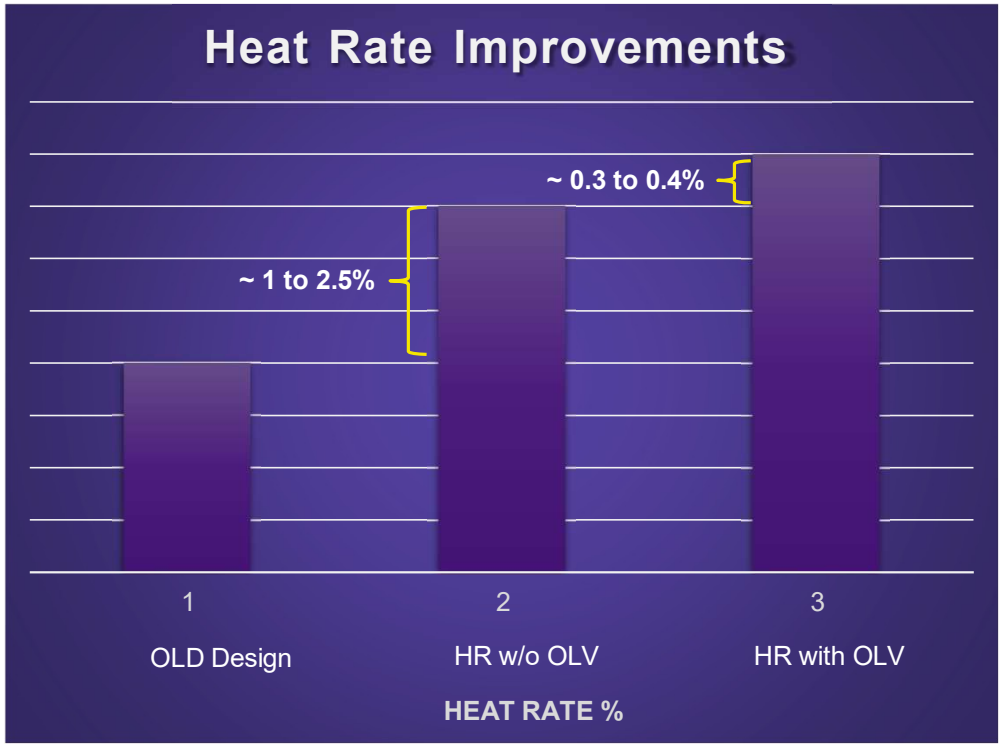
Steam Turbine Modernization
KWU existing design improvements

Typically, Improvements from ~ 1.0% to 2.5% from original KWU design

New OLV with existing control valves will give the additional benefit of ~0.3 to 0.4%, depends upon the TMCR throttle margin

- However, much larger scope with new OLV, piping, HP outer casing and control system upgrade
- Thus, much higher cost and reduced ROI

If required, MW output could be increased, while retaining the same heat rate improvements



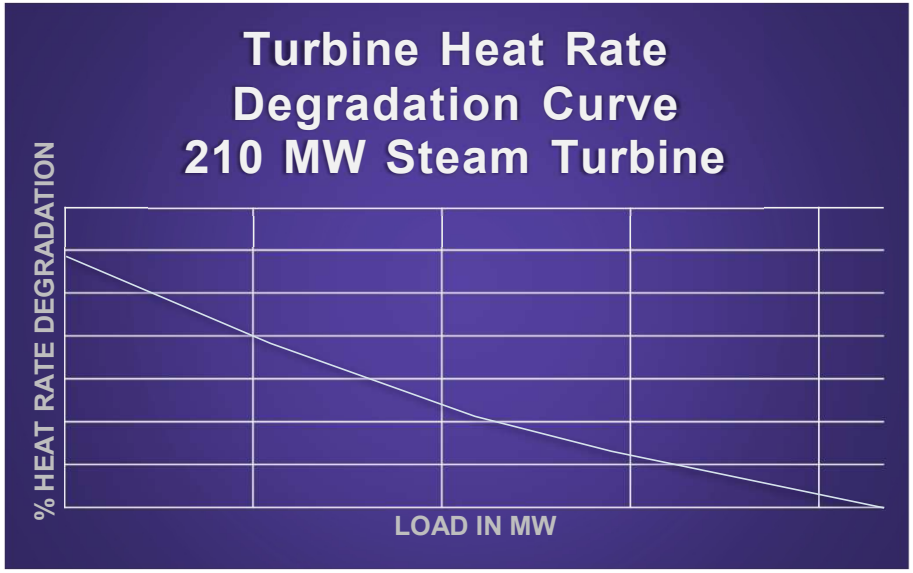
Steam Turbine Modernization
Part Load Operations

Part Load Efficiency Improvements

Base load heat rate can be optimized, and existing improvements will also be reflected in part load

If <70% load has higher weightage - nozzle control will give the additional improvements from ~0.5 - 0.8% based on load range

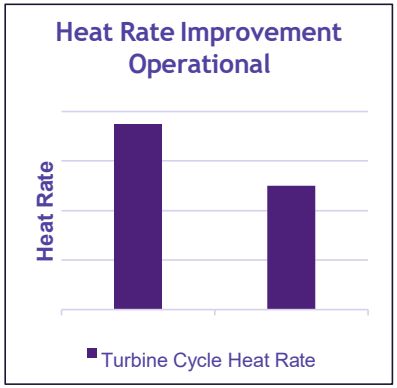
- However, depending on control stage efficiency, plus additional cost
- Much larger scope with new HP outer casing, HP control valves, and control system upgrade
- Heat rate at 100% TMCR will degrade equally



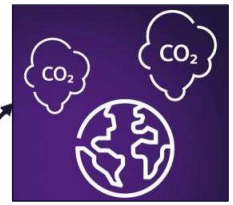
Customer Benefits:

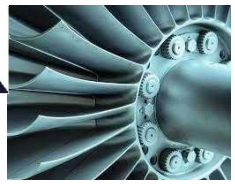
- Enhance part load efficiency
- Increase operational flexibility
- Reduce part load fuel consumption and emission

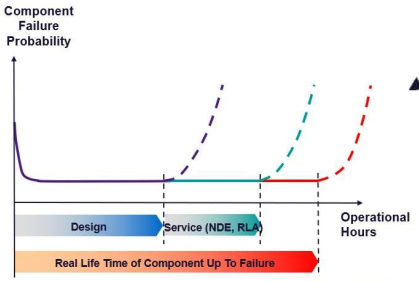
Steam Turbine Modernization
Overall Benefits



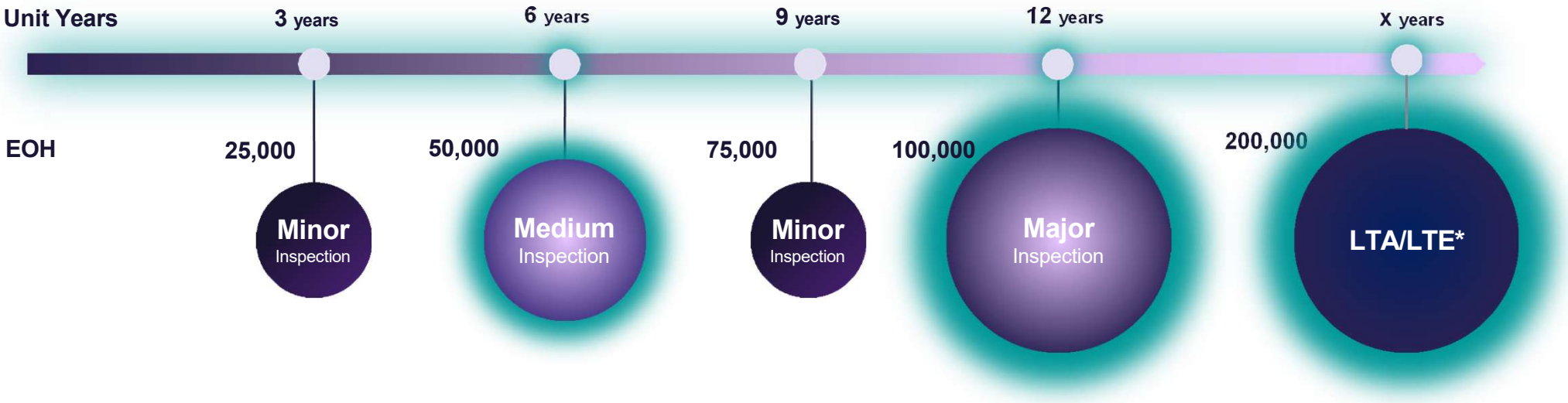
Component	Impact
Heat Rate Improvement	~min. ***1.5%*** from modules & ~ ***0.5%*** from boundary conditions
Variable Cost Reduction and improvement in merit order	As per merit order and discom benefit transfers mechanism (min. ~15 – 30 p)
Reduction in CO2 emissions	***5000 T/y coal -> 8400 T/y CO2*** for 2.0% heat rate improvement
Lifetime Extension	~ ***15-20*** years
Spares Flexibility (as per scope)	Scope of in-kind and retrofit to be resembled between units for ***better unit availability***







Standard Maintenance Concept for Siemens Energy ST's



Minor Inspection ~ 2 weeks

- Visual Inspection
- Functional checks on valves & control components
- Alignment checks
- Optional: Borescope Insp.

Medium Inspection ~ 3 weeks

- Minor Inspection Scope
- Valve Overhaul
- Bearing Inspection
- Insp. Of last stage blades
- Insp. Of auxiliaries

Major Inspection ~ 6 weeks

- Medium Inspection Scope
- Opening of all turbine sections
- Insp. Of rotors, casings and bolts
- Insp. Of welds & blades
- Clearance & wear checks
- Run-out check

LTA/LTE ~ tbd weeks

- Lifetime Assessment of Components
- Individual recommendations to meet expected end of operation
- Lifetime Extension repairs or replacements
- Optional: Mods and Upgrades

Performance Benchmarking & Optimization Services – The Need ?

Performance Benchmarking

- *How can you Identify the unknowns – in terms of losses?*
- *How accurately detect the aging and separate it out from undue degradation?*
- *How do you assure the validation results?*
- *How do you realize asset level diagnostics capability within the tools for boiler and steam turbines?*
- *How to ensure accuracy in terms of tools and instrumentation – double assurance for customer?*

Performance Monitoring

- *How to monitor real time thermal power plant performance?*
- *How to monitor financial impacts and optimize plant economics?*
- *How to predict power plant individual equipment degradation for extended period?*
- *How to optimize your capex and opex budget?*

Optimization

- *How can I monitor and improve efficiency and emissions for minimum, part and base load?*
- *How can I earn more money through more efficient, faster and better scheduled starts and shutdowns?*
- *How can I reduce outage time and increase start readiness?*
- *How can I reduce minimum load, increase base load and income from grid services?*
- *How can I automate and optimize trading, dispatch and fleet control?*

Contact

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