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Voith Hydro Experiences with Application of Large High-End Pump-Turbine / Motor-Generator Units

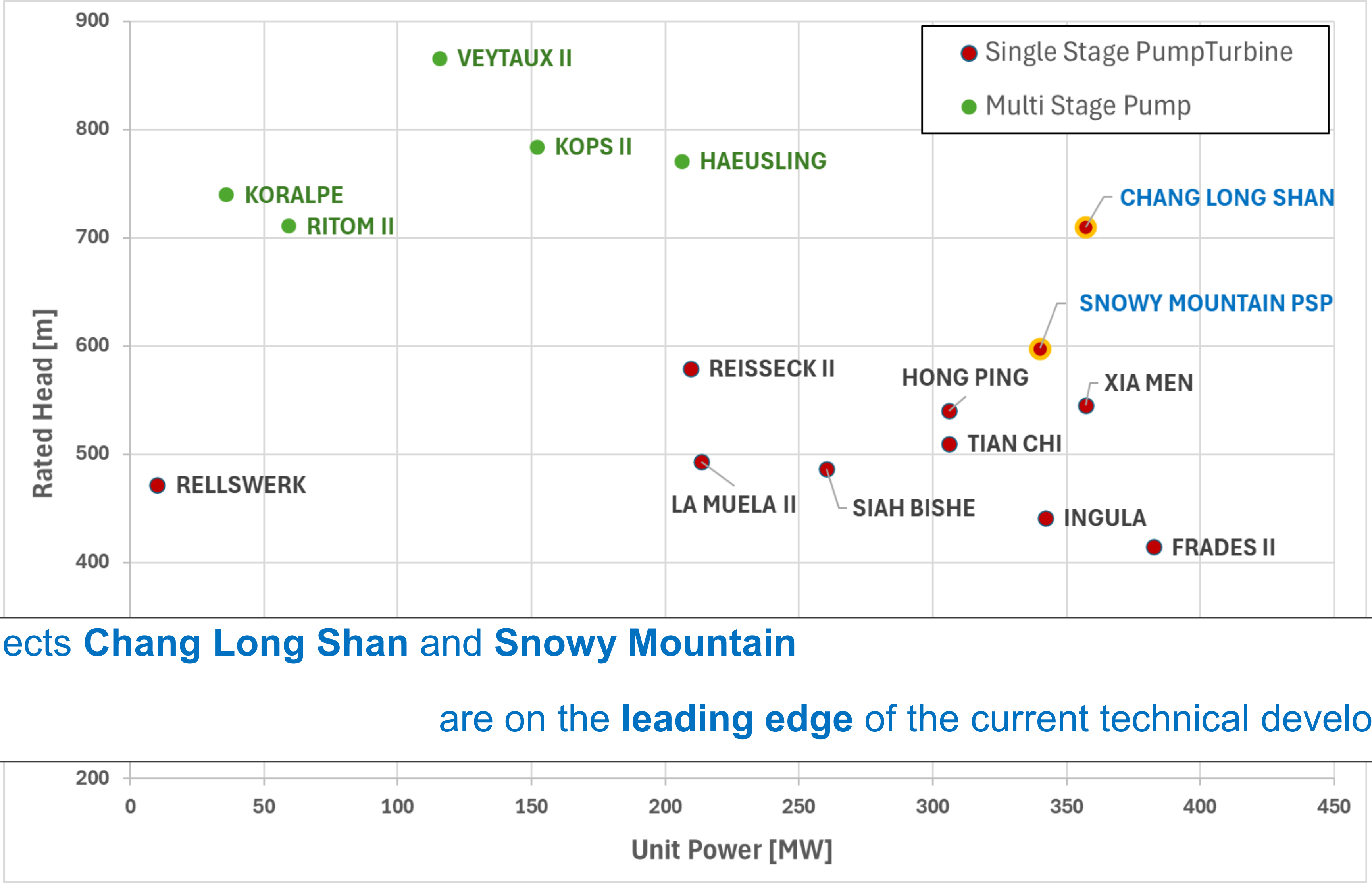
Thomas Aschenbrenner

Voith Hydro GmbH & Co. KG

Graz, 2025-09-16

Contents

Overview of major PT units supplied by Voith Hydro

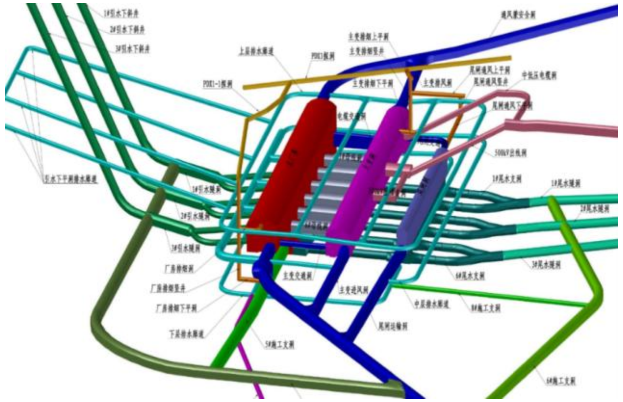


Both projects **Chang Long Shan** and **Snowy Mountain**

are on the **leading edge** of the current technical development

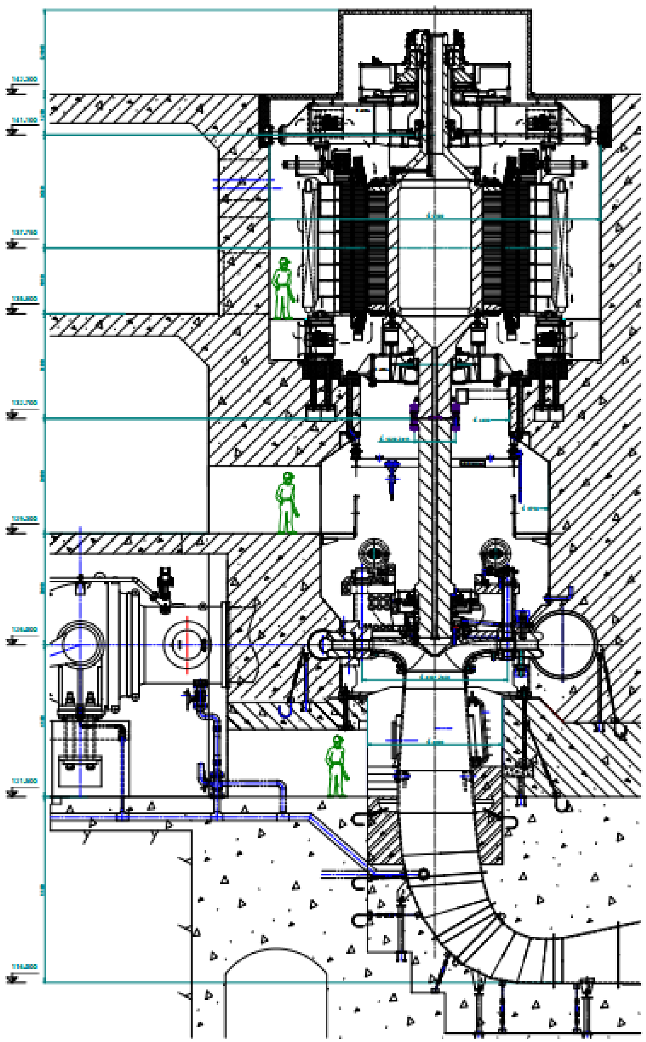
ChangLongShan units
Main data

- Located 180 km West of Shanghai
- In total 6 units, P = 357MW, Hmax = 760 m
- 4 units from competitor with N = 500 rpm
- **2 units from Voith Hydro with N = 600 rpm**
- Successfully commissioned in 2020



ChangLongShan units – 600 rpm

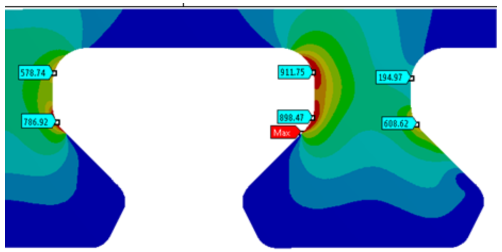
Design concept



1. Cutting edge hydraulic design for pump turbine, which integrates High head **710m**, High speed **600rpm**, and High output **350MW**
2. Innovative technology for MIV with super high difficulty Index (DI) (PN*DN=12MPax2.1m)
3. Intensive research for High speed thrust bearing with large thrust load
4. Creative feature for rotor rim with **one forged solid ring** for generator with motor fan ventilation method.
5. Strong driving force for leading the development of raw materials for key components in terms of turbine and generator such as **high strength, ductility, fatigue strength**……

ChangLongShan Units - 600rpm

Major challenges



Hydraulic design:

- Pressure pulsations, cavitation safety margin
- S-Shape and Pump stability – safety margin
- High efficiency – Pump & Turbine

Electro-magnetic and ventilation design:

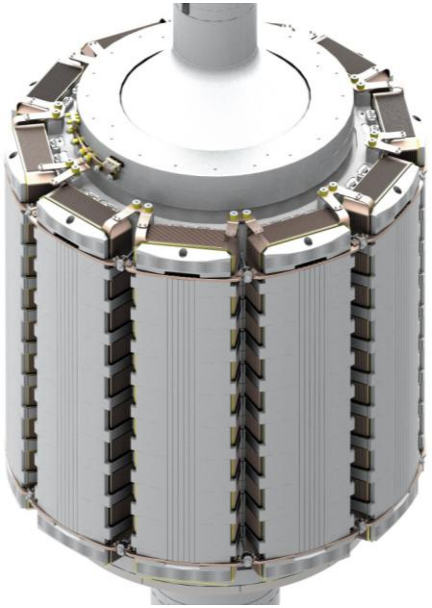
- Air-cooled motor-generator for 600 rpm, High efficiency
- Available space available for the winding and circuit rings
- Single pole dismantling

Mechanical design:

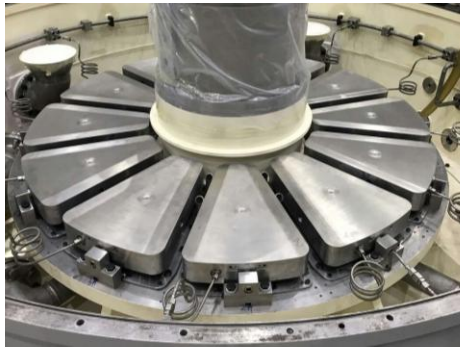
- Specified load universe in combination with high centrifugal force
- Specified criteria for strength assessment
- High contractual penalties for higher bearing vibrations & noise level

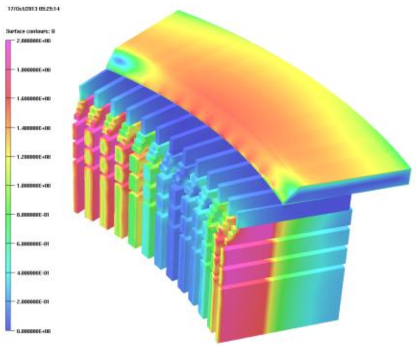
ChangLongShan units – 600 rpm

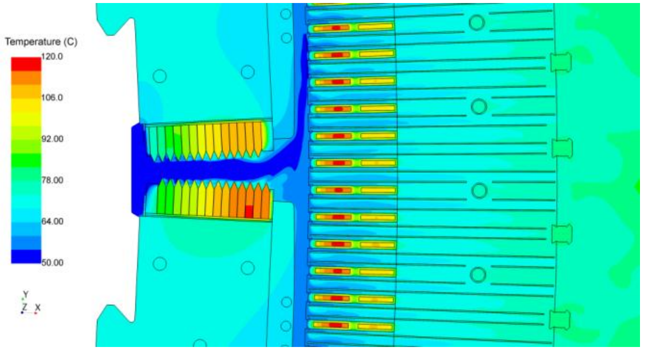
Mitigation strategy



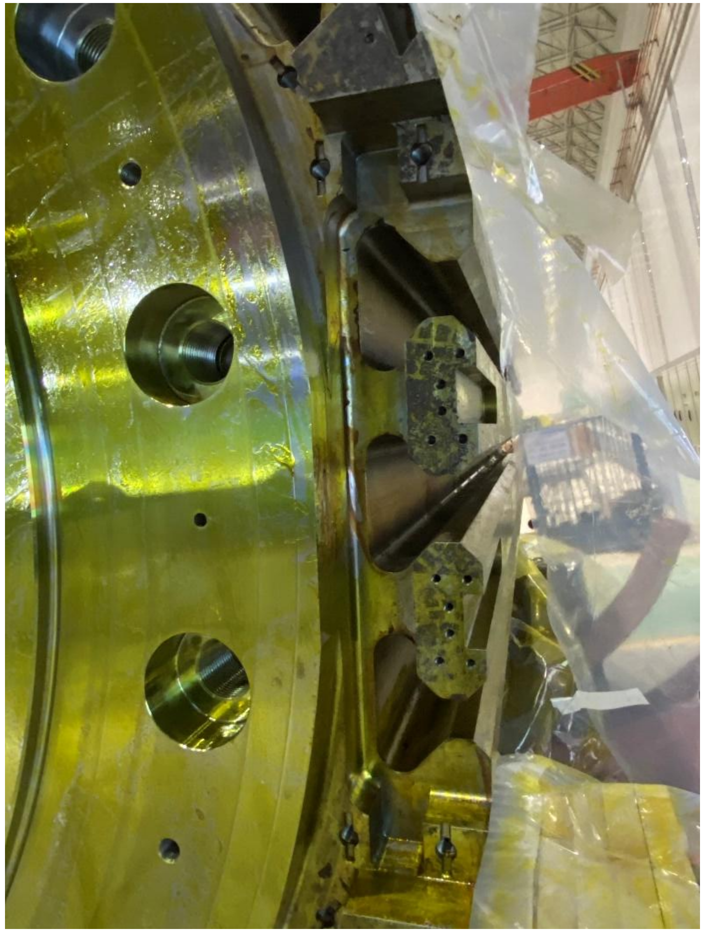
- Extensive model testing in the hydraulic laboratory
- Forged rotor central part – 115to → high quality material requirements
- Thrust bearing → full size test at test facility in China
- Optimization of support structure by detailed FEA simulations, increase of stiffness
- Electromagnetic and cooling optimization loops
- Stator bar manufacturing tests







U5&U6 rotor center part and its lower shaft
Manufacturing



ChangLongShan units – 600 rpm

Generator

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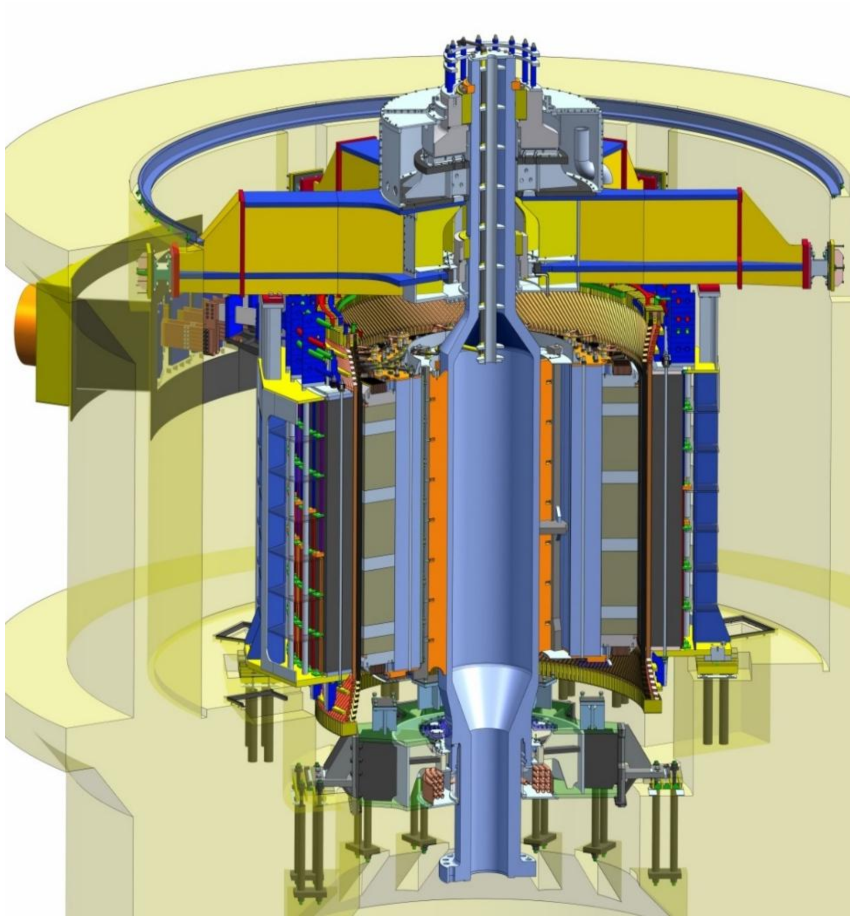
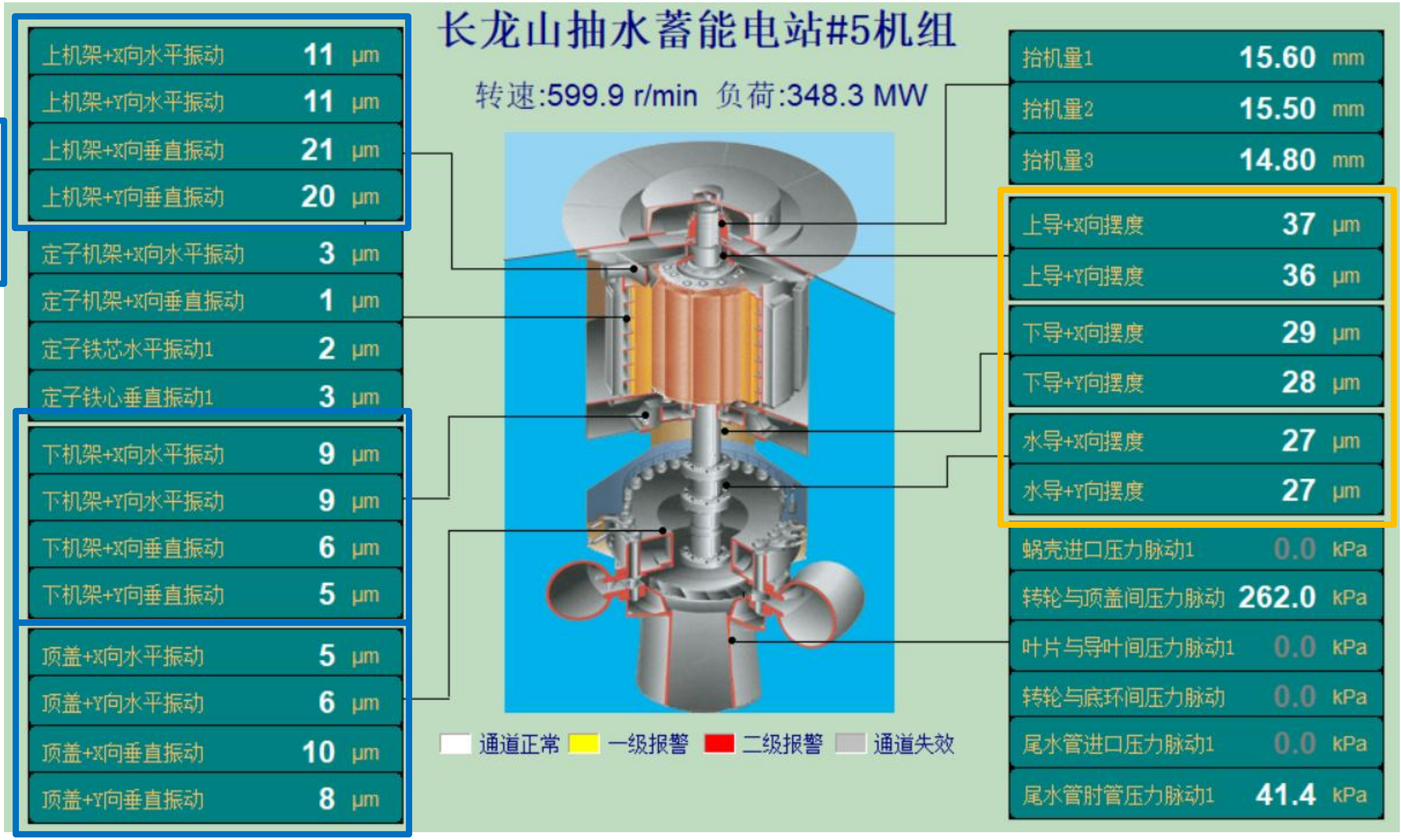


ChangLongShan units – 600 rpm

Vibration data @ Full load → very smooth operation



Absolute bearing vibrations

Relative shaft vibrations

Snowy 2.0 scheme

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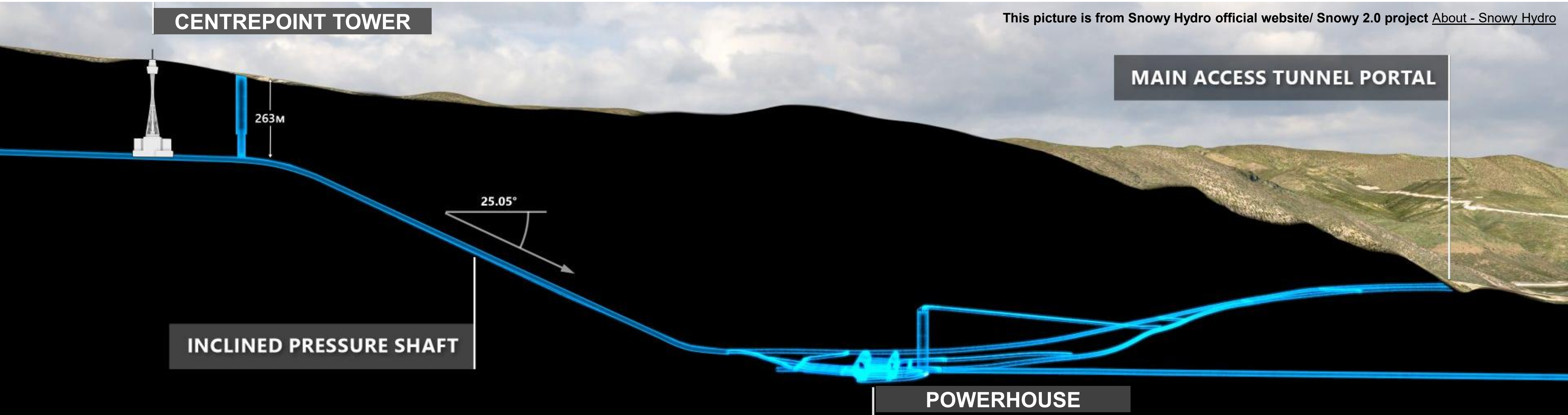
Snowy 2.0 project is the largest committed renewable energy project in Australia. Snowy 2.0 will underpin the nation's secure and stable transition to a low-carbon emissions future at the lowest cost for consumers.

The project involves linking two existing dams, Tantangara and Talbingo, through 27km of tunnels and building a new underground power station."

Voith Hydro is the Electrical & Mechanical **(E&M) Subcontractor** of an EPC Turnkey contract (FGJV)



This picture is from Snowy Hydro official website/ Snowy 2.0 project About - Snowy Hydro

Snowy 2.0
Project overview

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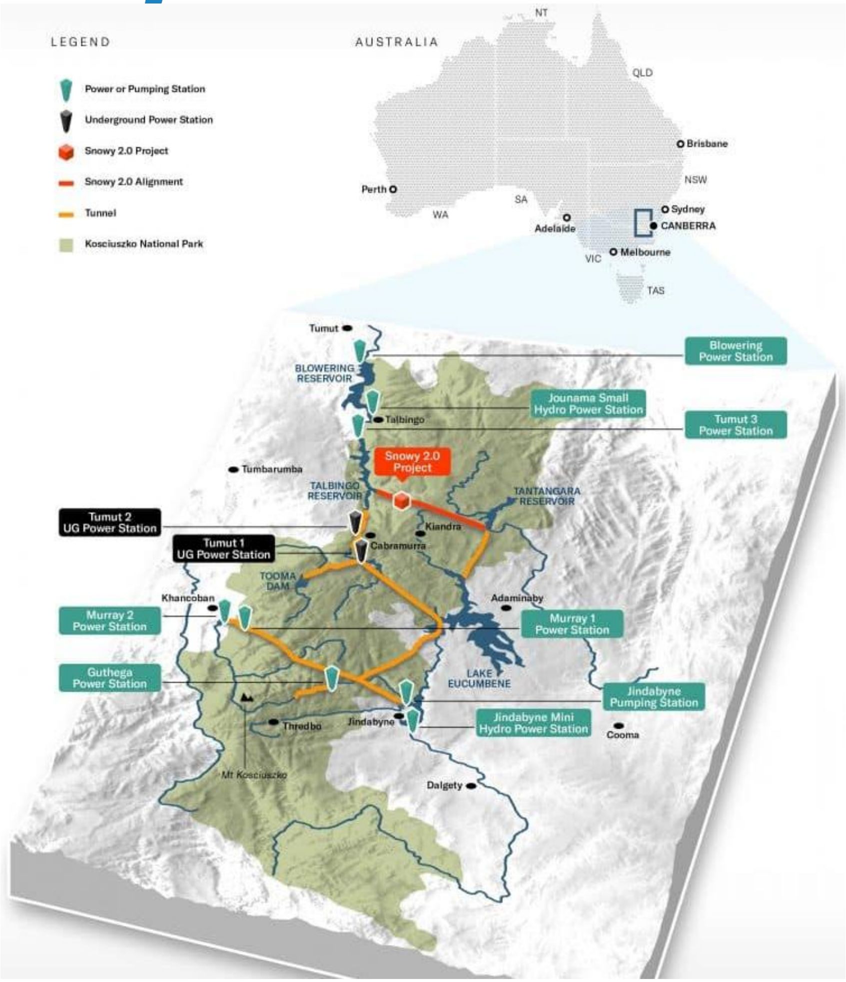
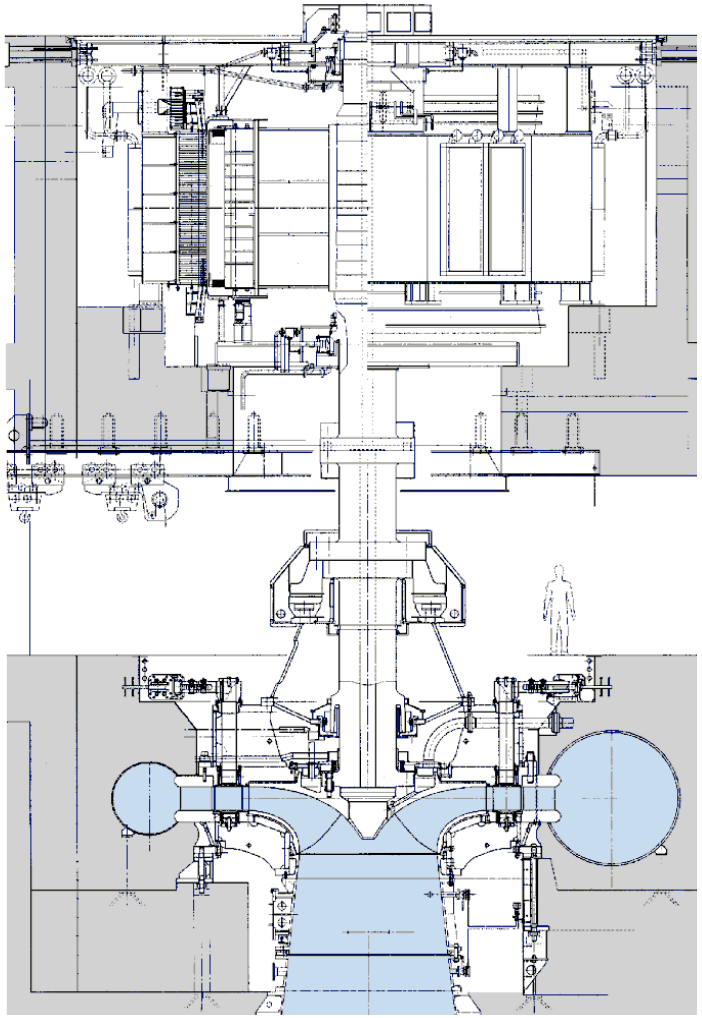


1. Snowy 2.0 Pumped Storage Power Station is located in New South Wales, Australia, 212 km from Canberra, the capital of Australia. Snowy 2.0 pumped storage power station is equipped with 3 fixed and 3 variable speed pump storage power units.
2. Upon its completion, “Snowy 2.0 will provide 2,200 MW (6 * ~350MW) of dispatchable, on-demand generating capacity and approximately 350,000 megawatt hours of large-scale storage to the National Electricity Market”
3. As scheduled, the last unit is targeted to be put into commercial operation in Dec 2028.

SNOWY 2.0 / SNOWY Hydro
Main Data



Project	SNOWY 2.0
Type of Plant	Pumped Storage Hydro Power Station
Country	Australia
End-Customer	SNOWY Hydro
Date of Award	Preferred E&M supplier: Jan 31st. 2019 . EPC award: April 2nd 2019
Number of Units	6 (3 fix + 3 var)
Scope of Supply	Complete Mechanical + Electrical + Auxiliary Systems
Project Time Frame	2019 – 2029 (10 years)

SNOWY 2.0 / SNOWY Hydro
Powerhouse Capacity

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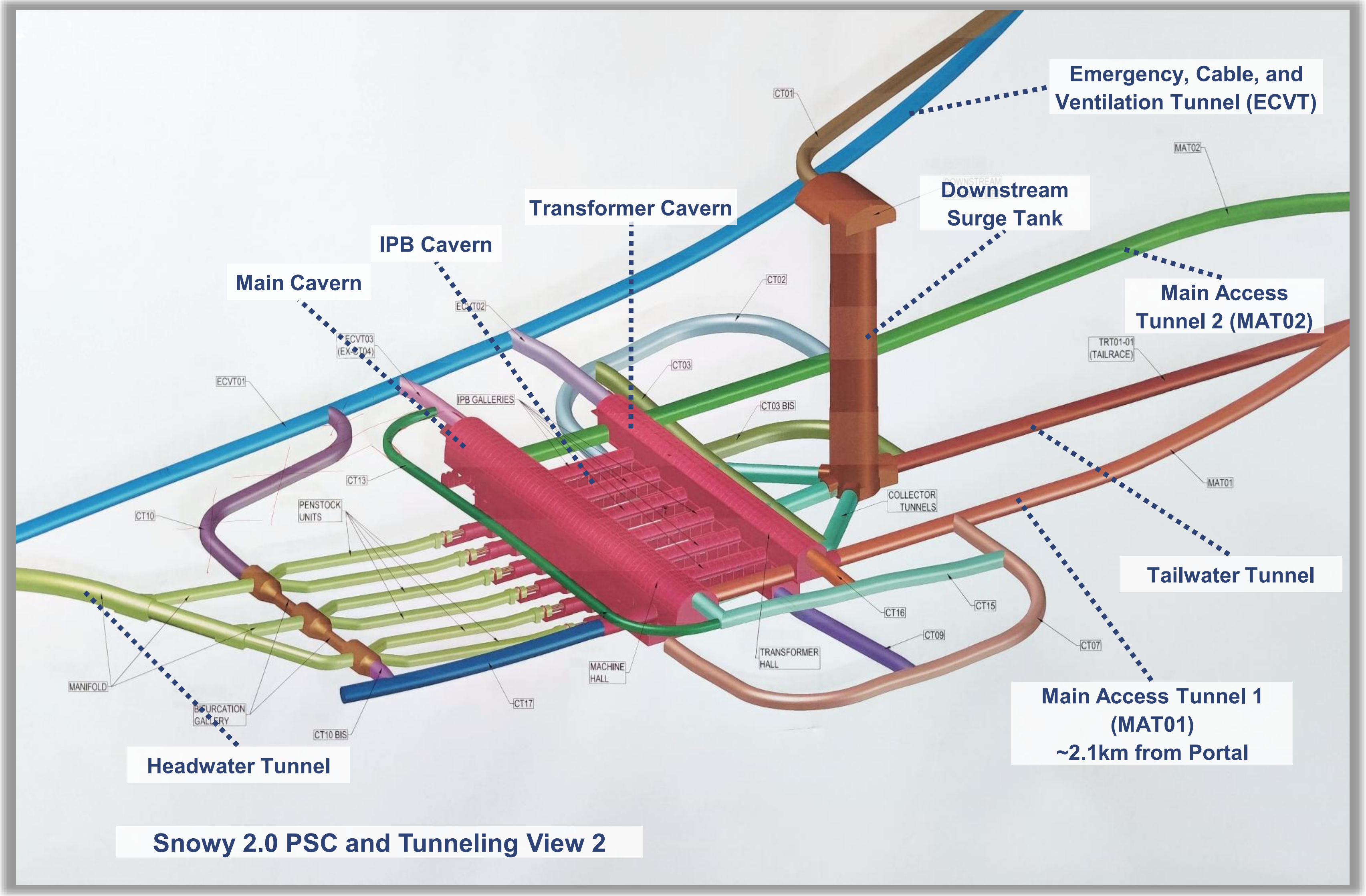
6 x 340 MW PT units, 3 fix + 3 varspeed - Cavern Powerhouse

- 6 (six) vertical Pump-Turbine and Motor-Generator units
- P_{rat} = 340 MW; P_{max} = 374 MW
- H_{rat} = 588,6 m; H_{pmax} ~ 730 m
- Q_{tr} ~ 67 m^3/s
- n = 500 rpm (+6,5 / -9,0%)
- D ~ 4,1 m
- S_{max} = 410 MVA, cosφ = 0.9, U = 15 kV, n_{max} = 662 / 784 rpm (stationary / transient)

Snowy 2.0 – Powerhouse and Tunneling view



These photos are from Snowy Hydro website BREAKTHROUGH MILESTONE FOR SNOWY 2.0 - Snowy Hydro

Voith's Scope of Work in Snowy 2.0

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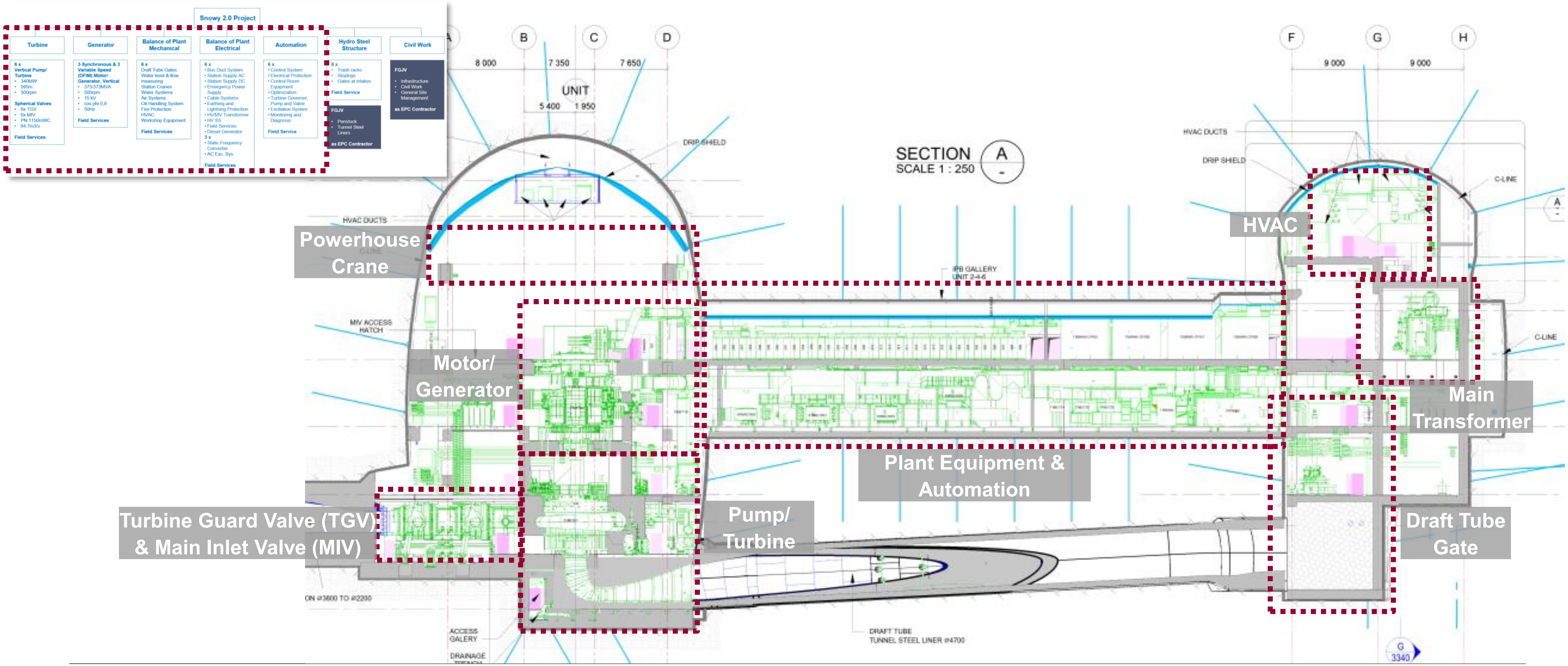
Voith Scope of Work for Electrical and Mechanical component are highlighted in the drawing below in green line.



SNOWY 2.0

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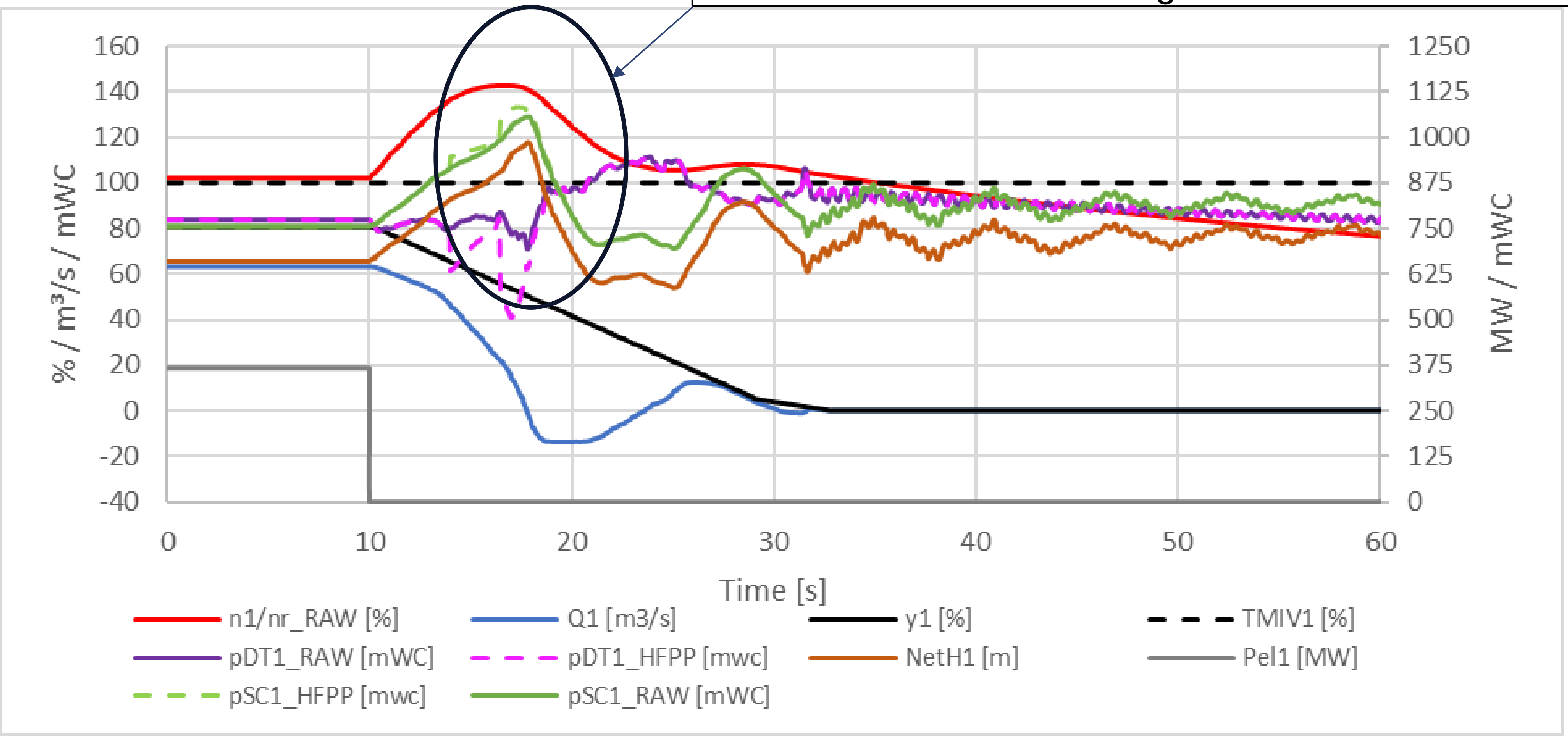
Major design challenges

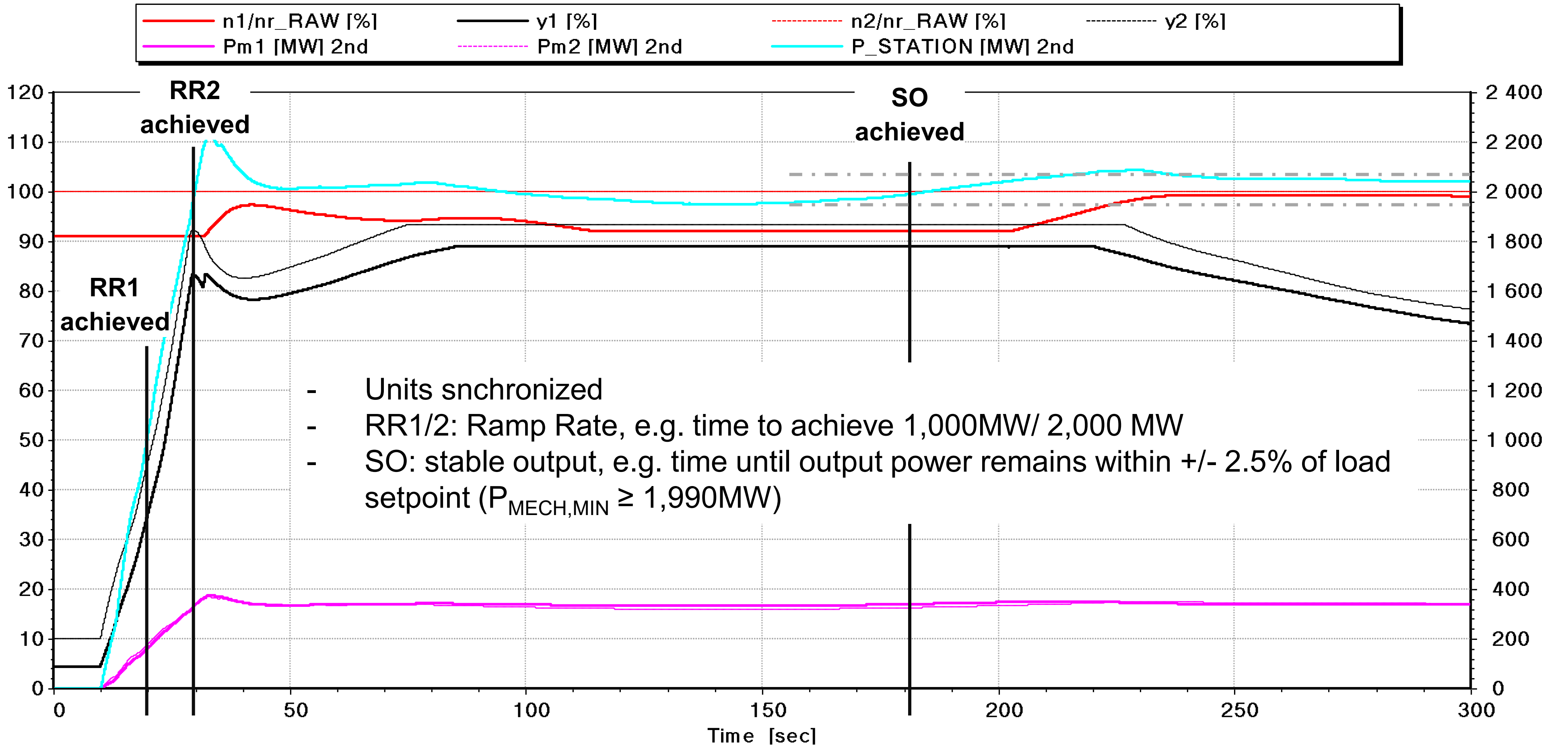
- Challenging waterways → several optimization loops between civil (penstock) and unit design
  - Safety & Mechanical design relevant load cases in various combination of all 6 units
  - Operational relevant load cases e.g. start from 0 to 2000MW → guaranteed starting time
- Extremely high requirements on start – stop cycles and design lifetime, both turbine and generator components
  - Relevant for all steel parts like spiral case or motor-generator rotor
  - Relevant also for rotor bars and the winding carrier fixation parts of the variable speed units
- Grid connection studies – still ongoing
- Design of HVAC and Firefighting system
- Implementation of BIM collaborative approach

Load Rejection load case
Including pressure pulsation consideration

Consideration of High Frequency Pressure Pulsations derived from model testing

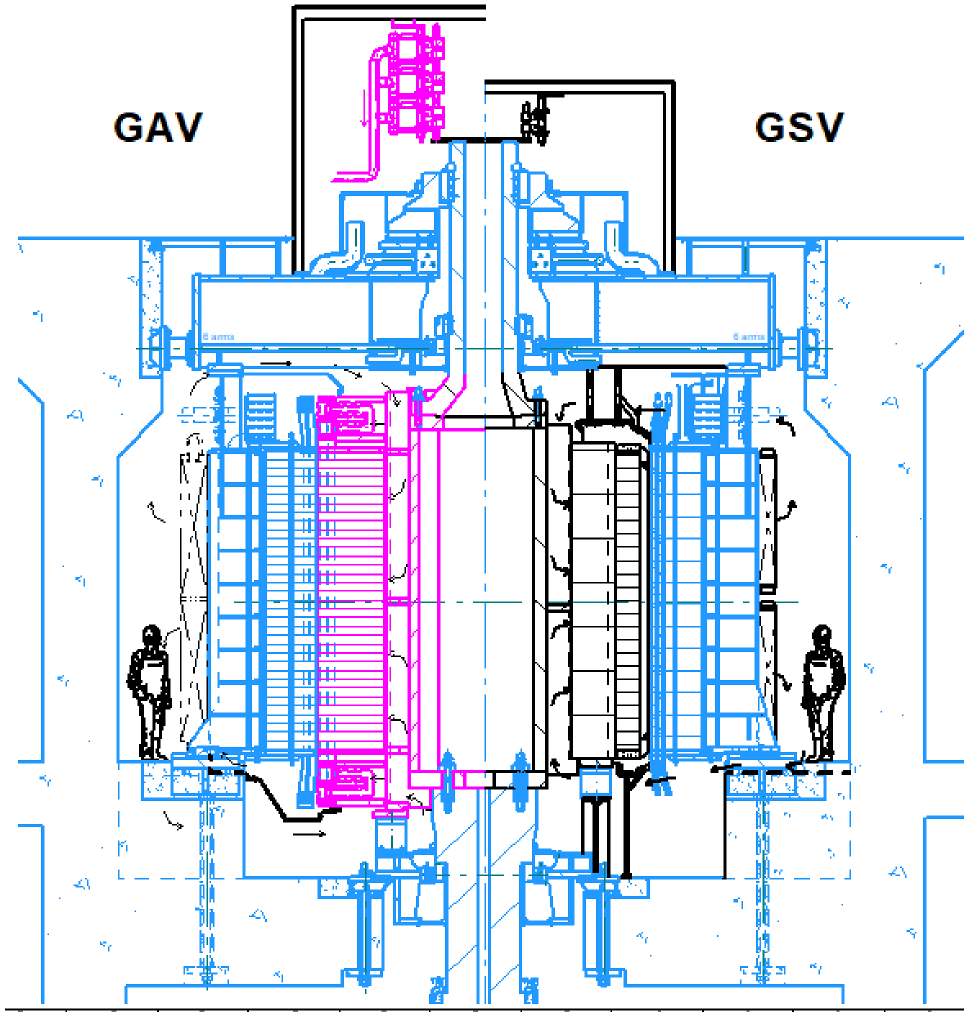


2000 MW Station Capability
Fast Loading - Definitions



- Units snchronized
- RR1/2: Ramp Rate, e.g. time to achieve 1,000MW/ 2,000 MW
- SO: stable output, e.g. time until output power remains within +/- 2.5% of load setpoint ($P_{MECH,MIN}$ ≥ 1,990MW)

Motor-Generator Design
Common design for GAV and GSV

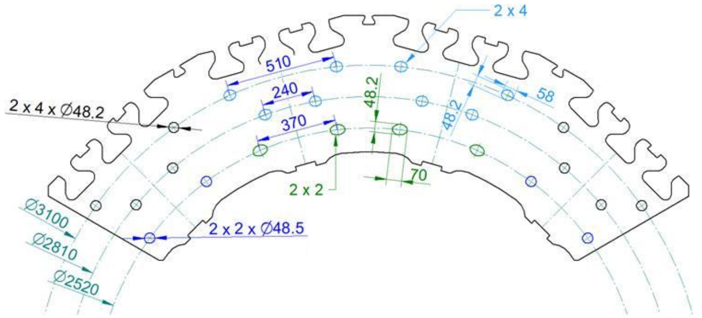


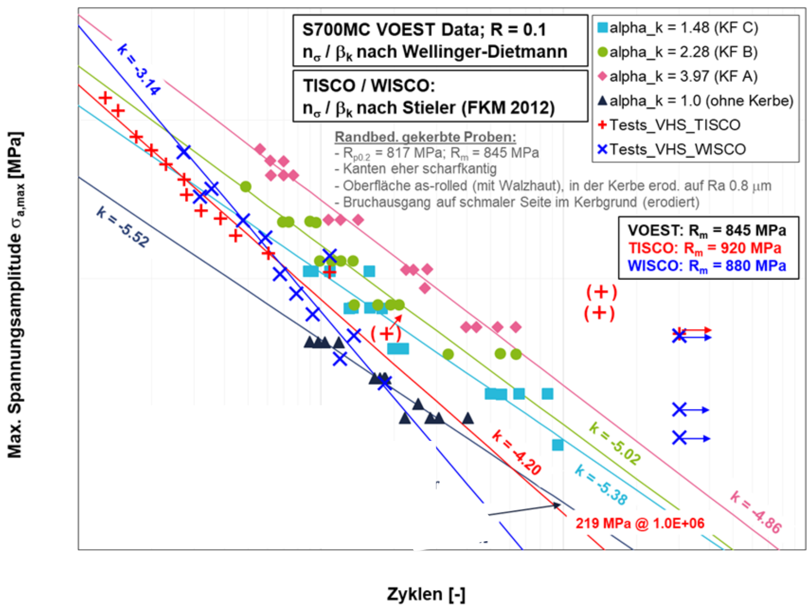
Rotor pole (GSV)

Rotor bars (GAV)

Motor-Generator Design

Strength assessment & optimization – example rim GSV

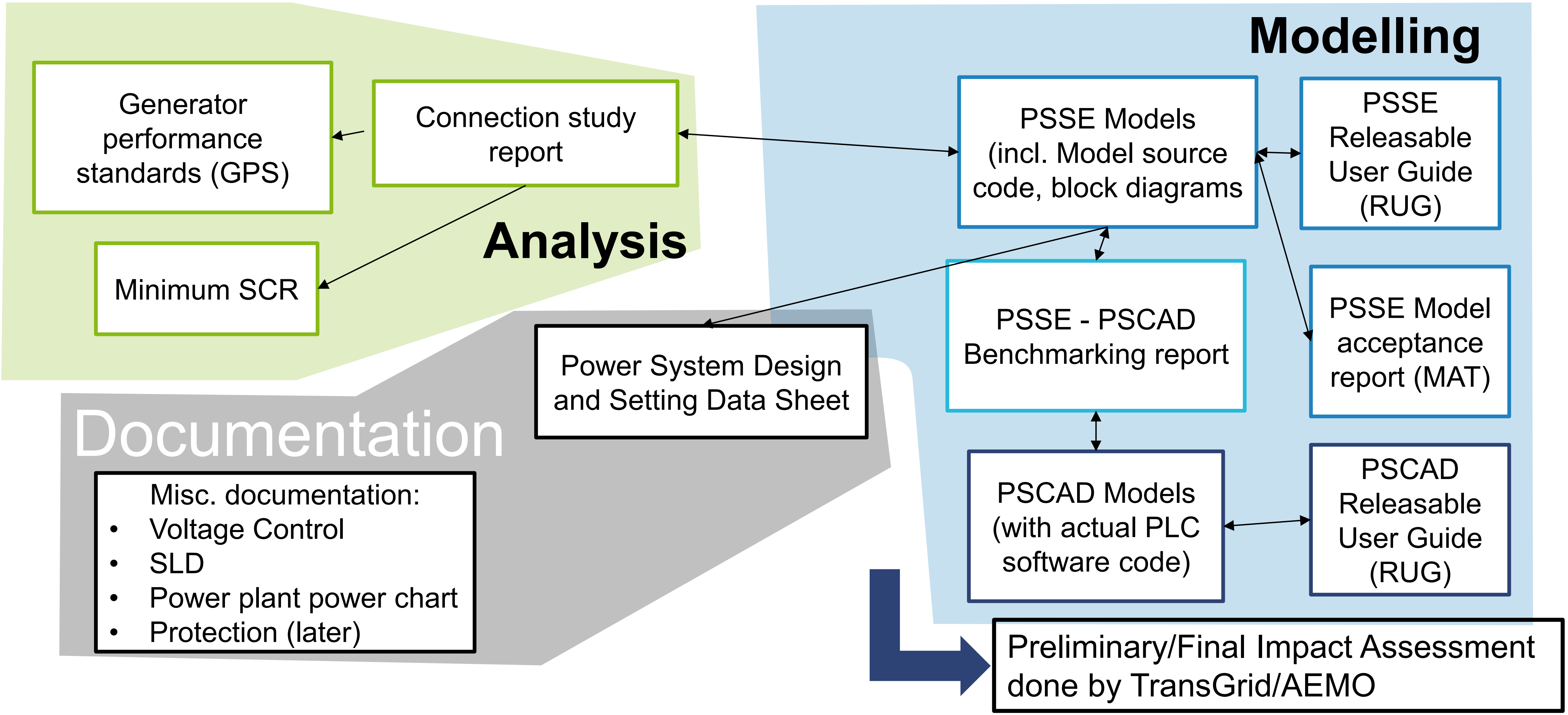




Design optimizations:

- Optimization shape of holes in non-overlap area
- Increase of min. compression in rim
- cut free of extremities → reduction of local peak stresses
- Extensive material testing – samples from different suppliers
- Statistical assessment and application of corresponding safety factors acc. to FKM

2200 MW Station Capability
Grid connection study - regional grid code



2200 MW Station Capability
Grid connection study - regional grid code

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Different fulfillment levels for each requirement - **Access standards** (AS):

- **Automatic AS**: If met, plant will not be denied access because of the corresponding technical requirement.
- **Negotiated AS**: An agreed standard of performance between AAS and MAS.
- **Minimum AS**: If not met, plant will be denied access because of that technical requirement.

Simulation models to be supplied for multiple simulation programs

- PSSE (Dynamic simulation simplified)
- PSCAD (Dynamic simulation with OEM PLC software detail level / hardware in the loop)
- PowerFactory (Harmonic distortion)
- SSAT, MudPack (Small signal stability)

FRT: System under investigation

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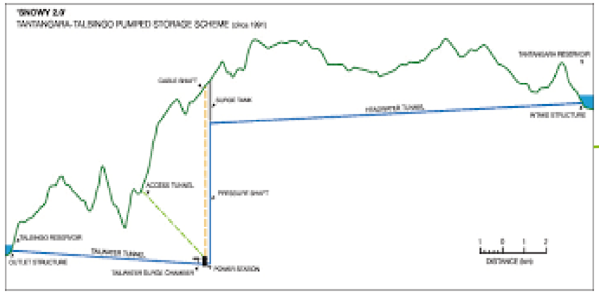
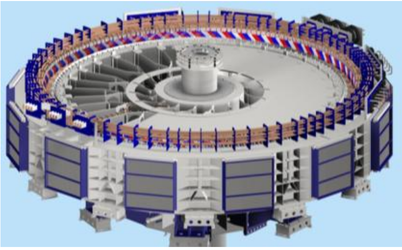
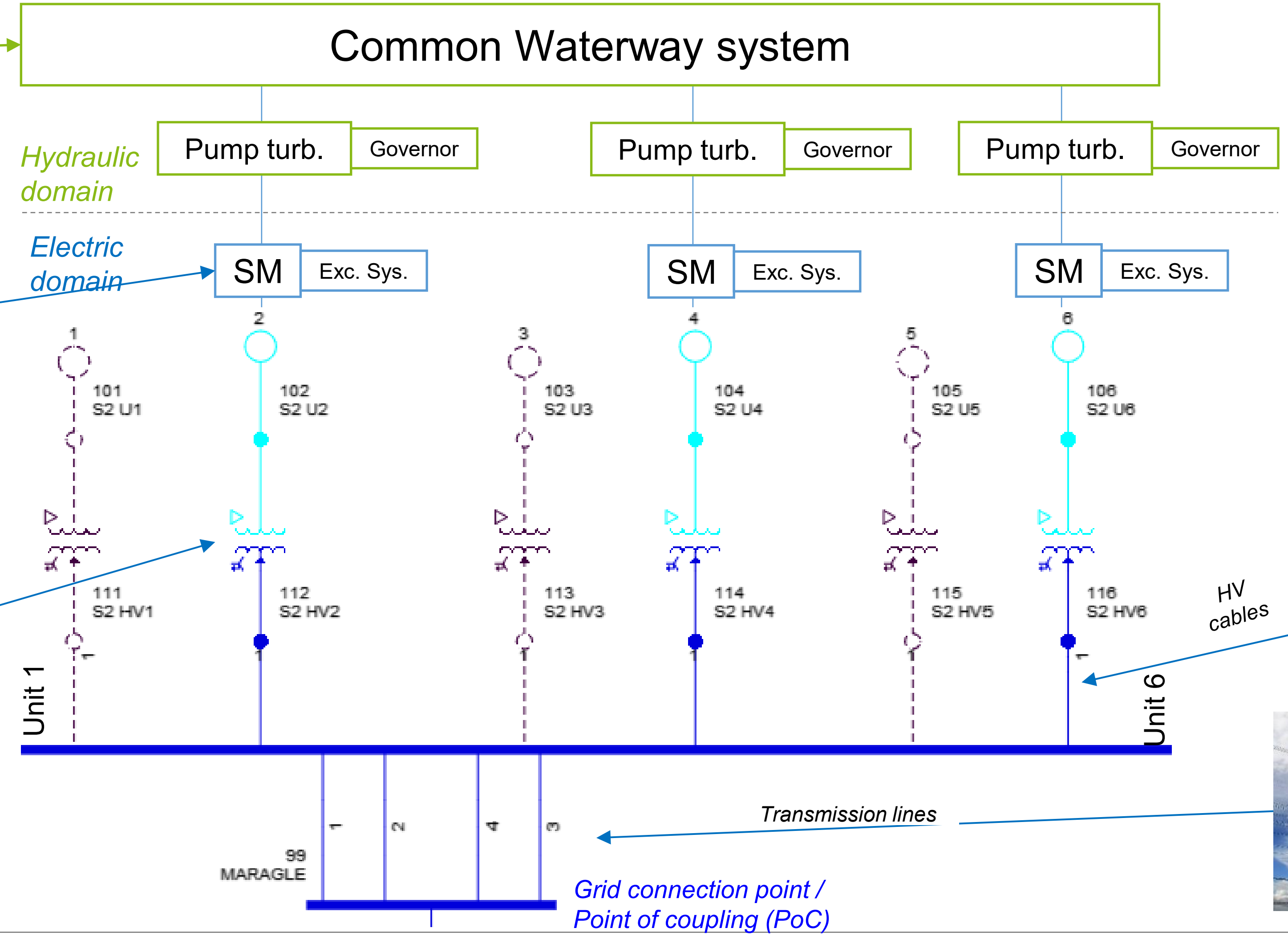
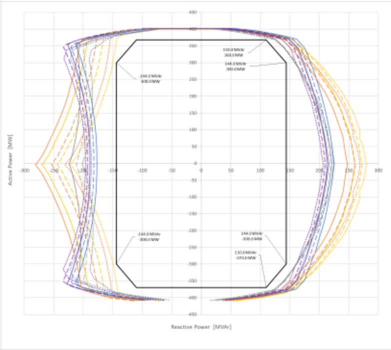
Incl. both fixed and variable speed units









FRT: Main dynamics of disturbance
During fault & After fault

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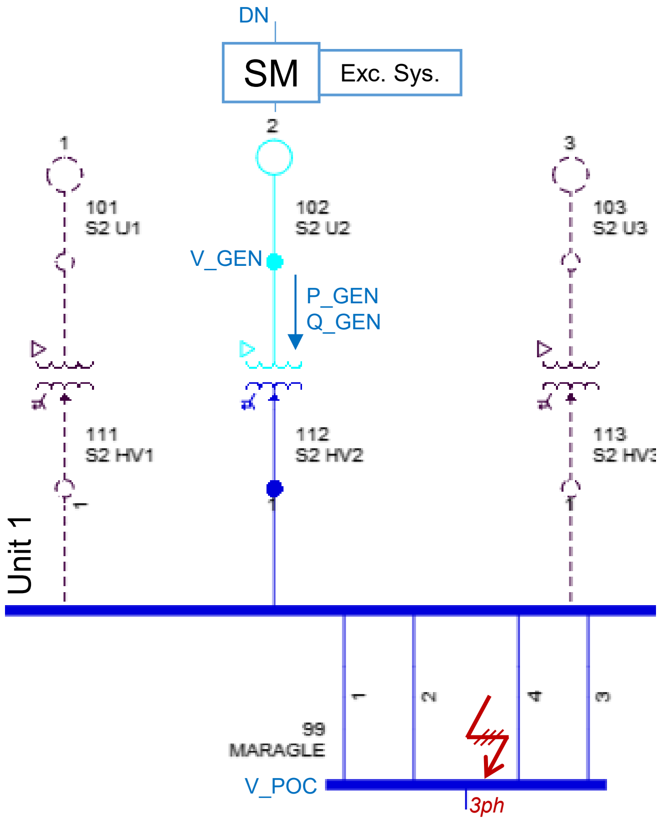
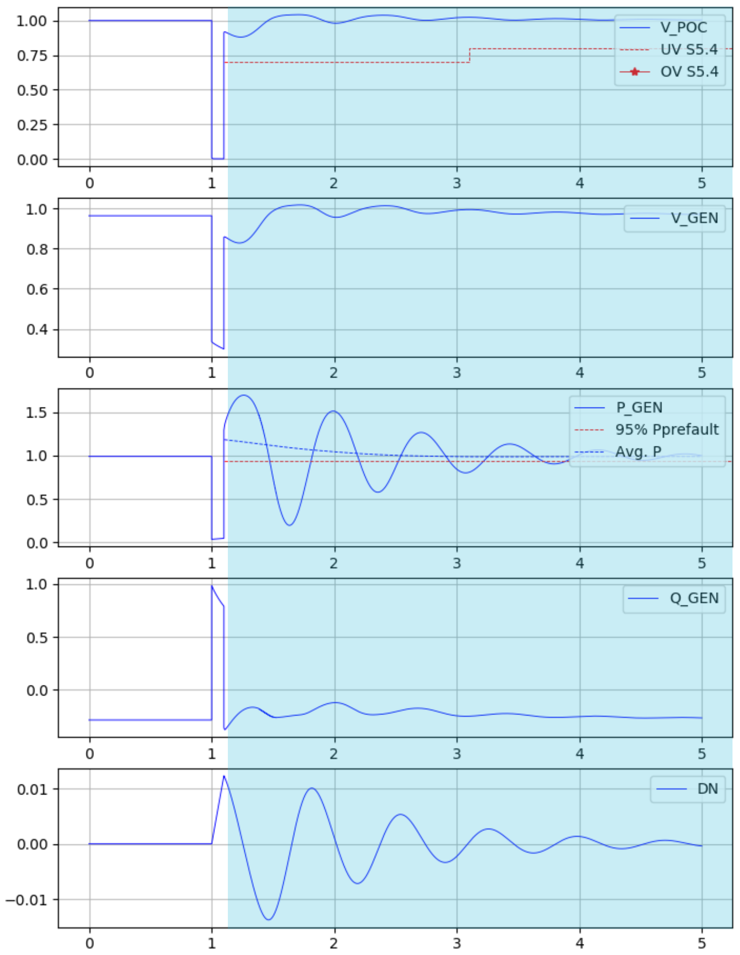
- POC voltage drop decreases SM terminal voltage
- SM accelerates due to active power transfer curtailment
- SM injects high reactive current towards fault location
- Excitation increases field voltage to compensate voltage drop

- SM terminal voltage recovers
- SM decelerates by injecting excess active power
- SM oscillations damped additionally by PSS





Locations – Upper (Tantangara) Intake
Progress tracking using BIM models

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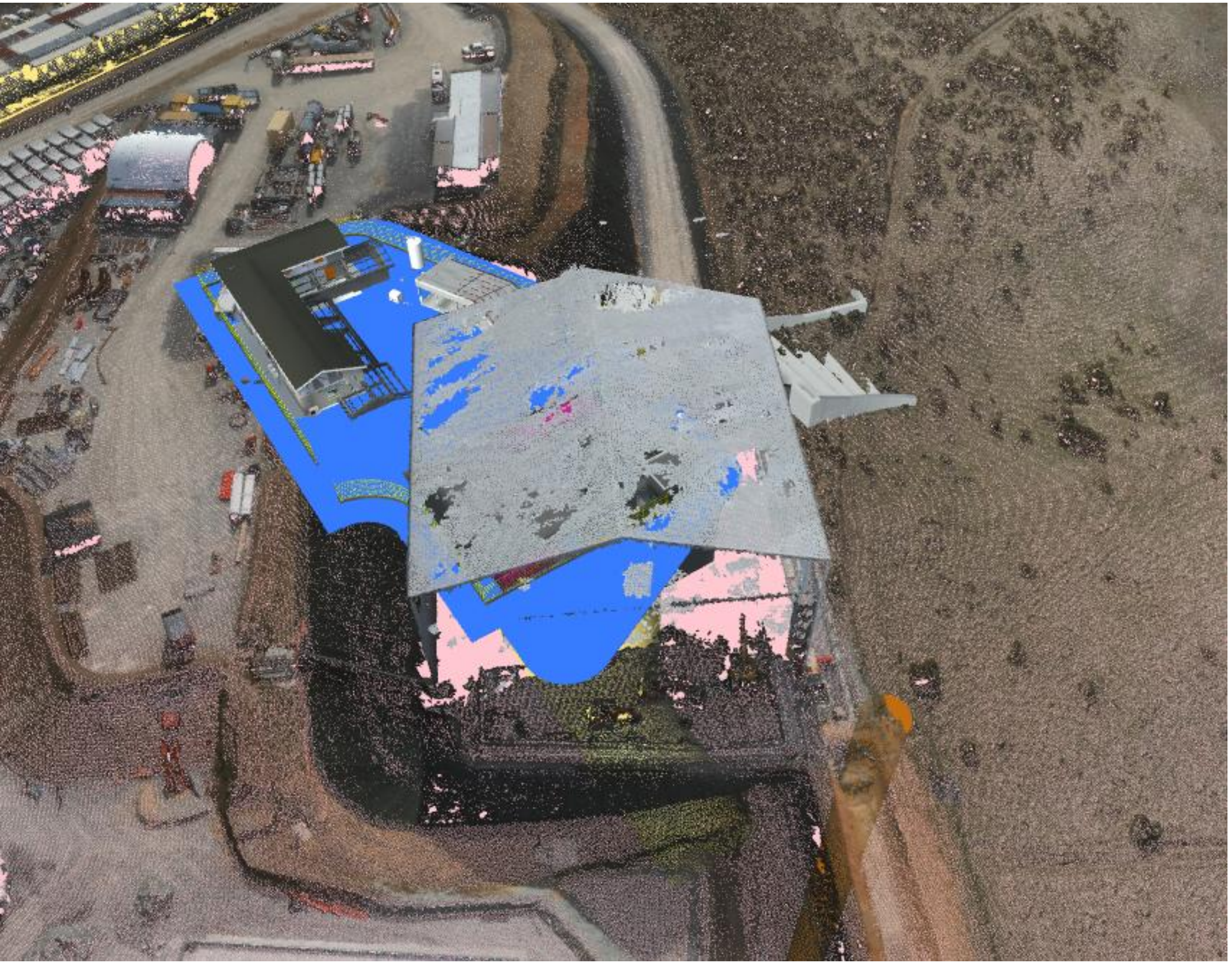

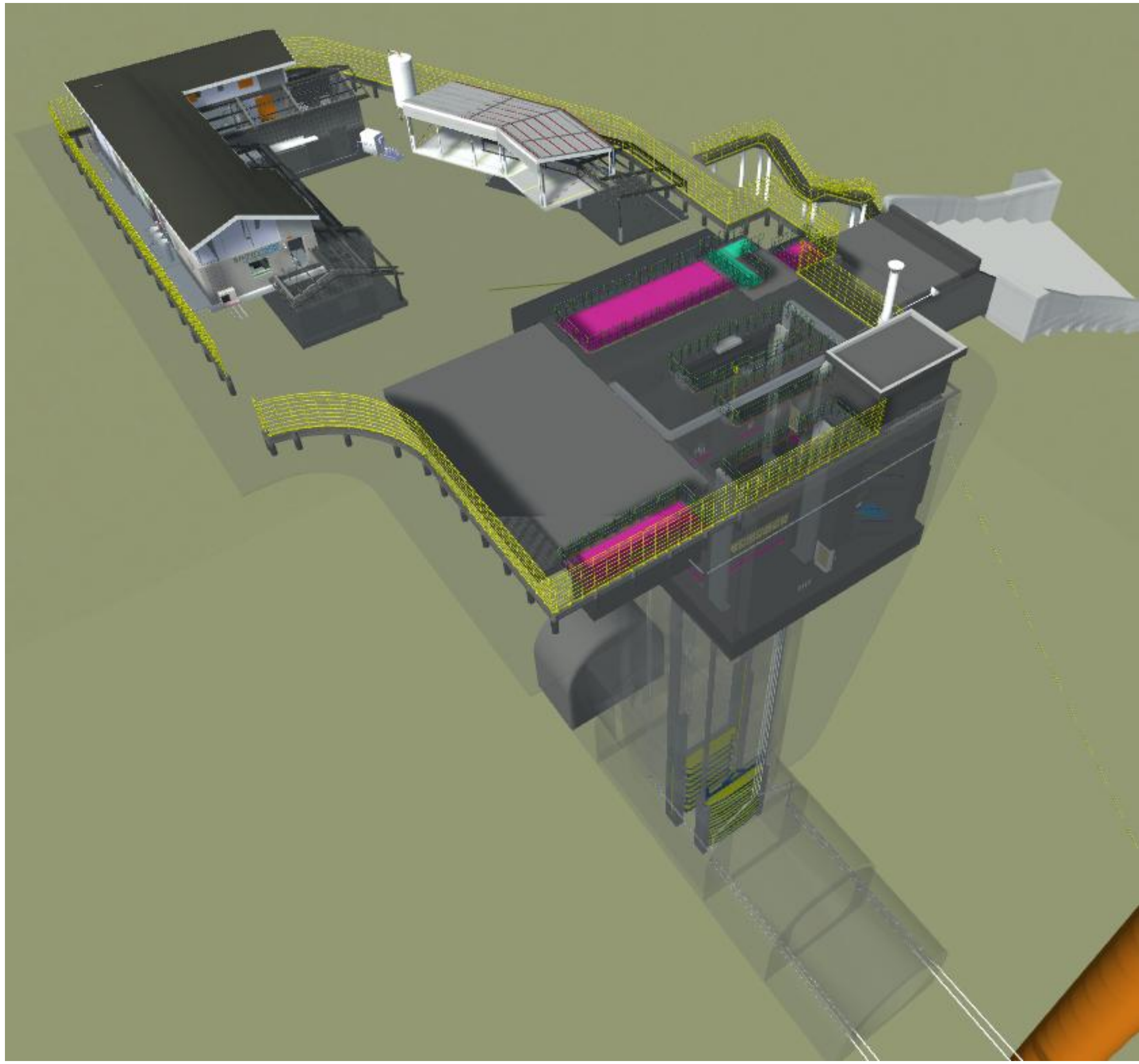

Site progress

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Upper chamber lower surge shaft

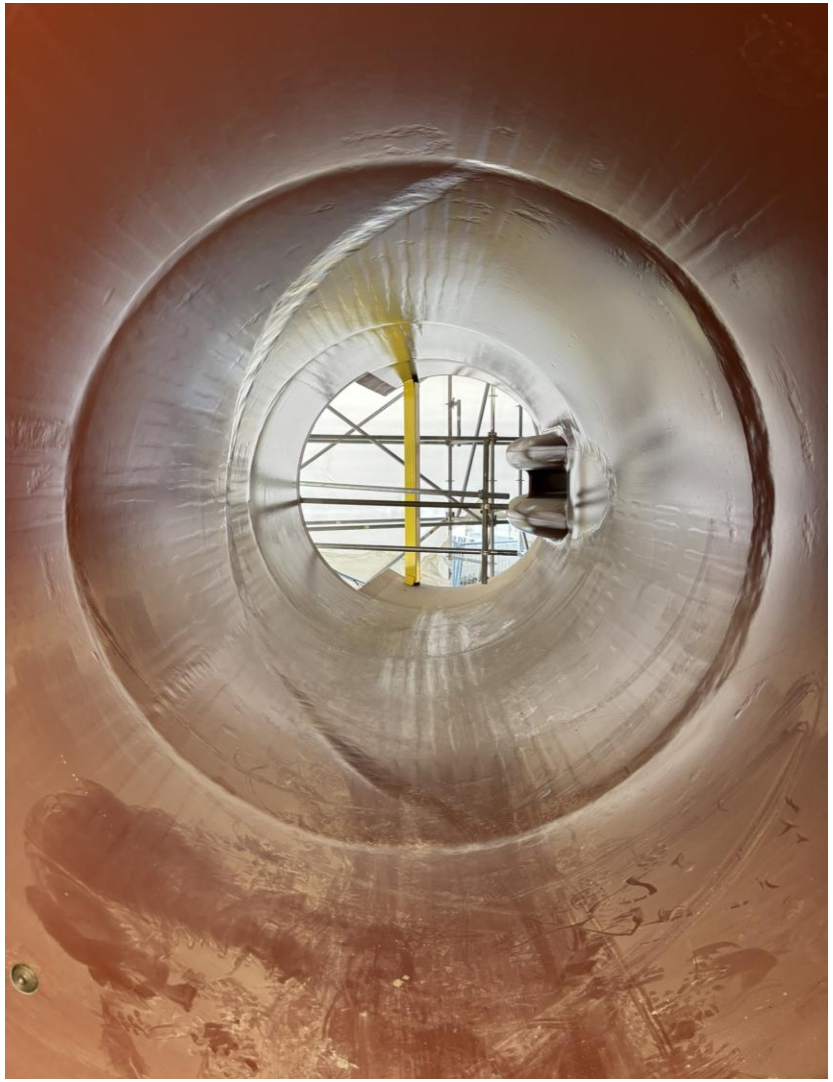

Talbingo (lower) intake

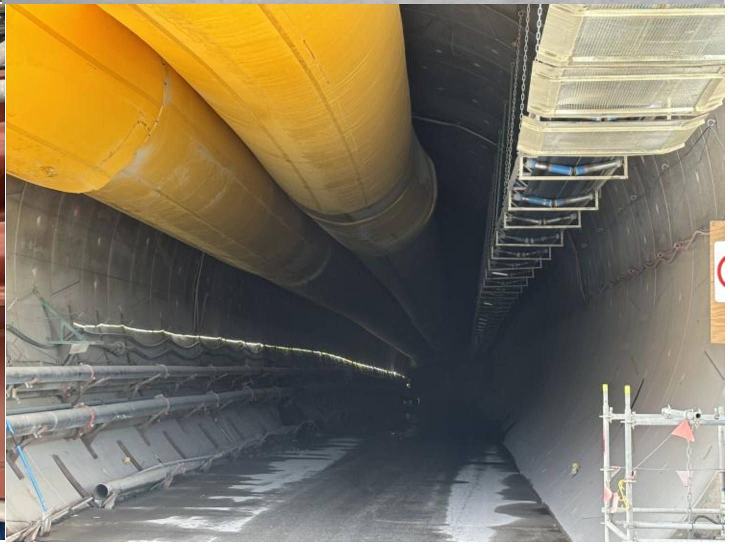

Transformer hall


Machine hall

Site & Manufacturing progress - examples







Manufacturing progress - examples

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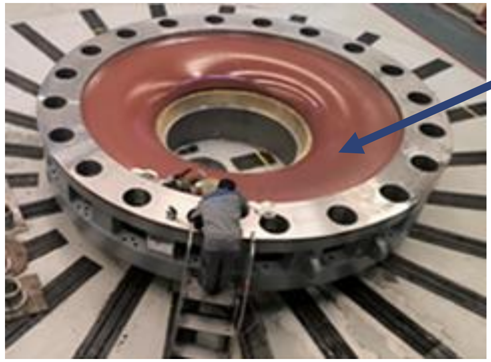
Wicket gates

&

WG levers



Distributor pre-assembly

Thrust block & runner assembly

Rotor core sheets (GAV)

Carrier ring (GAV)

Conclusions

- Modern PT trend is focusing on high head applications and variable speed technology
- Dynamic loading of mechanical components is getting more design relevant – including influence of complex waterways and the electrical grid
- Requirements on load universe as well as on continuous operating range increase
- Influence on overall power plant design & penstock layout
- Grid connection study and related acceptance process represent significant effort during the project execution phase with possible impact on the equipment sizing
- Voith Hydro and its competent expert team provides optimized solutions for complex projects

Contact:
Dr. Thomas Aschenbrenner
Project Manager Commissioning and Grid Connection Snowy 2.0
Voith Hydro GmbH & Co. KG
Tel. 07321 37-2871
thomas.aschenbrenner@voith.com

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