# ASSOCIAZIONE IDROTECNICA ITALIANA
## SEZIONE FRIULI VENEZIA GIULIA

Ai Signori: *Soci dell'Associazione Idrotecnica della Sezione del Friuli Venezia Giulia*

*Soci dell'Associazione degli Ingegneri*

*Operatori dei settori di interesse dell'AII*

LORO SEDI

Udine, 13 settembre 2010

Oggetto: Visita tecnica all'impianto idroelettrico con accumulo mediante pompaggio di AVCE in Slovenia sul fiume Isonzo di Venerdi 24 Settembre.-

Gentilissimi Soci e Simpatizzanti,

è con grande piacere che a mio nome e di tutto il Consiglio Direttivo dell'Associazione ho il piacere di invitarVi alla visita organizzata presso l'impianto idroelettrico di Avce in Slovenia realizzato dalla Società Idroelettrica del fiume Isonzo (Soske Elektrarne Nova Gorica) che rappresenta un'importante opera di ingegneria idraulica all'avanguardia nella gestione dell'energia mediante processo di accumulo. L'occasione sarà anche estremamente utile per prendere contatti con le Organizzazioni dei colleghi ingegneri della Slovenia che si occupano di problematiche idrauliche in modo da favorire la conoscenza e lo scambio di esperienze in materia di reciproco interesse. Alcune informazioni preliminari sull'impianto sono disponibili nella brochure allegata ed al sito *www.seng.si*.

La visita aperta a tutti i soci e simpatizzanti è prevista per venerdì 24 settembre c.a. e si svilupperà secondo la seguente modalità:

- ore 8.00 : per chi parte da Udine, ritrovo al parcheggio scambiatore di via Chiusaforte a Udine e partenza in comitiva con mezzi propri verso Gorizia;
- ore 8.45 : per chi non raggiunge Udine, ritrovo presso il valico Casa Rossa di Gorizia e ripartenza verso la sede della società SENG a Nova Gorica;
- ore 9.00: visita della sede della Soske Elektrarne situata in via Erjavceva 20 a Nova Gorica dove i tecnici ci illustreranno il progetto dell'impianto;

- a seguire, accompagnati dai tecnici della società partenza verso AVCE e visita dell'impianto. La conlusione della visita è prevista indicativamente per le ore 12.30.

Per quanti vorranno ci sarà la possibilità di concludere la giornata con un pranzo conviviale in zona.

Per consentirci di organizzare al meglio la giornata, invitiamo a far pervenire le adesioni per tempo ed al più tardi entro lunedì 20 settembre p.v. con relativo nominativo e punto di incontro (Udine o Gorizia) all'indirizzo e-mail: assidrofvg@libero.it o contattando direttamente il segretario Comuzzi Massimo al numero di cell. 333 2951774.

Colgo l'occasione per porgerVi i più cari saluti ed auguri di buon lavoro.

A presto.

**IL PRESIDENTE**
- Prof. Ing. VERRI Giorgio –

Allegata – brochure dell'impianto di AVCE.

SENG 60 let
SOŠKE ELEKTRARNE NOVA GORICA d.o.o.

# PSPP AVČE

## THE FIRST PUMPED STORAGE HIDROPOWER PLANT IN SLOVENIA

HSE

# Contents

- SENG HPP
- Avče PSPP basic data
- plant overview:
  USR, HRT, ST, VCH, PSK, PHS, PHB, TRC
- Pump/Turbine and Generator/Motor
- Variable speed / constant speed unit
- Project economy & milestones

# SENG hydro power plants

25 plants:

- 5 plants above 10 MW – HPP on Soča river:

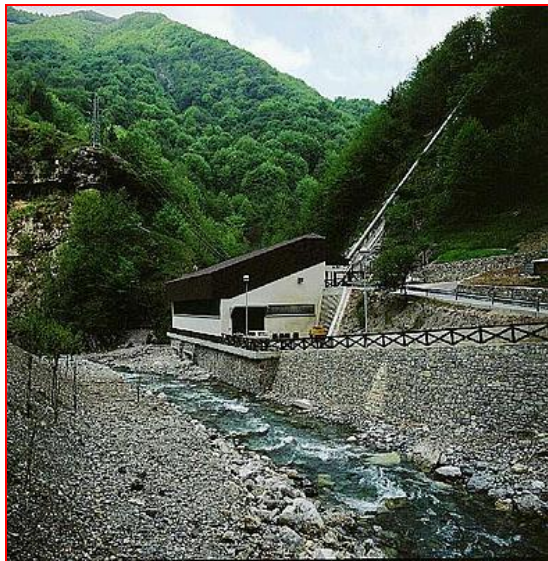
  *HPP Doblar I, HPP Doblar II, HPP Plave I, HPP Plave II, HPP Solkan*

- 20 plants up to 10 MW – HPP on Soča river
  *subsidiary streams*

Electical energy production - 520 GWh

Remote control - HPP over 10 MW

Remote supervision - HPP up to 10 MW

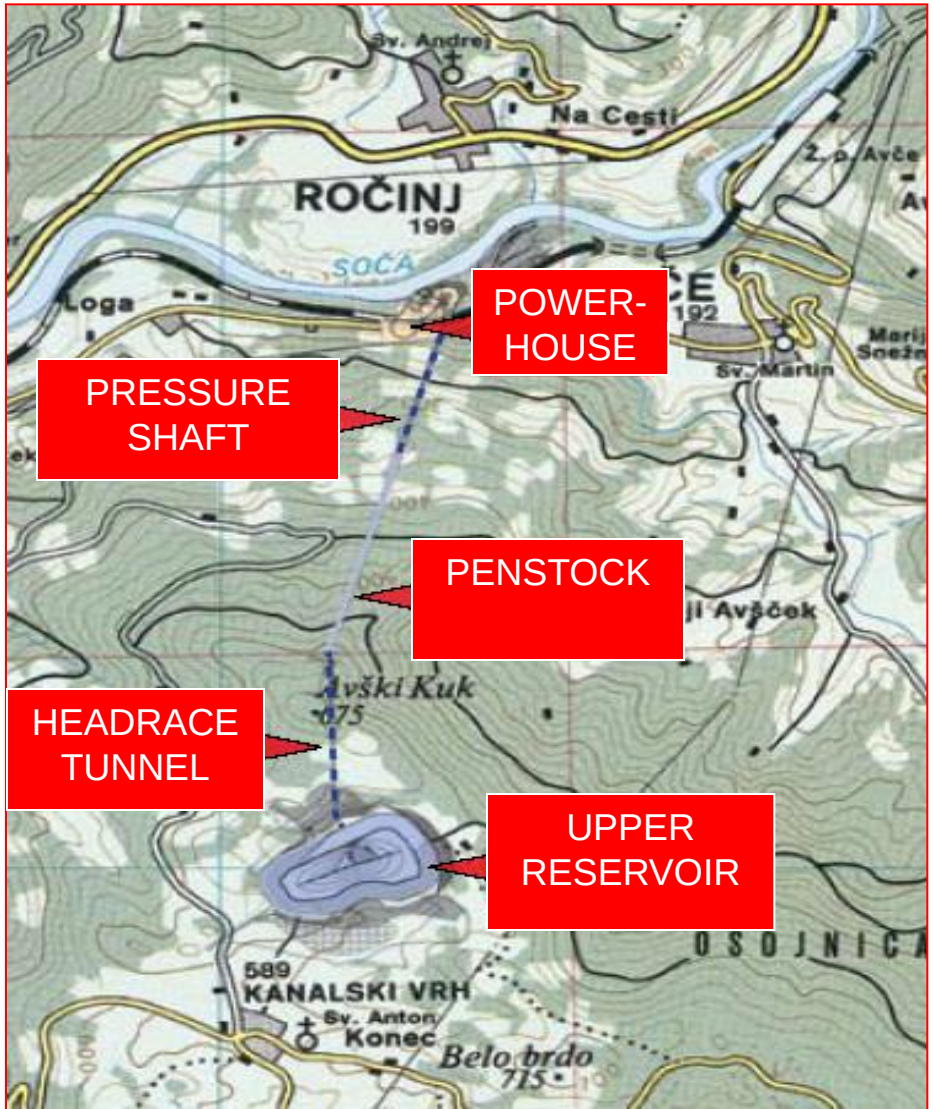



HPP SENG
+ HE LOG
HE MOŽNICA +
HE PLUŽNA +
HE BAČA +
+ HE KNEŽKE RAVNE 1
+ HE KNEŽKE RAVNE 2
HE ZADLAŠČICA +
+ HE TOLMIN
HE CERKNO +
HE DOBLAR 2 +
+ HE PODMELEC
HE DOBLAR 1 +
+ JEZ PODSELO
+ ČHE AVČE
+ JEZ AJBA
HE PLAVE 2 +
HE PEČNIK +
HE PLAVE 1 +
HE KLAVŽARICA +
+ HE MAROF
+ HE SOLKAN
HE JELENK +
HE MESTO +
+ VZDRŽEVALNE DELAVNICE
HE TREBUŠA +
CV SENG +
+ HE MRZLA RUPA
+ HE HUBELJ
+ HE GRADIŠČE
HE PLANINA +
BOVEC
KOBARID
TOLMIN
KOMNA
POLOVNIK
TRENTA
SEŽANA
AJDOVŠČINA
VIPAVA
NANOS
UDINE-VIDEM
CIVIDALE-CEDAD
MONFALCONE-TRŽIČ
GRADO-GRADEŽ
Razdrto-POSTOJNA

# Benefits of the Avče project

- Peak energy production
- Flexibility in the open electric energy market
- System reserve
- Turist development on upper storage reservoir area

# Location in detail



# AVČE PSPP – basic data

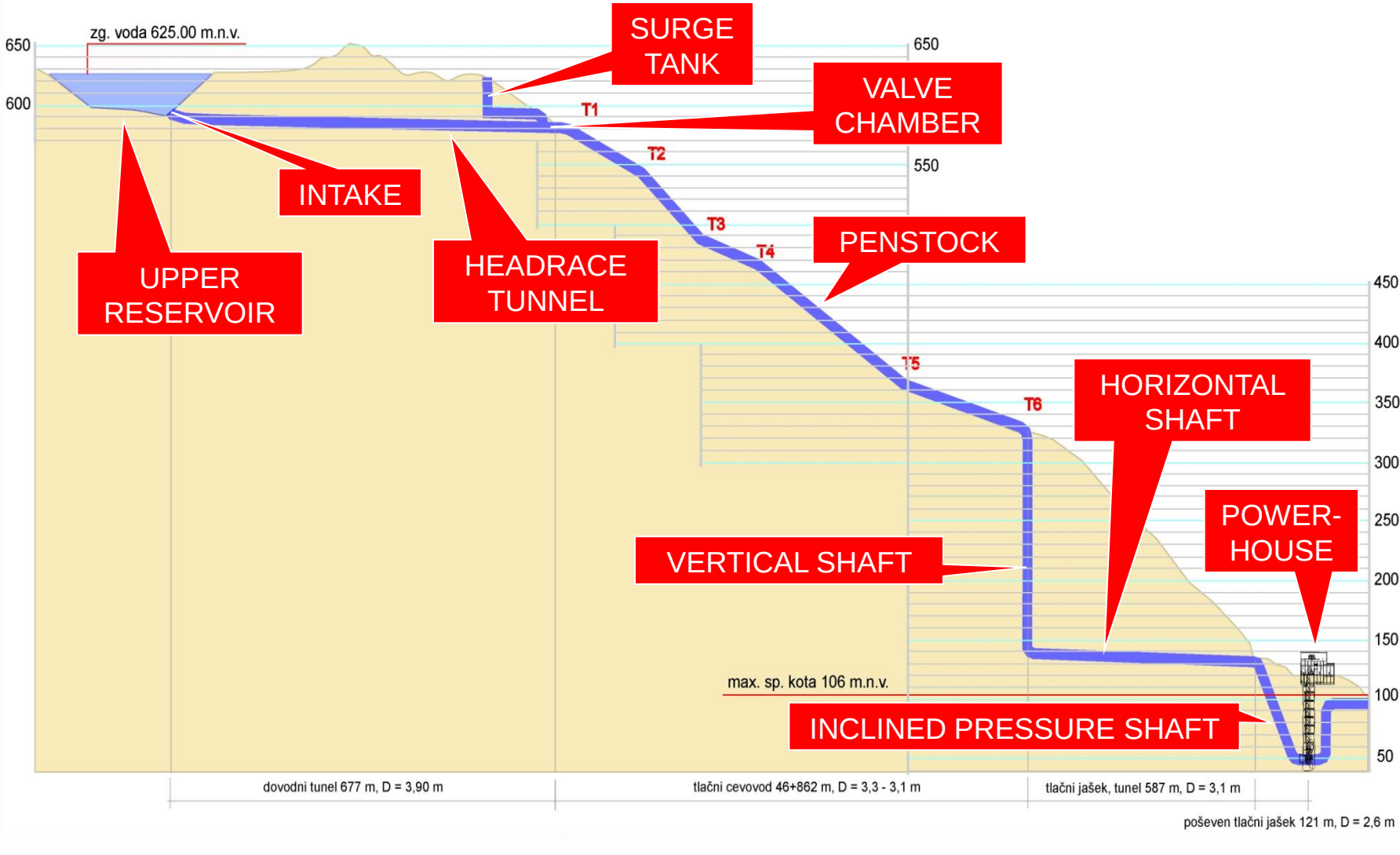
**General data**

| | |
|---|---|
| Maximal discharge - turbine / pumping mode | 40 / 32 $m^3/s$ |
| Maximal / minimal head | 521 / 491 m |
| Installed power - turbine / pumping mode | 185.4 / 180.0 MW |
| Efficiency | 0,77 |
| Upper storage reservoir | 2,3 mio $m^3$ |
| Lower storage reservoir | 0,42 mio $m^3$ |

**Electrical and mechanical equipment in the Powerhouse**

| | |
|---|---|
| Pump/Turbine | Francis, 7 blades |
| Generator /Motor | 195 MVA, 18kV |
| | 600 min-1 (-4/+4 %) |
| Main crane | 300 t |
| Main transformer | 200 MVA, 18/116 kV |
| Switchgear (GIS) | 110 kV |

# Facility cross – section

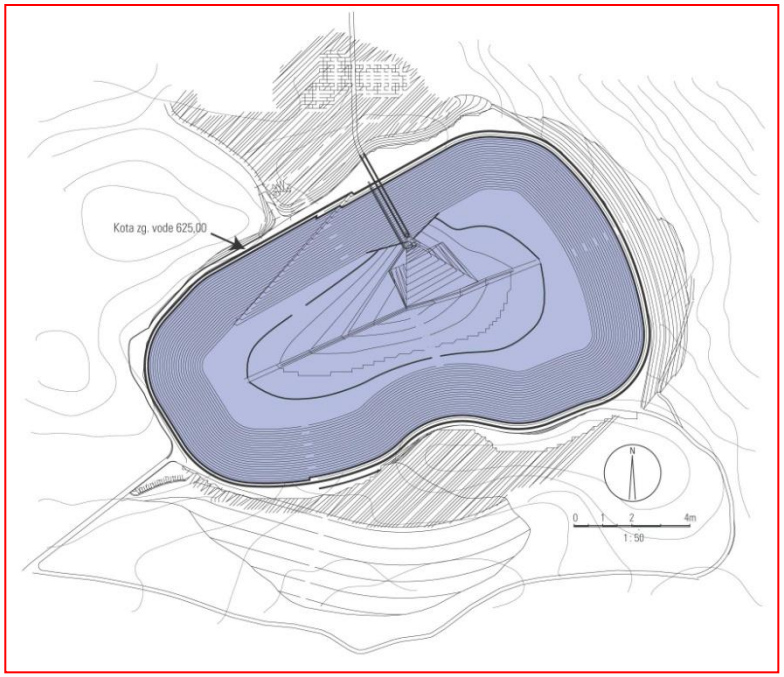


## Upper storage reservoir

- $H_{bmax}$ - 521,0 m
- $H_{bmin}$ - 491,0 m

- $H_{max}$ - 625 m n.m.
- $H_{min}$ - 597 m n.m.

- Volume $2{,}3\ 10^6\ m^3$

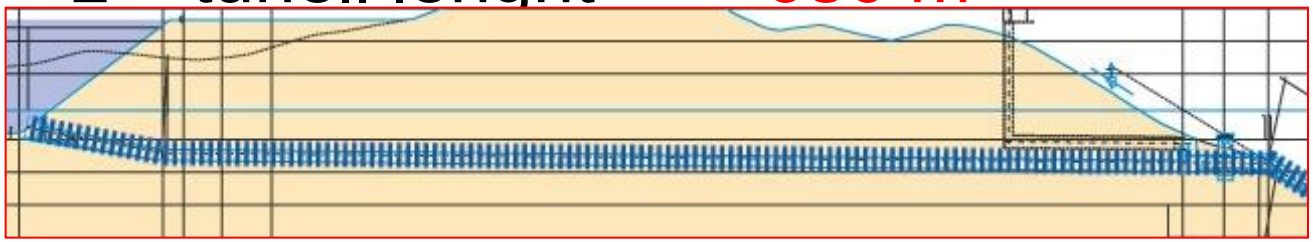


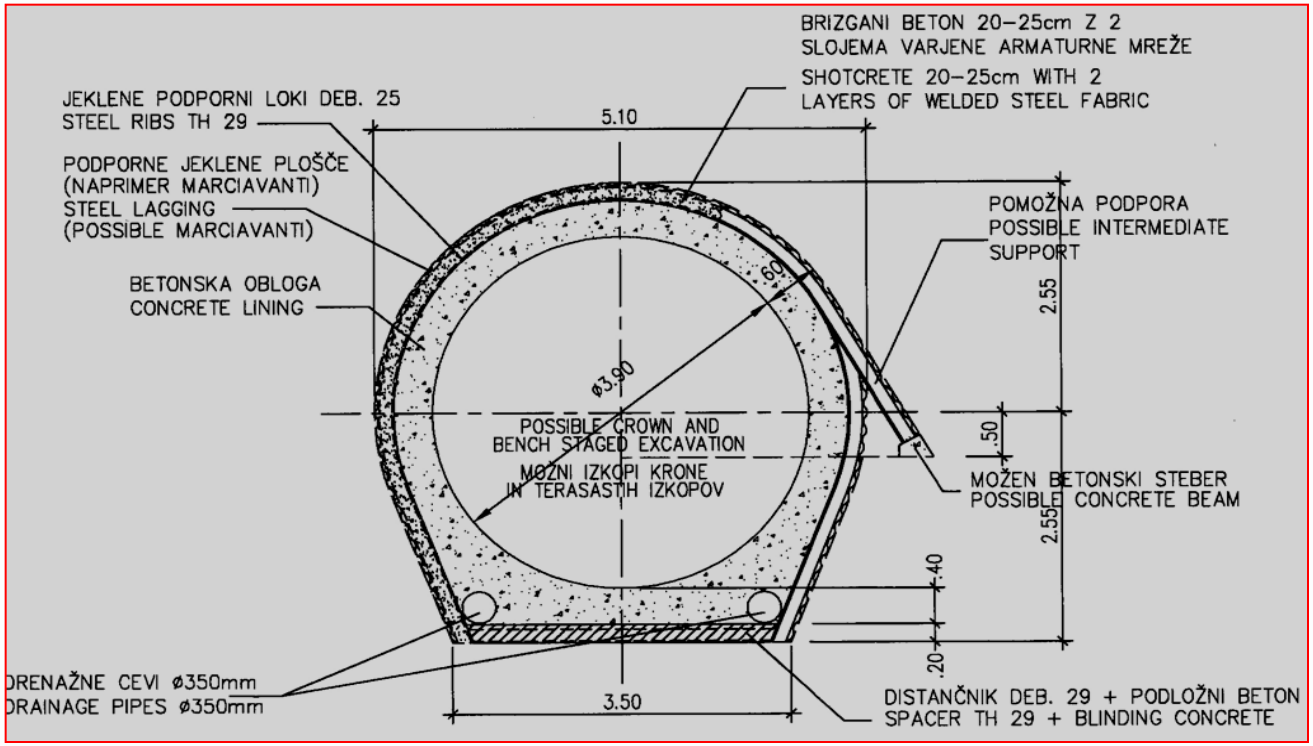

## Lower storage reservoir

- $H_{max}$ - 106 m n.m.
- $H_{min}$ - 104,5 m n.m.
- $V_{olume}$- $0{,}42\ 10^6\ m^3$

# Headrace tunnel

- Dn – inner diameter 3,9 m
- L – tunell lenght 680 m



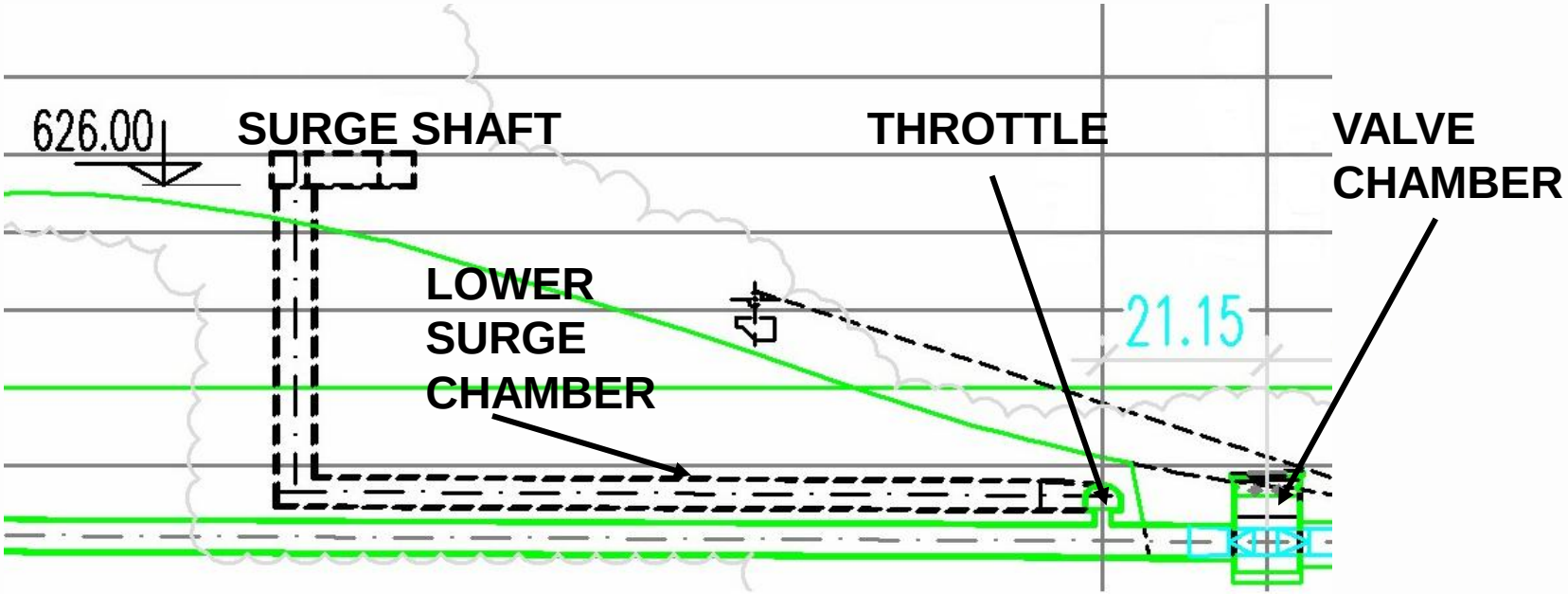


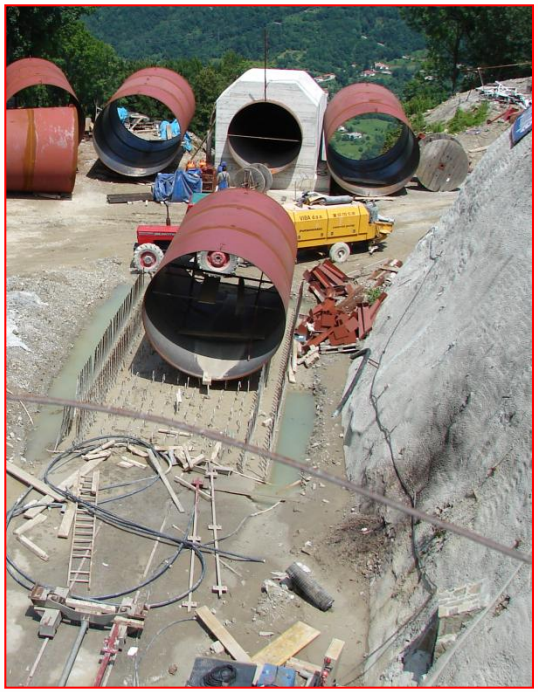
# Surge shaft

- Dn – inner diameter 4,5 m
- L – surge lenght 39 m

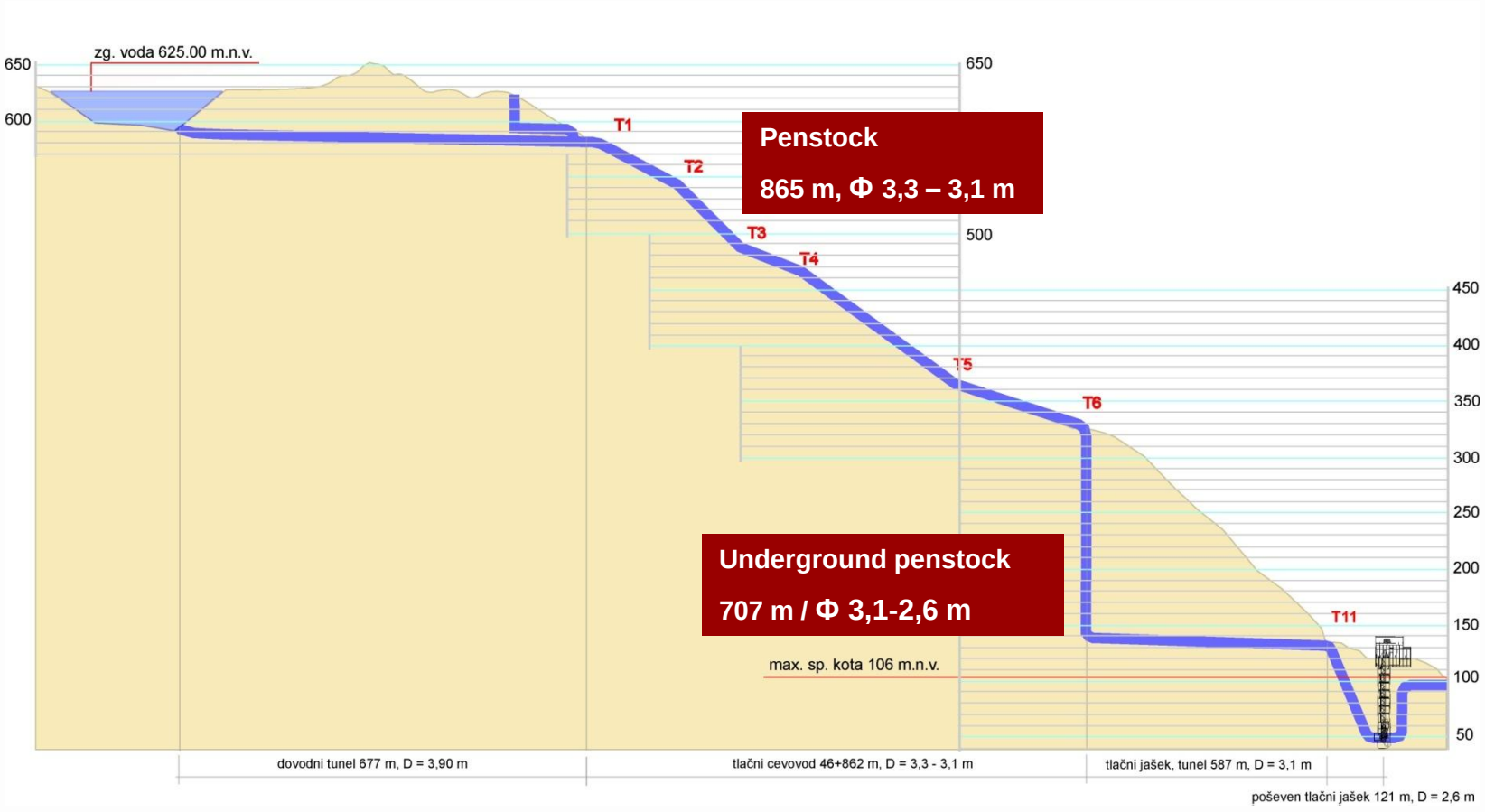
# Lower surge chamber

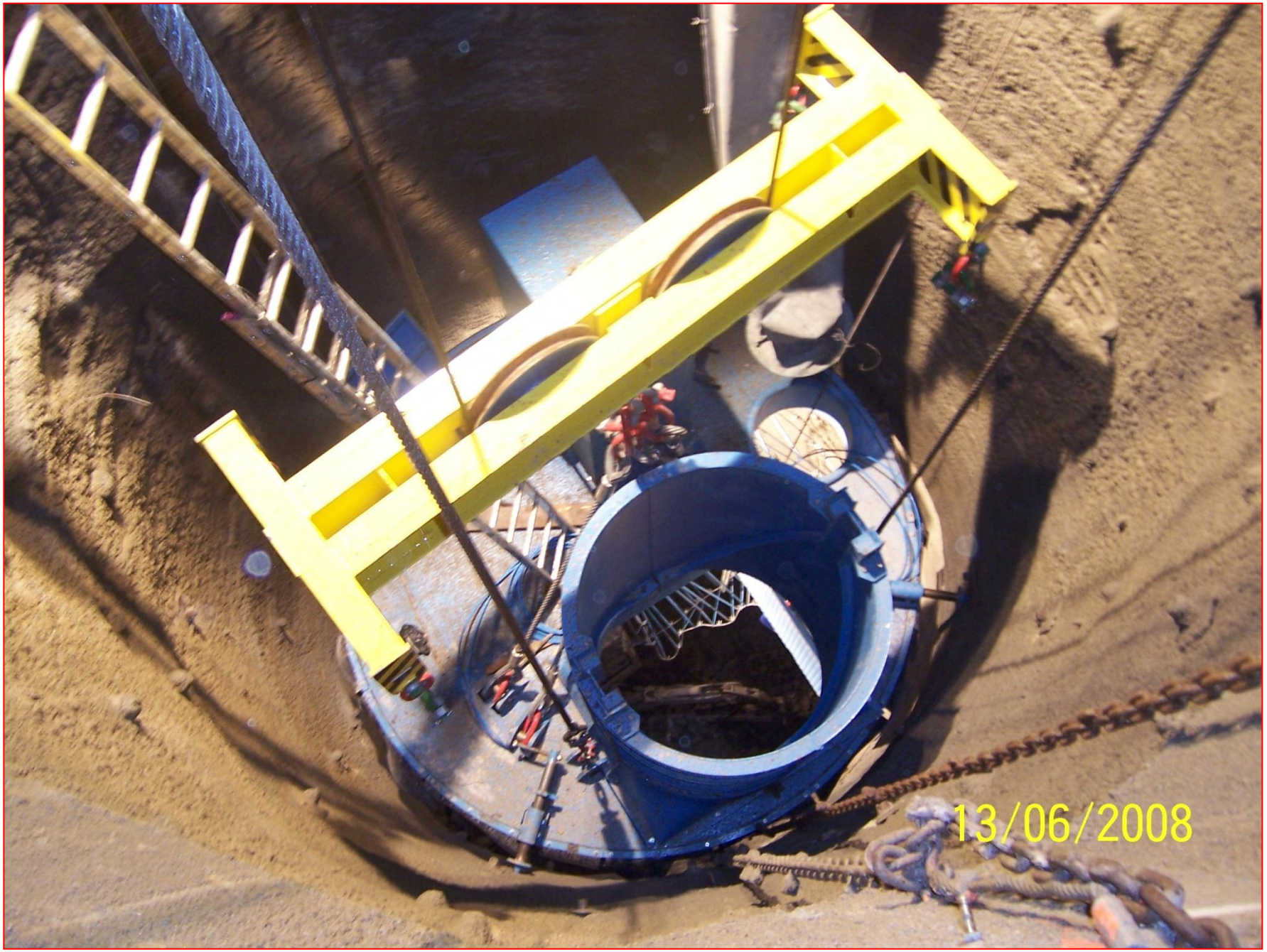
- Dn – inner diameter 3,5 m
- L – chamber lenght 113 m





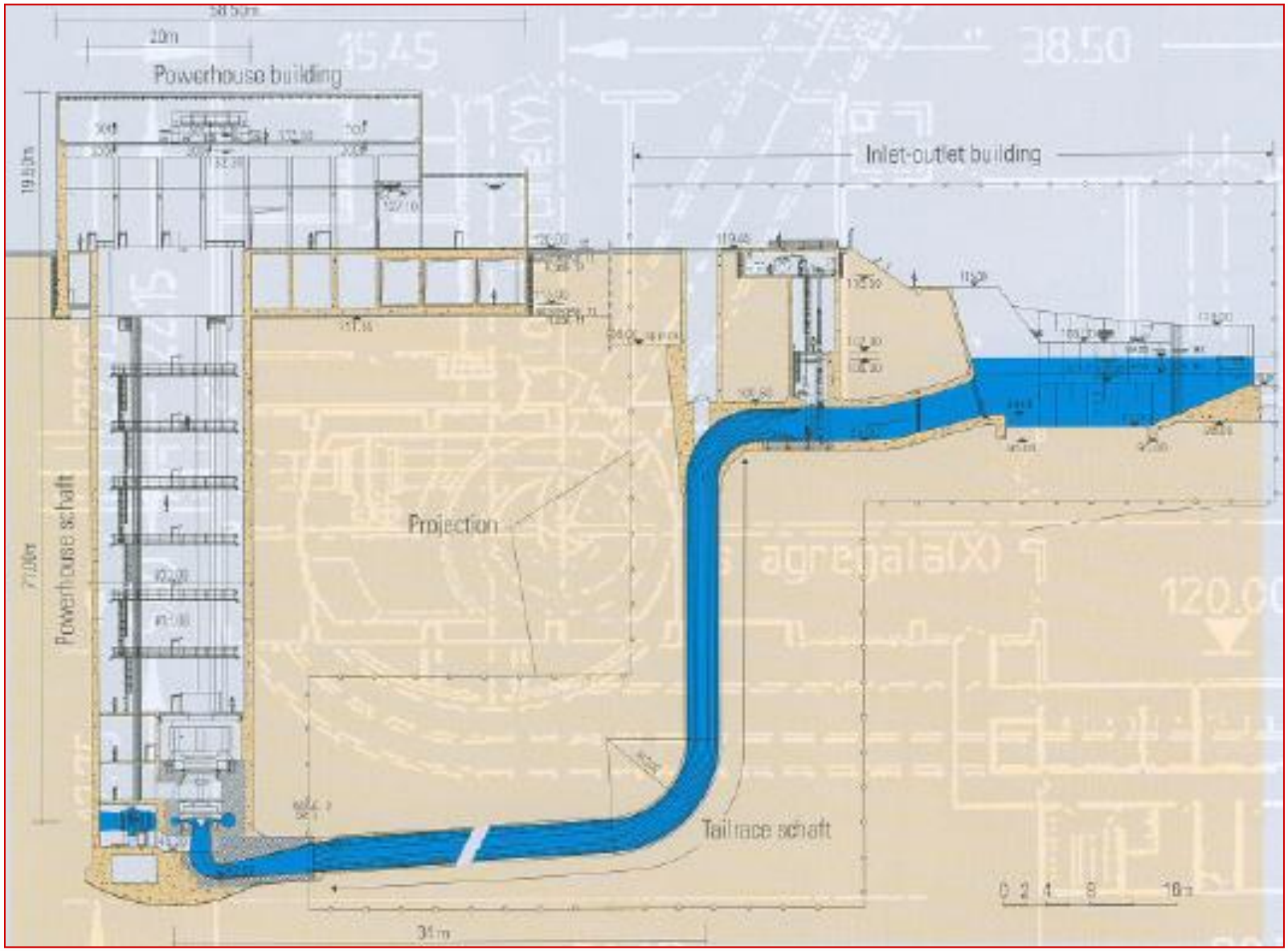
# Penstock longitudinal profile

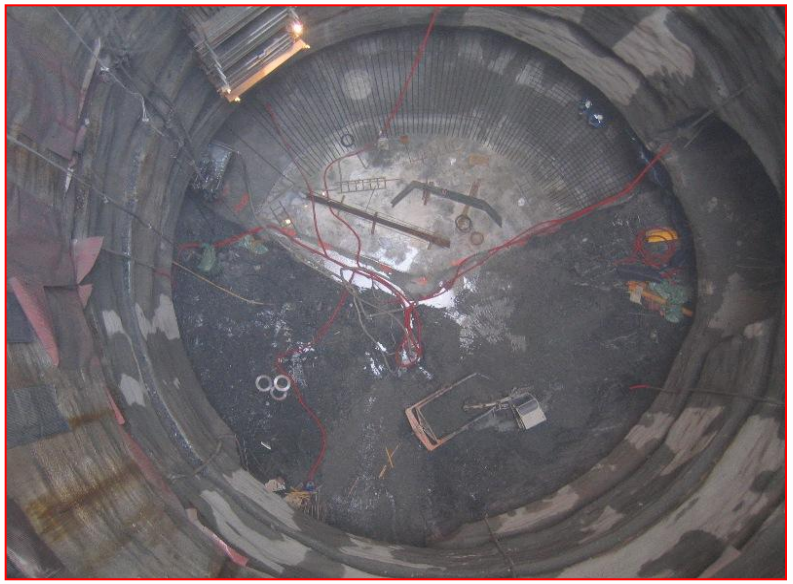


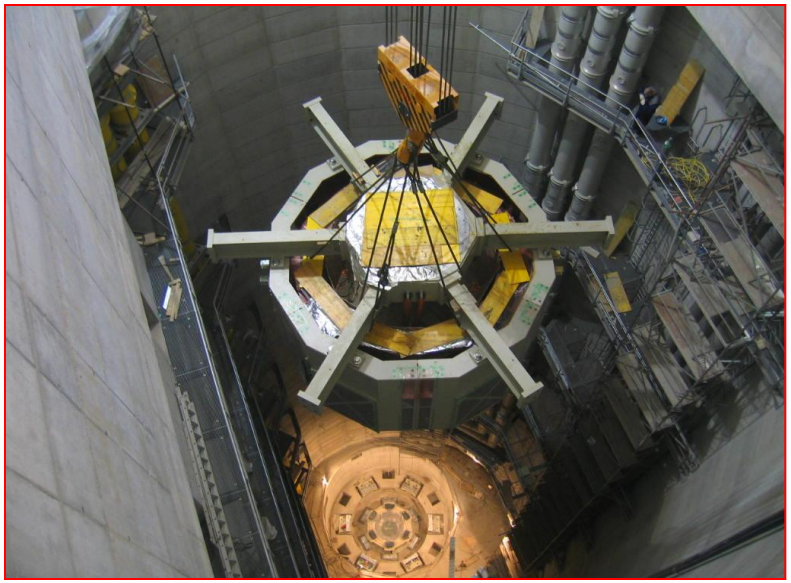

13/06/2008

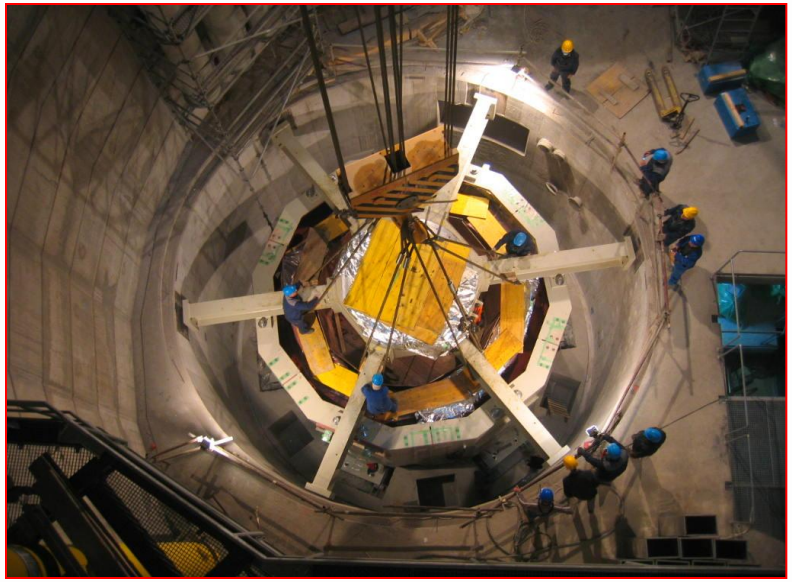

JCB

# Powerhouse with inlet-outlet building










primorje

# Turbine model testing in contractor laboratory (Mitsubishi, Japan)

Relation model/prototype: 1/5,923

Average guaranteed efficiency of turbine: 92%

Average guaranteed efficiency of pump : 92,67%

Average guaranteed cycle efficiency: 85,26%

# Manufacture of turbine equpement in MHI (Mitsubishi Heavy Industry)

Manufacturing of runner

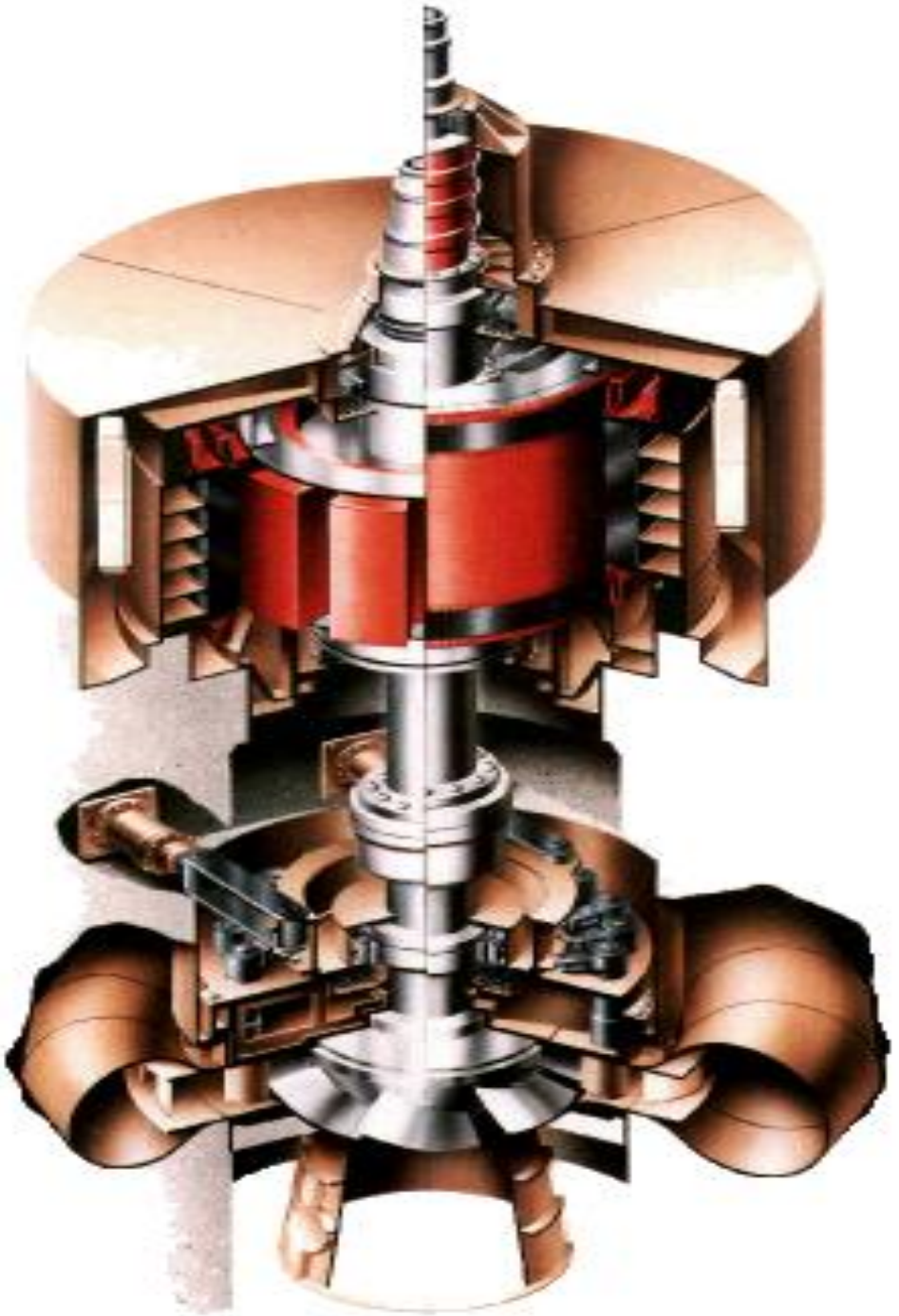
Manufacturing of main inlet valve

# Sinchronous and asinchronous generator (DFIM)

## Specifications of the AVČE generator/motor

| | |
|---|---|
| Generator capacity | 195 MVA |
| Motor capacity | 190 MVA |
| Rated voltage | 18 kV |
| Rated rational speed | 600 r/min |
| Runaway speed | 900 r/min |
| Moment of inertia ($GD^2$) | 2100 $tm^2$ |
| Power factor | 0,95 |
| Frequency | 50 Hz |
| Excitation voltage | 1980 V |
| Maximum excitation voltage * | 7000 V |
| Maximum excitation current | 4800 A |

* a max. excitaion voltage is applied at the start-up in the motor mode

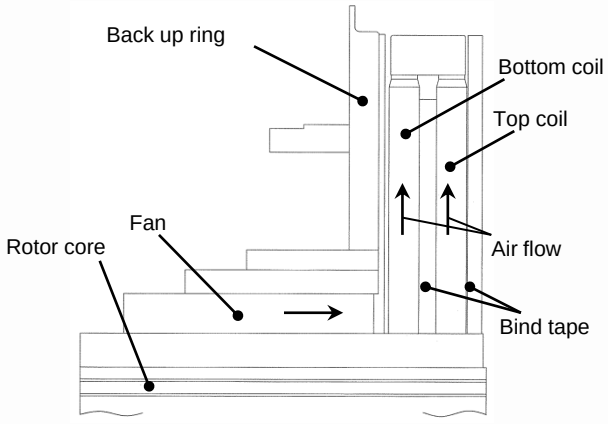


# Rotor

- rotor is cylindrical type with 3-phase windings are held in the slots;
- collector ring connect G/M to exitation system;
- rotor is completely assembled at the site.

## Rotor coil end support

- coil end portion is exposed from the slot where a large centrifugal force acts during the operation;
- the support of the rotor coil end is achieved by a back up ring and a bind tape;
- as for the bind tape material, the Aramid tape is applied;
- coil end is cooled by air flow through paths between the adjacent rotor coils.

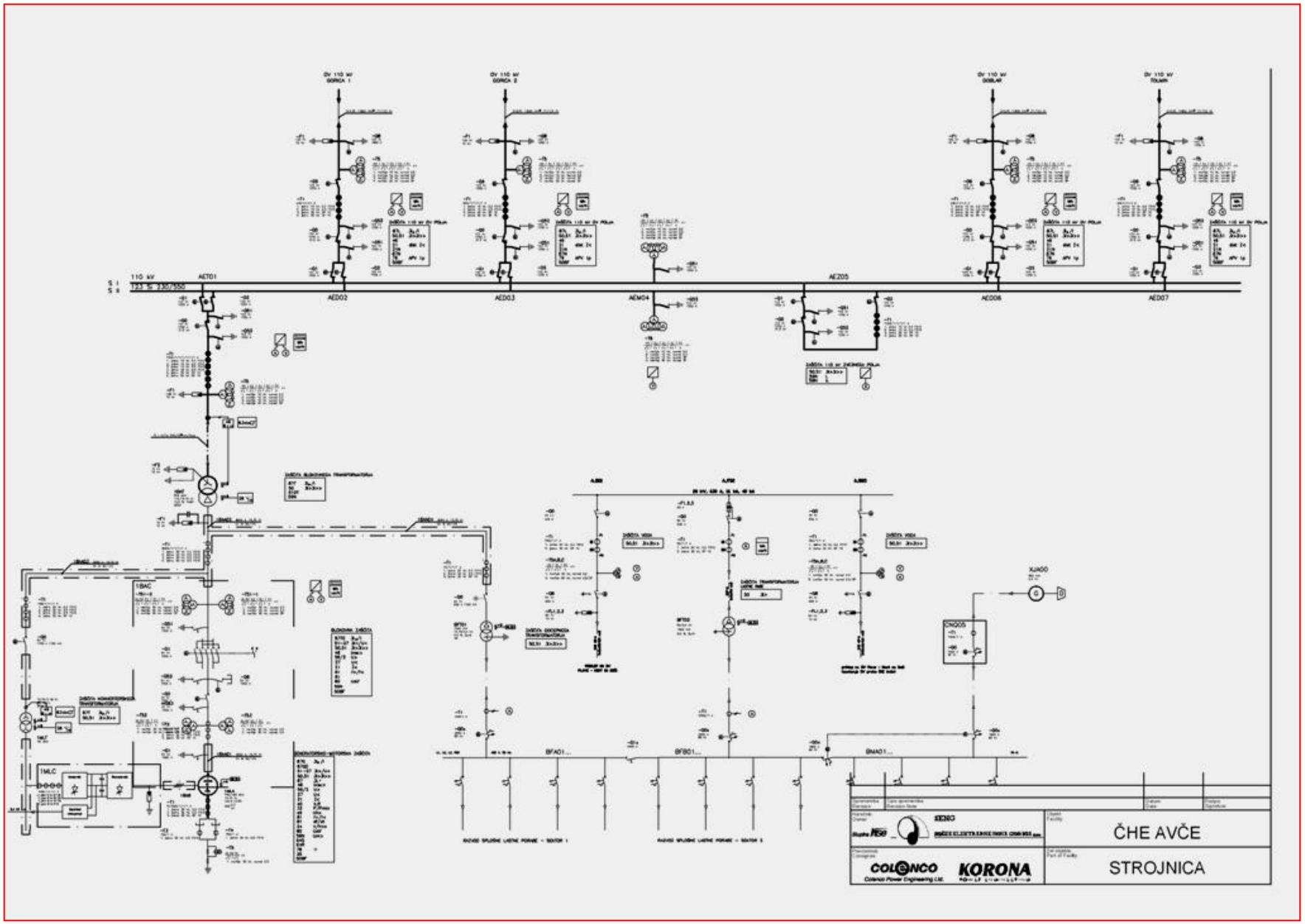



## Rotor core

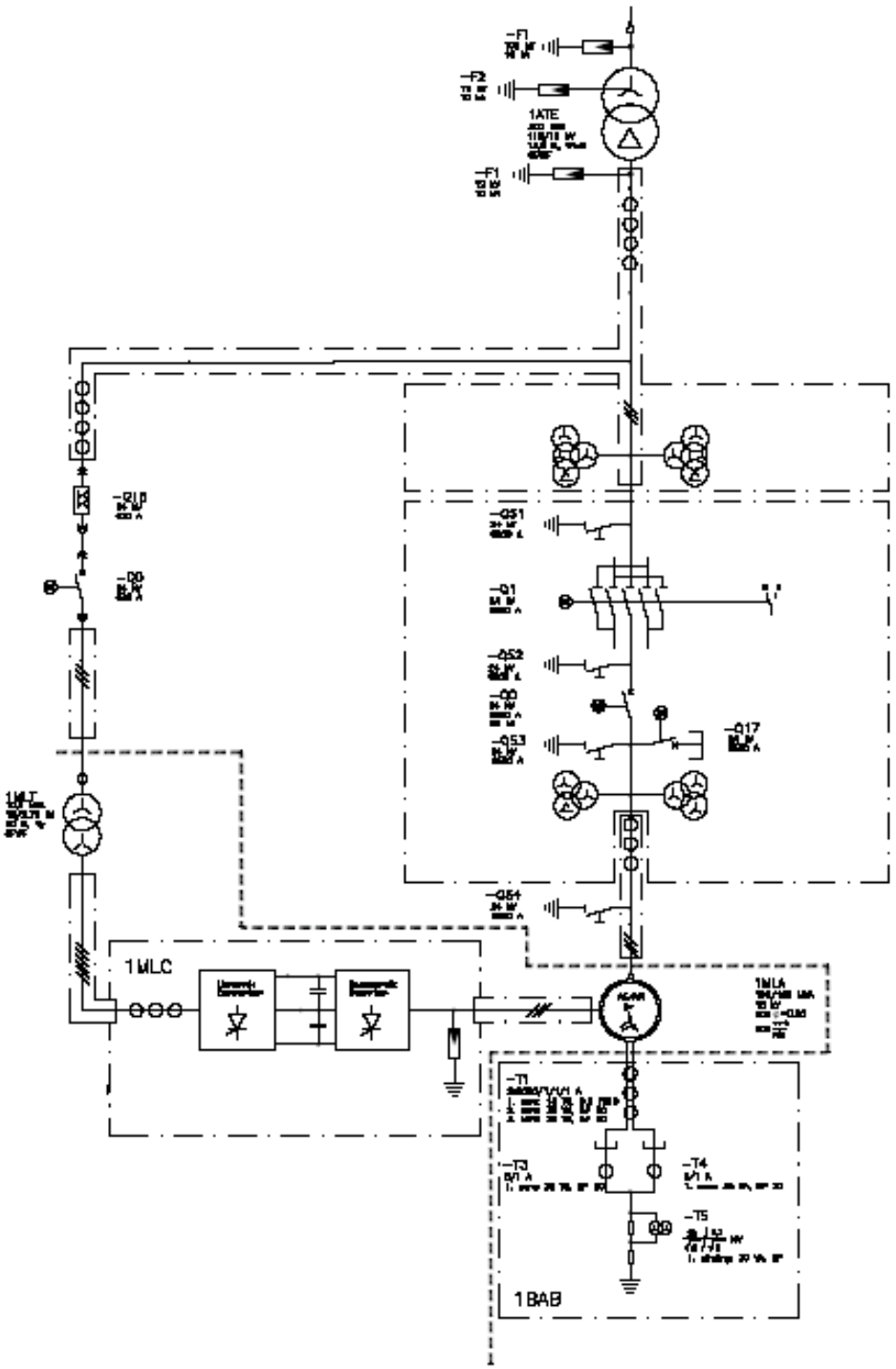
- the rotor core consists of thin steel plate laminations bolted together;
- ventilating ducts are provided within the core laminations.


106

# Single line diagram



# Generator with the excitation system



# Advantage of adjustable speed system

**Constant Speed Machine**

① Constant Speed ⇒
Pump Input Power is constant ( impossible to regulate )

② Mechanical Power Control
⇒ slow response

③ Constant Speed ⇒
not improve efficiency of P/T

**Adjustable Speed Machine**

① Speed Variation ⇒
Pump Input Power change !!
( possible to regulate )

② Electrical Power Control
⇒ quick response !!

③ Speed Variation ⇒
improve efficiency of P/T !!

**Improovment of operation of Nuclear and Thermal P/S**

**Soft start in pump mode on relatively week grid**

**Improvement of Grid stability**

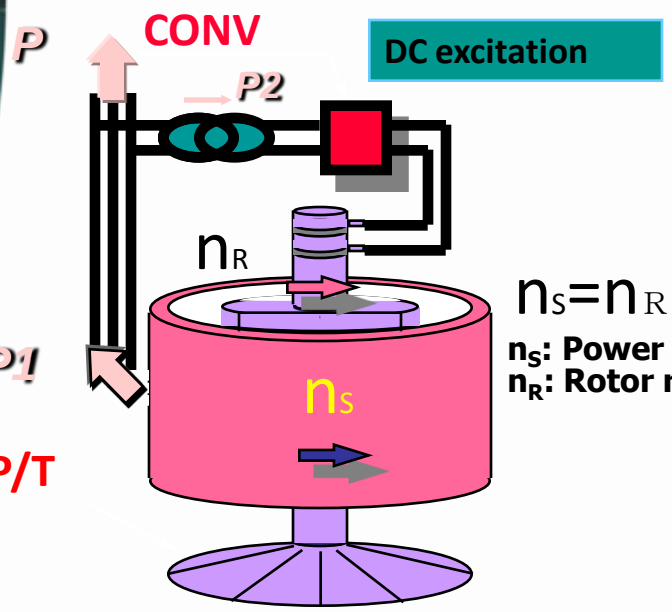
**Convenient for wind power fluctuation**

**Effective application of natural energy**

# Comparison of constant speed with adjustable speed

[1] System output/input is not equal to G/M terminal output/input.

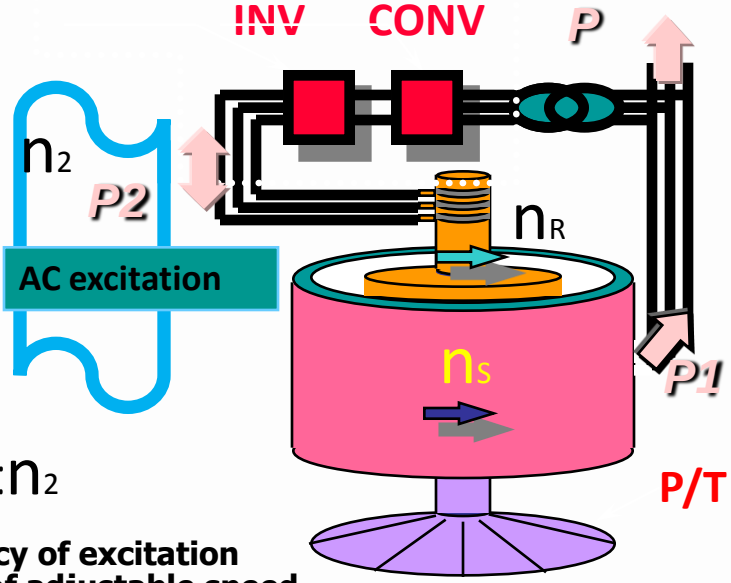
Excitation system of adjustable speed generator-motor




$n_S = n_R$

**$n_S$: Power system frequency**
**$n_R$: Rotor rotational frequency**

**Constant speed machine**




$n_S = n_R \pm n_2$

**$n_2$: Slip Frequency of excitation system of adjustable speed generator-motor**

**Adjustable speed machine**

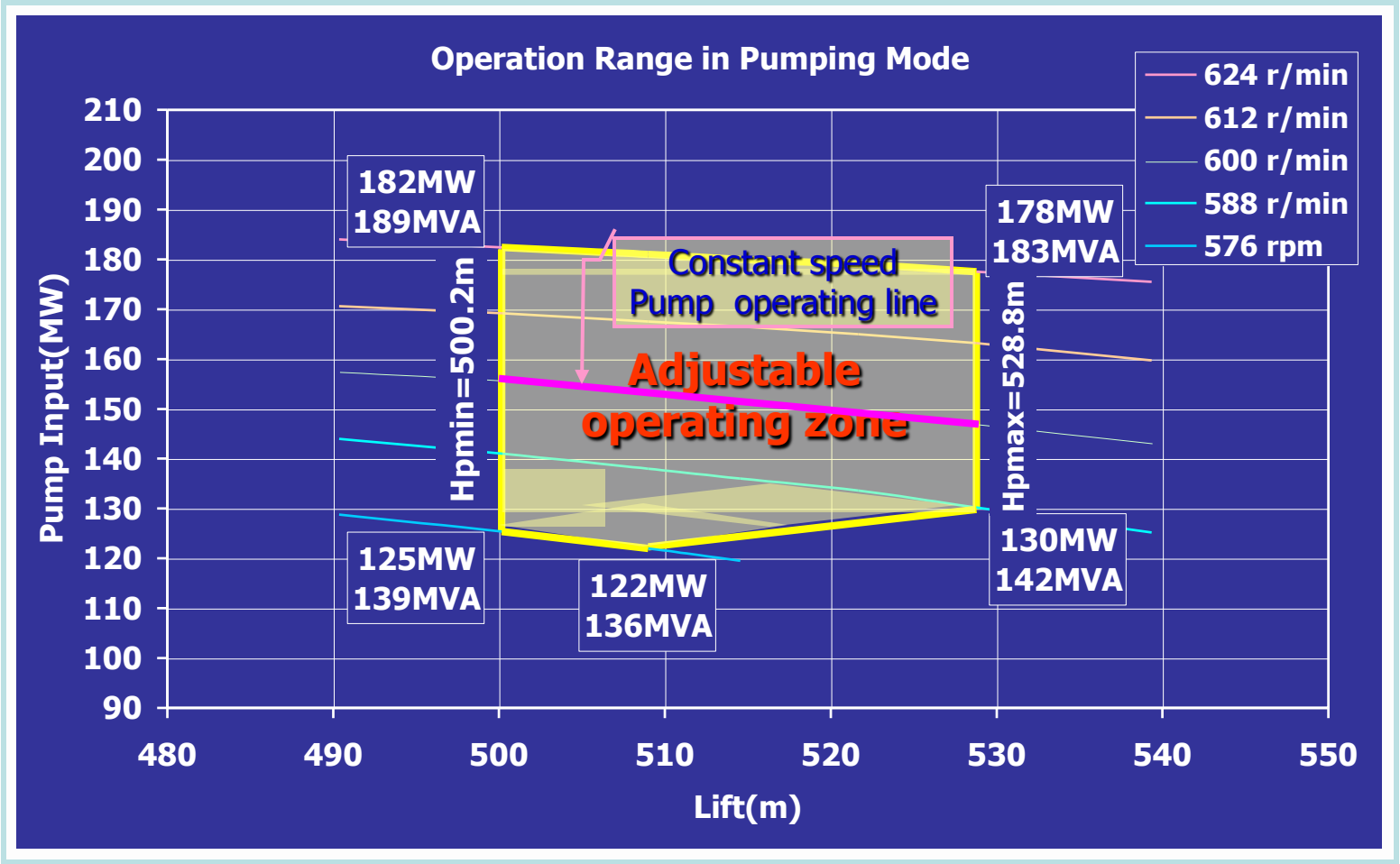
**P>>P2 ∴P≒P1**

**P : System output**
**P1: Generator terminal output**
**P2: Power to exciter**

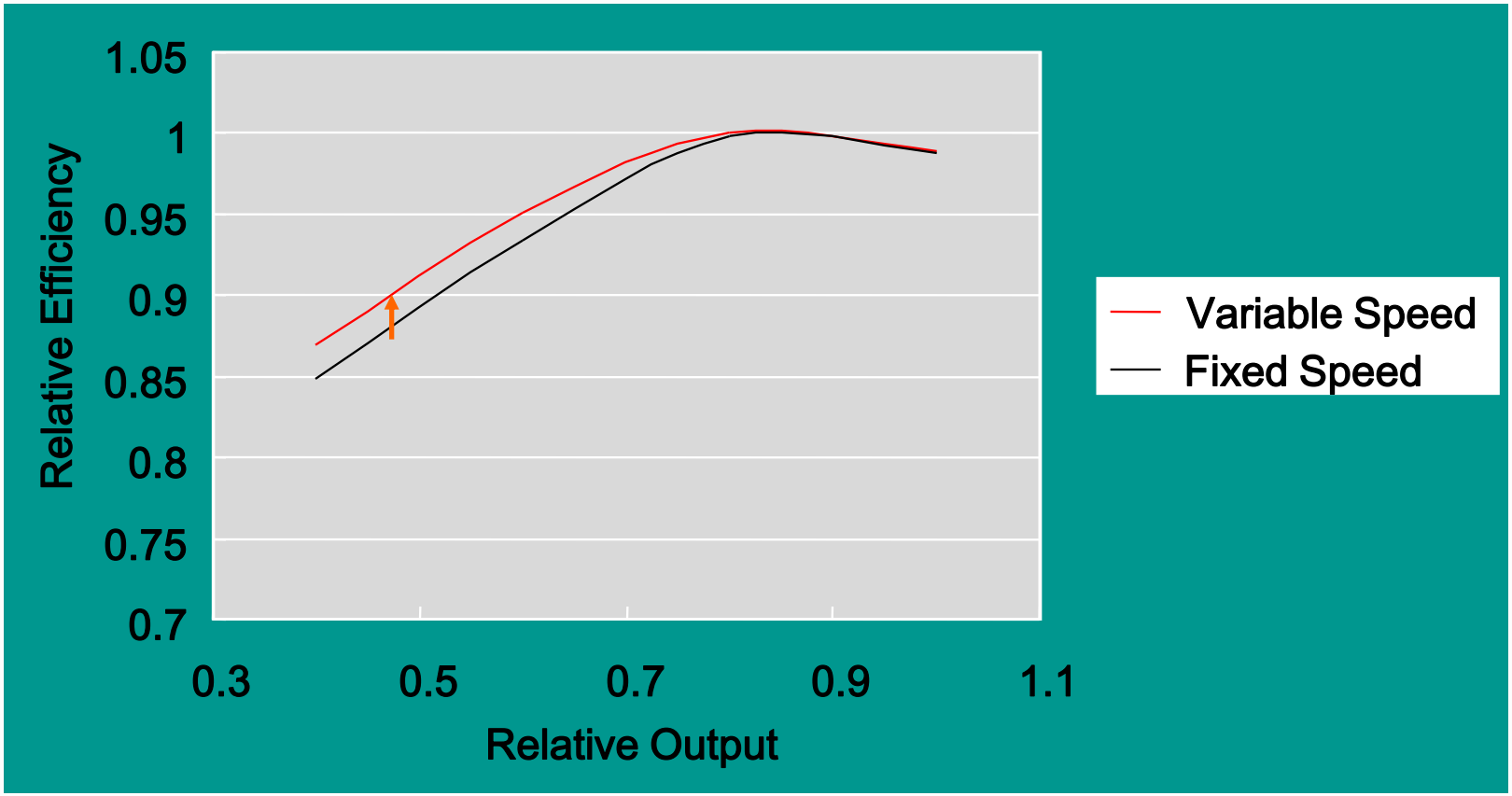
Value and/or direction of “P2” is changed due to the value of “n2”.

**∴ P≠P1**

# Operating range in pumping mode



# Turbine efficiency




Increase Turbine Operating Condition Especially in Partial Operation (Improve Turbine Efficiency, Turbine Runner Inlet Cavitation Characteristics etc.)

# Avče PSP milestones

- 2003: preliminary studies, invest program
- Sept. 2004: building permit
- Dec. 2004: start od preliminary works
- Jun. 2005: start of civil works and LOT T/G works
- Oct. 2005: start of Lot C/H (penstocand and HM equipment) and Lot D (cranes)
- Jun. 2006: start of Lot EE (electrical equipment)
- Dec. 2007: start of overhead 110 kV lines
- Avg. – Sept. 2009: dry tests
- Oct. 2009 – Mar 2010: wet tests
- Apr. 2010: trial operation

# Avče PSP – economical data

- Investment cost of 120 million EUR
- The most expensive are civil works and electrical eqipment
- Financing:  42% SENG,  58% EIB and other banks.