Teknologisk Møteplass 12 mai 2011

Regulering og utfordringer

Bjørn Åril

RAINPOWER

EU - mål for 2020

20%

- 20 % reduksjon i utslipp av CO2
- 20 % høyere energi-effektivitet
- 20 % energi fra fornybare energikilder (hvilket betyr at i elektrisitetsforsyningen må 35% av kraftproduksjon komme fra fornybare kilder).

RAINPOWER

Fremtidens energisystem, hvorfor vannkraft?

Vindkraft er i flere land allerede en viktig bidragsyter i kraftforsyningen, men…..

Bilde: Vestas

Vindkraften trenger system for energilagring og regulering.

Vannkraften er det beste system for energilagring, både hva angår kapasitet,virkningsgrad og reguleringsegenskaper

RAINPOWER

Hydropower – support of regulation services

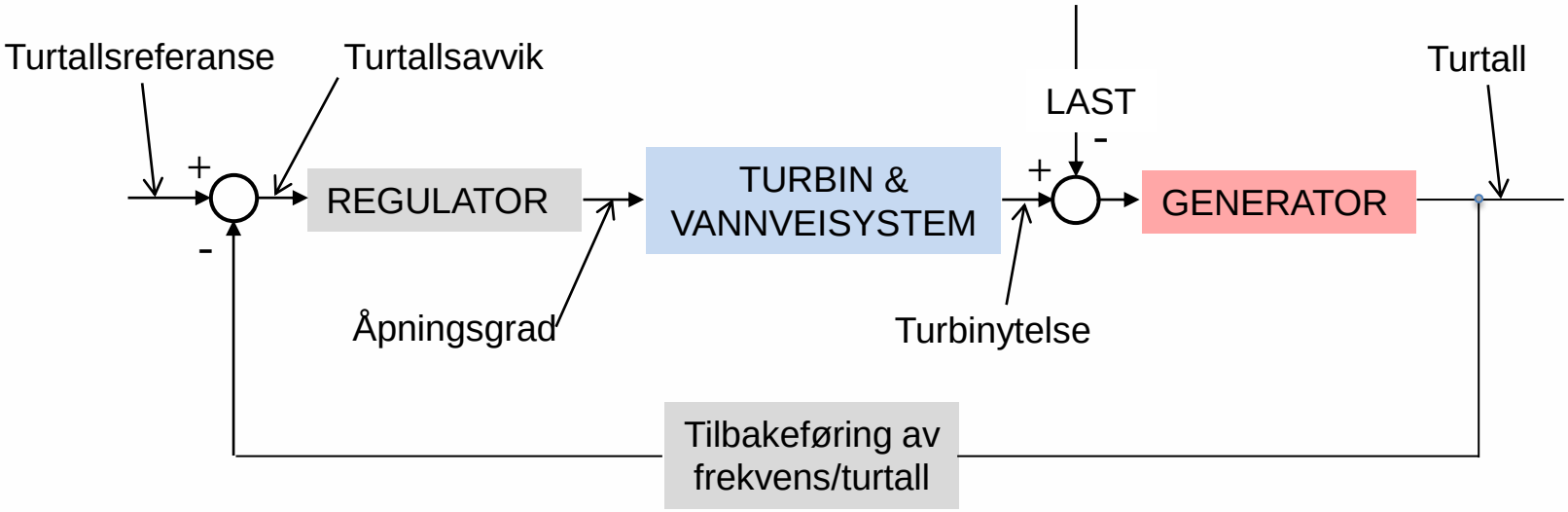
The planned development of wind power according to the goals for 2020 could lead to total collaps of Europe´s electricity grid system. It will be increased demand for:

- Peak power
- Frequency control
- Regulating gain and active power back-up

- Hydro can take the role to fulfill these requirements.
- It will be customized to ensure grid stability, long term reliable operation and with focus on green values

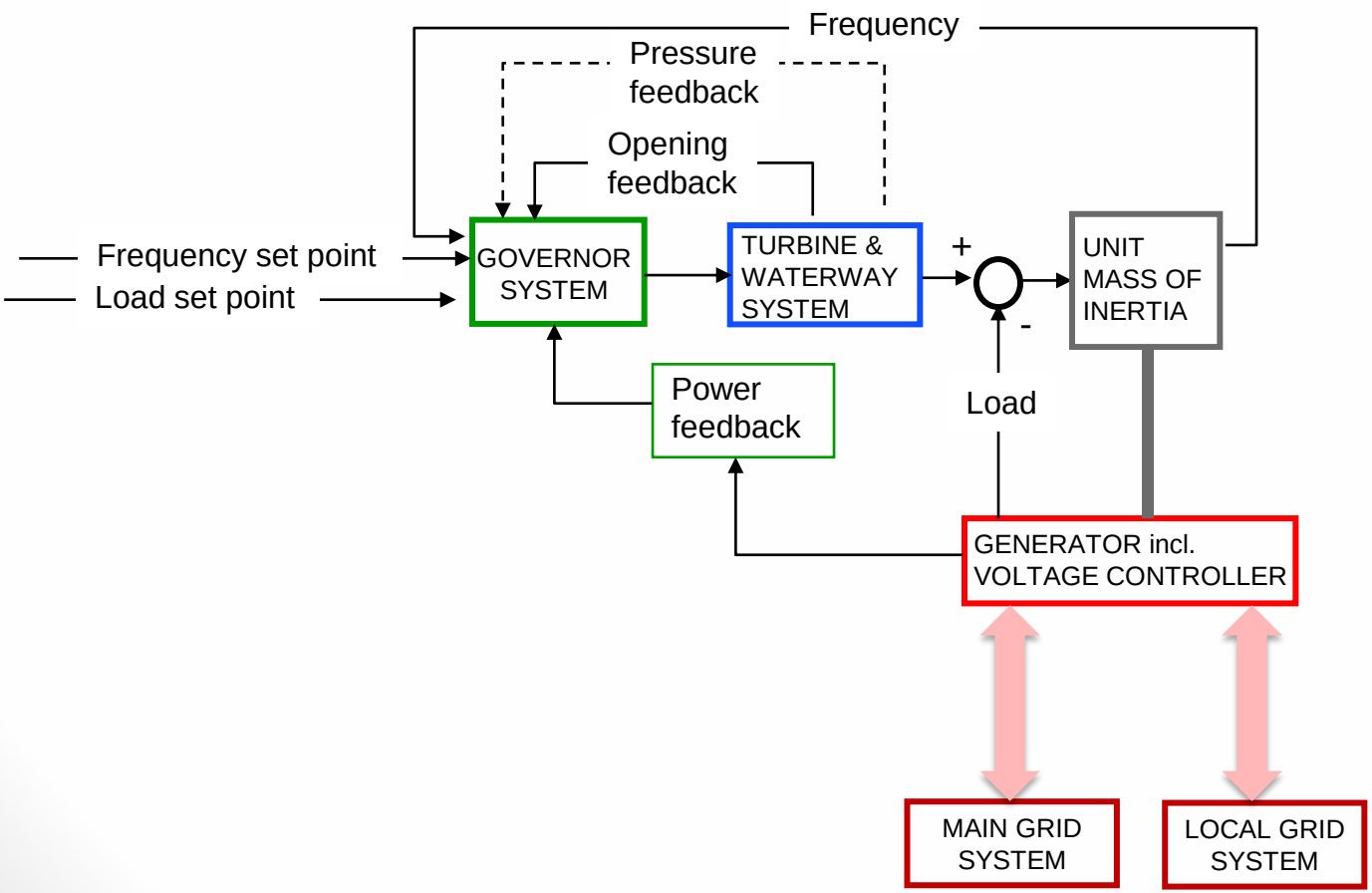
RAINPOWER

Enkelt blokkskjema for regulering



RAINPOWER

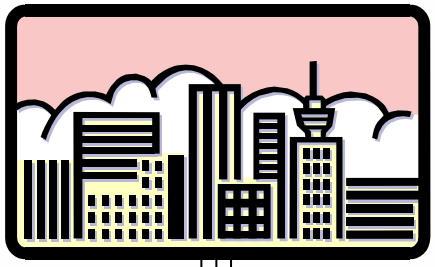
General System Structure – Block Diagram



RAINPOWER

Overall System – Technical Evaluation

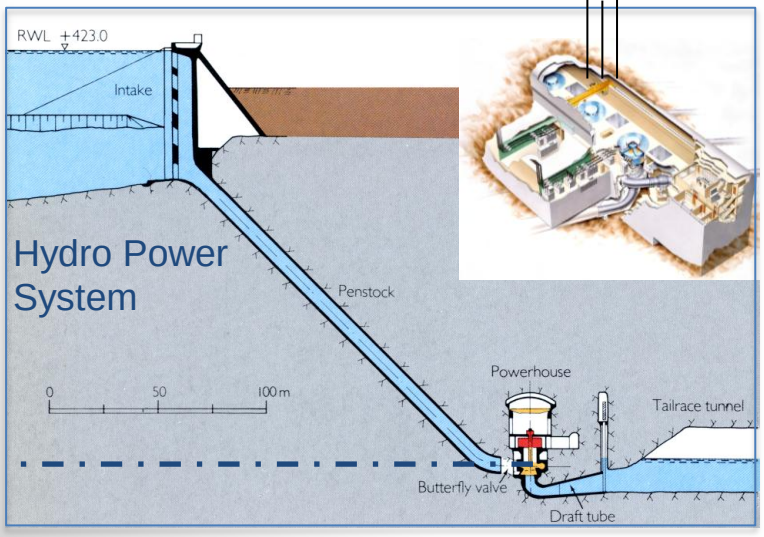
Grid System



Grid System Operating Requirements

- Frequency Control
- Load Control
- Reserve Power
- Peak Power
- Load Rejections
- Condenser Operation

Technical Evaluation!!

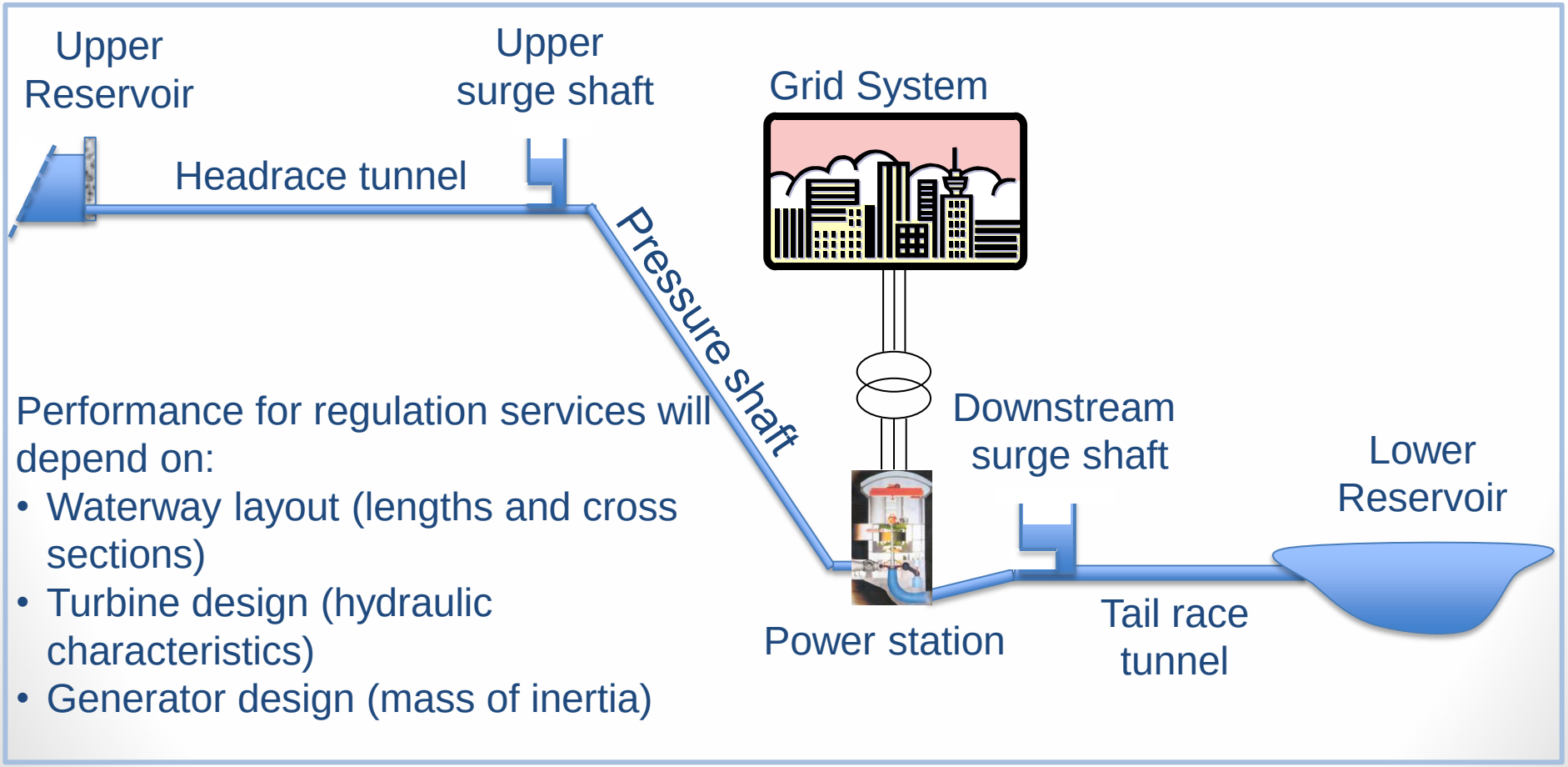


Hydro Power System Main Characteristics

- Unit Acceleration Time (Ta), sec.
- Head
- Flow
- Water Inertia Time (Tw), sec.
- Water Hammer Number (hw)
- Turbine governor parameters

RAINPOWER

Schematic overview of typical hydropower system



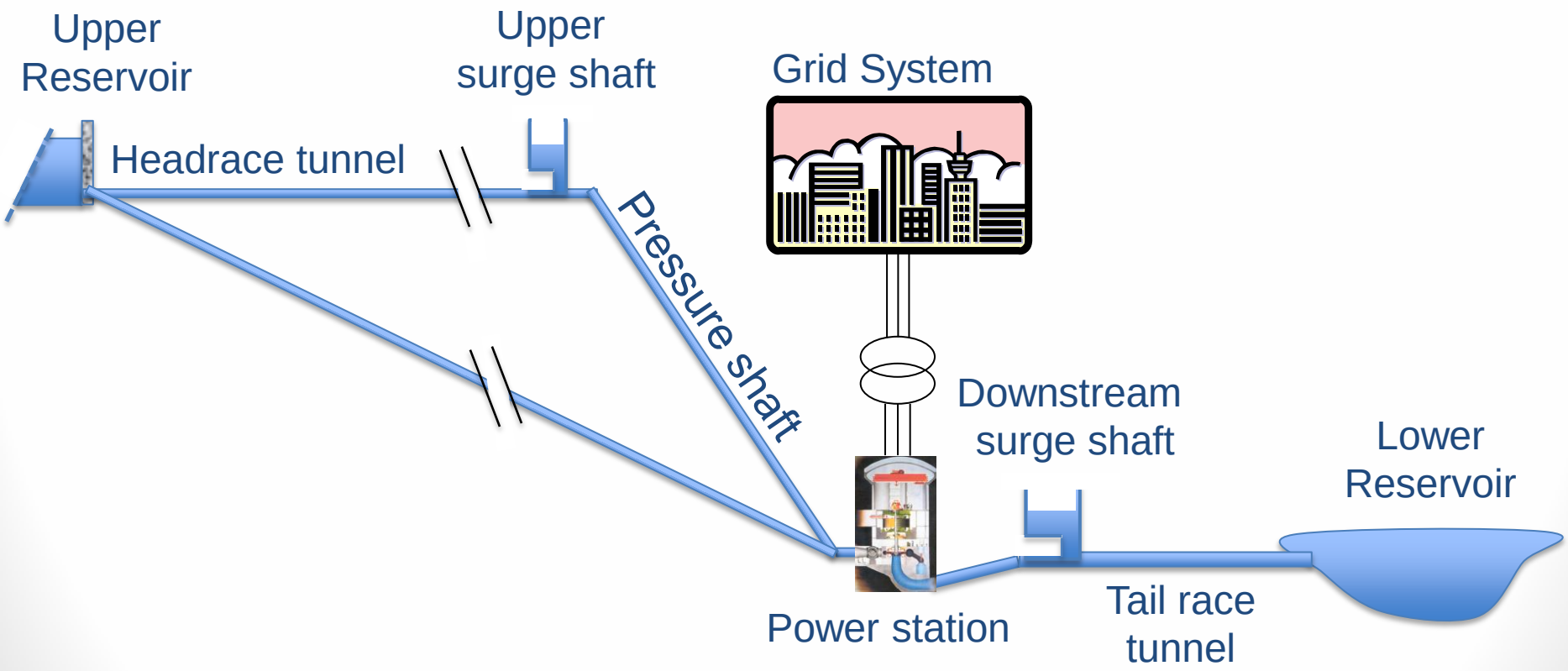
Performance for regulation services will depend on:

- Waterway layout (lengths and cross sections)
- Turbine design (hydraulic characteristics)
- Generator design (mass of inertia)

System integration and optimization with focus on dynamic characteristics for grid control

RAINPOWER

Hydropower System – Waterways Characteristics

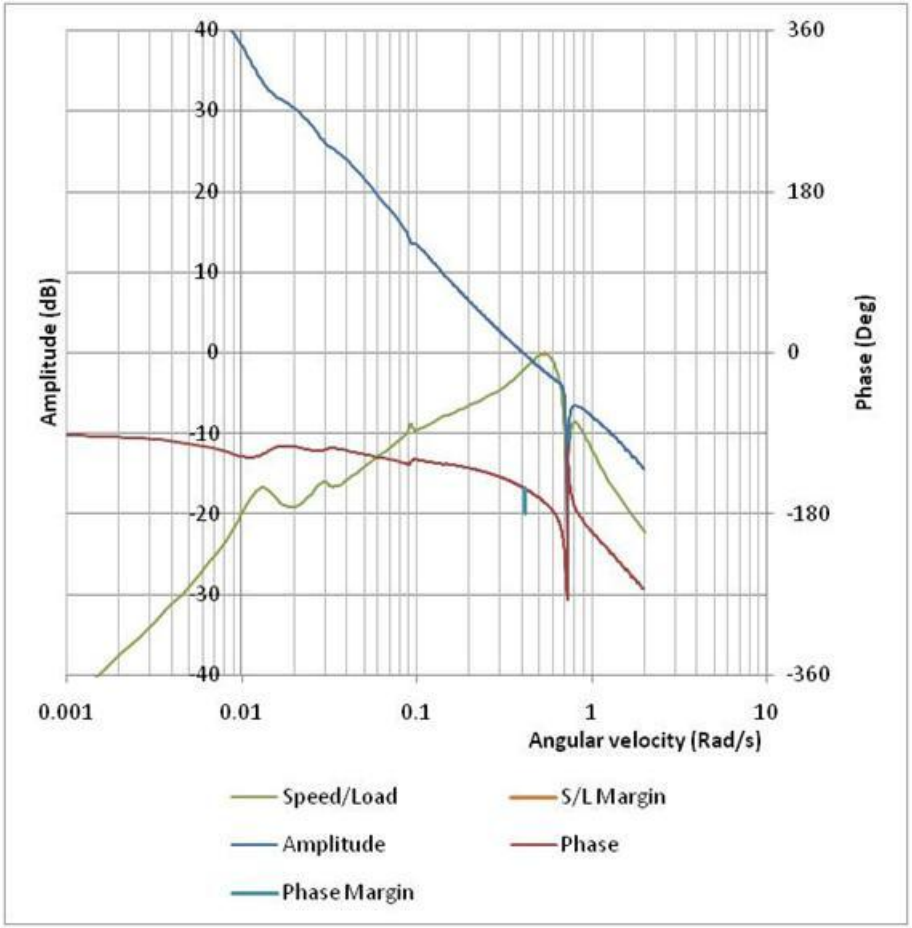


System with surge shaft: May have excellent regulation capability

System without surge shaft: May have limited regulation capability because of critical dynamic characteristics

RAINPOWER

Rendalenen – stabilitetsanalyse



Forsterkningsmargin i åpen sløyfe	ΔK	=	3.3 dB
Fasemargin i åpen sløyfe	Δf	=	29.2º
Maks turtallsavvik/lastforstyrrelse i lukket sløyfe	$(\Delta n/n_o)/(\Delta P/P_o)$	=	-0.14 dB

RAINPOWER

Fra: Funksjonskrav i kraftsystemet (FIKS) om regulering

5.3.5 Hastighet
Reguleringshastigheten bestemmes av PI(D)-parametre,
hvor normalt Kp >2 og
Ti >12s.

Vedlegg 3 om turbinregulatorer:

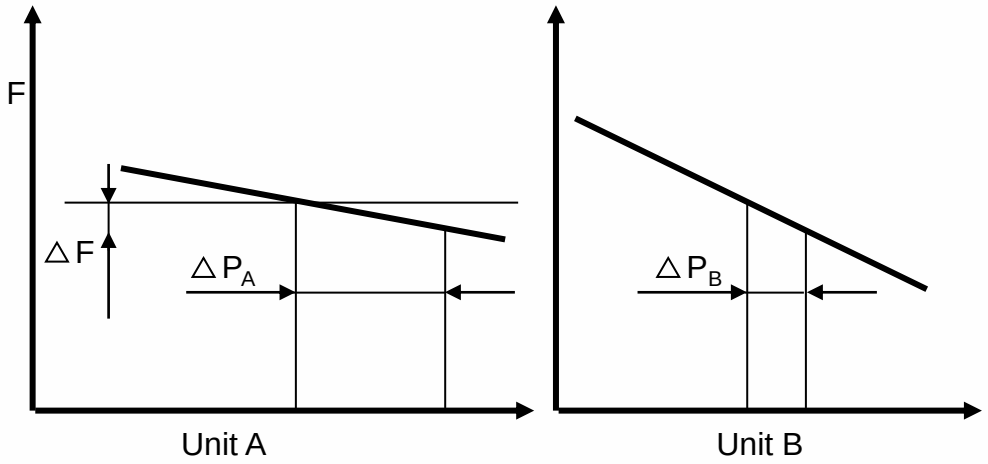
Det har fra systemansvarlig mest vært stilt krav mhp. den langsomme respons etter lastpå-/avslag eller driftsforstyrrelser. Transient respons har vært målt som sprangrespons, der utreguleringstiden har et stort variasjonsområde. Det har vist seg nødvendig å stille strengere krav til den transiente *(momentane)* responsen. Pga. den rivende tekniske utviklingen som er skjedd på regulatorfronten, har den *transiente responsen stor betydning for kortvarig frekvensavvik, total utreguleringstid, fordeling av transient regulerstyrke mellom aggregater og evne til å* overleve i *separat nett.*

Nye regulatortyper har svært mange innstillingsparametre og *tilleggsfunksjoner. Dette* kan introdusere både fordeler og ulemper for den systemansvarlig med hensyn på hva som best tjener den totale systemdrift. Transient respons har stort sett vært forutsigbar i de gamle mekaniske/elektromekaniske regulatorene og har vært optimalisert så godt det har latt seg gjøre ved prøving. Nyere elektroniske, og spesielt digitale regulatorer er så vidt komplekse at gal parametrering iht. praksisen i angjeldende kraftsystem, kan gi helt uønskede egenskaper.

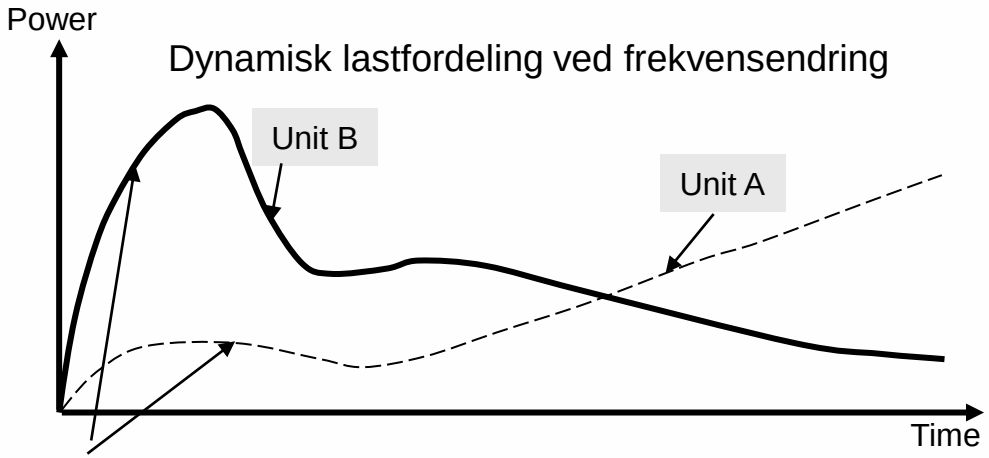
RAINPOWER

Reguleringsparametere og lastfordeling

Lastfordeling med forskjellig statikkinnstilling



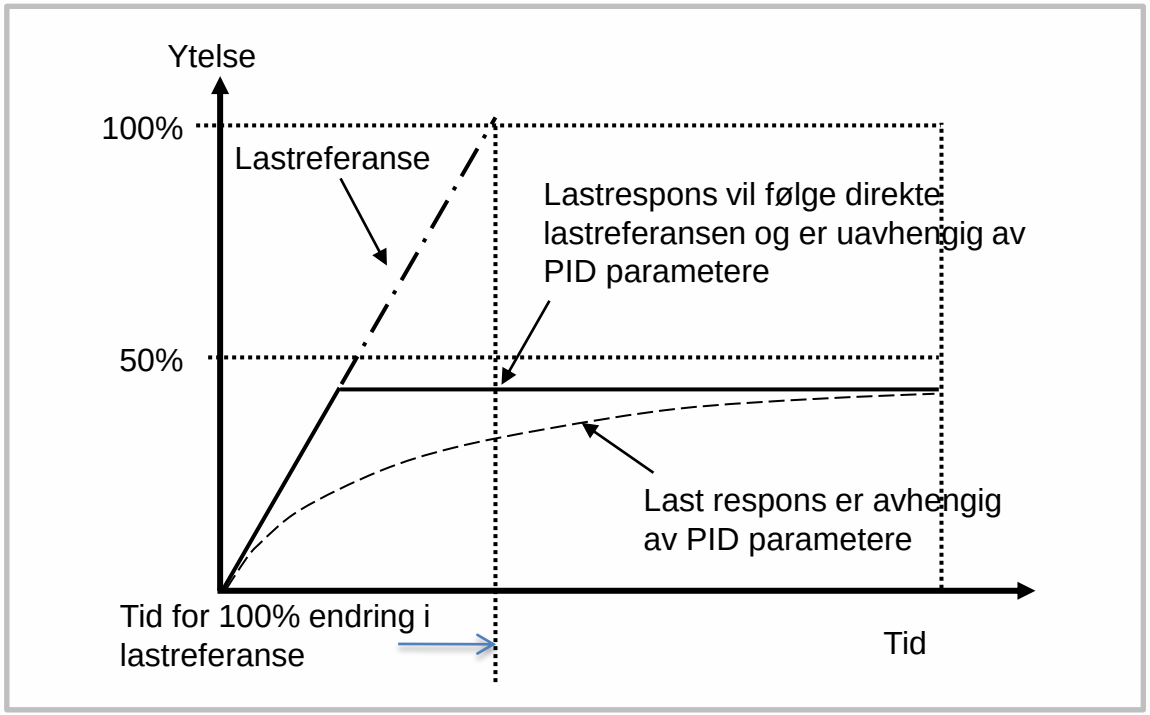
Dynamisk lastfordeling ved frekvensendring



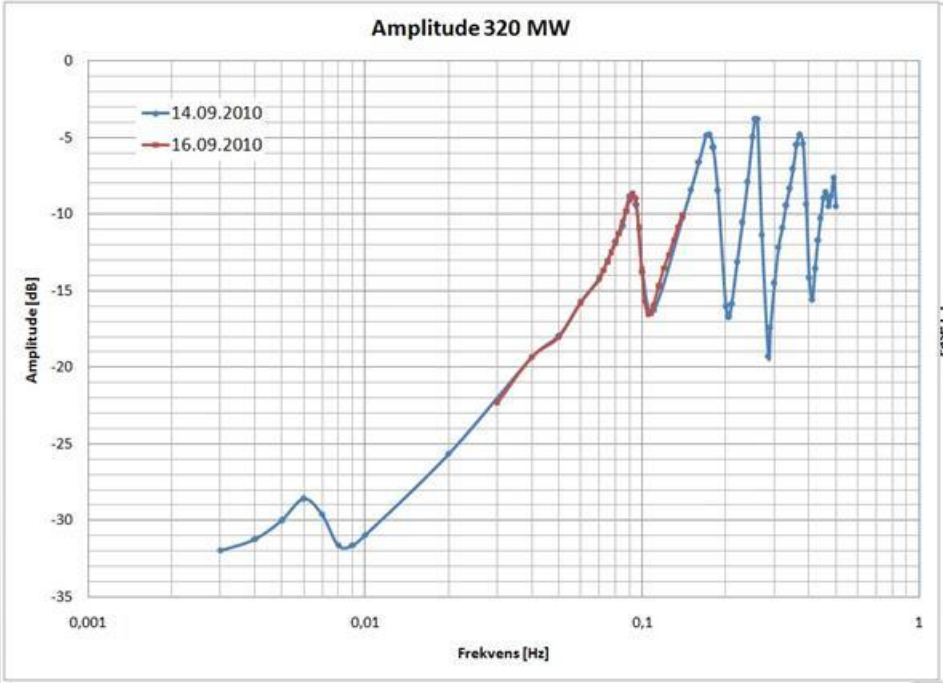
Lastrespons avhenger av PID innstilling og statikk

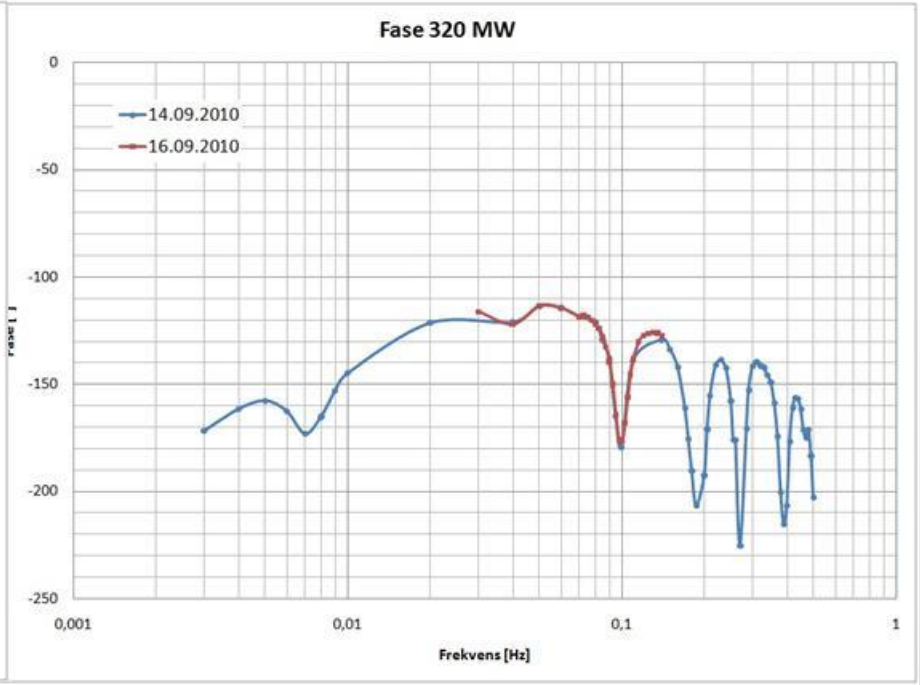
RAINPOWER

Turbinregulering – direkte lastrespons

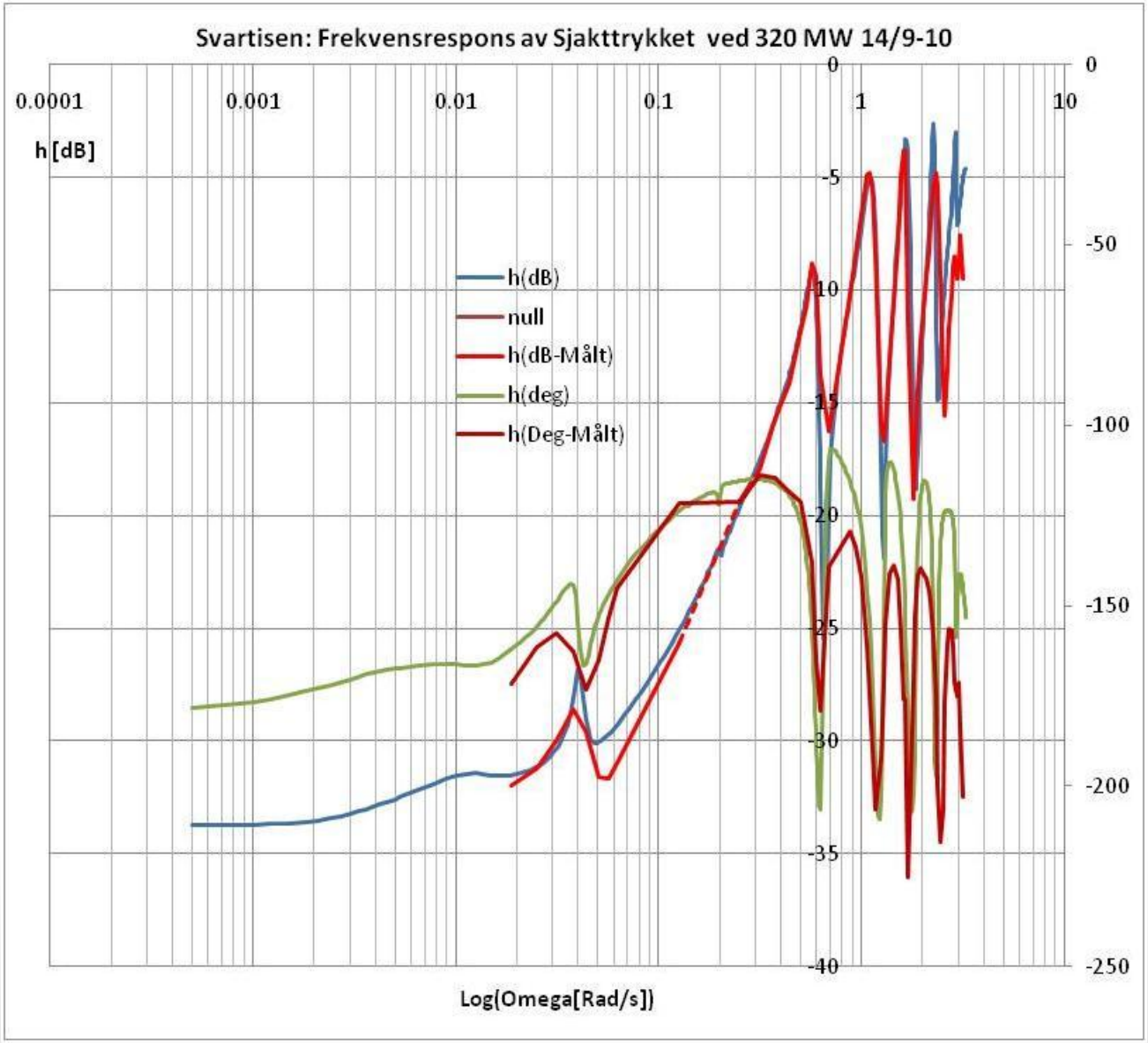


RAINPOWER

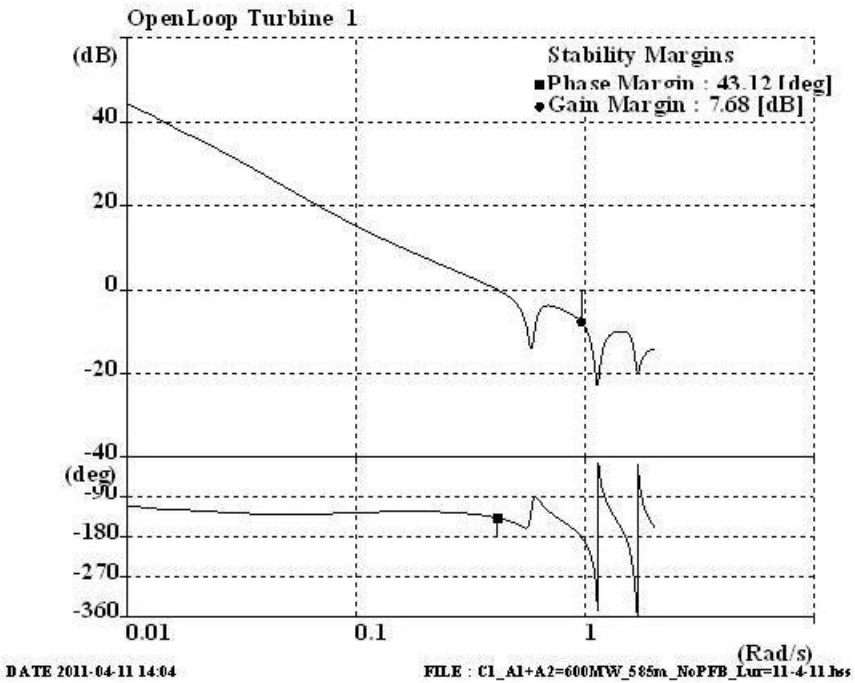

Amplitude 320 MW
14.09.2010
16.09.2010
Amplitude [dB]
0
-5
-10
-15
-20
-25
-30
-35
0,001
0,01
0,1
1
Frekvens [Hz]


Fase 320 MW
14.09.2010
16.09.2010
Fase [ ]
0
-50
-100
-150
-200
-250
0,001
0,01
0,1
1
Frekvens [Hz]

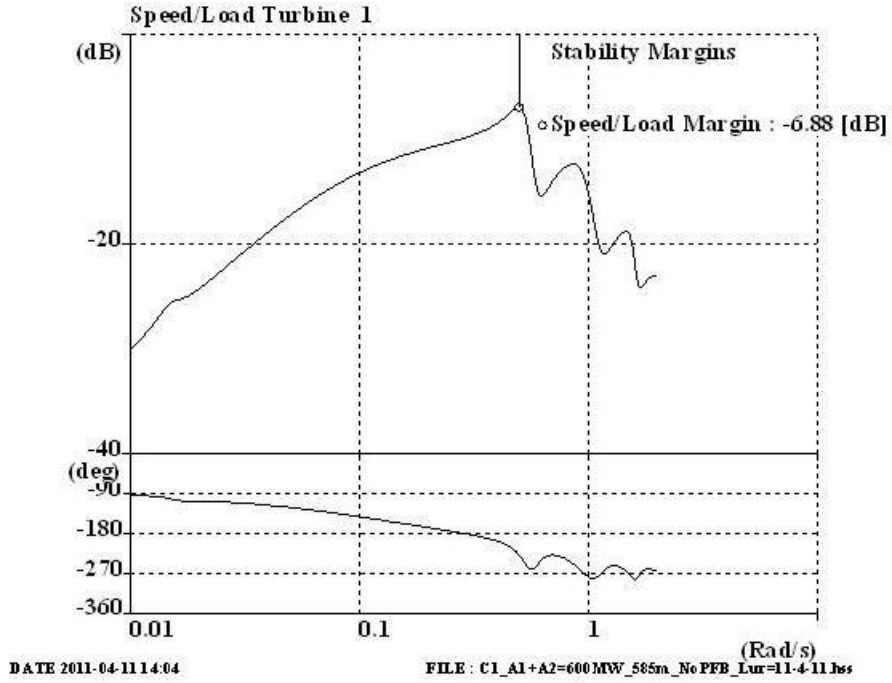
RAINPOWER


Svartisen: Frekvensrespons av Sjakttrykket ved 320 MW 14/9-10
0.0001
0.001
0.01
0.1
1
10
h [dB]
0
-5
-10
-15
-20
-25
-30
-35
-40
0
-50
-100
-150
-200
-250
h(dB)
null
h(dB-Målt)
h(deg)
h(Deg-Målt)
Log(Omega[Rad/s])

RAINPOWER



Åpen sløyfe med nominelle data for begge turbiner på Svartisen.

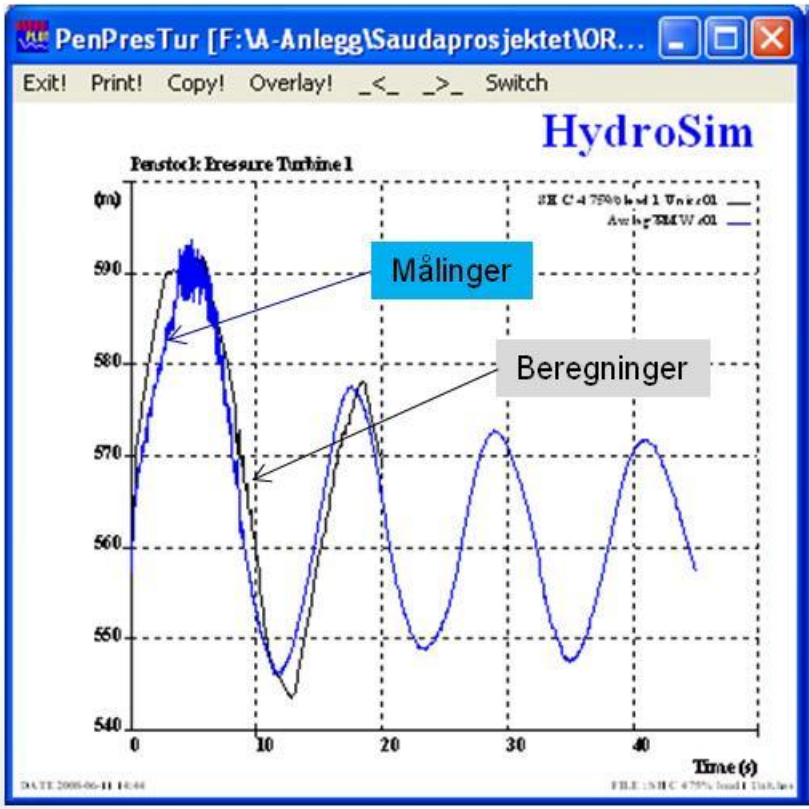


Lukket sløyfe med nominelle data for begge turbiner på Svartisen

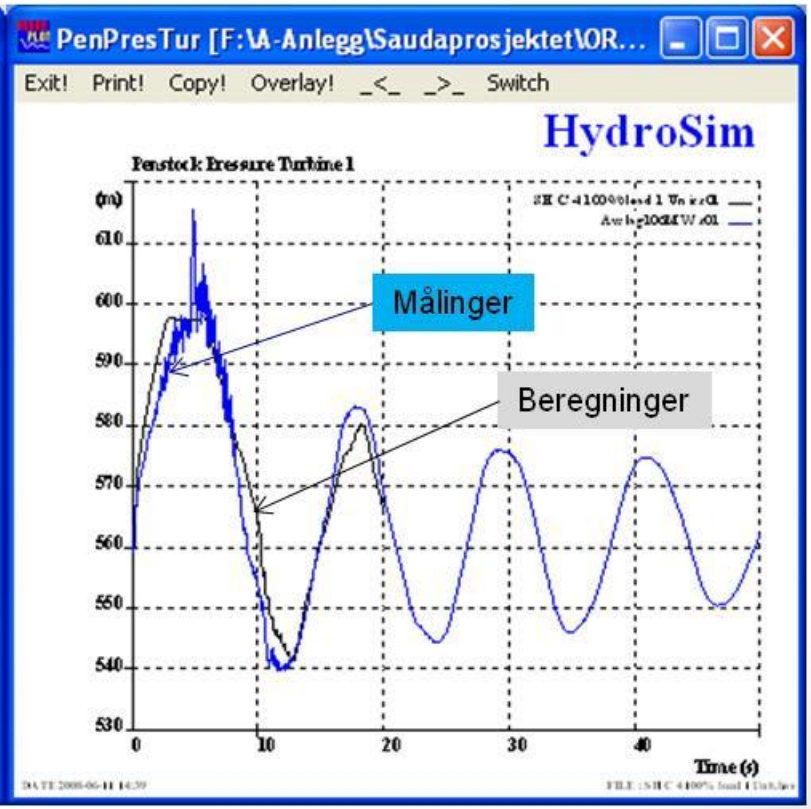
RAINPOWER

Sønnå – lastavslag

Sønnå- lastavslag 79 MW

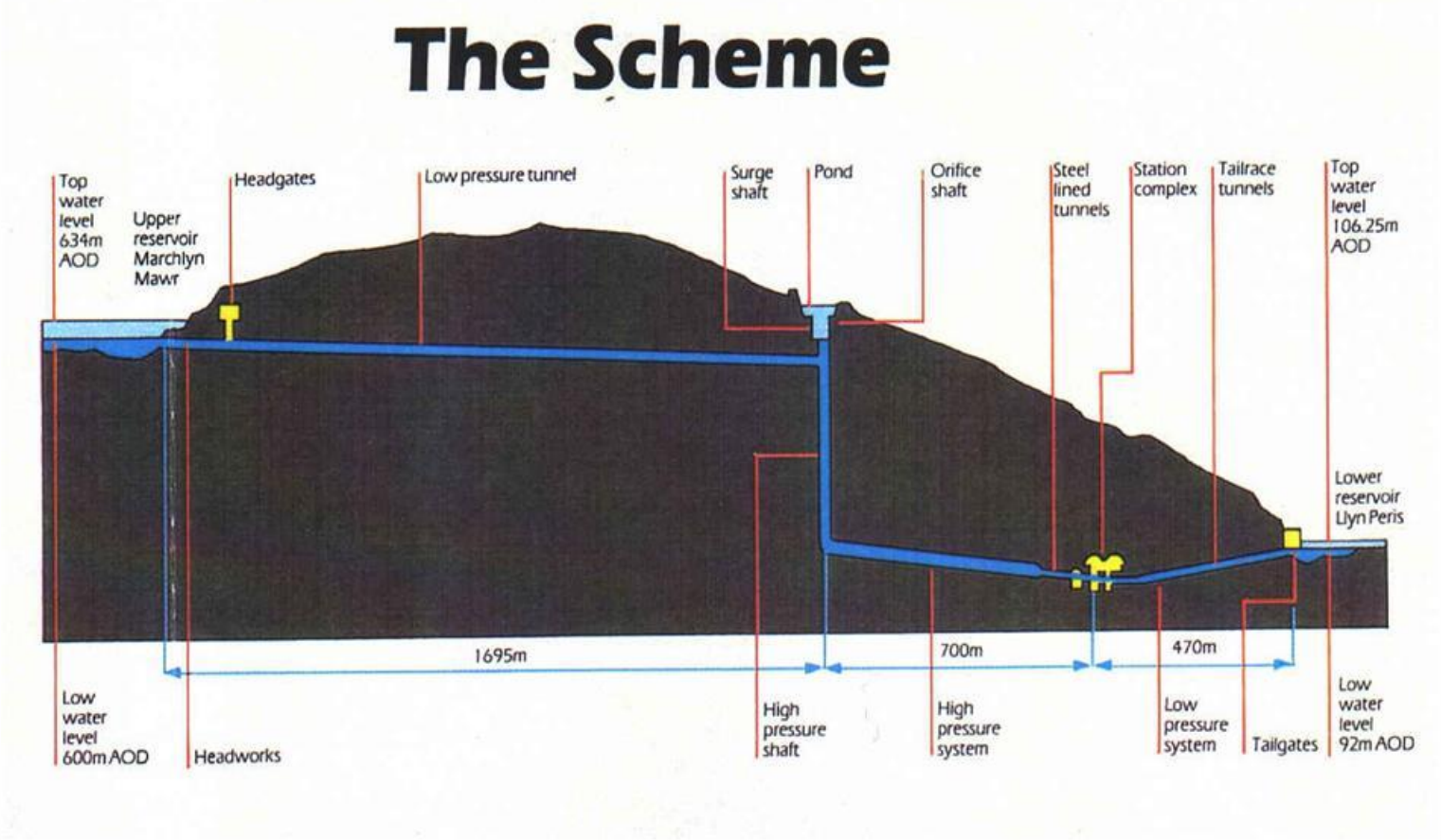


Sønnå- lastavslag 106 MW



RAINPOWER

Dinorwig - Pumped Storage for Grid Control

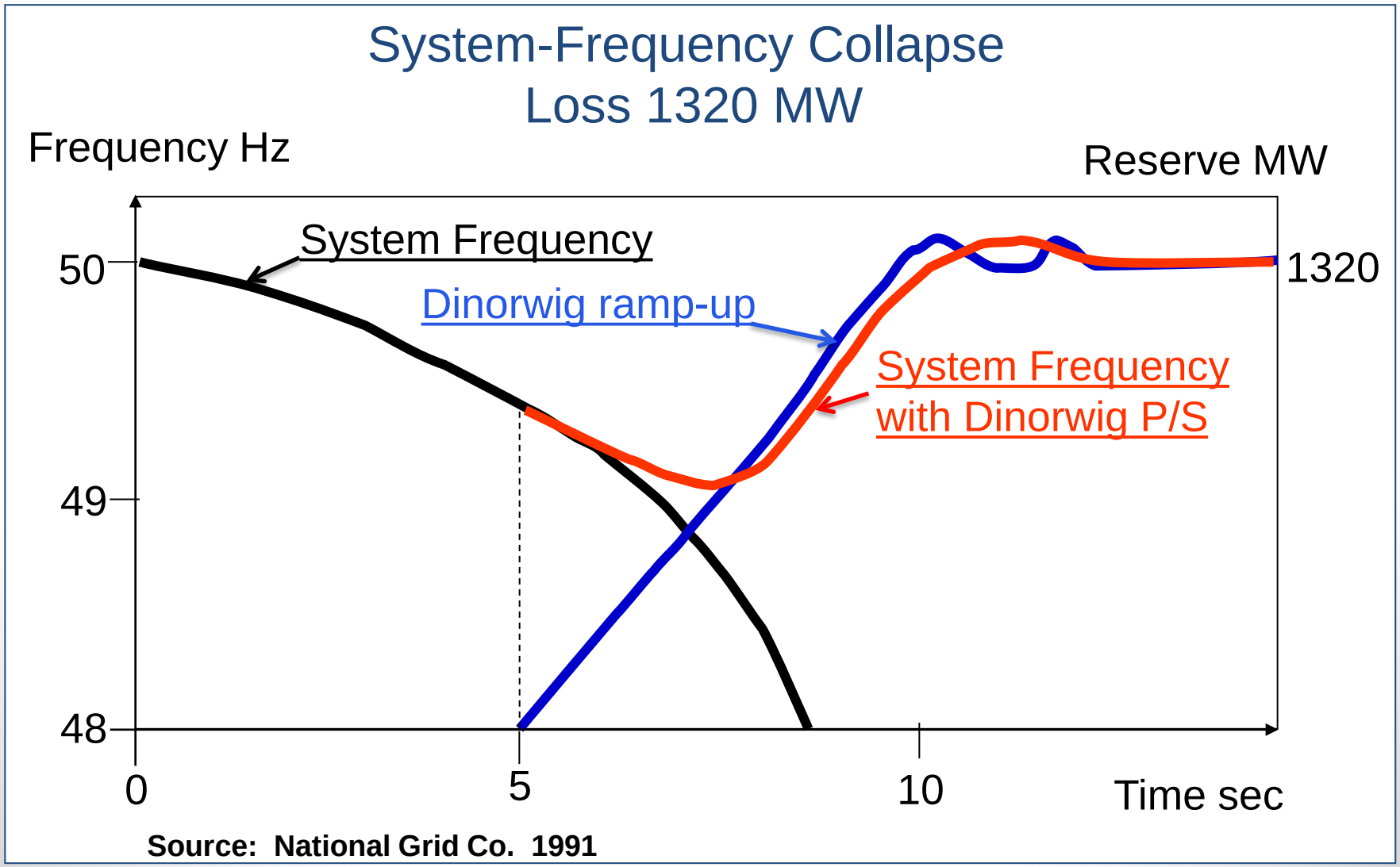


- Typical generation time of 5 - 8 hours at full load

Short waterway – Hi dynamic capability: Load on 0 - 1320 MW in 10 secs.

RAINPOWER

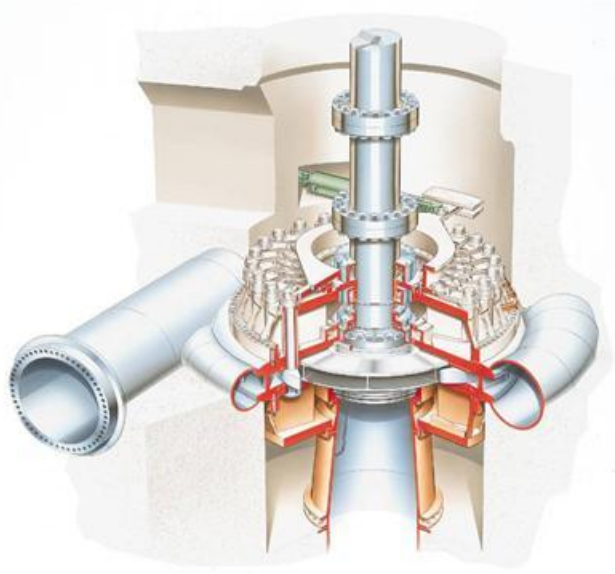
Dinorwig - built to support for loss of large power units

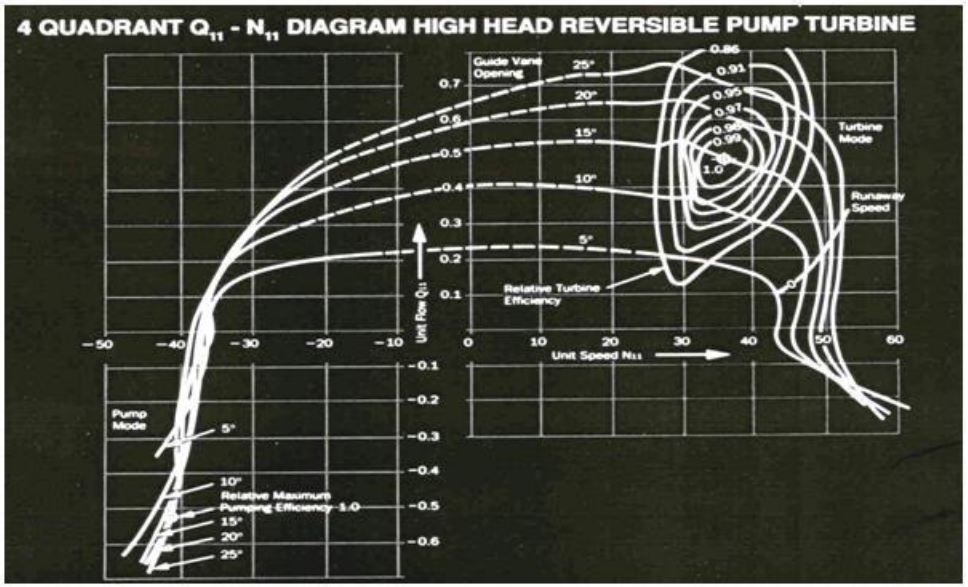


RAINPOWER

Pump Turbine Dynamic Characteristics:

Instability caused by the special “S-shape” turbine



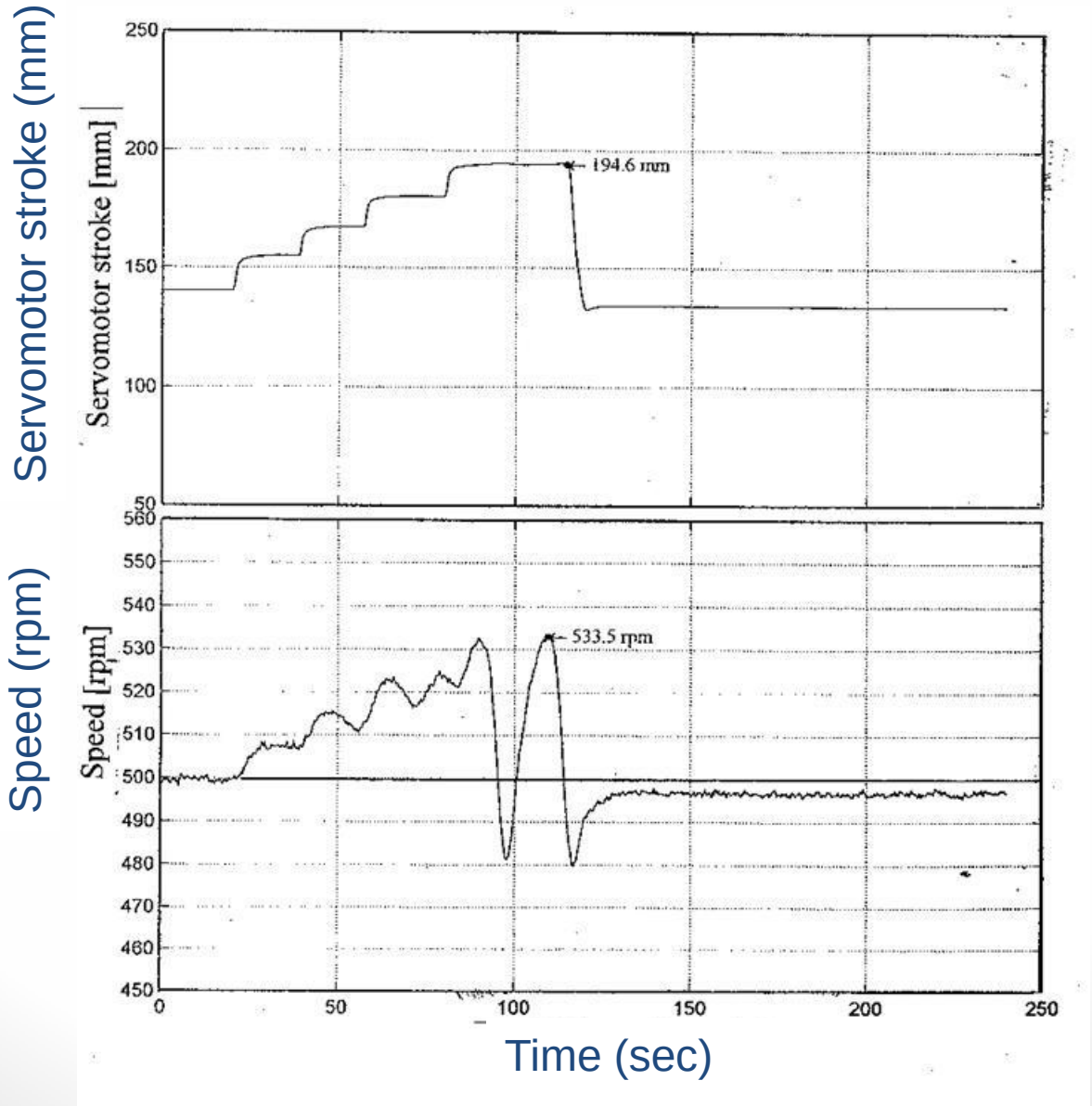


Challenges:

- Transients under control at load rejections
- Stable frequency control at low heads

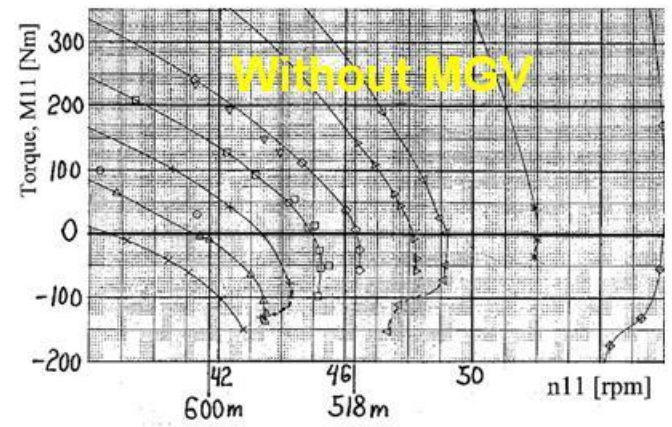
RAINPOWER

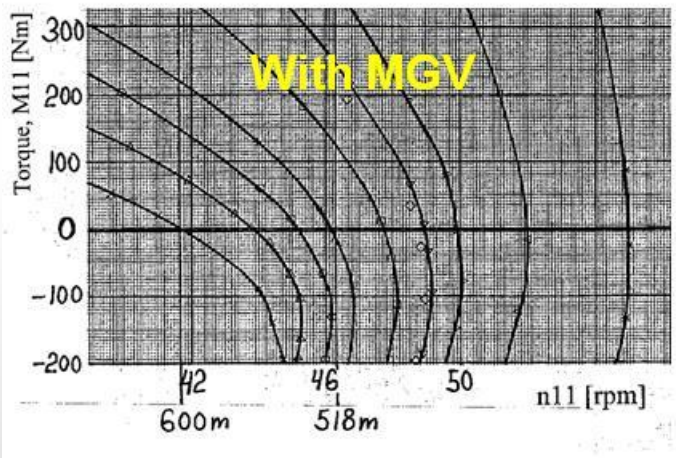
TIANHUANGPING - stability at speed-no-load tests

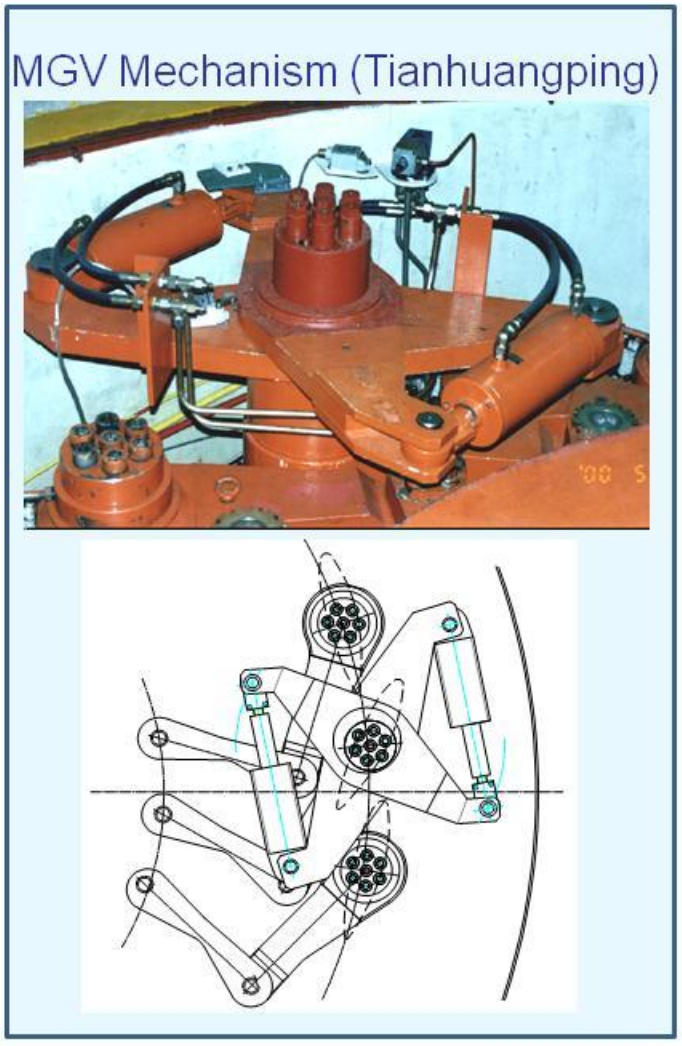


RAINPOWER

TIANHUANGPING - stability at speed-no-load model tests



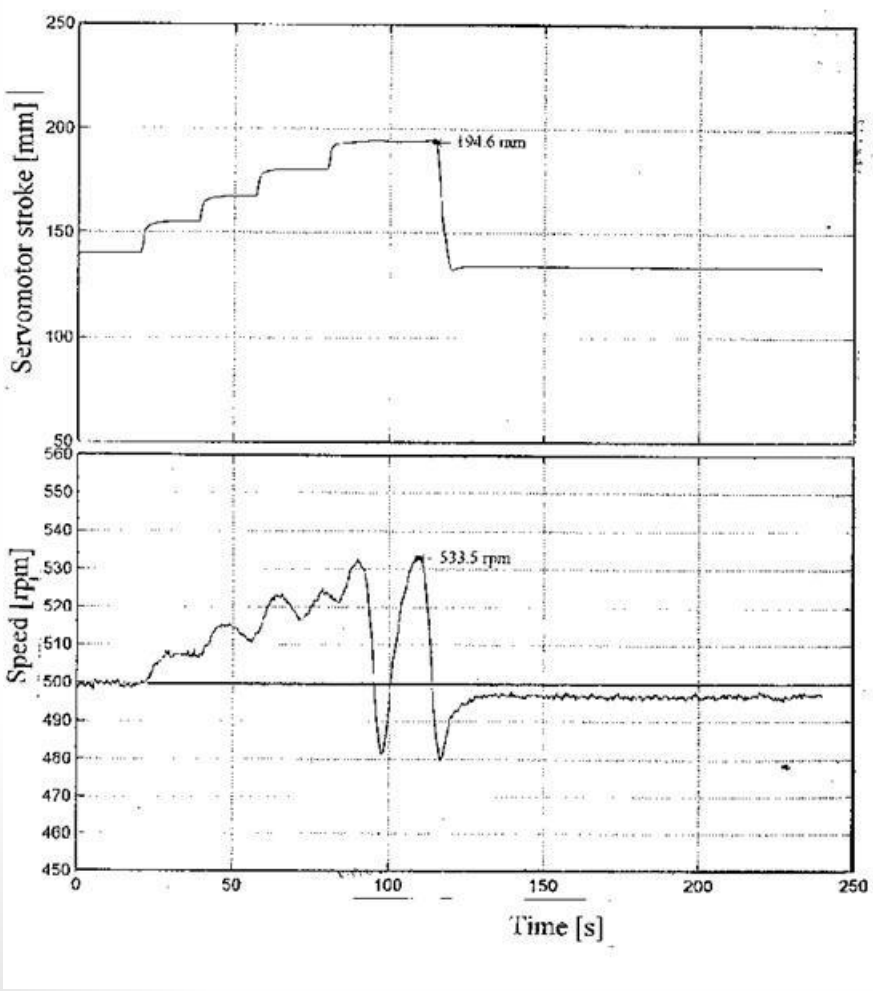


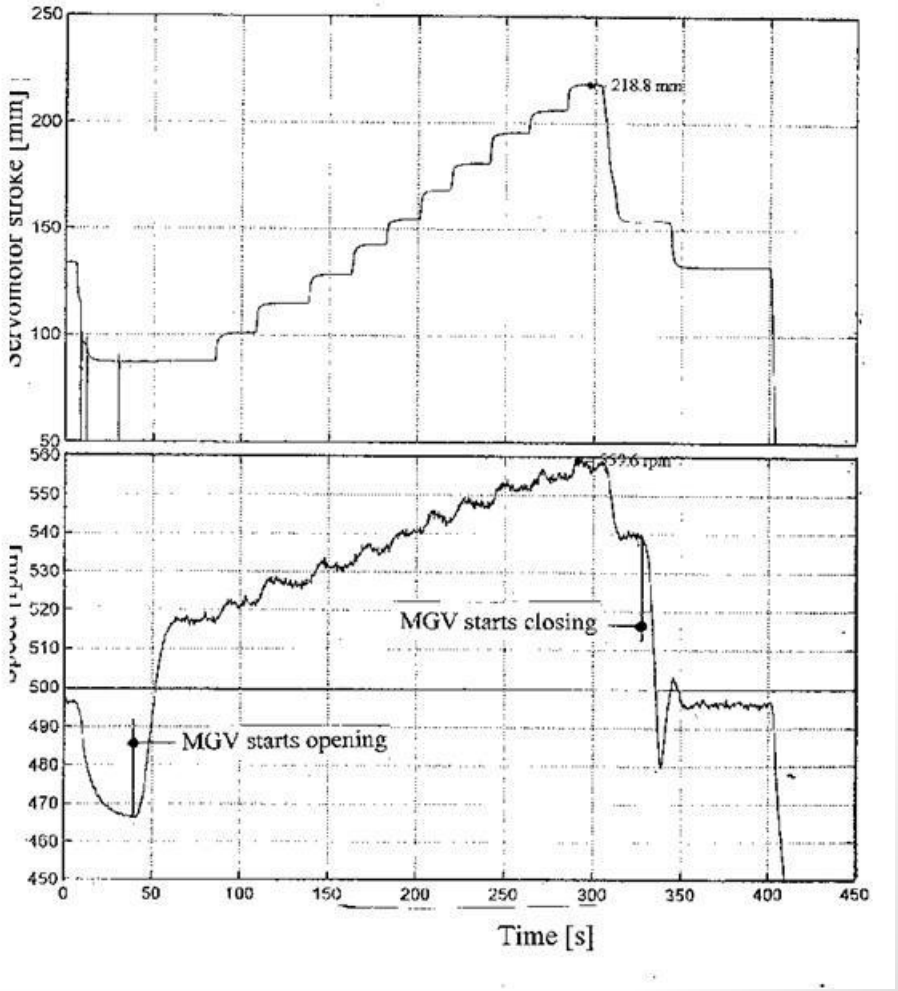


Improved pump turbine characteristics

RAINPOWER

TIANHUANGPING - stability at speed-no-load tests



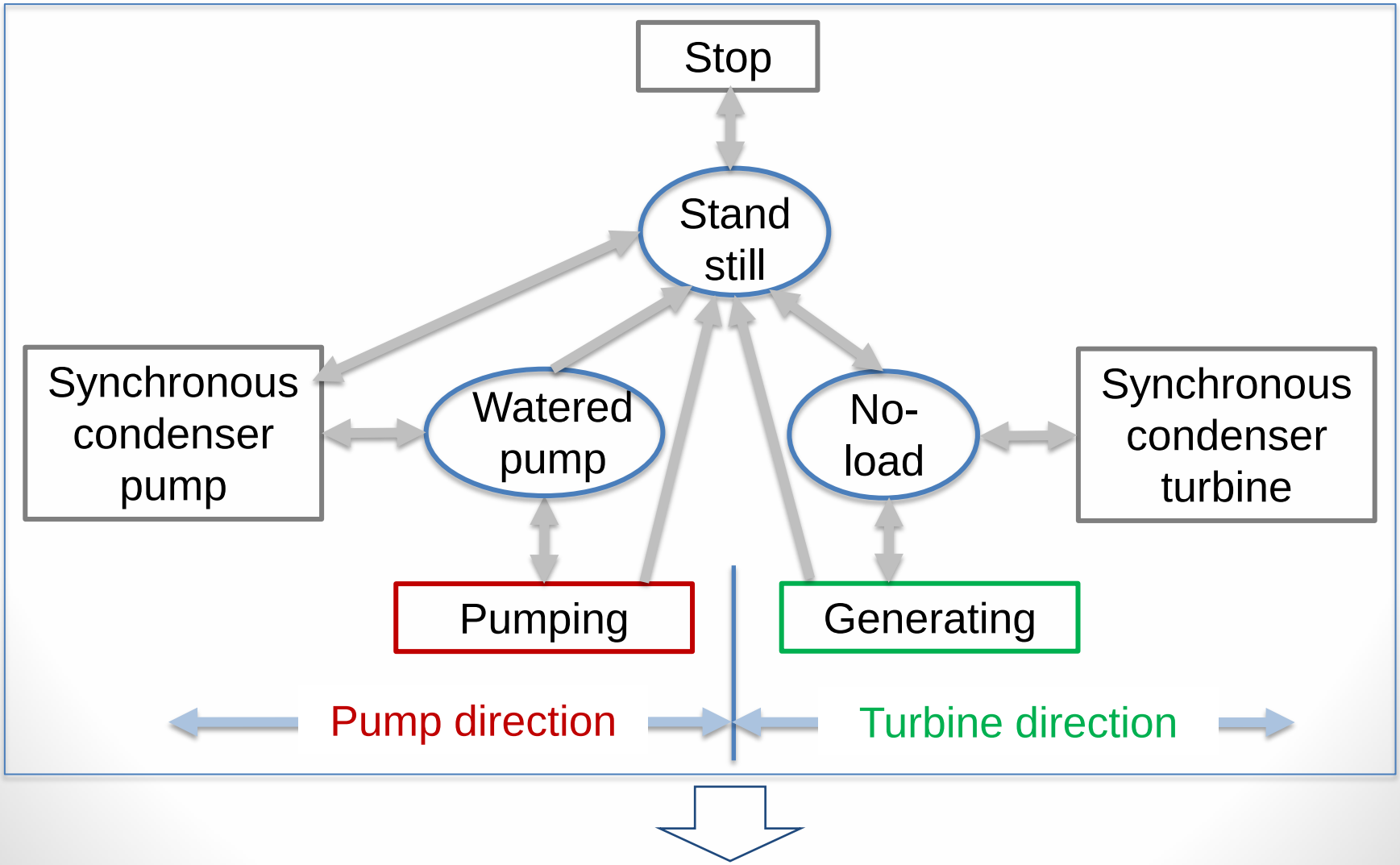


Without MGV

With MGV

RAINPOWER

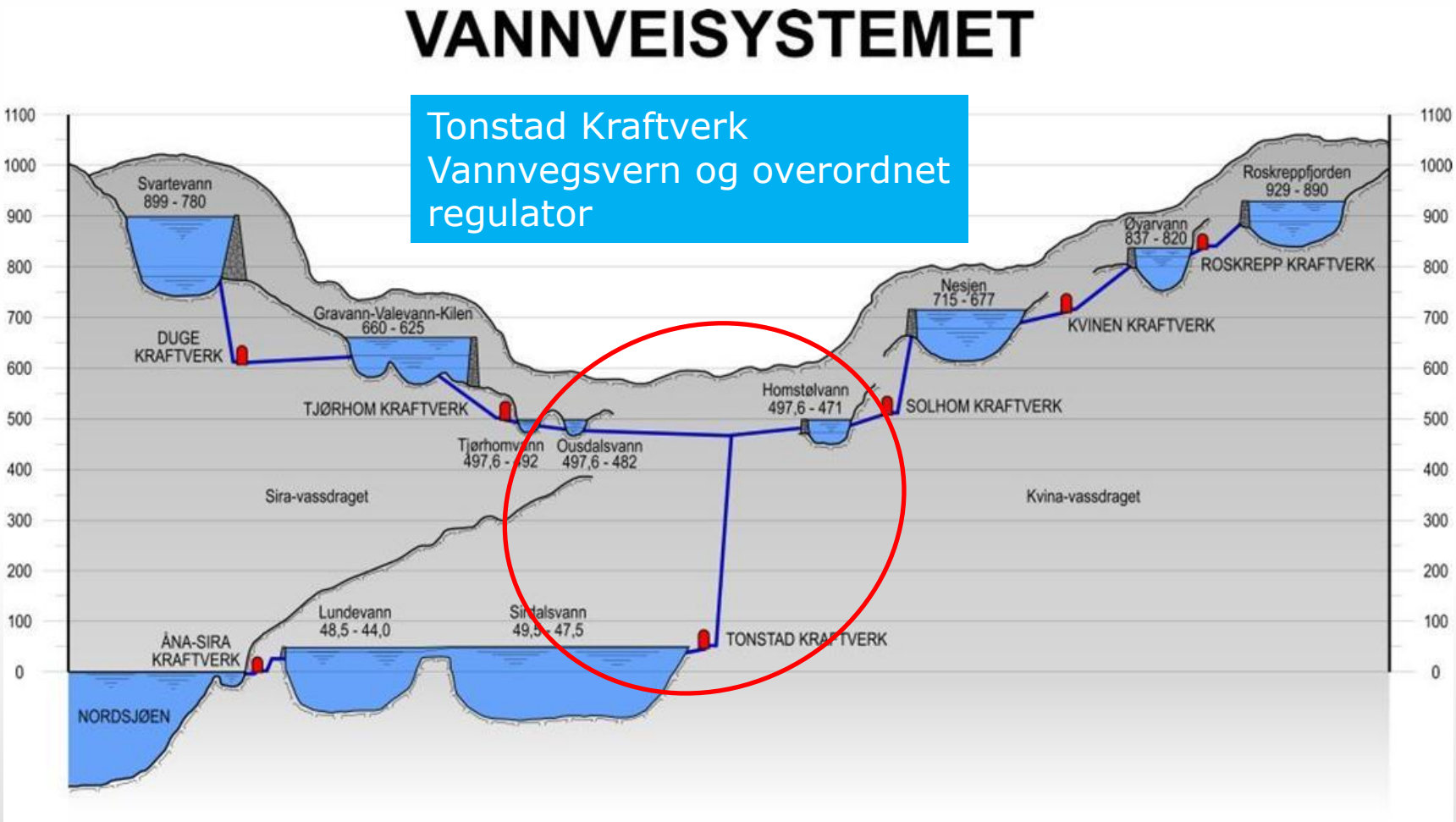
Pumped Storage Plant – Mode Changes



Technical challenges: Smooth transfer for all mode changes

RAINPOWER

Sira-kvina Tonstad

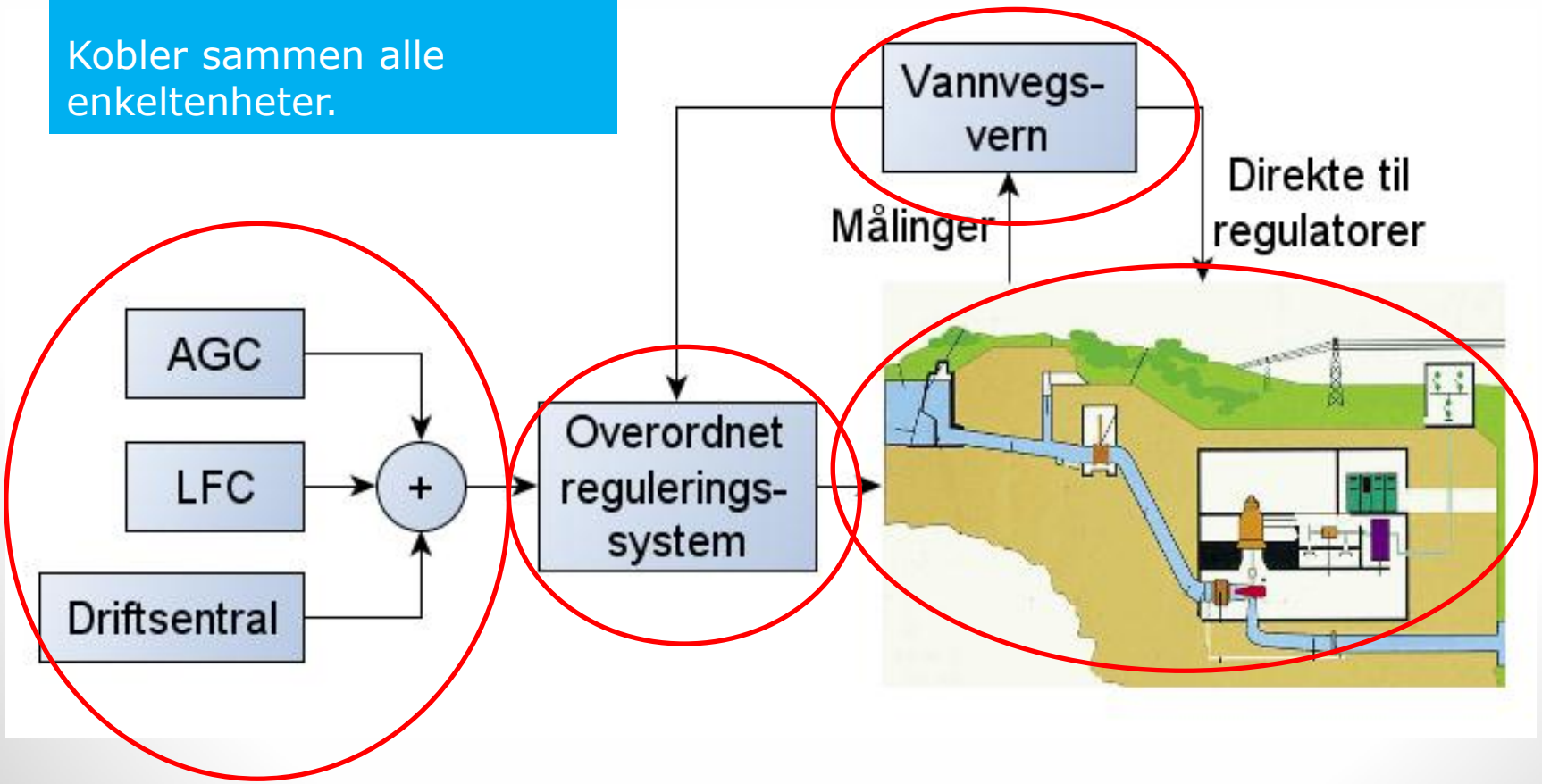


RAINPOWER

Tonstad - hele systemet

Fibernett

Kobler sammen alle enkeltenheter.



RAINPOWER

Takk for oppmerksomheten!

RAINPOWER