ZHAW
Energie- und Umweltforum
Wasserkraft Schweiz

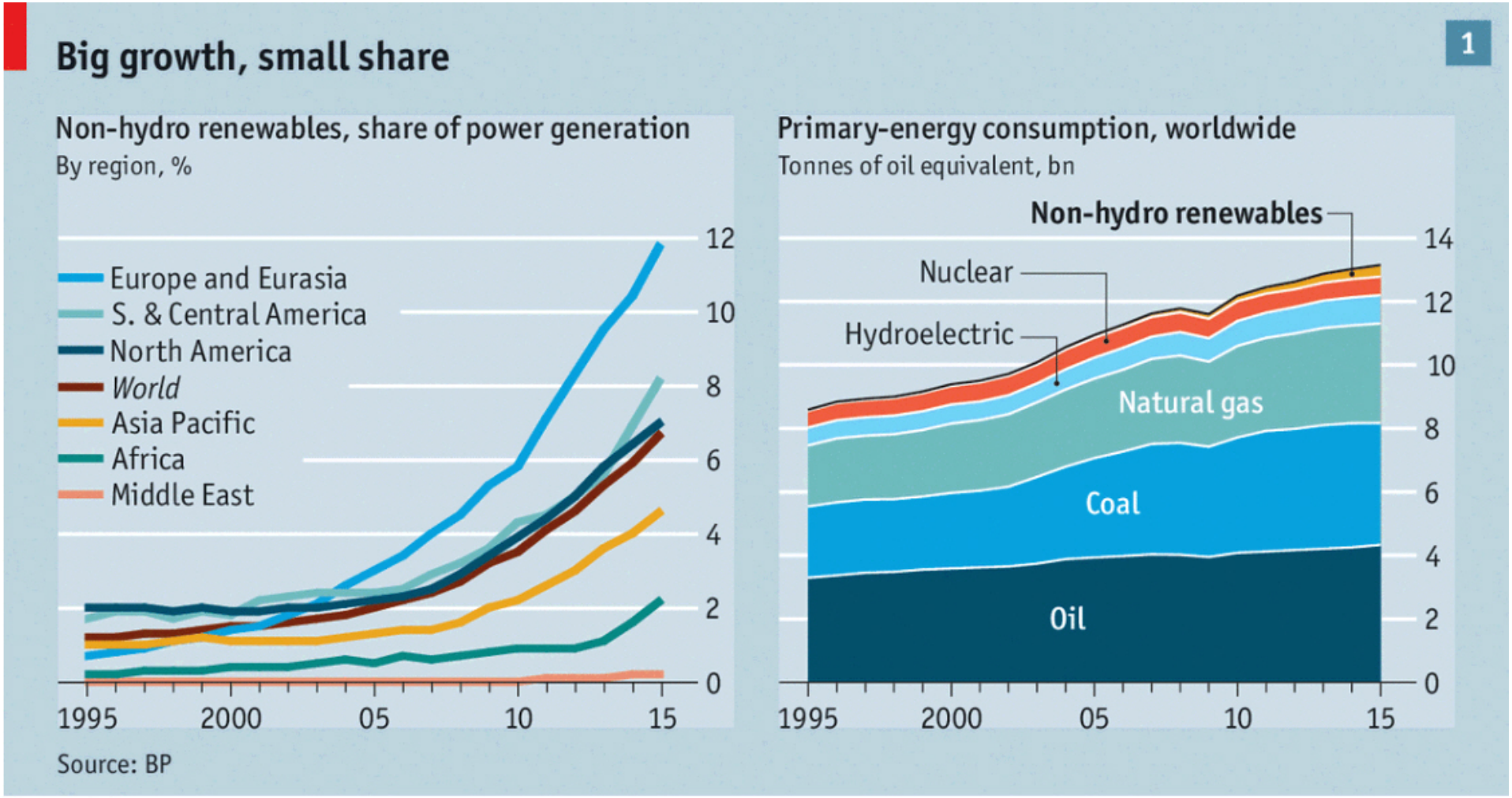
Technologie - Wasserkraft für den Strommarkt der Zukunft: Von der Komponentenoptimierung zur Systemoptimierung

Mirjam Sick, VP R&D Programm und Innovationsmanagement

ANDRITZ Hydro

Energy worldwide

Last 20 years



Economist.com

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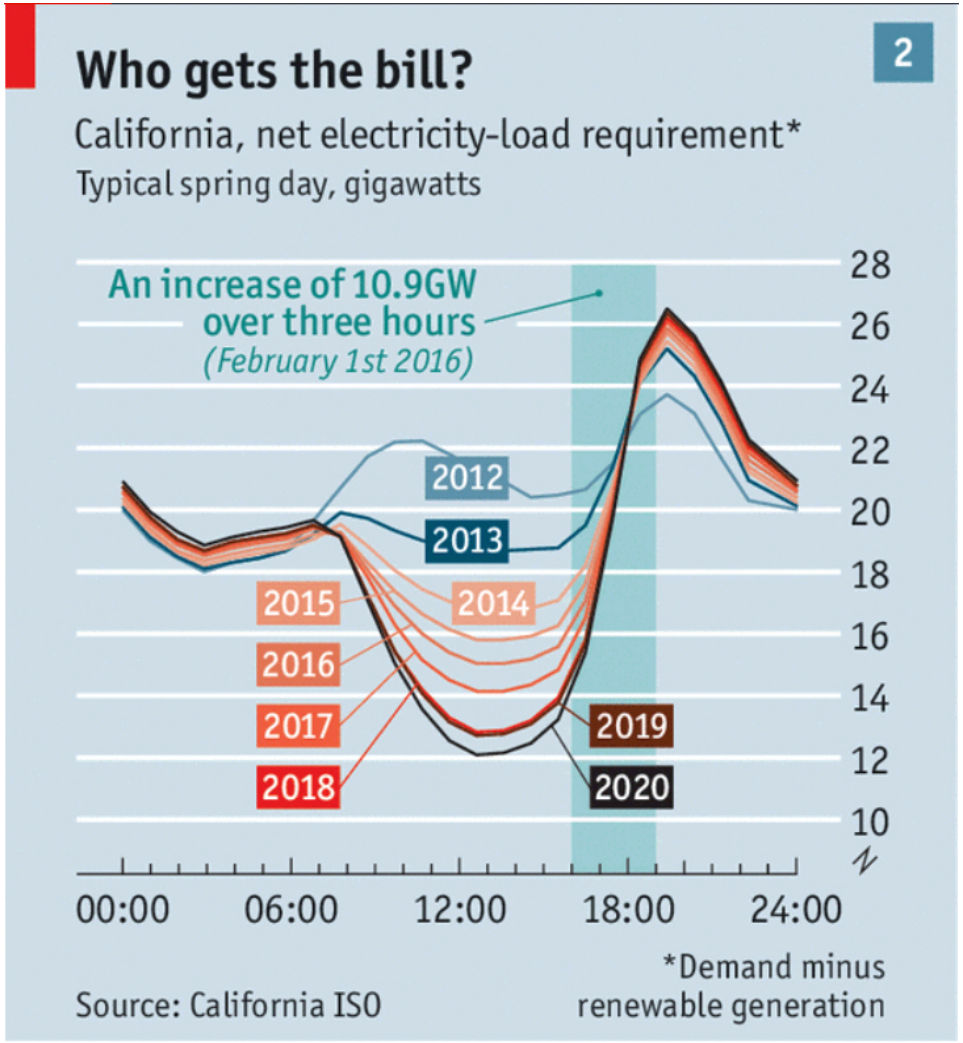
New renewables, wholesale price and grid stability

From dromedary to duck



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Electricity Market

Major issues

- **Increasing share of New Renewables: solar, wind**
- **Costs and low market price: Europe 30€/MWh (down from 60 €/MWh in 2011)**
- **Decentralisation**
- **Grid stablity**
- **Grid services and energy management**

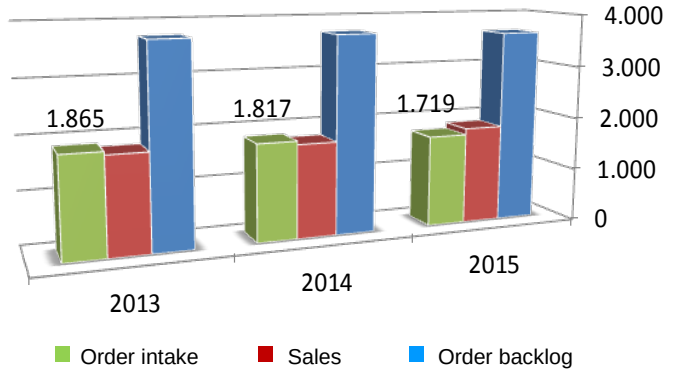
ANDRITZ HYDRO

Facts and figures

ANDRITZ HYDRO					
Central Function					
	Large Hydro	Compact Hydro	Service & Rehab	Pumps	Turbo Generator

ANDRITZ HYDRO FIGURES 2015

	Unit	2015
Order intake	MEUR	1,718.7
Order backlog	MEUR	3,640.9
Sales	MEUR	1,834.8
EBITA	MEUR	145.3
Employees (without apprentices)		8,230



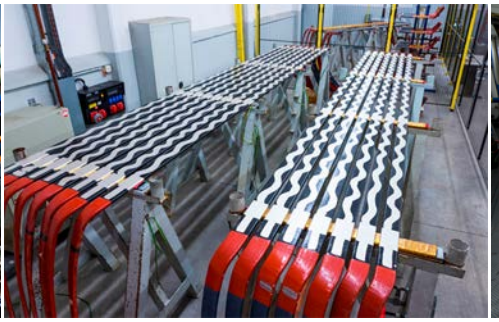
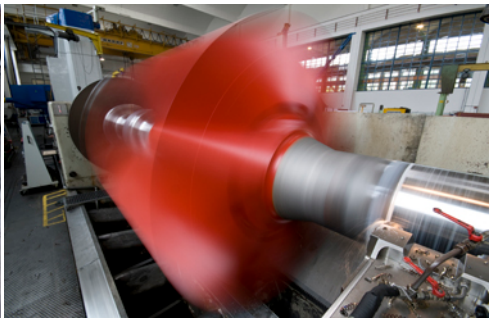
ANDRITZ HYDRO

Global research and development

- **Global test facilities**
  - **14 hydraulic test rigs**
  - **5 generator laboratories**
  - **Pump laboratory**
- **Advanced numerical calculation methods**

- **Highlights**
  - **Turbine test facilities including all types:**
    - **High heads up to 2,000m**
    - **Low head Bulb turbines**
    - **Pump turbines**
  - **Generator test fields for:**
    - **Large rotating electrical machines up to 850 MVA**
    - **Bearings**
    - **Electrical insulation**



R&D focus: Grid services

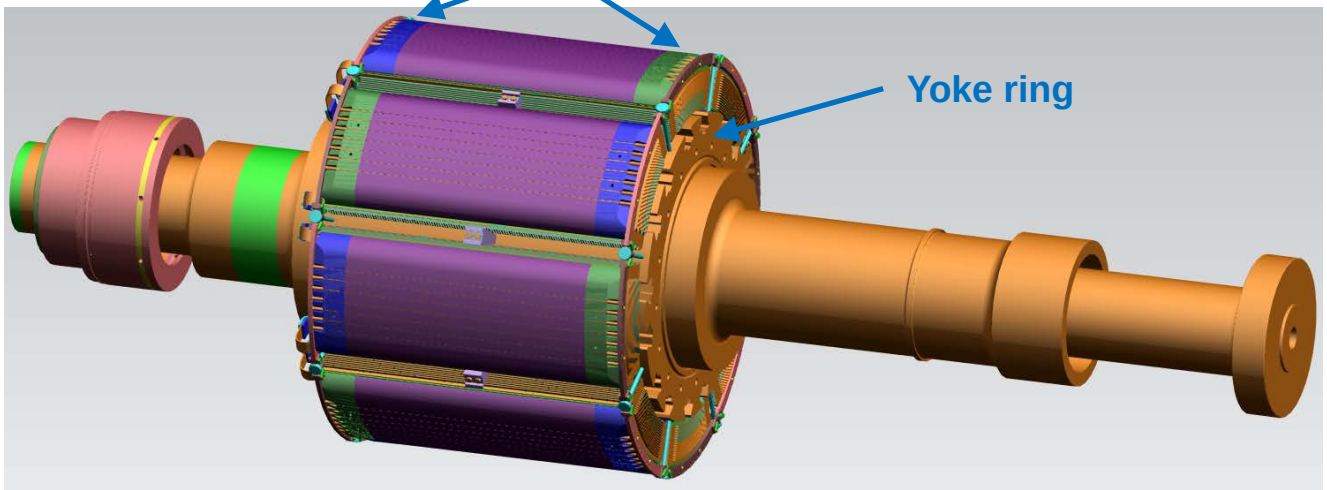
Flexible operation of hydropower plants

- **Example: Generator pole endplate: residual life**

Cycle fatigue

Rotor

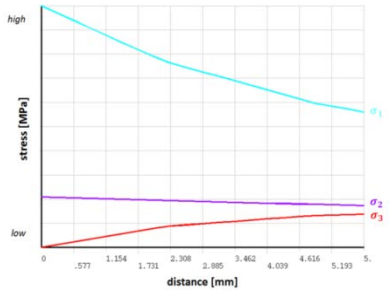
- **In the past**
  - **static strength assessment was sufficient to guarantee safe operation**
- **Today**
  - **increased frequency of start/stop cycles**
  - **Fatigue may limit service life**
- **Critical parts**
  - **Rotor rim or yoke ring**
  - **Pole endplate**

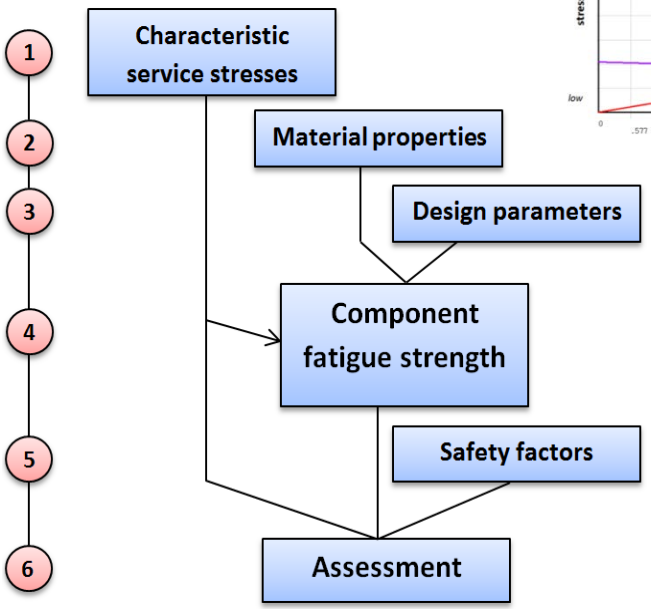


Cycle fatigue pole endplate

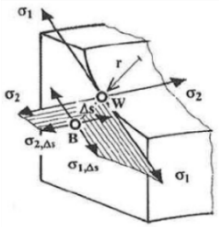
Analysis

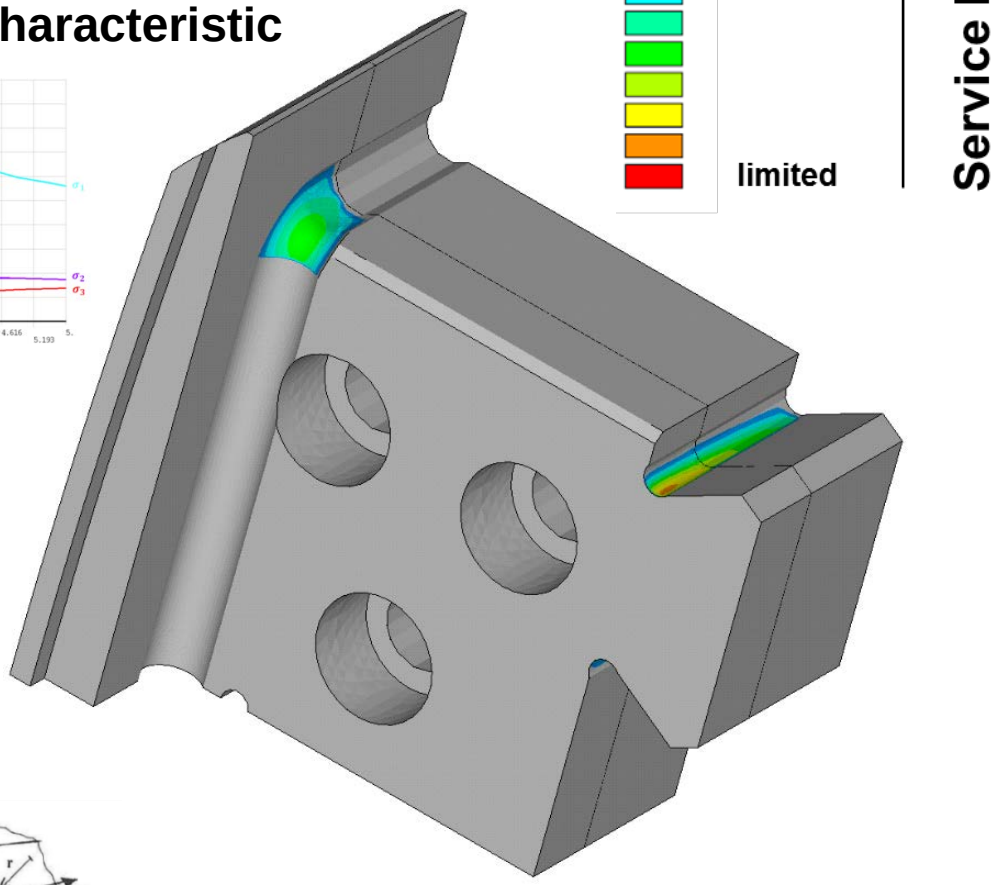
- **Fatigue Analysis according to *FKM* Guideline**
- **Assessment of Service Life due to Characteristic Stress Pattern**





***FKM* Guideline, *"Analytical strength assessment of components in mechanical engineering"*, 5th revised edition, 2003**





Half Model of Pole End Plate with contours of expected Service Life

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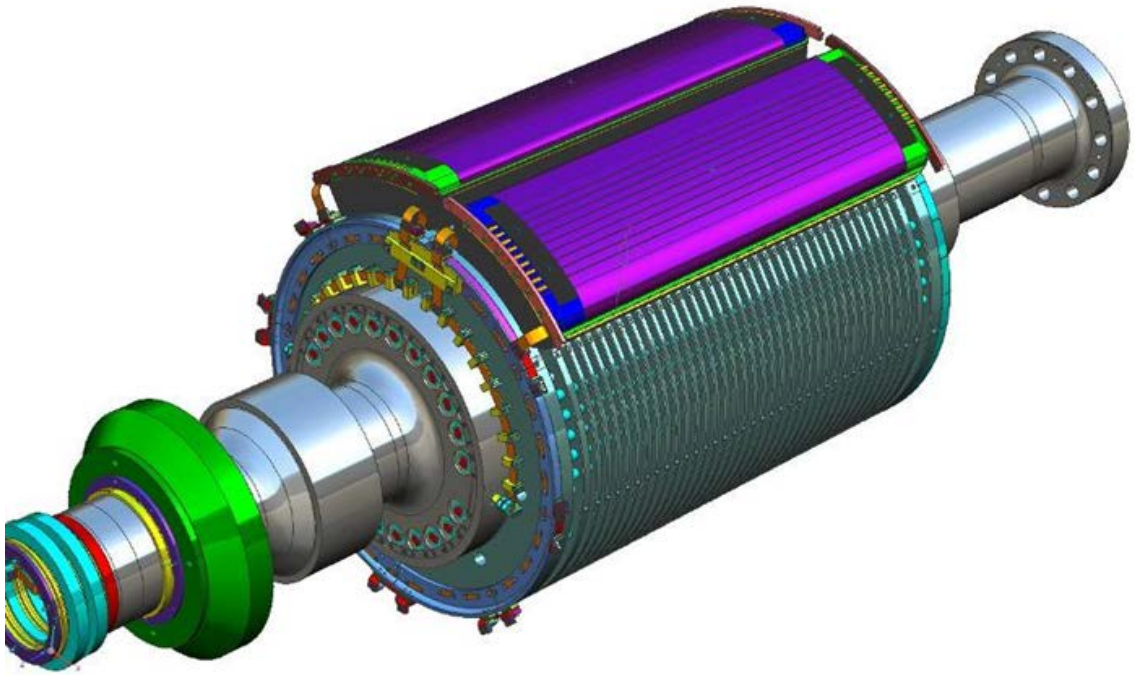
Cycle fatigue pole endplate

Solution

- **Comb Type Pole Fixation**
- **Lower Peak Stress than T-head or dovetail**
- **Maximum Service Life**

	peak stress & fatigue	slipping & fretting	manufacturing & costs
T-head	negative	positive	positive
dovetail	neutral	neutral	positive
comb	positive	positive	negative



R&D focus: Grid services

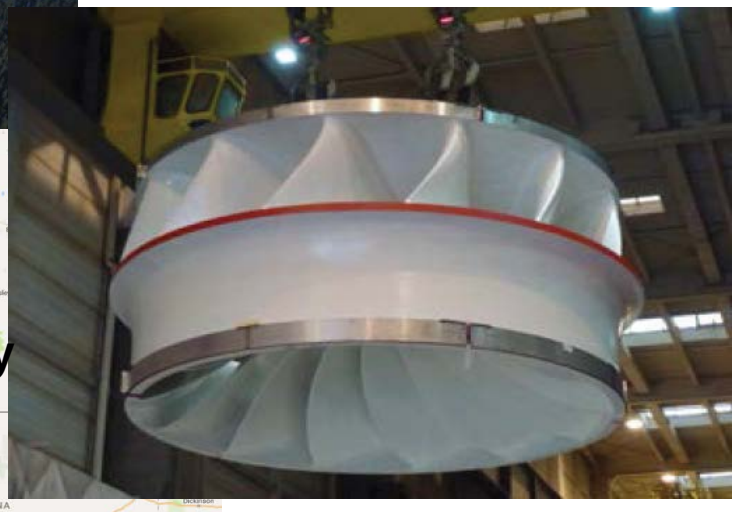
Flexible operation of hydropower plants

- **Example: Turbine Runner Life Extension by in situ Start-up optimization**

Mica U5 measurement campaign

Optimizing the start-up

- 700 km Northeast of Vancouver
- Existing U1 to U4 in service since 1977
- New U5 & U6 in service since 2015 (1 000 MW)
- Total of 2 805 MW



Unit 5 & Unit 6

- H_{max} = 183 m
- P_{max} = 570 MW
- D_{th} = 5 600 mm
- N = 133.33 rpm
- 13 blades
- 20 guide vanes

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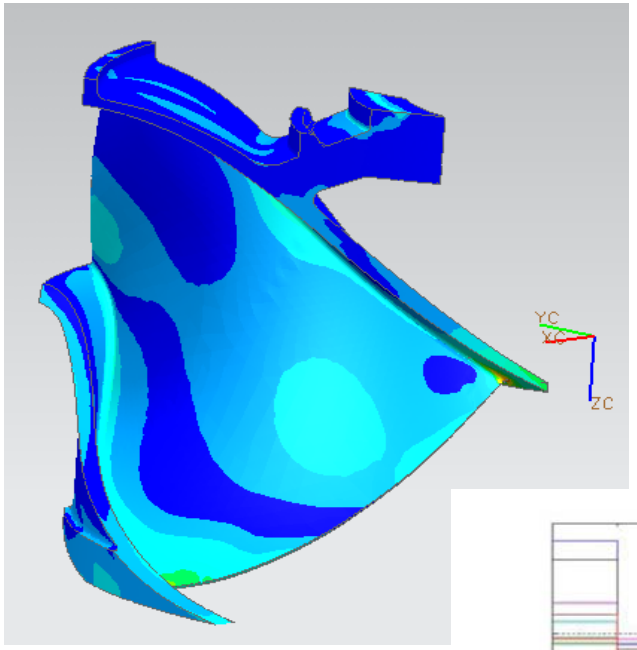
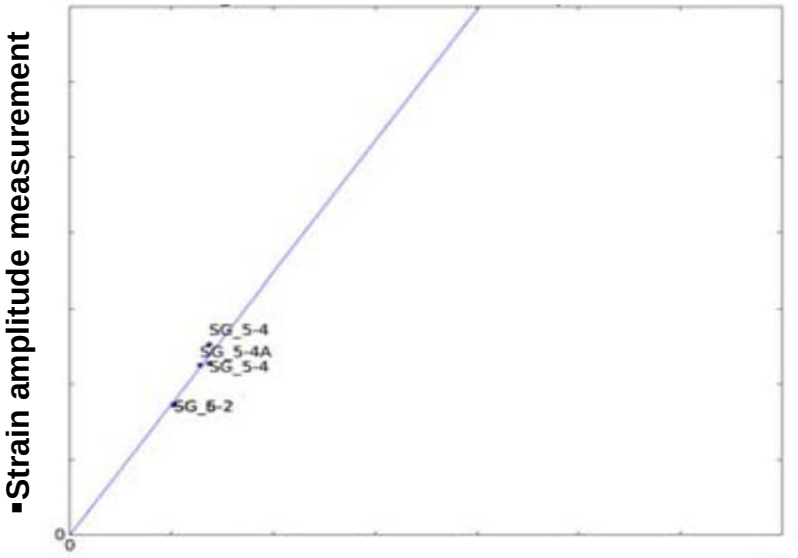
Combination of measurement with computational analysis

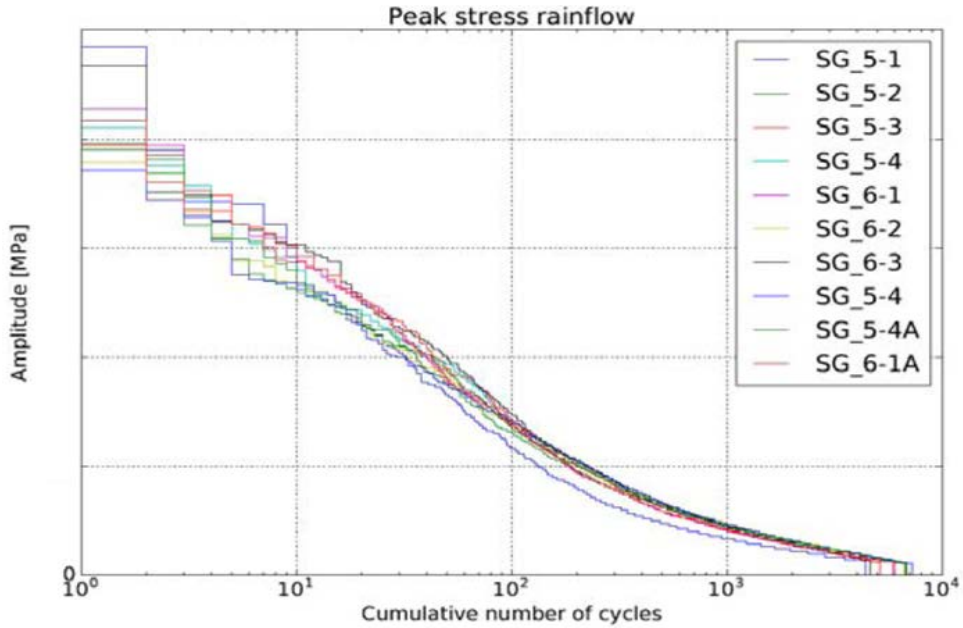
In situ life damage calculation

- **Fatigue damage per start-up is calculated using:**
  - **Peak stress rainflow**
  - **Cumulative Miner's rule**
  - **Design fatigue curve**





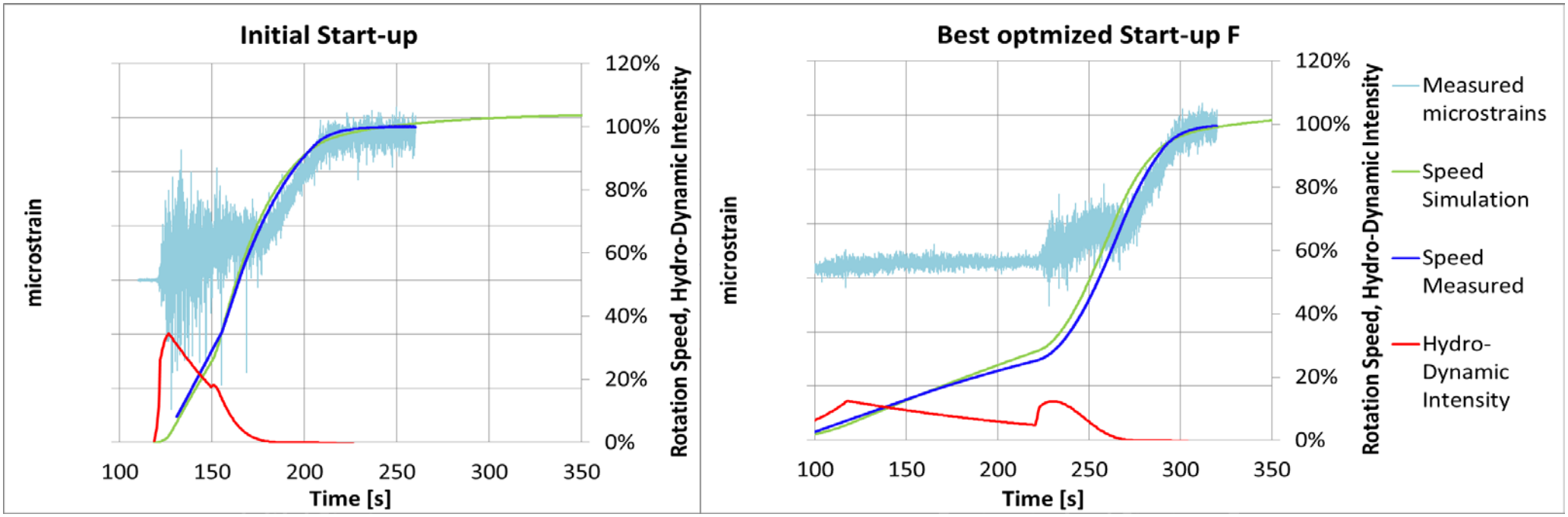
▪Predicted pattern strain amplitude



Hydro

Start-up Numerical Optimization

Comparison to stress measurement results



- **For all tested start-up sequences:**
  - **Acceleration curve is well predicted**
  - **Start hydro-dynamic intensity follows quite well blade stress range**
- **Optimization: life extension by factor 50**

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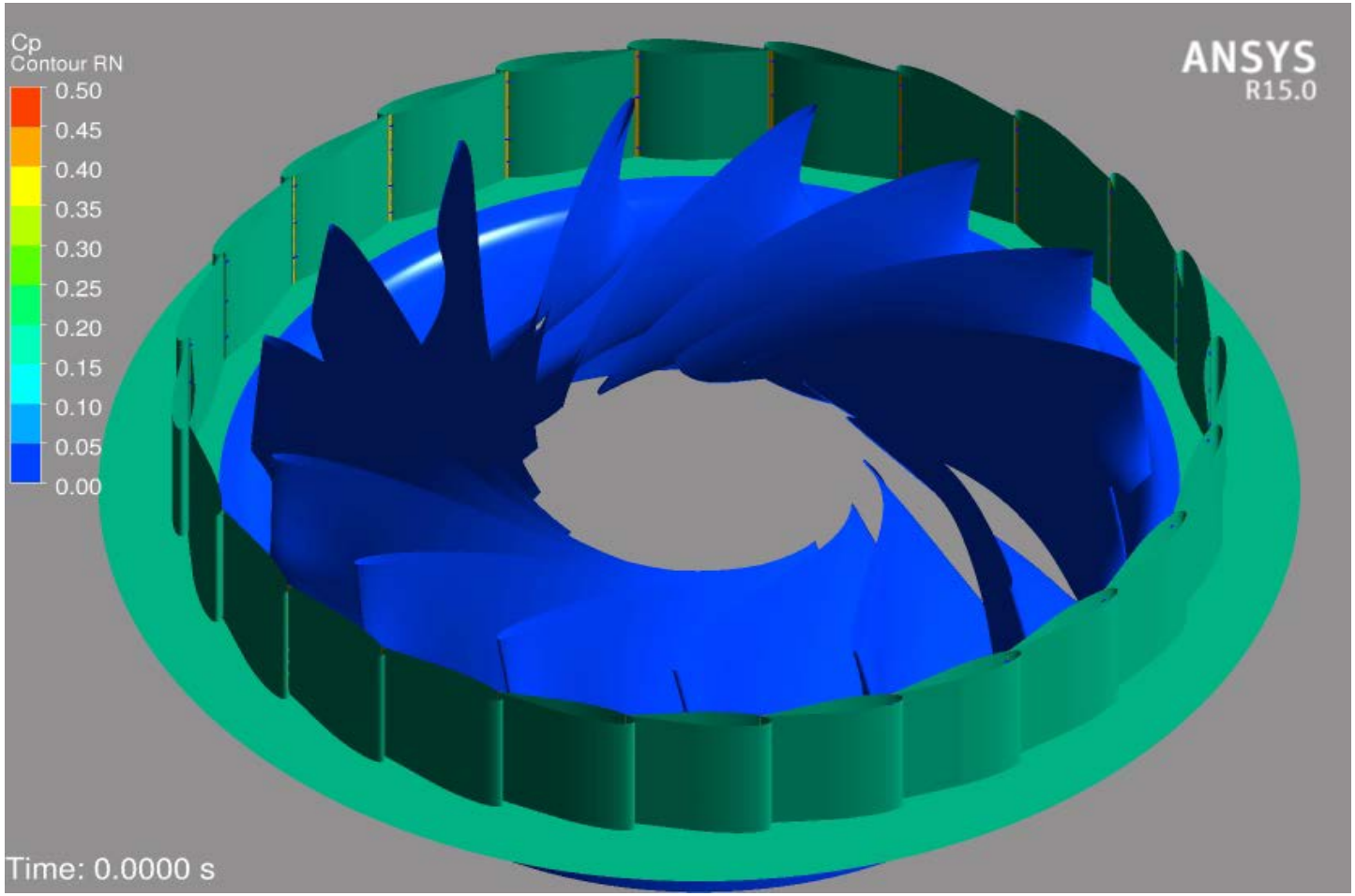
Start-up numerical optimization

Numerical start-up transient analysis



R&D focus: Cost optimization over lifetime

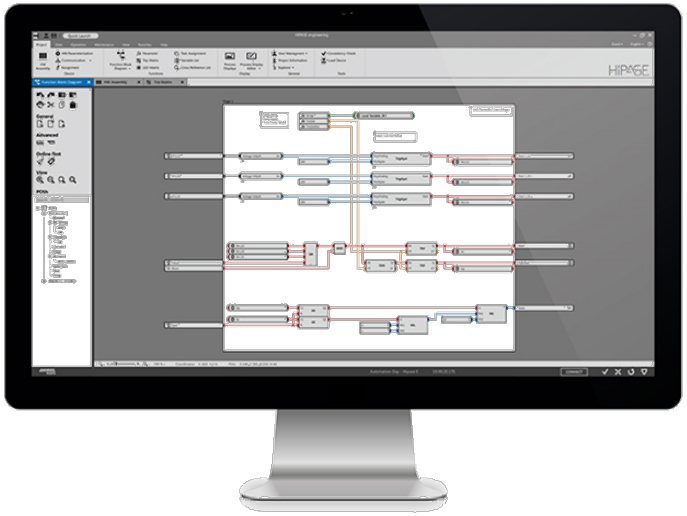
Automatization solutions

ANDRITZ HYDRO Spark 2016 – Innovation Contest

HIPASE – A new automation platform for ANDRITZ HYDRO

What are the benefits?

One product for all kinds of automation applications
Ergonomic and intuitive engineering and visualization
Designed for integration of future demands
(e.g. generator & turbine monitoring)



HIPASE Engineering Tool

Simply Made For You

Who will benefit?

ANDRITZ HYDRO

- **Cost reduction in terms of hardware and engineering**
- **Less hardware components required**
- **Simplification of engineering workflow**
- **Increased order probability**
- **Less staff on-site necessary**

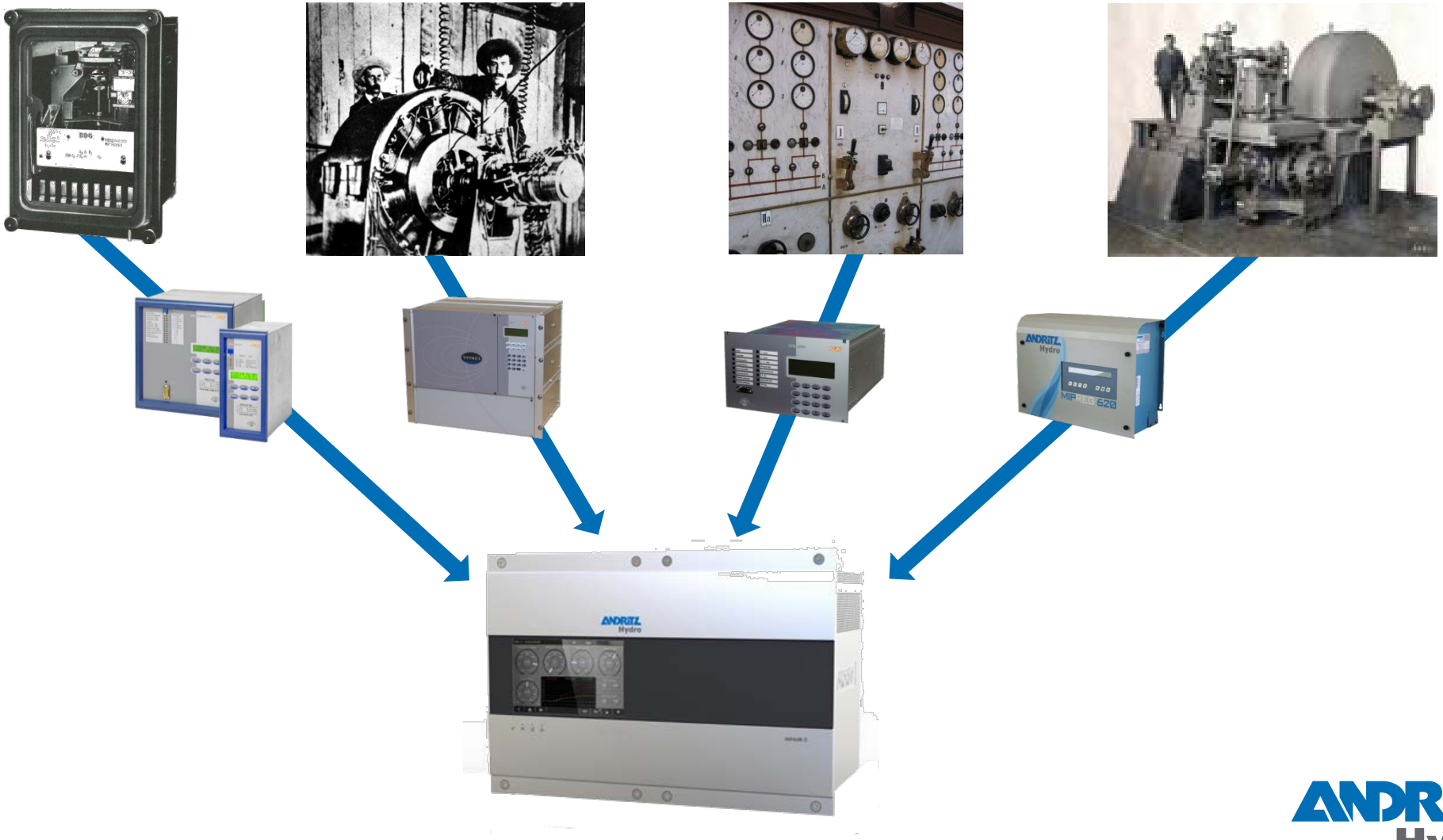
Clients

- **Less training efforts**
- **Less costs for spare parts**

ANDRITZ HYDRO new automation platform

HIPASE –Development of “All-In-One” Devices

Protection **Excitation** **Synchronization** **Turbine governor**



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Automation platform: ingredients

HIPASE – Ready for the Future

Cross-functional thinking

R&D competence meets application know-how
in one business location

Industrial design

Co-operation with professionals to achieve a
state-of-the-art industrial design for device and engineering tool

Optimization functions

Excitation: PSS – Power System Stabilizer already available
Turbine governor: ACC – Adaptive Cam Control in development
Additional functions will be implemented

Open interfaces

Interface to ePlan for cubicle design possible

Standardized communications protocols, e.g. OPC UA

HIPASE

Big Data

Integration of Monitoring & Diagnosis possible
Connectable to SCADA systems

Future oriented

Multi core technology
Designed for integration of future demands

Smart Sensors

Ready for integration of smart sensors due to the
modular structure of HIPASE

Virtualization

HIPASE is already useable in a
virtual environment

Cyber Security

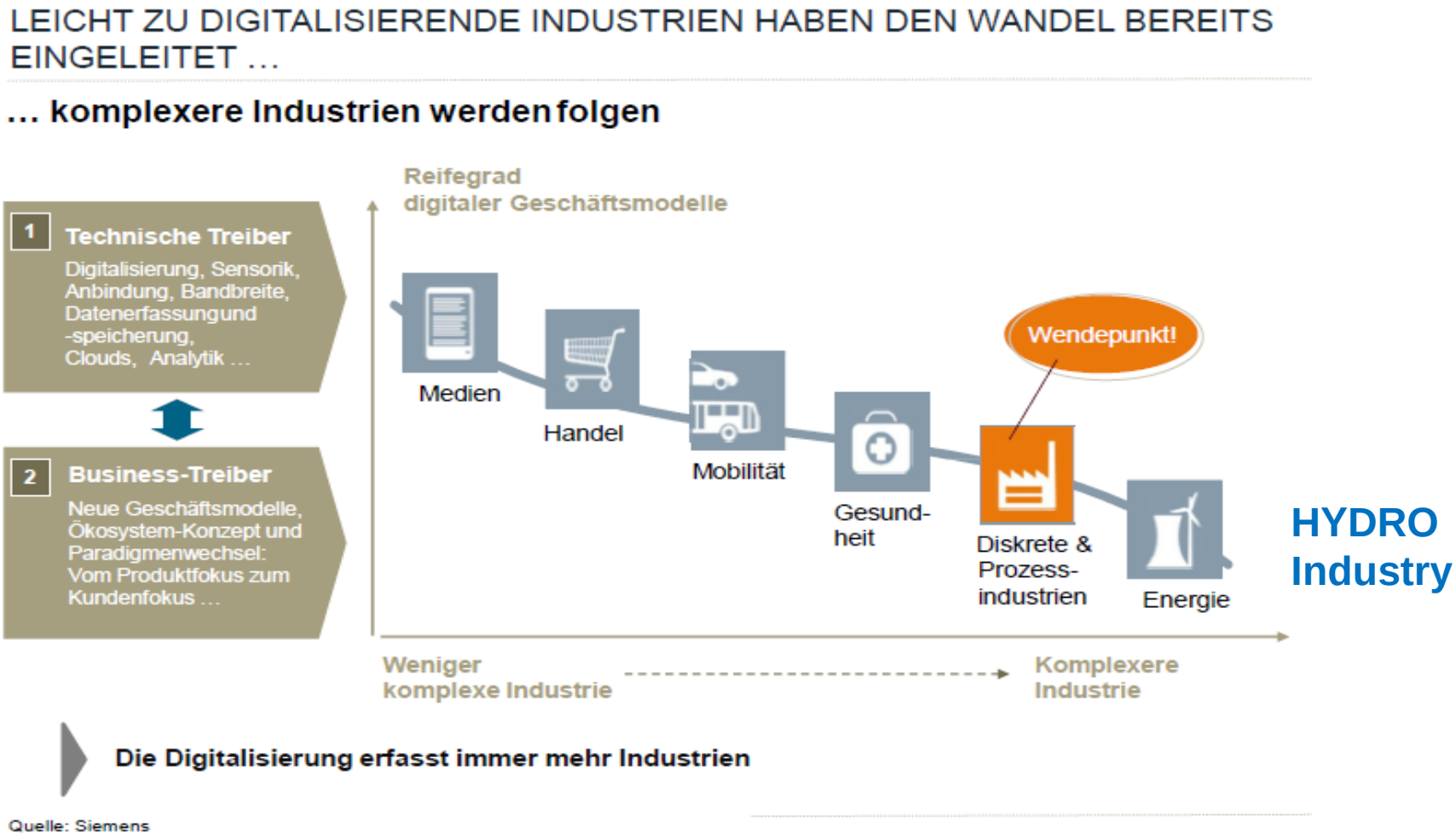
HIPASE is designed from the beginning to be highly secure by the use of:
Encrypted connections, sandboxing, signed firmware,
integrated firewall, VPN tunneling, TPM Trusted Platform Module processor

R&D focus: Digitalization

Digitalization in operation and maintenance

Hydropower industry

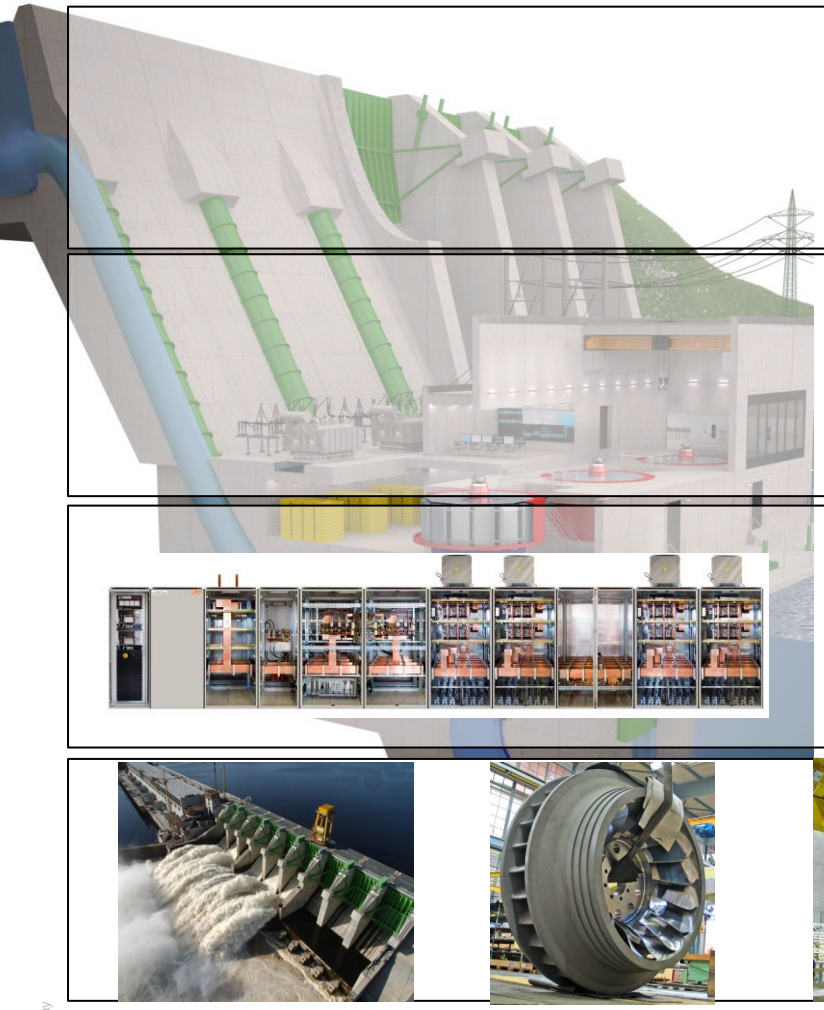
Status of digitalization



HYDRO Industry

Hydro power plant

Optimization of power generation assets and performance



Plant management

software platform
O&M, asset management,
performance optimization

Plant operation

control system
SCADA

Process

automation
sensors
actuators

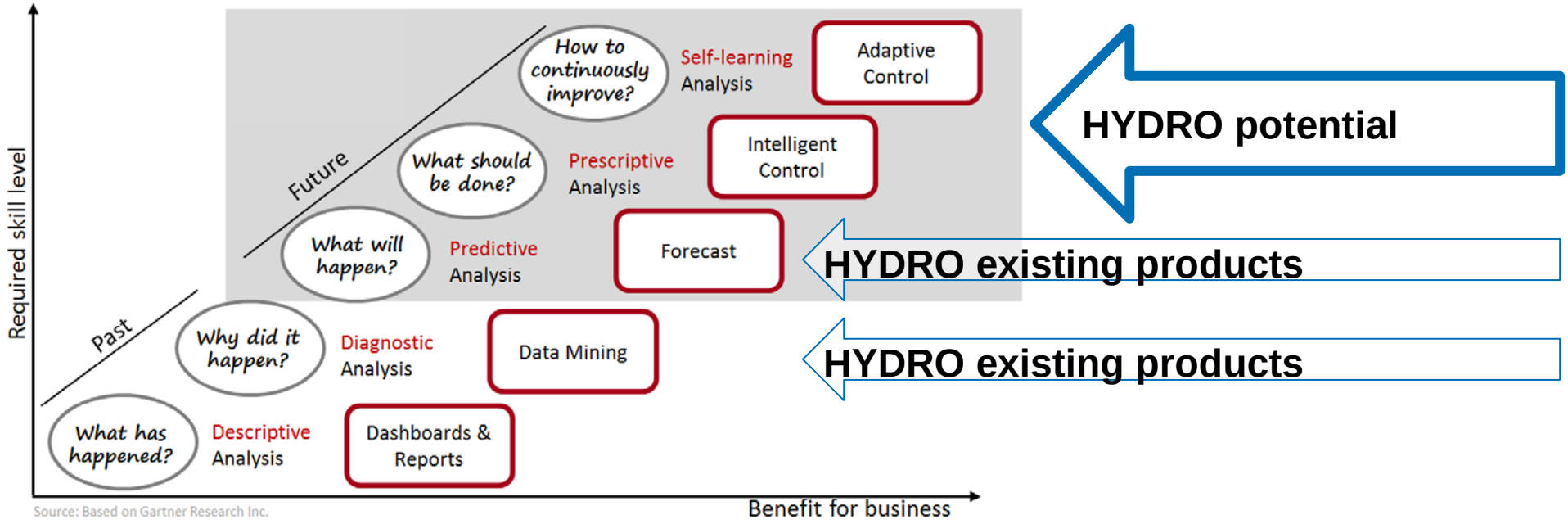
Power generation

system& components
penstock&gates, turbines
generators, balance of plant

Predictive Maintenance

Potential

- **Problem: one HPP produces relatively small amount of data**
- **Possible answer: deep learning algorithms within unique power station**

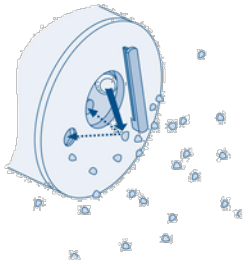


Sand monitoring

Particle measurement system based on turbidity & filtration

Automatic sampling

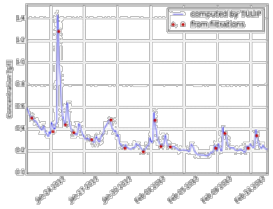
Extract & weight solid part

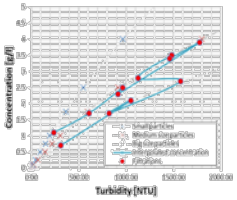


Measure water turbidity

Detection of change in turbidity

Permanent auto-calibration





Analytics

AndrOMeda

Turbine monitoring platform

Concentration (t)

Filtration test

Flow signals from automation

$Q, P, n \ldots$

Target:

Determining the amount (tons) of sand passing through the turbine

$$= \int Flow(t)\, Concentration(t)\, dt$$

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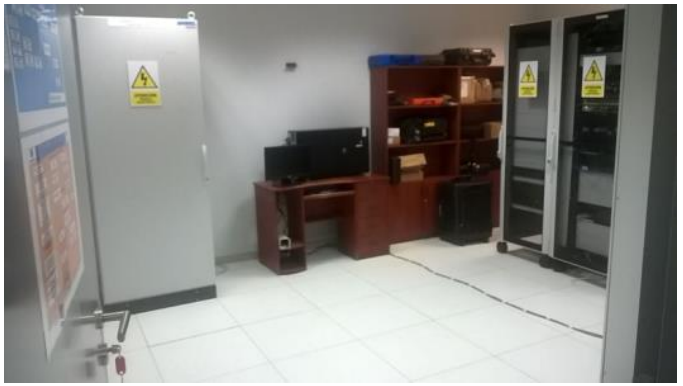
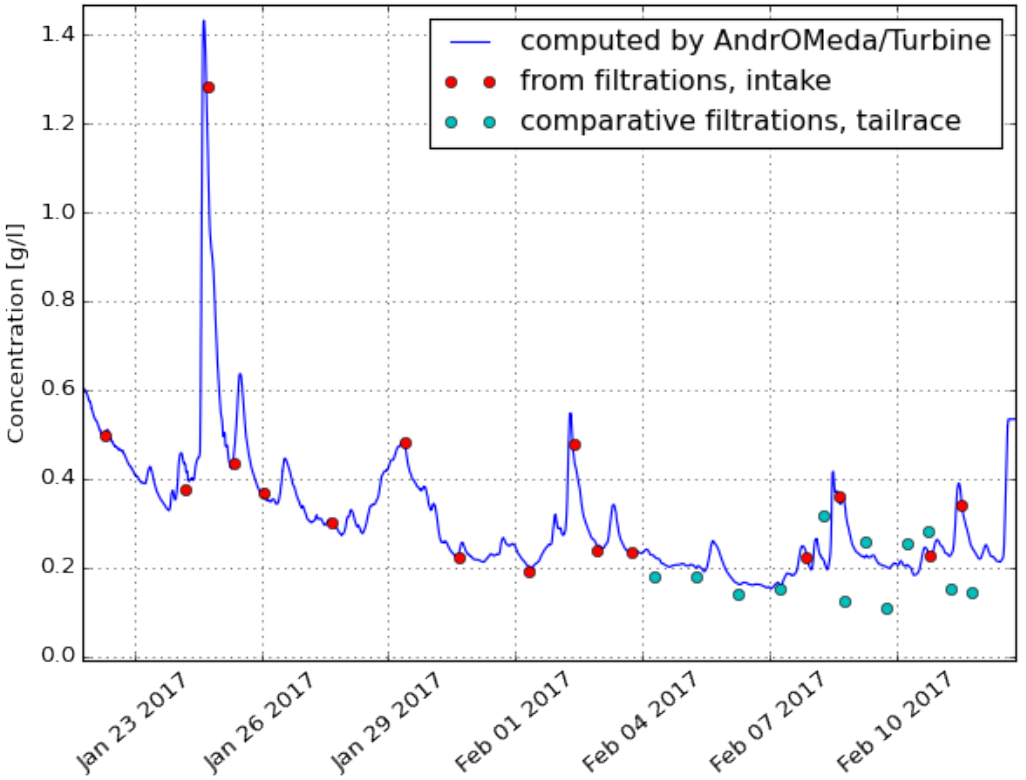
Sand Monitoring

Pilot Project SANTA TERESA

- **Pilot project : 2 x 49 MW FR, Peru, only 1 coated runner**
  - Operation data
  - Full sand monitoring equipment
- **Commissioning in December 2016**





Technologieentwicklung Wasserkraft

Von der Komponentenoptimierung zur Systemoptimierung

- **Trends**
  - **Dezentralisierung in der Stromerzeugung**
  - **Flexibilität der Anlagen**
  - **Kostendruck**

- **Systemoptimierung**
  - **Flexibilität der Komponenten**
  - **Optimierung des Produktlebenszyklus**
  - **Optimierung der Gesamtsysteme**

- **Technologietreiber: Digitalisierung**