HydroFlex

Increasing the value of Hydropower through increased Flexibility

Introduction to the HydroFlex project

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Project coordinator

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 764011

HydroFlex – Facts

- Duration: 4 years
- Project start: 1st May 2018 End 30th April 2022
- Budget: 5,7 M€
- 16 partners, 5 countries:
  - R&D Institutes: Norwegian Institute for Nature Research, SINTEF
  - Universities: NTNU, Luleå Technical University, Uppsala University, Chalmers University of Technology, University of Skopje, Aachen University, University of Strathclyde
  - Manufacturers: Rainpower, ABB
  - Utilities: Vattenfall, Statkraft, Lyse
  - Consultants: EDR Medeso, Multiconsult

LCE-07-2016-2017: Developing the next generation technologies of renewable electricity and heating/cooling

Hydropower: Increasing flexibility of hydropower:

Hydropower is still amongst the largest sources of renewable energy. The challenge is however to make hydropower available in a time as short as possible independent of plant size. *New technologies, generators and turbine designs need to be developed to increase ramping rates and* ***to allow start-stop-cycles to reach up to 30 times per day*** *depending on head and volume, while lifetime of components and respective life time prediction methods under heavy duty operating conditions are considerably improved and at the same time avoiding adverse effects on downstream water courses.* The refurbishment and simultaneous upgrading of hydropower stations offers a huge potential to increase renewable electricity production; the challenge is to leverage the storage potential of hydropower for grid balancing on the base of new technologies, finally allowing plant operators to operate successfully in the modern power markets and to make a significant contribution to European renewable energy objectives and policies

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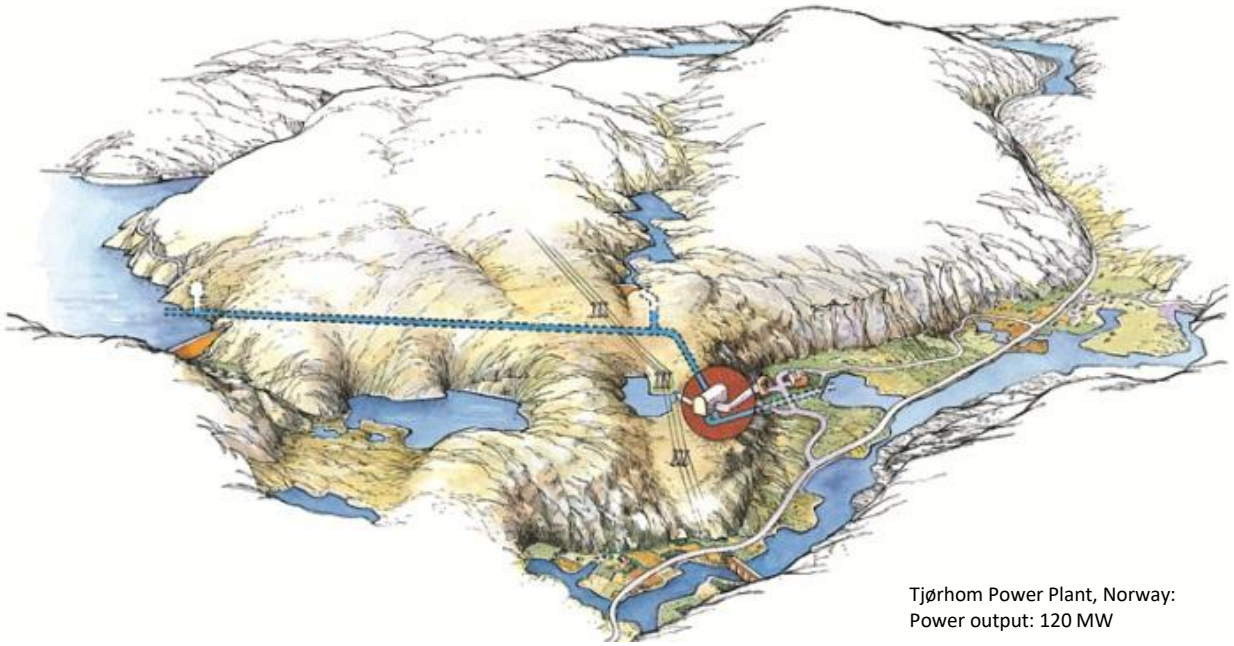
Main Objective

The HydroFlex project aims towards scientific and technological breakthroughs to enable hydropower to operate with very high flexibility in order to utilize the power and storage capability. The project will create the fundamental and technical basis for successful future industrial developments by performing well-focused research and innovation activities on the key bottlenecks of hydropower units that restricts their operating range and thus limiting their flexibility.



Tjørhom Power Plant, Norway:
Power output: 120 MW

Source: Sira-Kvina Kraftselskap

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Reference Power Plants

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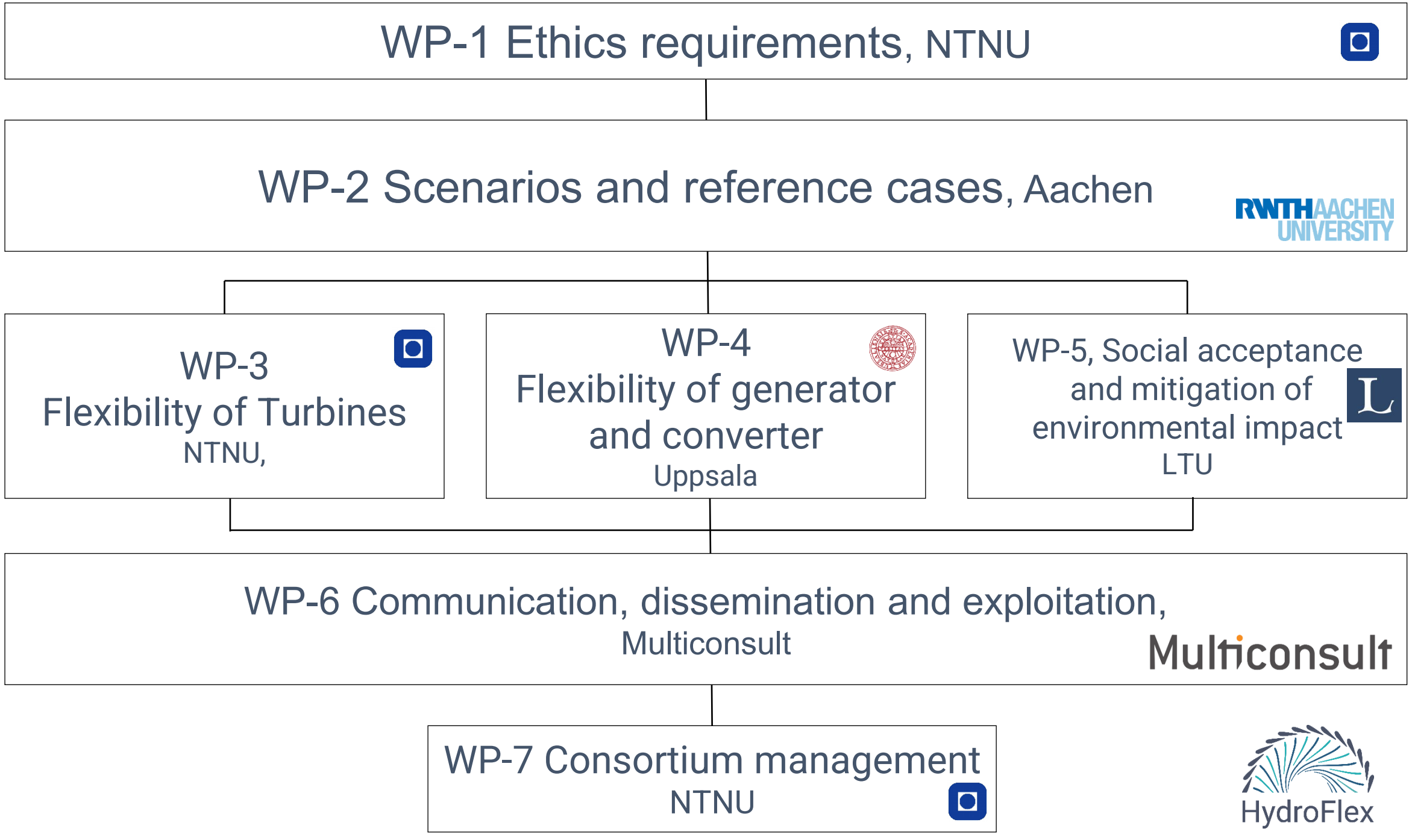
WP-1 Ethics requirements, NTNU
WP-2 Scenarios and reference cases, Aachen
RWTH AACHEN UNIVERSITY
WP-3
Flexibility of Turbines
NTNU,
WP-4
Flexibility of generator and converter
Uppsala
WP-5, Social acceptance and mitigation of environmental impact
LTU
WP-6 Communication, dissemination and exploitation,
Multiconsult
Multiconsult
WP-7 Consortium management
NTNU
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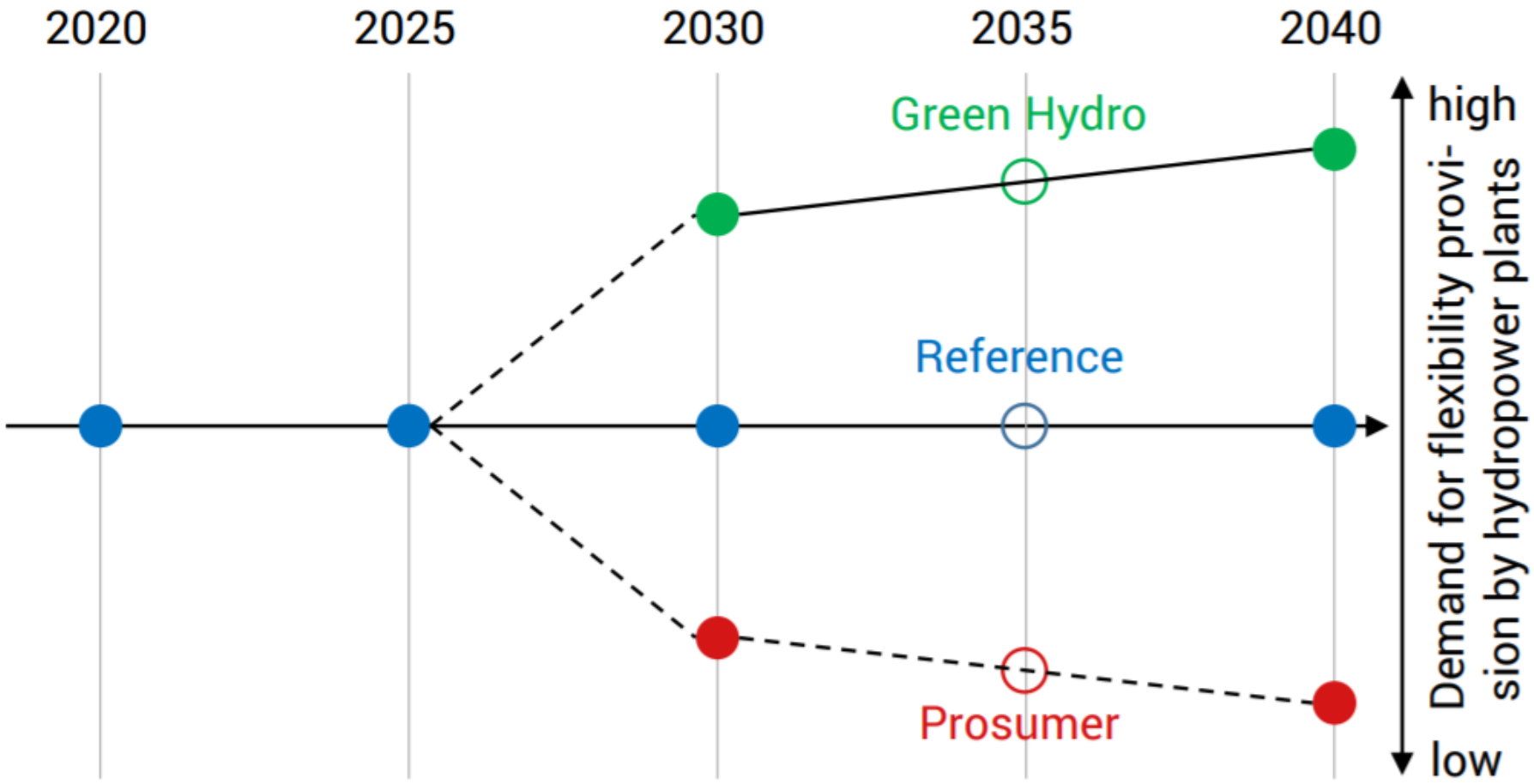
Flexibility Scenarios



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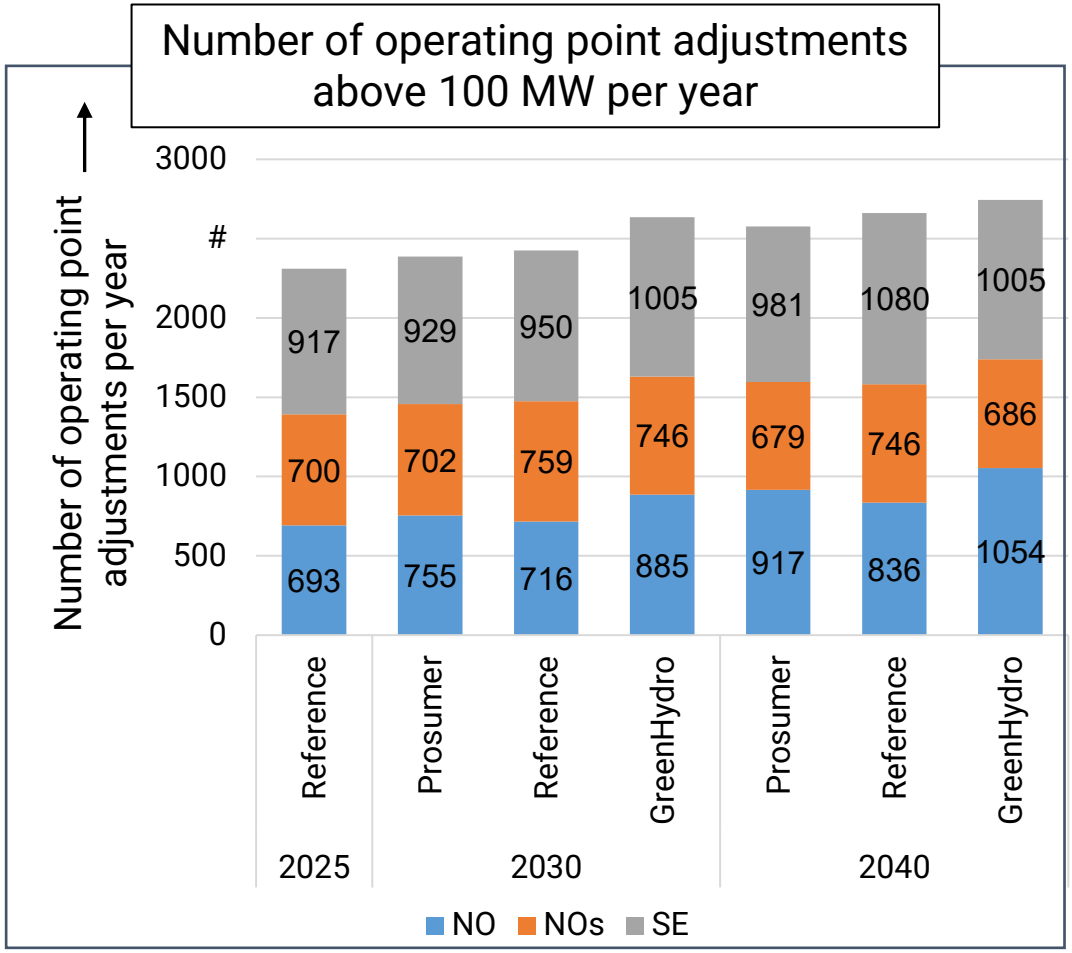
Comparing the number of operating point adjustments above 100 MW

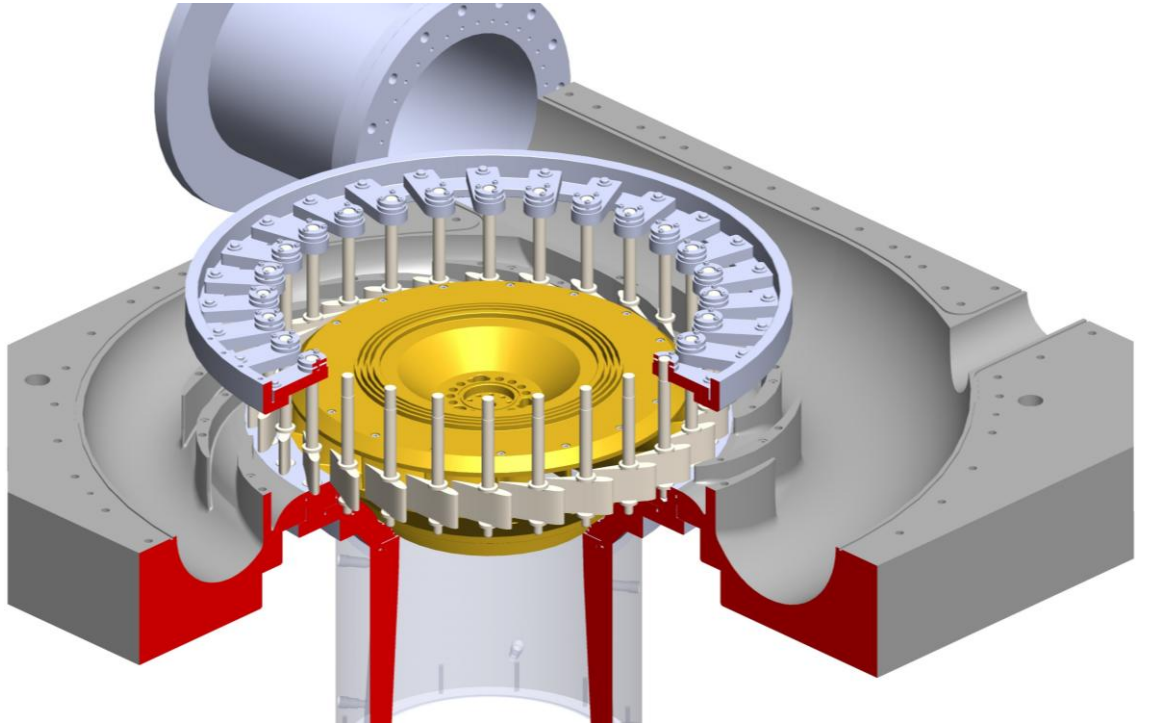
How will Nordic hydropower as part of the European power supply system be operated?

- Comparison of the aggregated feed-in time-series of all hydropower plants per bidding zone
- The number of operating point adjustments above 100 MW is between 700 and 1100 per year and differs only slightly between scenarios
- Number of operating point adjustments highest in bidding zones and scenarios with a comparatively high share of wind turbines



Turbine research

- Turbine lifetime model
- Fluid Structure Interaction
- Material tests
- Francis turbine design
- Model tests
- Verification of stresses in the turbine during flexible operation



EDR MEDESO

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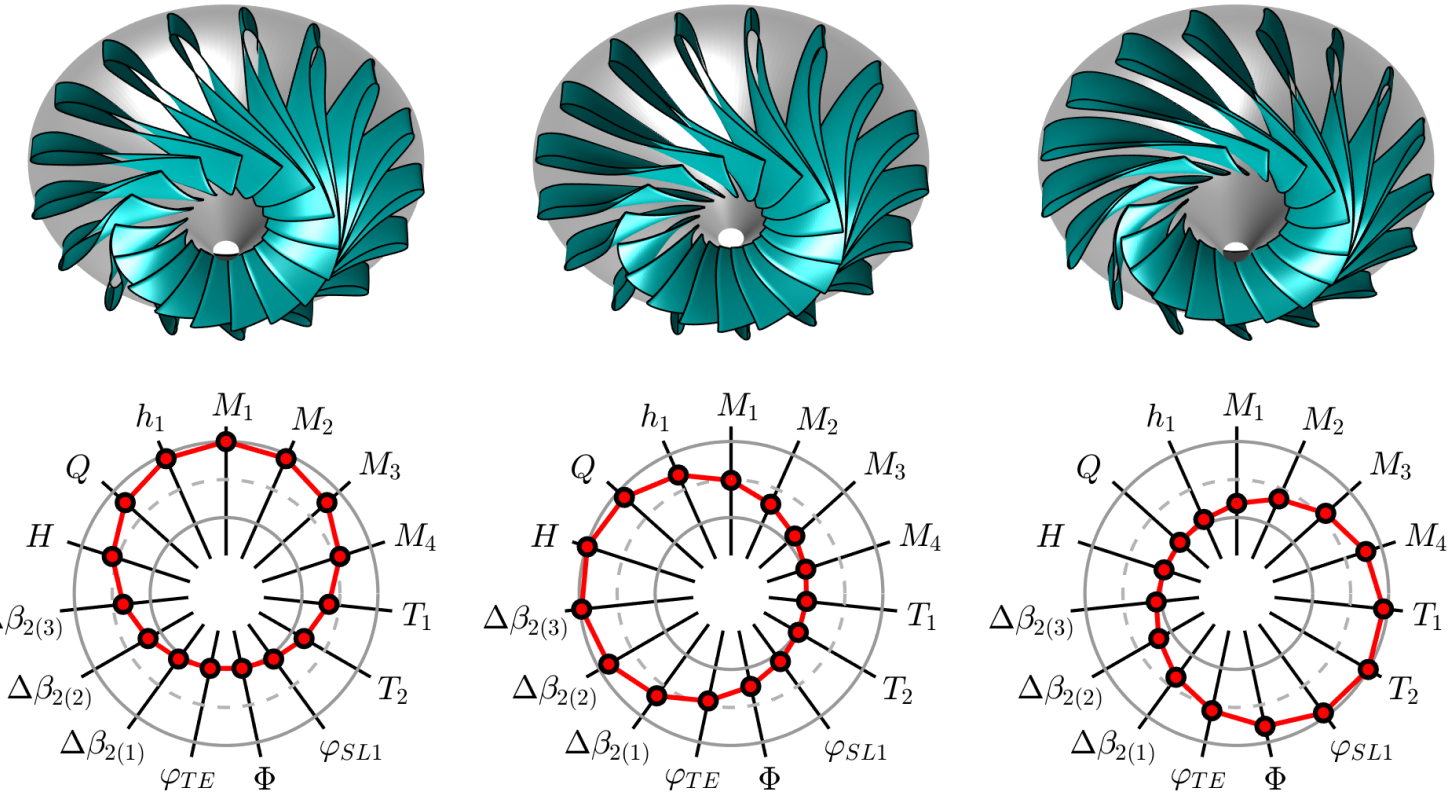
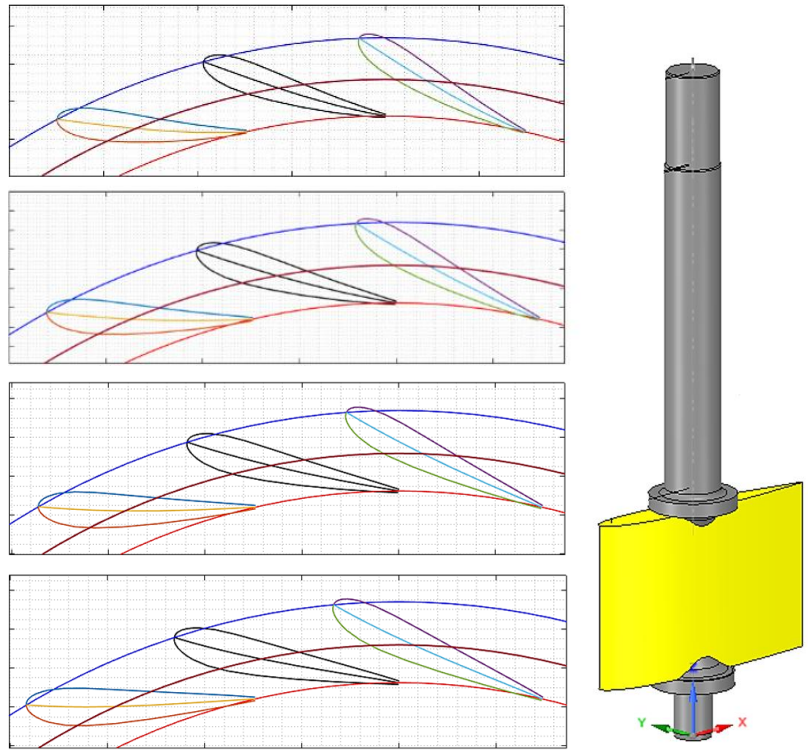
Parametric design environment

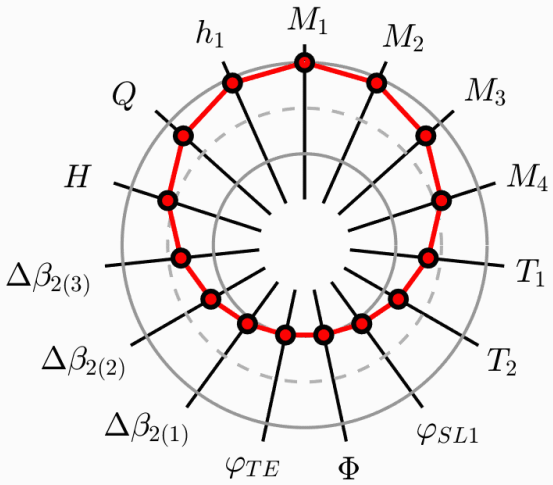
Parametric definition of the runner

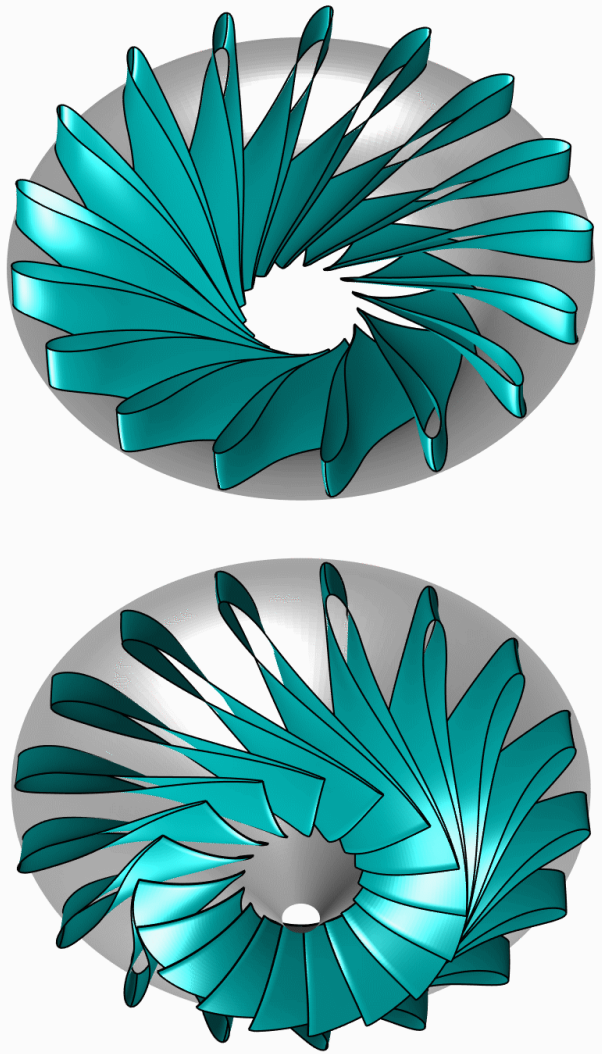


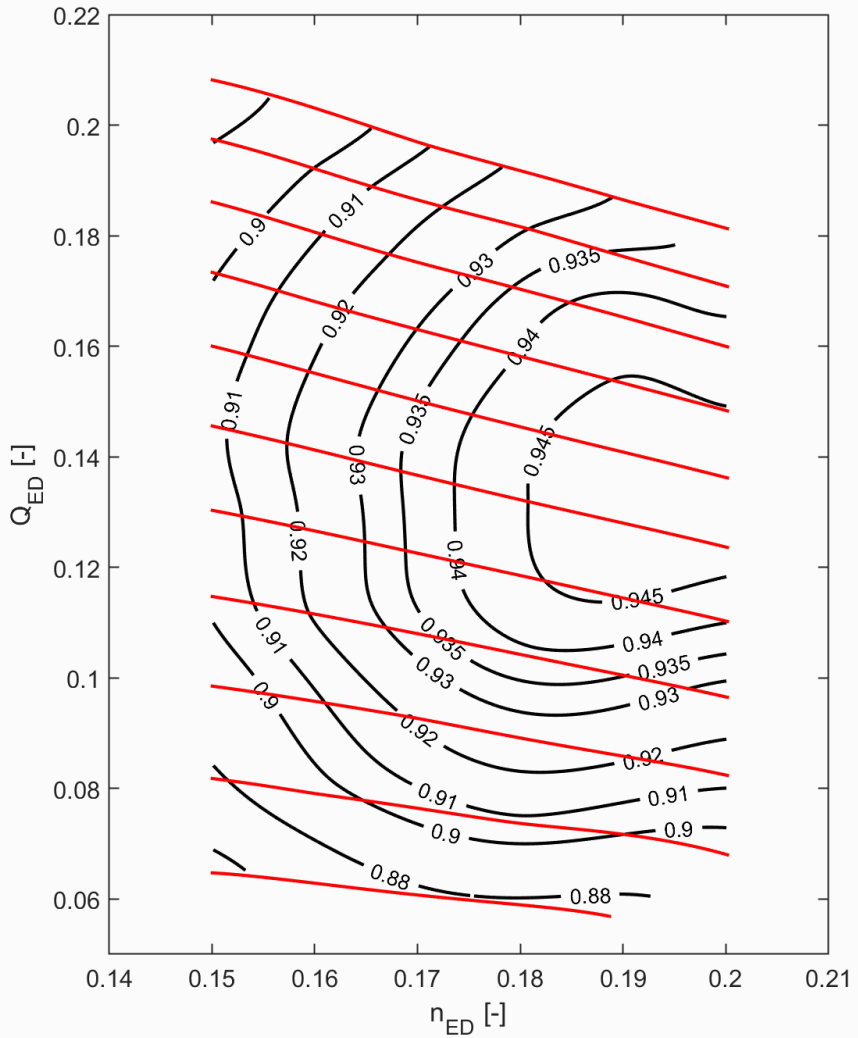
Parametric definition of the guide vanes



HydroFlex parametric design tool







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Research on the generator and converter

- Variable speed operation
- High power frequency converter
- Joint control of converter and rotor magnetization
- Mitigate the effect from high power electric converter fast voltage switching

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ABB

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What does a flexible generator mean?

Our answer is

"A highly efficient generator with a full power converter that can support the electrical grid"

How

"Develop new power station electrical layouts, generator rotor, magnetization systems and power electronic converters and control for increased flexibility and strong grid support"

Several areas needs to be addressed

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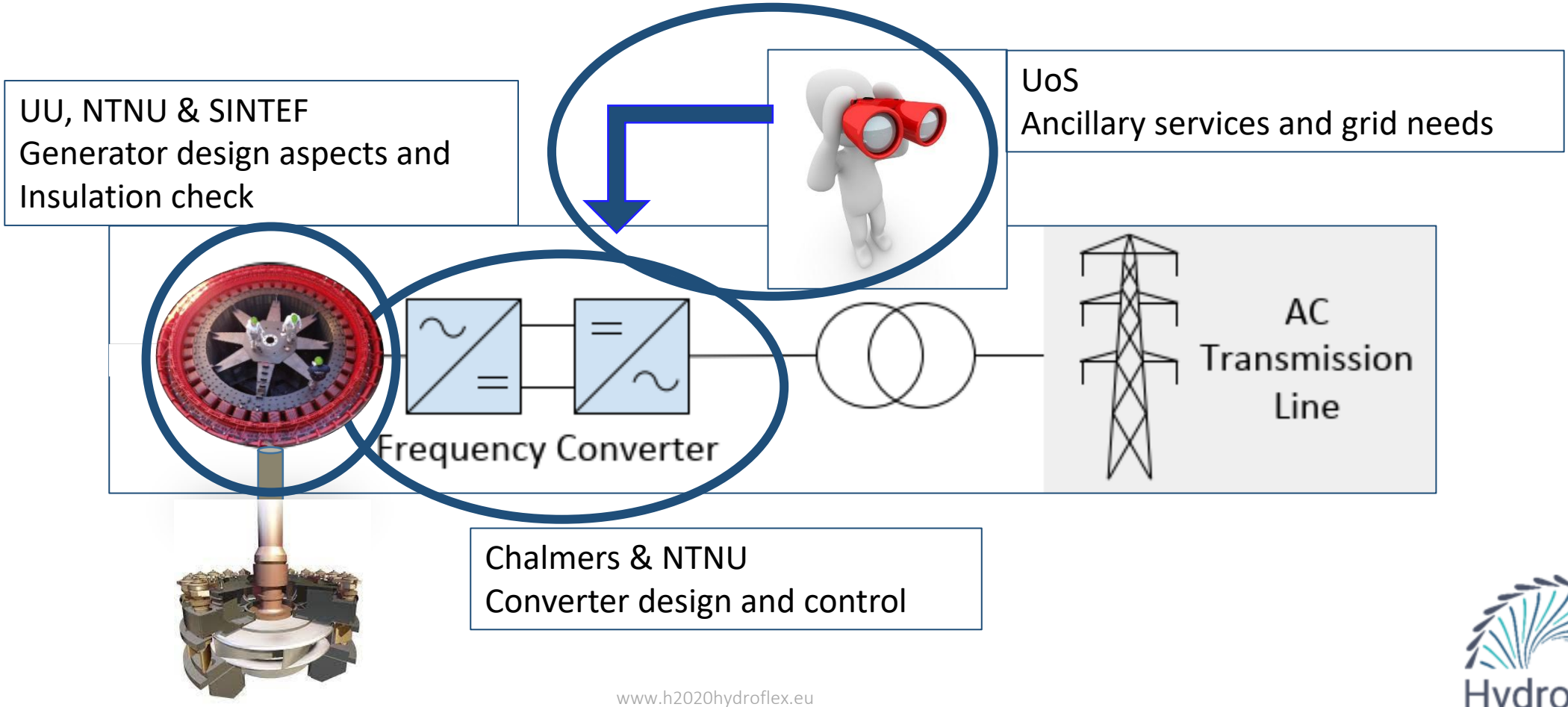
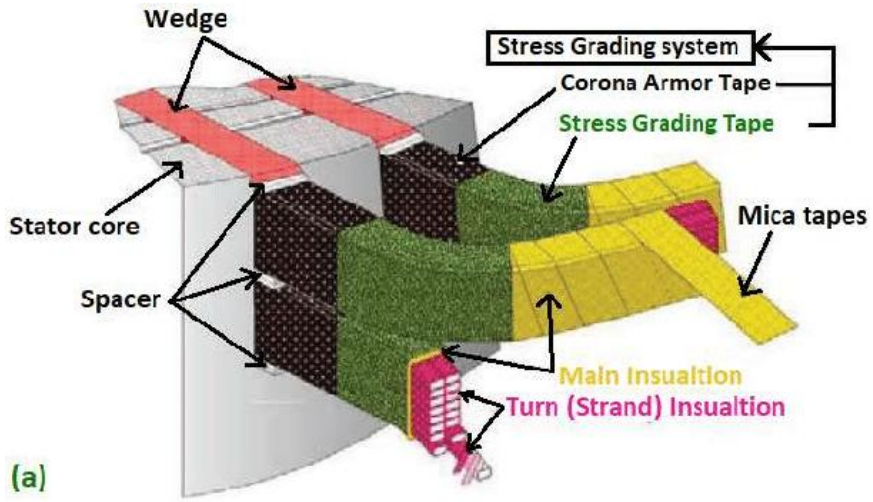
What does a flexible generator mean?



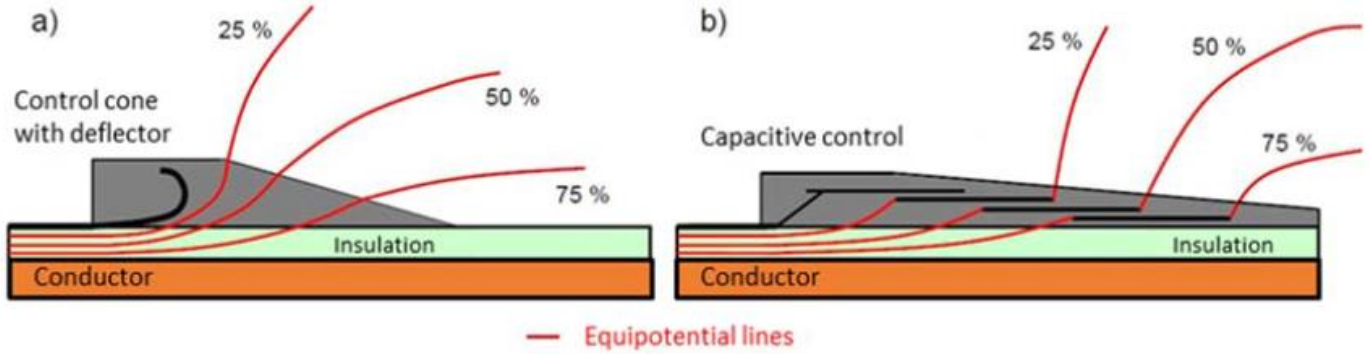
Insulation system



Temperature, Electrical discharges, size, stress from converter driven

Trade-off

Electrical / thermal properties (both degrading)



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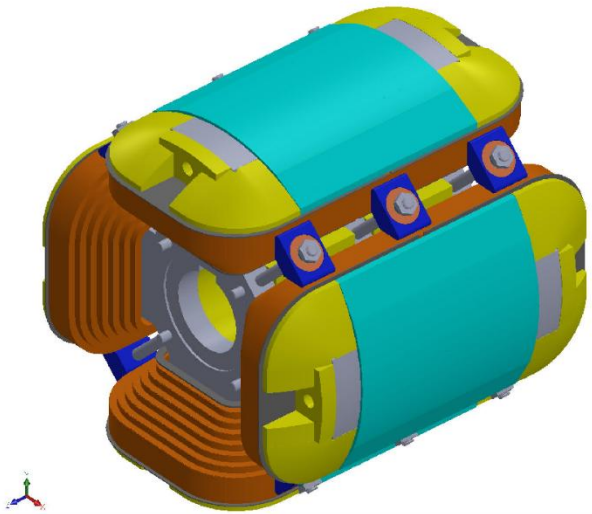
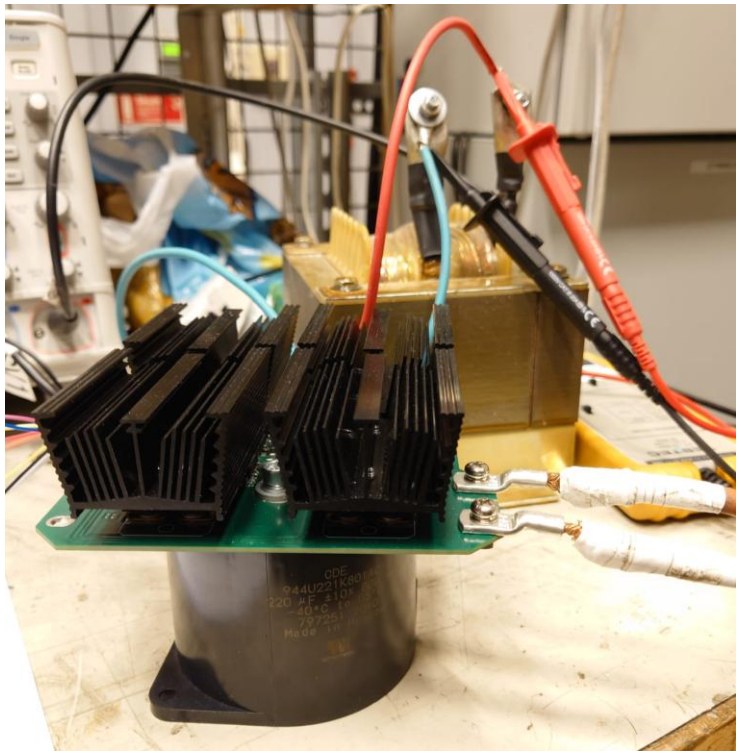
Novel rotor concept+Magnetization system

In order to reduce losses and enhance grid support, damper bars can be removed. This requires novel rotor and magnetization control





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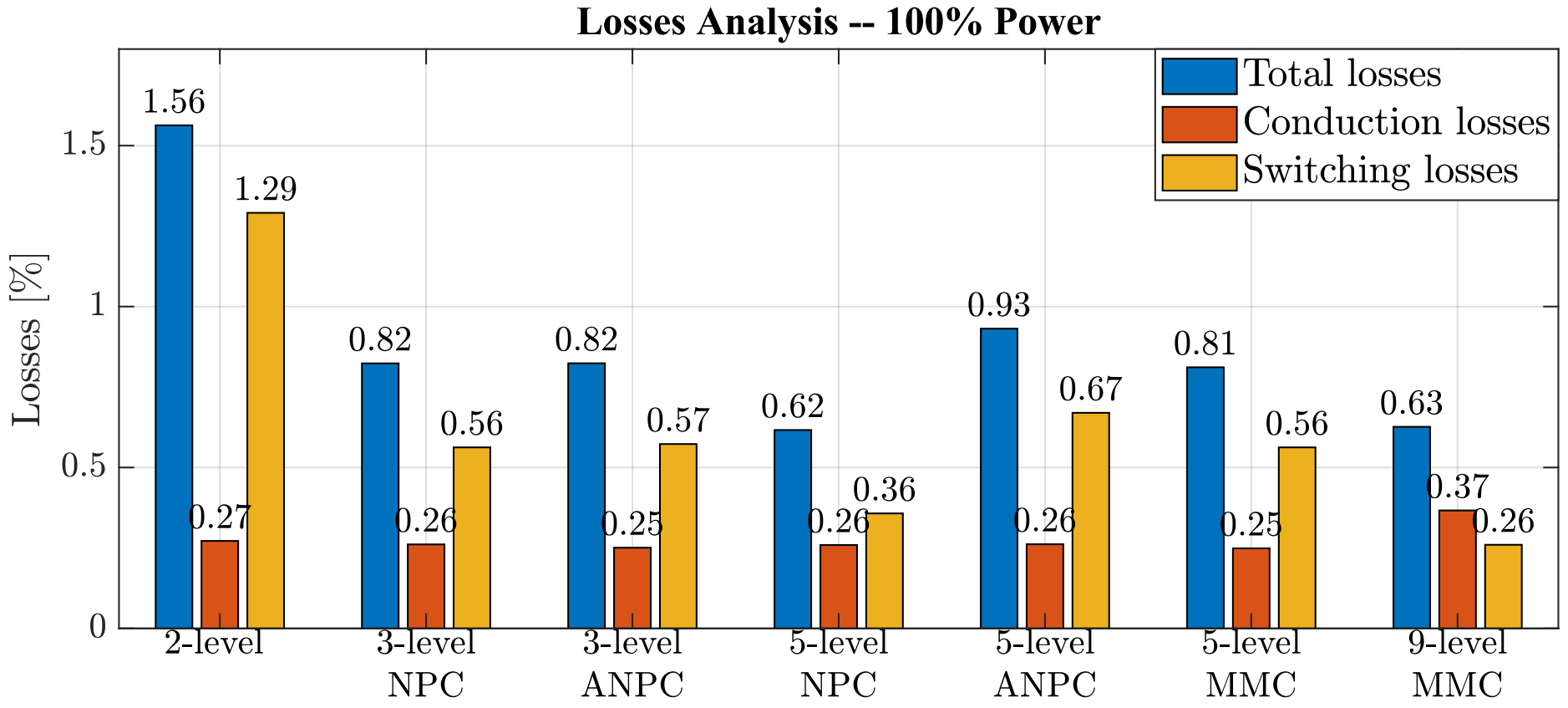
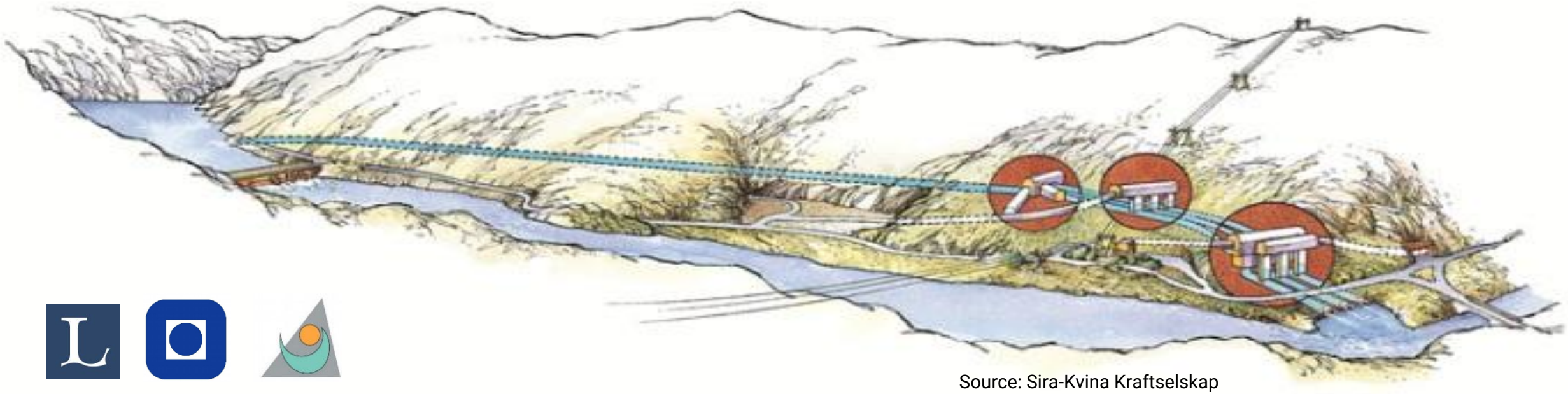
Suitable converter



- Total converter loss <1%
- Multilevel preferred (high voltage, low THD)
- Common mode voltages reduced

Environmental impact and mitigation

- Active storage of water that will enable high ramping rates
- Investigate the influence on river ecosystems subjected to 30 start-stops per day with and without mitigation
- Social acceptance



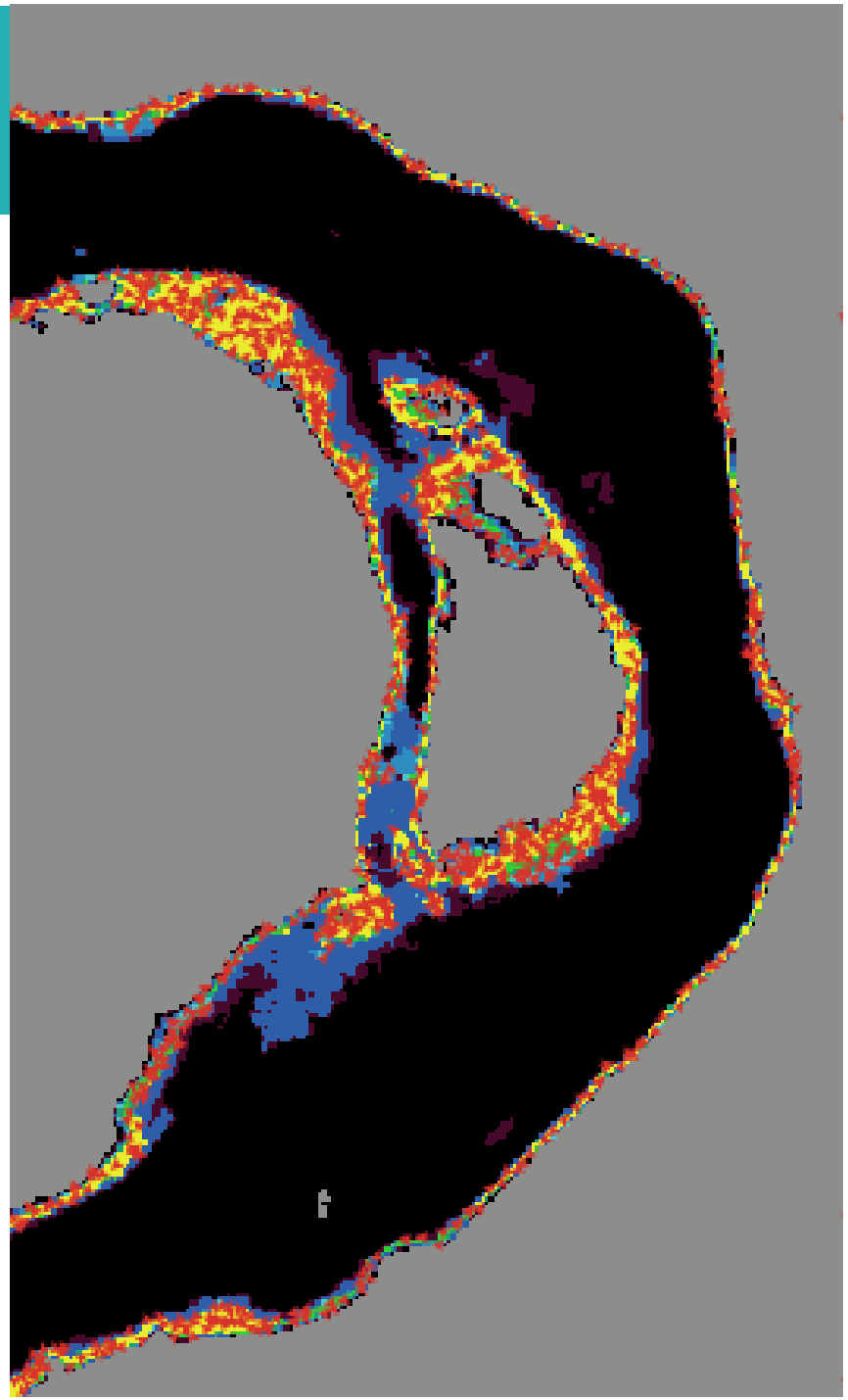
Source: Sira-Kvina Kraftselskap

The new modelling approach

1. Habitat preference based on hydraulic conditions (velocity and depth)

2. Salmon behavioral characteristics
   - Move towards optimal habitat
   - Avoid other salmon

3. Salmon mortality occurs if they are present in a dewatered area



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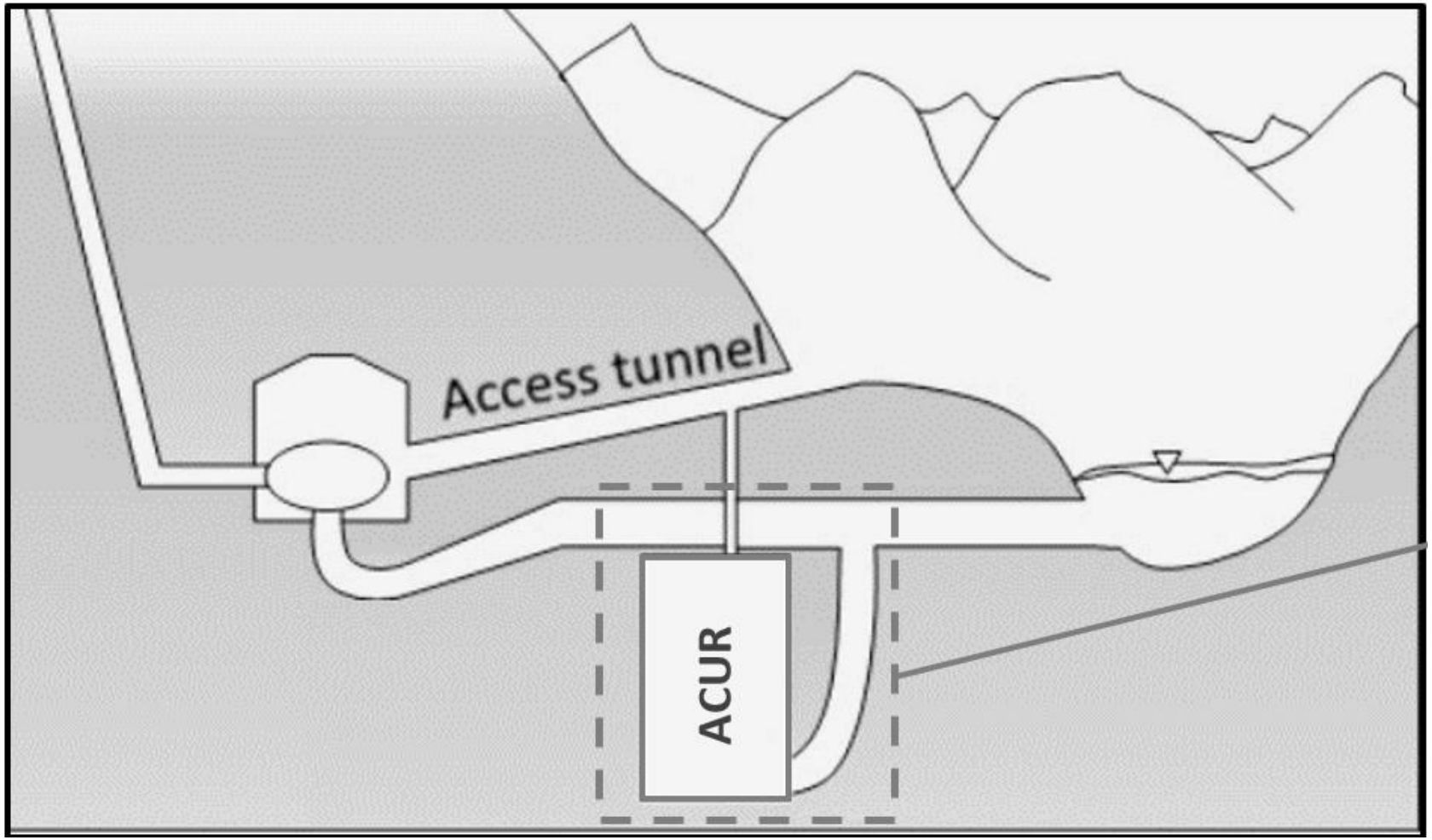
NINA Norwegian Institute for Nature Research

NTNU

Air Cushion Underground Reservoir, ACUR



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Expected impact

- Enabler of other renewables through flexible, reliable and secure energy and power supply
- Reduced maintenance costs and extended lifetime
- Increased turbine and generator performance
- Reduction of life-cycle environmental impact
- Strengthening of the European industrial technology base
- Provide knowledge on how to reduce the social barriers for flexible operation of hydropower plants

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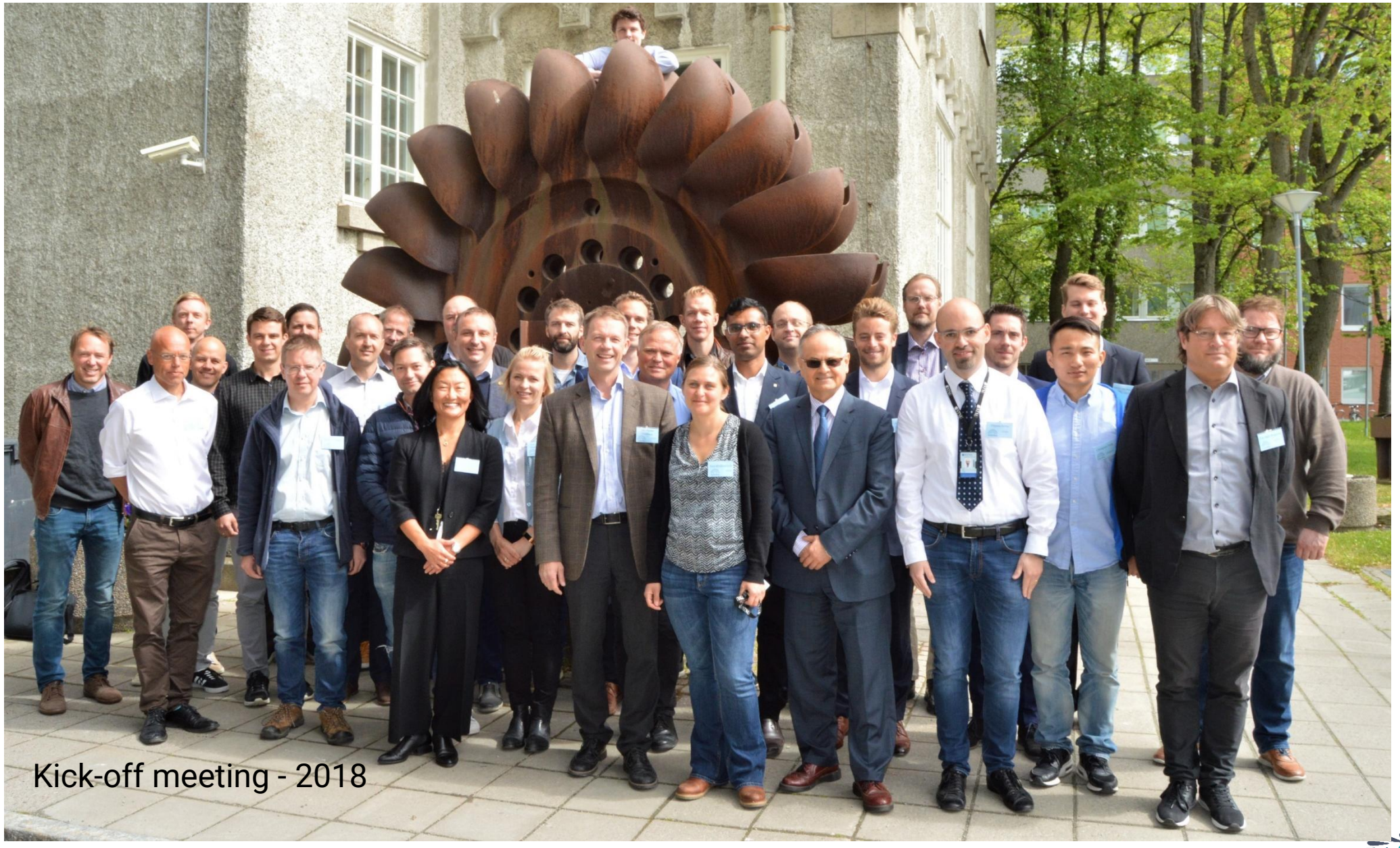

Kick-off meeting - 2018

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