SCCER SoE

SWISS COMPETENCE CENTER for ENERGY RESEARCH
SUPPLY of ELECTRICITY

FLEXSTOR

Solutions for flexible operation of storage hydropower plants in changing environment and market conditions - progress @ 12.09.2016

Dr Pedro Manso

Annual Conference 2016

In cooperation with the CTI

Energy
Swiss Competence Centers for Energy Research

Schweizerische Eidgenossenschaft
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Commission for Technology and Innovation CTI

Outline

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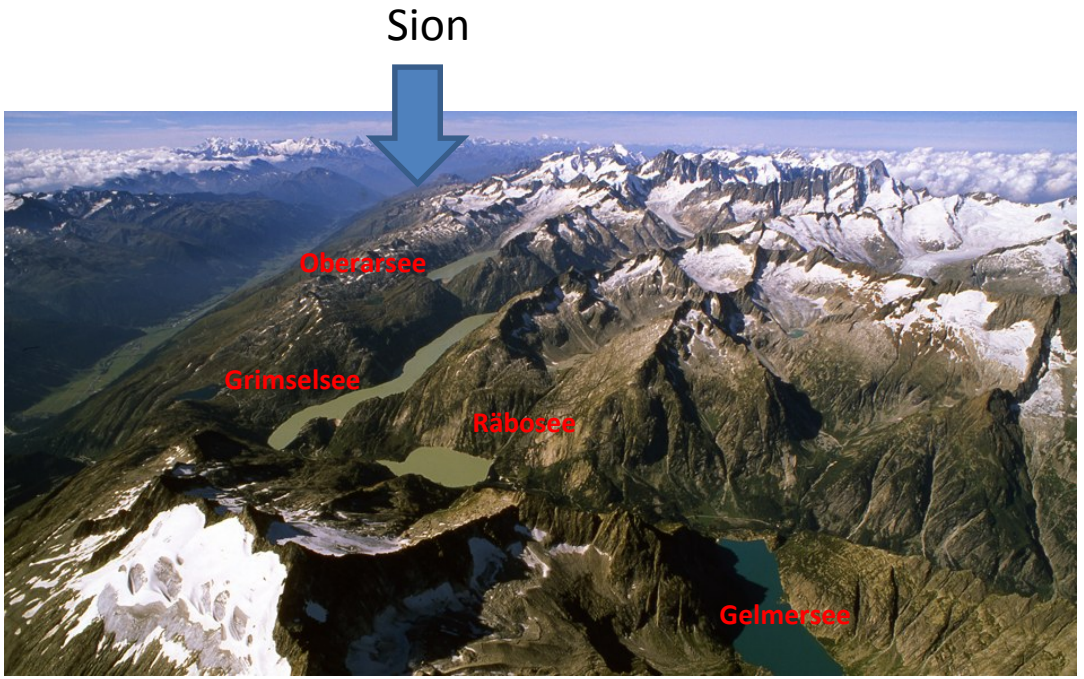


Innovation business case

Swiss hydropower role in domestic /regional energy mix

- CH hydropower is net provider of revenues annually, but on negative trend
- Winter deficit, CH is net importer
- Hydropower is paramount for intermittent Solar/Wind integration & grid balancing

Develop approaches for cutting-edge issues that represent market opportunities or threats with yet un-mastered risks

Premium remuneration at reach only of highly flexible plants, with storage

Need of methodologies for hydropower assets upgrading projects

- Concentrate production in less hours < > mitigate negative impacts, river up/down surges
- Sediment management < > perennial live storage, compliance with Waters Protection Act
- Mountain slopes instability in periglacial zone may lead to preventive reservoir lowering
- Changing demand structure < > changing storage management
- Operate more rapidly and more frequently < > extend operation range, avoid instabilities

Proof-of-concept at KWO and later replication

Relevance of FLEXSTOR

Hydropower rehabilitation, extension or new projects face new issues linked with operation flexibility and sediment management, with direct impact on their intra-day or intra-annual competitive profile.

Intra-day operation

- Hydropeaking (WP1)
- Turbine start/stops (WP6)

Intra-annual operation

- Limit preventive lake drawdown due to risk of impulse waves (WP2)
- Optimal storage management (WP3)
- Cascade sediment flushing (WP4)
- Turbine abrasion by fine sediment (WP5)

What is Flex….Stor…?

Specific for Large Hydro with Storage

6 work packages

5 research partners

1 industrial partner

1.3 MioCHF for 26 months

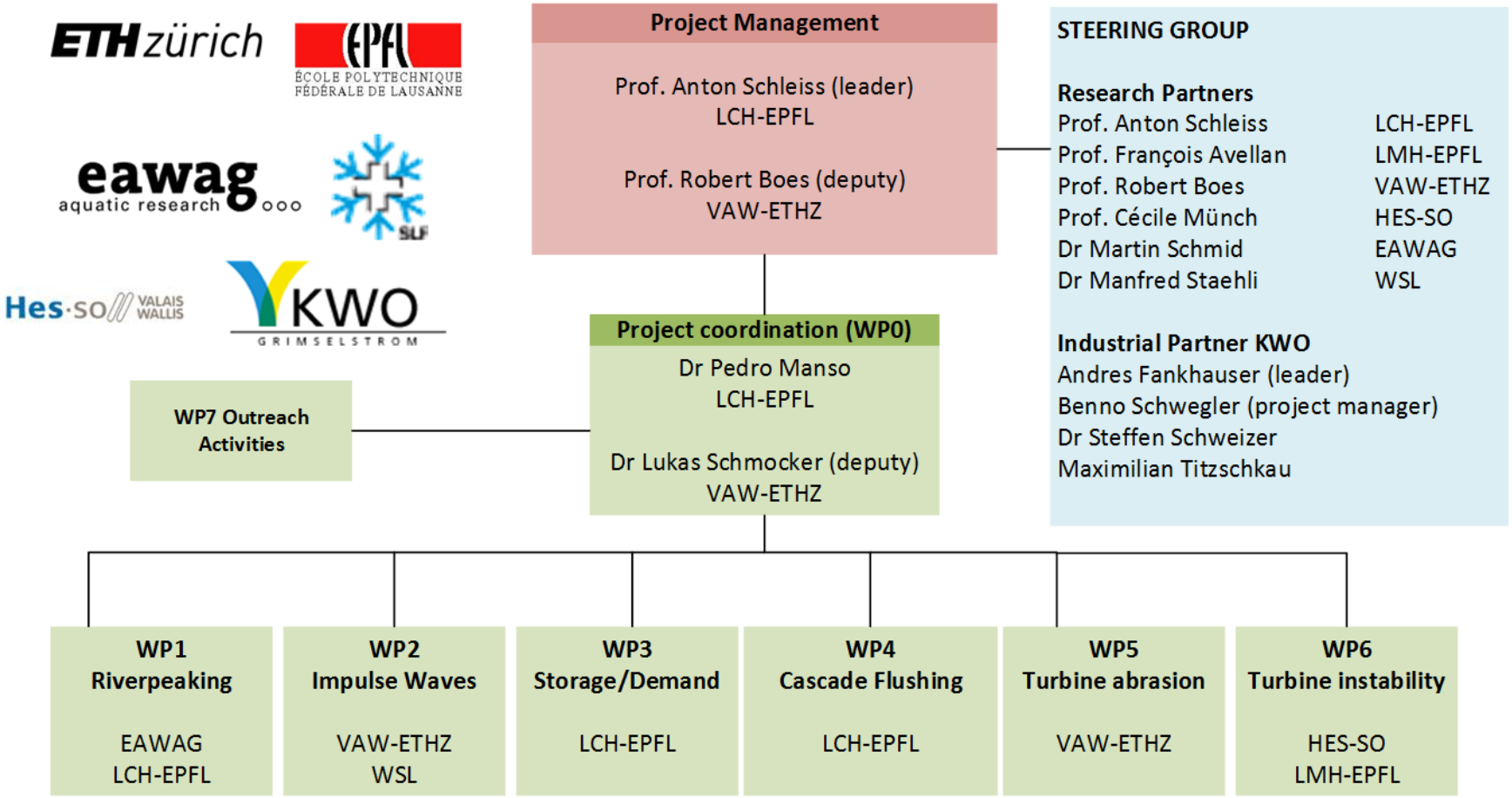
40 people @peak

Contract signature: Today!

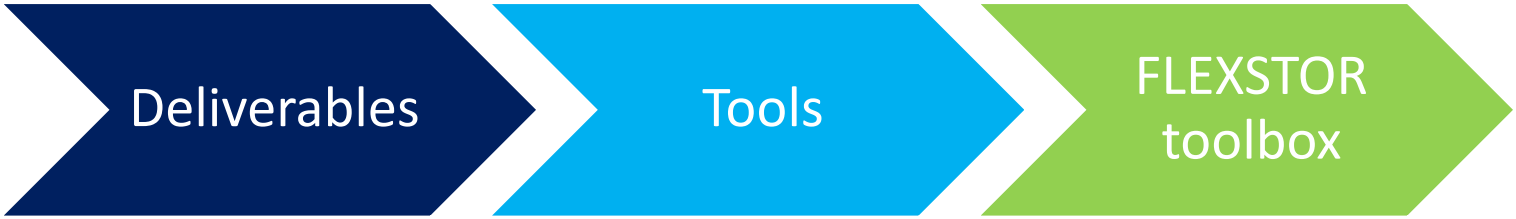
Expected positive impact on existing HPP operation in changing context

Expected positive contribution to the new Trift HPP and to the Grimsel plus project.
+ 180 GWh/a new
+ 460 GWh/a in winter

Organizational chart



From methods to products



1. WP tangible deliverables
   - Algorithms
   - Field test datasets / benchmarks
   - Methodologies
   - Protocols
   - Guidelines
2. Implementation
   - Improvements to existing tools
   - New tools
3. Set of tools => FLEXSTOR toolbox for practitioners

WP1 Hydropeaking

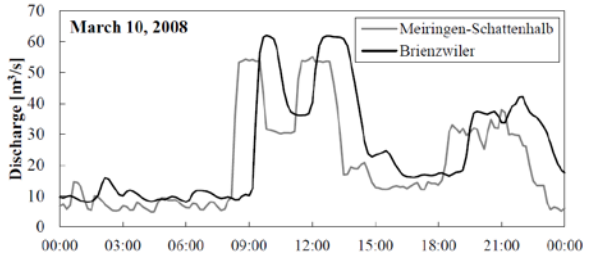
Purpose: mitigate up/down surges

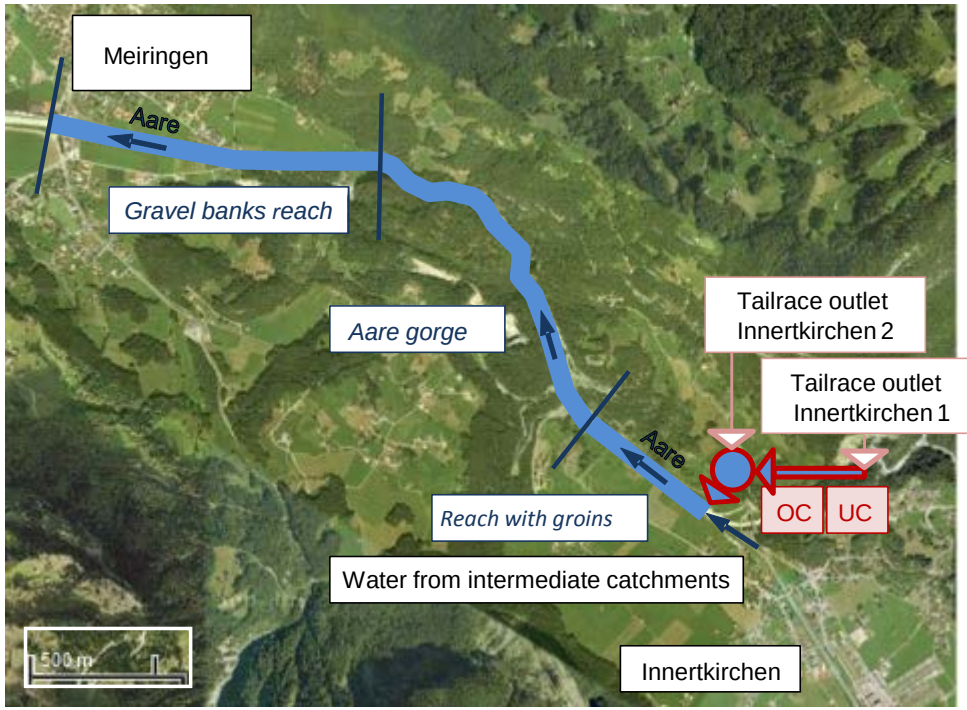
How: combining compensations basins and buffer river reaches

Tech challenge: multi-goal optimisation

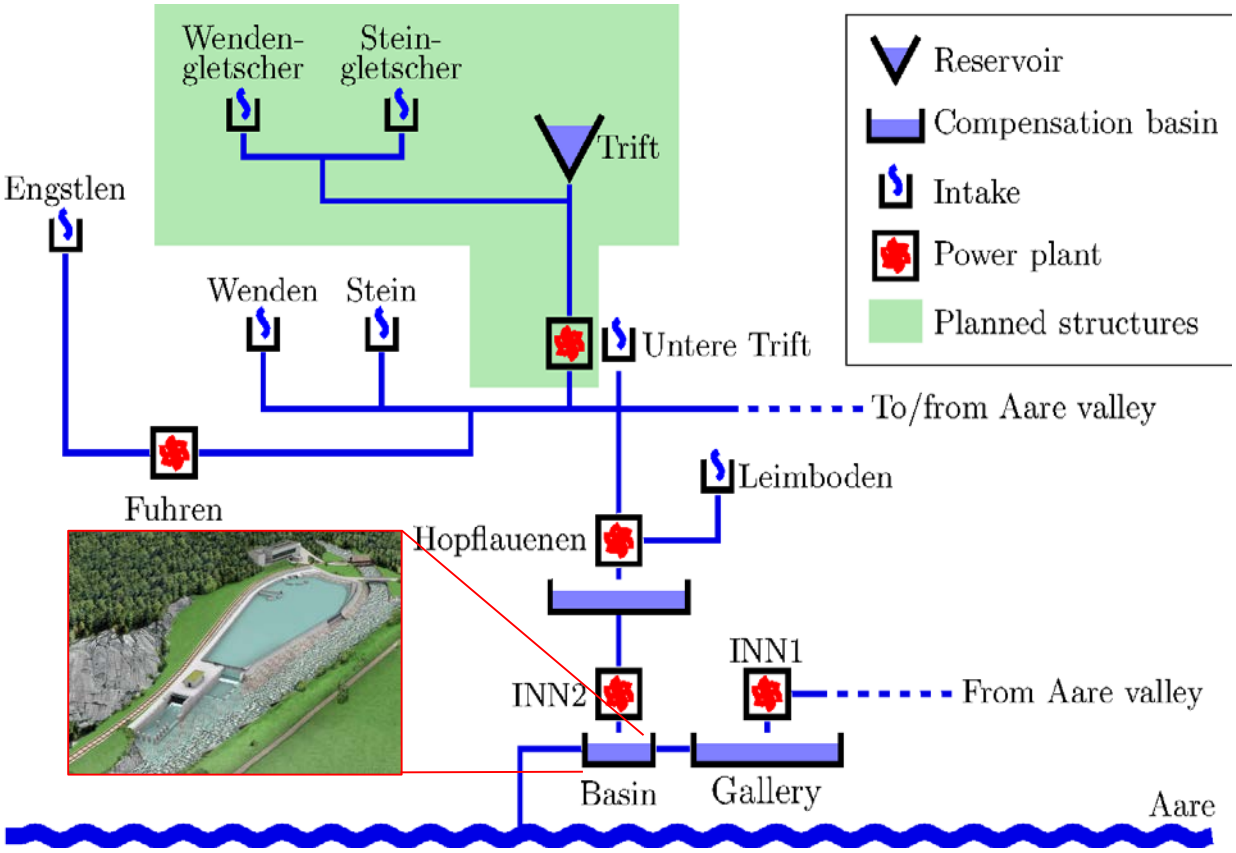
Innovation: multi-basins coupling, multi-HPP schedule coupling, integrate river morphology contribution

Market relevance: 20-30 new basins expected until 2050 for flexible operation, which are to be implemented in disputed land. There are TSO incentives and new directives from Authorities.





WP1 Winter flows modelling & Optimisation



WP1 Progress

Task	Deliverables (open-source)	Deadline
1. Scenarios	A set of scenarios	Done (+)
2. Future performance of retention volumes	Multi-entry multi-parametric model (homogen_vol_tool)	Q3 2016
3. Detailed hydraulic modelling of the retention volume (extreme conditions)	Free-surface surge propagation in gated tailraces (gated_surge_tool)	S2 2016
4. Propagation of hydropeaking signatures (1D/2D)	Flowchart for river surge attenuation assessment & criteria	S1 2017
5. Optimal management of retention volumes	Optimisation model (basin_opt_tool)	Q3 2016

[1] Meier P., Manso P., Bieri M. Future Operation Scenarios. Report 1.1
[2] Bieri M., Meier P., Manso P. Simulation des Betriebs des Dämpfungsbeckens unter Berücksichtigung künftiger Betriebsszenarien. Bericht 1.2
[3] Meier P., Manso P., Bieri M., Schleiss A., Schweizer S., Fankhauser A., Schwegler B. Hydro-peaking mitigation measures: performance of a complex compensation basin considering future system extensions. Hydro 2016 Montreux
[4] Mosimman M. Improved Operation of a Hydropower System for Hydro-Peaking Mitigation. MSc Thesis ETHZ (co-Eawag).

WP2 Impulse Waves

Purpose: quantify impulse waves generated by a mass sliding into lake

How: improvement of mathematical description of physical events

Tech challenge: highly site-specific

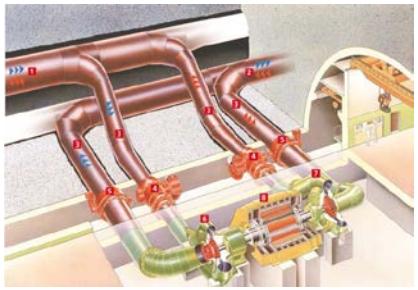
Innovation: large-scale testing, soil/rock/ice modelling, improvement of existing tools

Market relevance: over 120 artificial lakes in CH, 10-20 new glacier lakes expected until 2050 in high altitude with unstable slopes. Secure lake levels during avalanche season.

Avoid excessive drawdown due to inability to assess wave amplitude and uncertainty. Safer operation at near-full dam reservoir levels in Spring, Summer and Fall.

Test preparation → Test 2017/18 → Analysis → Guidelines

WP6 Turbine instability at start/stop



Schlunegger & Töni, 2013

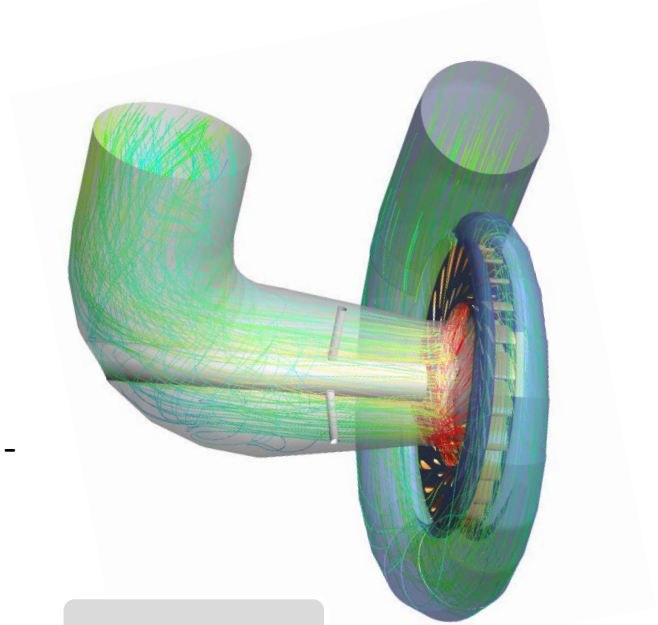
Purpose: identify alternative start/stop path preventing unacceptable instabilities

How: site testing, flow simulations

Tech challenge: in-situ measurements with strain gages on-board turbine runner

Innovation: in-situ testing at high-head Grimsel 2 PSP, fluid-structure interaction modelling

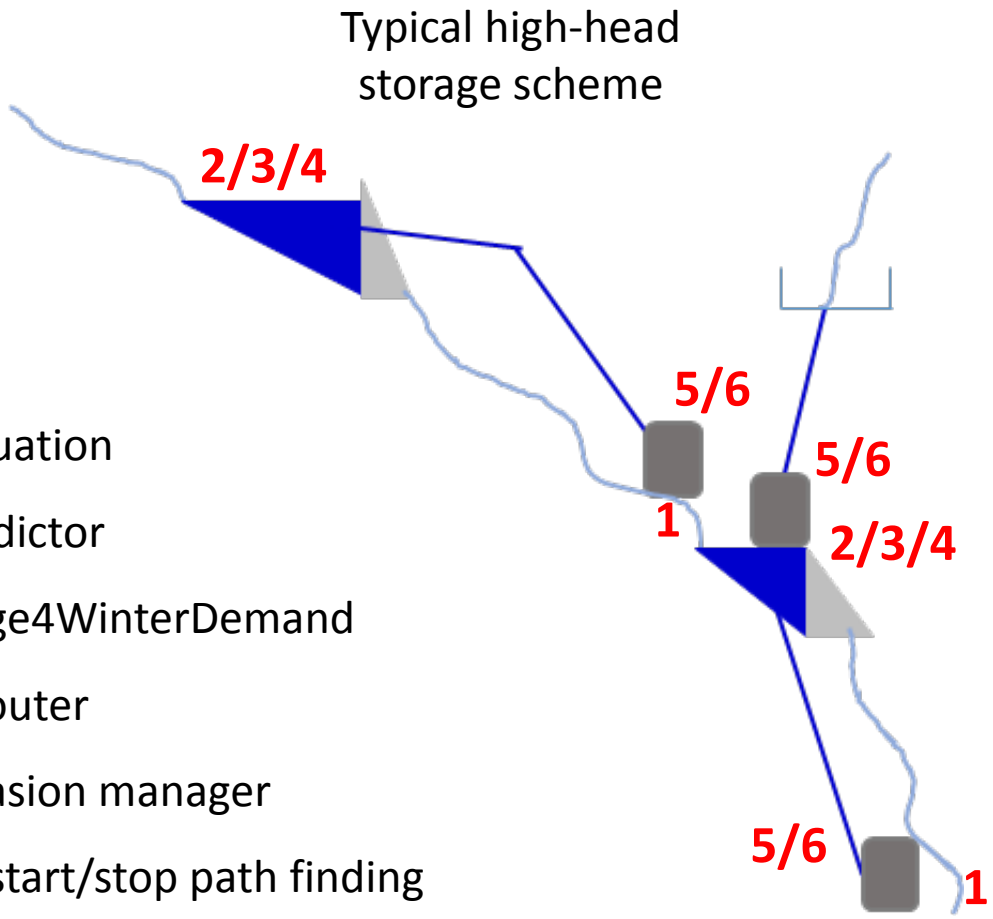
Market relevance: over 40 high-head Francis runners in CH, growing pump-turbine interest, flexible operation requires intra-hour multiple start/stop manoeuvring. Premium remuneration corresponds to peak slots and grid regulation services



©Decaix et al. 2016

Test preparation
CFD + Workshop → Test in situ
Dec' 2016 → Analysis → Guidelines

Main outputs



1 - Surge Attenuation

2 - Impulse Predictor

3 - OptimStorage4WinterDemand

4 - Sediment Router

5 - Turbine abrasion manager

6 - Alternative start/stop path finding

Main output (2)

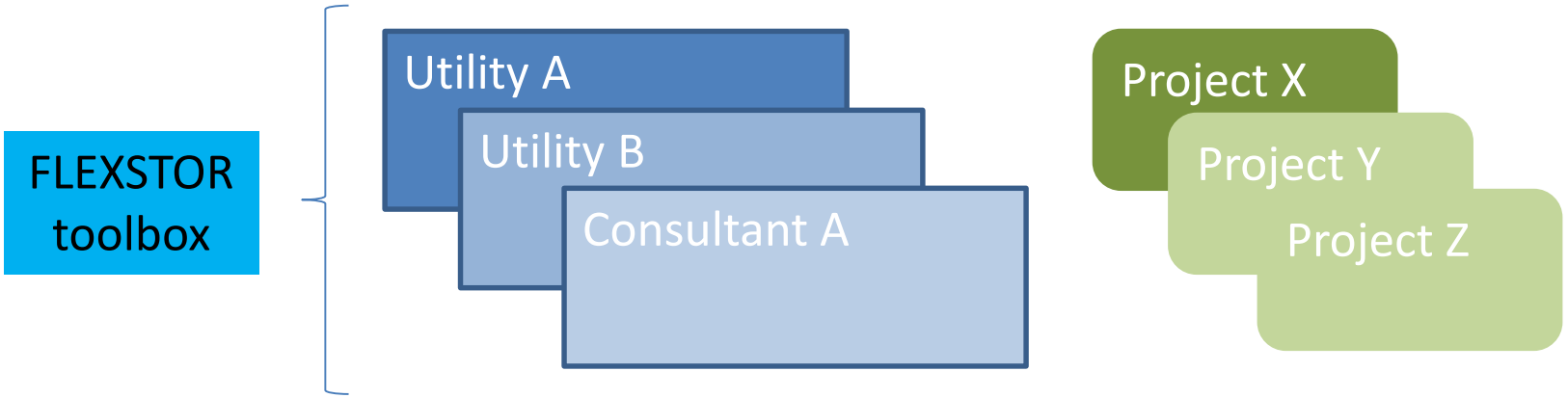
1	Set of optimal strategies, future operation rules	Eco-friendly hydropower premium "kWh"
2	Benchmark metadata + design guidelines	Seasonal reservoir storage "TWh"
3	Production rules tailored to demand variability	Winter storage "kWh"
4	Model for cascade flushing + operation guidelines	Perennial live storage and "end-of-winter kWh"
5	Benchmark metadata + correlation with turbine abrasion rates + operation guidelines	Live storage Anti-abrasion runner coatings
6	Benchmark metadata + diagnosis protocols + operation guidelines	Stable Francis turbines & P/T Primary regulation

Road to a successful project

Evaluation criteria @ M11:
WP1: tasks 3 out of 5 accomplished, model operating
WP2: tasks 2 out of 2 accomplished, deliverables 2 out of 3 completed
WP3: tasks 3 out of 4 accomplished, deliverables 2 out of 3 completed
WP4: tasks 2 out of 4 accomplished, deliverables 2 out of 4 completed
WP5: tasks 2 out of 2 partly accomplished (first tests), idem f/deliverables
WP6: tasks 2 out of 3 accomplished, deliverable 1 out of 3 completed
WP7: -

Decision points:
- Proceed (Y/N)
- Carry out complementary field tests (Y/N)
- Allocate 40% funds

Overall potential of this innovation



- Tool kit for Flexible-Storage hydropower plants
- Internal proof-of-concept on KWO complex scheme
- Public appreciation with Trift project development
- Replicable knowledge in domestic & foreign markets

High-quality Swiss-based Innovation in Engineering