MINUTES OF MEETING

Hydropower Summit

WHAT:	Summary from Breakout Sessions
TYPE	Minutes
DATE	5th and 6th February 2020
PLACE:	NTNU
PRESENT:	Participants at the Hydropower Summit

Breakout Session 1 – Hydropower Optimization

This breakout sessions consisted of presentations and discussions related to the following topics:

1. Electricity markets in US and the Nordics, differences and similarities.
2. Market modelling/production cost modelling
3. Research activities and industrial perspectives related to hydropower planning and operation Norway and US
4. The future role of hydropower

Some observations from presentations and discussions.

System studies (production cost modelling) are in the US done by using commercially available tools (PLEXOS was mentioned). Several projects were presented, among them a project where PLEXOS was coupled to an inhouse utility model (Riverware) for improved representation of hydropower. Further research related to representation of hydropower in production costs models is on the research agenda.

Research and development of tools where the hydro details are a fully integrated part of the production cost models is and has always been one the main activities at SINTEF. SINTEF also develops general river system models used by Nordic and central European utilities.

Hydropower operation is different in the US from the Nordics, especially the flexibility is often more constrained because more weight is given to other usages of the water. Hydro power production in the Nordics constitutes a much larger share of the electricity production.

Appropriate hydropower models depend on the system and the application area.

Everybody wonders about hydro in the future electricity system. Hydropower is renewable, flexible and low marginal costs, but has large investment costs, long lead times and fixed location.

Some specific follow up possibilities

1) PhD exchange (Linn Emelie Schäffer) related to modelling of environmental constraints in hydro power optimization models. Try to find one person in the US to collaborate so exchange can go both ways.
2) Julia based modelling framework and the modelling principles discussed in the presentation "Open-source, ground-up hydro/power modelling". SINTEF has developed a model with similar principles and have started a possible transition to Julia based modelling. A new project is just about to start.
3) US cases for flood and drought control IEA work, also related to HydroCen work.

General interesting research questions

1) Electricity markets in power systems without thermal reference costs

2) Future value of hydropower
    a. Future costs of alternative providers of different types of flexibility
    b. Costs of increased variable hydropower operations
    c. Methods and procedures for investment and refurbishment of hydro power including PHS.

Breakout Session 2 – Technological Challenges

This breakout session had three main topics:

1. Innovations in Hydropower Technology
2. Turbines and Pumped Storage Advancements
3. Asset Management and Digitalization

Each of these had presentations from the USA and Norway and thereafter a discussion from each topic. The following was discussed in the meeting:

Innovations in Hydropower Technology

This topic gave a fruitful discussion where several topics was discussed:

- Improve the production capability/technology (modularity) in order to reduce costs
- New innovative solutions and methodologies for design and construction
- Verification of numerical tools being used for the evaluation of new and old hydropower plants and its equipment
- Introduce variable speed turbines to achieve increased flexibility
- Sediment handling technologies
- Environmental combability/design

Turbines and Pumped Storage Advancements

This topic became a very realistic discussion and it turned towards the lack of markets for pump storage plants in both USA and in the Nordic power marked. From the presentations, we learned that no new pump storage has been constructed in USA the last 20 years and the European experience has been relatively negative due to low energy prices. Several of the newly developed pump-storage powerplants are facing financial problems after huge investments. For turbines in general

- Introduce variable speed turbines to achieve increased flexibility

Asset Management and Digitalization

Here, a large number of common topics was discussed The power plants in US, Europe and Australia are now in a transition for being operated in a more intermittent way, with frequent start/stop and fast ramping rates. This contrasts with the traditional way with continuous operation and slow variation in power output. Future flexible operation require new and improved condition monitoring, improved data analysis and new maintenance strategies. The questions that comes up are:

- What is the cost of flexible operation ?
- How can we optimize the maintenance ?

The following technical challenges will be suggested as topics to build future cooperation:

1. Improved production technology for hydro turbines
    a. Utilizing new production technology
    b. Developing design tools which perform necessary analysis (flow, strength, fatigue, etc.) and optimize the turbine for the given site.
2. Environmental combability/design
    a. Develop mitigation technologies to prevent the environmental impacts from flexible operation of hydropower plants
    b. Develop solutions to improve the habitat and the behavior of fish and other aquatic life
3. Develop procedures/algorithms for life cycle analysis of hydro power plants
4. Develop digital twins, condition monitoring and fault detection systems, and introduce condition based repair/ maintenance
5. Develop algorithms to do data analysis. This requires access to data from many power plants. This require a methodology on how to evaluate normal operation and abnormal operation of the power plant. In the discussion, the development of sheet signature and fingerprints were mentioned as a necessary mean for such data analysis
6. Develop methods to find the cost of dispatch variability (flexibility)

Breakout Session 3 – Environmental Conditions

In Breakout session 3 we discussed environmental challenges for hydropower development, how to improve conditions in existing plants and how to mitigate impacts in a future with more flexible operation of hydropower.
This breakout session had three main topics:

1. Challenges and innovations for improving environmental conditions in hydropower rivers
2. Two-way safe fish migration and innovative methods
3. Mitigation measures for improved environmental conditions and increased power production

In the first part of the session, presentations were given highlighting the challenges and innovations for improving environmental conditions in hydropower regulated rivers. Examples from Norway, United states of America and Austria were given and revealed both similarities and differences between the different nations. Following this first part, the discussions were concerned with how to utilize new and innovative tools and methods such as ; eDNA, photo-manipulations for recreation impacts, lidar, electronic tags, drones, electrical fish protection and ROV for measurements. A common problem with many such tools is the vast amount of data produced and challenges related to storage and processing of such data. Discussions regarding the problem of super saturation and knowledge gaps on thresholds of fish impact and survival and long-term effects of non-lethal events were also mentioned.

The second topic of the environmental conditions were two-way safe fish migration and innovative methods. Examples from Norway, the United States and Germany were given. Following these presentations the state of knowledge regarding two-way fish migrations were discussed. Recent years projects have led to more knowledge regarding upstream and downstream fish migration solutions and much of this knowledge is ready to be utilized. Yet, there is still a knowledge gap concerning impacts of "post-passage" of fish; the long-term effects which are yet to be discovered. This is an important factor which may influence survival and fitness of fish, and ultimately fish production in rivers with such barriers.

The third topic of breakout session 3 was mitigation measures for improved environmental conditions and increased power production. Here presentations were given by hydropower companies from Sweden and Norway and from scientists from Norway, Sweden and the United States. The following list of topics captures the discussion

- Perspective of investors – what's in it for us? R&D supporting growth
- Environmental solutions that do not impact climate change mitigation and power system security
- Upgrade and extend capacity in existing power plants
- Compensatory measures in tributaries and other rivers? (off-setting)
- Restoring environmental damage not caused by hydropower

- Co-optimization of power and environmental needs
- Licensing and re-licensing decision making unclear
- Stakeholder process in each catchment – what is the best option for each catchment?
- Rapid methods for large scale physical characterisation of rivers and lakes (remote sensing)
- Decision support tools to choose cost-effective mitigation measures
- Sector coupling and policy integration – across technologies

Overall, the presentations and the following discussions demonstrated that many of the challenges related to hydropower and environmental impacts and mitigation shows strong similarity between the different countries. There is thus important to collaborate with each other, across nations, to make advances in hydropower and at the same time reduce environmental impacts. As a results of the discussions during the session a list of future topics for possible collaboration and projects were listed:

New methods and technologies:

- Remote sensing is the only solution for large scale mapping of "all" rivers- water quality, hydro morphology & ecology (satellites, drones, laser, combining methods)
- Apply all the new remote sensing techniques
- Investigate existing data – exploratory work to create better understanding
- Smaller tags for fish with embedded sensors
- Mimic fish tissue
- Turbulence representation and characterisation

eDNA:

- Early warning of exotic species
- Estimate spawning stock
- Ecological classification

Supersaturation:

- Screening method for risk by remote sensing
- Using satellites to screen the risk
- Impact by saturopeaking
- Monitoring plan at high risk sites

Fish migration:

- Better guidance combining mechanical and electrical protection
- Use for medium and large size hydropower
- Guidance to get fish downstream in large projects

Mitigation measures:

- Tools to facilitate all discussion with stakeholders
- Tools and methods to compare environmental impacts and benefits across technologies
- Targets, objectives and evaluation – what are reference and "natural" situation
- Using inflow part of reservoir as "a river"