# Pacific Northwest Renewable Energy Laboratory

# Advancing Modeling Tools for Assessment of Long-Term Energy/Water Risks for Hydropower Meeting

*Notes*

June 27, 2017
Denver, Colorado

**Meeting Participants:**

| Name | Organization |
|---|---|
| ***In Person Participants*** | |
| Paul Jacobson | EPRI |
| Kara Opel | Kearns & West (facilitation team) |
| Anna West | Kearns & West (facilitation team) |
| Patrick O'Connor | ORNL |
| TJ Heibel | PNNL |
| Cory Anderson | Seattle City Light |
| Vibhu Kaushik | Southern California Edison |
| Herbie Johnson | Southern Company |
| Ken Odom | Southern Company |
| James Everett | TVA |
| ***Webinar*** | |
| Hien Ho | Bard College |
| luyin Zhu | Bard College |
| Kyle Zigner | Bard College |
| Ken Nowak | BOR |
| Alisa Kaseweter | BPA |
| Erik Pytlak | BPA |
| Allan Laca | CA SWRCB |
| Jeff Wetzel | CA SWRCB |
| Marcie Clement | Chelan PUD |
| Shaun Seaman | Chelan PUD |
| Jan Borchert | Current Hydro |
| Sam Bockenhauer | DOE |
| Simon Gore | DOE |
| Rupak Thapaliya | Hydro Reform Coalition |
| Joanna Barnard | Newfoundland Labrador Hydro |
| Marshall Richmond | PNNL |
| Mark Wigmosta | PNNL |
| Don Tinker | Seattle City Light |
| Bill Harris | Snohomish PUD |
| Chris Juchau | Tacoma Power |
| German Mojica | Transalta |
| Gregory Mueller | TVA |
| Jeff Arnold | USACE |

## Welcome and Project Overview

- Hoyt Battey, U.S. Department of Energy (DOE) welcomed participants and thanked them for their interest and participation in the project. DOE's interest in the project is motivated by a government-wide effort to coordinate work around the energy-water nexus. DOE released a report about this nexus, highlighting relevant issues.
- DOE is working to better understand future risks that are interlinked with energy and water systems and to improve the state of the art for methods to assess the interactions between energy production and water temperature.
- Thermoelectric cooling has a significant influence on water temperature.
- DOE hopes over the next few years to advance scientific capabilities that look at risks and vulnerabilities and help make better future decisions as the U.S. continues to build out infrastructure.
- Anna West, Kearns & West Facilitation Team, provided an overview of the workshop agenda and the Advancing Modeling Tools for Assessment of Long-Term Energy/Water Risks for Hydropower project, highlighting the following key points:
    - The framework will be nationally applicable;
    - PNNL is planning on conducting an initial pilot of the framework in the Pacific Northwest region and plans on conducting a second pilot in a second river basin farther down the road;
    - The framework will be applicable at both the plant and system levels.
    - The modeling framework addresses water quality processes in general and is initially focused on water temperature. Other water quality attributes may be addressed later.
- The workshop agenda is included in the Appendix.
- The full presentation can be found here: http://waterpower.pnnl.gov/hydropower/waterquality.asp.

## Overview of Findings in User Needs Assessment

- TJ Heibel, Pacific Northwest National Laboratory (PNNL), presented findings from the User Needs Assessment conducted by Kearns & West. PNNL is interested in advancing science and models to be the most useful to people who will use them.
- Specifically, PNNL wants to ensure that it hears stakeholders' feedback on the framework.
- The User Needs Assessment affirmed and clarified most of what PNNL knew (no surprise findings), grounding this information in stakeholder feedback.
- The following entities were interviewed as part of the Assessment:
    - AMP Hydro
    - Bonneville Power Administration (BPA)
    - Brookfield Renewable
    - California State Water Resources Control Board (CA SWRCB)
    - Duke Energy
    - Eagle Creek Renewable Energy
    - EPRI
    - Federal Energy Regulatory Commission (FERC)

  - Grant County PUD
  - National Marine Fisheries Service (NMFS)
  - Pacific Gas and Electric (PG&E)
  - Snohomish County PUD
  - Southern Company
  - Tennessee Valley Authority (TVA)
  - U.S. Army Corps of Engineers (USACE)
  - U.S. Bureau of Reclamation (BOR)
  - Washington State Department of Ecology
- Key findings from the Assessment are highlighted below:
  - The Assessment confirmed that it is difficult to agree on ways to address multiple uses of water.
  - PNNL wants to move towards probabilistic forecasting.
  - In some places compliance is monitored and enforced; in other places, it is just reported.
  - For high-resolution models, the more information PNNL has, the better. Operators' current plans can be very conservative, sometimes using information from the 1950s. With higher fidelity models, the industry can be more efficient with water use for power generation and operations.
  - Operators and regulatory entities try to talk to each other early and often and share best practices when possible.
  - For non-federal dams, models are typically used during licensing (FERC, etc.) when operators are in the planning stages.
  - Since agencies are not privy to some developers' models, it makes it hard to understand the results.
  - PNNL's framework will use open source simulation codes.
  - The Columbia Basin is a complex system, and will serve as the first pilot basin for PNNL's framework. More models with better accuracy will be very helpful.
- The time frame of the project is three years, with completion at the end of fiscal year 2019 (FY2019).
- PNNL understands that each region wants the framework to be as useful for their particular region, but it will need to be nationally applicable. PNNL is looking to the stakeholders participating in this meeting to help them with this balancing act.
- The following recaps the discussion on the User Needs Assessment Findings
  - What regulatory agencies (state and federal) were involved?
    - T.J. clarified that FERC, NMFS, and the State of California and New York. Open source information and access to the models was helpful for PNNL. States wanted to know more about how PNNL's framework would interact with existing models.
  - State agencies that some federal hydro operators interact with could have different pressures and levels of interest in the framework. Regardless, most state agencies need more data/models, and seem to be resource limited.
  - With many relicensings about to start in the Northeast, many operators will be spread very thin with their resources.

- An increase in reservoir sedimentation will be an important consideration moving forward.
- Some operators have challenges around making sure that everyone they work with fully understands the limitations of models being used. It is important for operators to be up-front about what models can and cannot do and associated uncertainties.
- Many operators are interested in short-term forecasting (e.g. 12-months ahead for water supply forecasts). How might this framework support short- and long-term forecasting?
- PNNL may want to consider adapting the model framework for people to use on existing dams, such as adding power at non-powered dams.
- PNNL wants to show the versatility of the models and hopes to choose the second basin of focus in FY2018.
- How is PNNL collecting data to input into the framework? Is there a standard scheme or format? It is challenging to get precipitation level data for short-term forecasting. USACE's HEC-CWMS could be considered as an addition. It combines other models into one package.

## Project Framework & Discussion

The following summarizes key points shared by the project team (Marshall Richmond, PNNL and Mark Wigmosta, PNNL).

- There is an interest in having future hydrologic regimes addressed.
- PNNL is focused on developing something nationally applicable, and not hard-wired to one region of the country. The framework will look at risks at the plant scale through the broad river basin system scale.
- PNNL's framework is a collection of models that communicate with each other. One example of this is direct coupling. Another is coupling through external data files.
- The project is initially focused on water temperature. Water temperature can be a surrogate for other water quality parameters. A key consideration for water temperature is looking at operational strategies such as selective withdrawal structures and using the high-performance computing capability to cover linking across multiple scales.
- PNNL will look at probabilistic scenarios and move beyond planning just for wet, normal and dry years. PNNL is interested in assessing risk at the plant and system scale.
- The end product for the modeling framework will not be a "ready to deliver" software tool.
- The initial models will be representative members of key classes of models that address the essential physical processes.
- Alternative operational scenarios will be developed with the appropriate basin user groups. PNNL wants to work with people who have the day-to-day responsibilities, to come up with scenarios that are meaningful and realistic. Climate simulations will be important for these scenarios. PNNL will be using the weather research forecasting (WRF) model which features dynamic downscaling. PNNL will calibrate hydrologic and river models to develop simulation models applicable to each river basin.
- Meteorology is a significant driver of the watershed and river reservoir models.

- The key aim of the project is linking multiple scales. Ultimately, PNNL wants to be able to feed this information, as needed, down to the engineered structure scale.
- In FY2019, PNNL will continue to meet with user groups and look towards wrapping up the project.
- To try to capture uncertainty, PNNL will look at five global circulation models (GCMs) in the climate modeling component of the project.
- With this framework, PNNL is looking at forecasting out to 2040-2070.
- In the initial model suite, PNNL is interested in performing high-resolution modeling. The ensemble based approach is good because it captures uncertainty in the meteorology.
- The DHSVM watershed model captures spatial variability and is open source. PNNL's framework will benefit DHSVM development efforts.
- PNNL may be able to use the framework as a potential tool for riparian management.
- The Clearwater River Basin is a very important basin in the Columbia. PNNL is performing a test of its high performance capability in this basin. For running the models using high performance capability, the runtime reduction in the watershed model of this basin decreased from 650 minutes to 12 minutes. This improvement will allow PNNL to model larger basins in greater spatial detail or allow use of multiple ensembles of future climate data.
- One dimensional (1D) models run very fast and provide the backbone for the water basin. 1D models provide a way to route the water and other constituents to the boundaries of higher dimensional (2D, 3D) models.
- PNNL wants to further explore how multiple constituents interact with each other.
- PNNL has already completed a few risk-based assessments in prior studies.
- The effect of dams on water temperature is not clear cut. Hydro projects have a thermal inertia effect. Regarding fisheries issues, timing is also an important consideration.
- In the future, the availability of cooler water may become a prevalent issue.

*Questions and Discussion on the Project Framework presentation:*

- USGS had a precipitation runoff modeling system (PRMS) which sounds similar to what PNNL is developing. USGS was working on coupling a groundwater flow model to a runoff model. Are there plans to look at coupling this with a groundwater flow model? That would be a nice component to have.
    - The watershed model does do this, however, this is not a sophisticated groundwater model. The framework will handle both surface and shallow sub-surface flow. Trying to accurately simulate the late-season base flow component is important.
    - The groundwater component of flow is part of the dissolved oxygen (DO) issue. Hot, dry, summer months are part of the equation.
- Regarding the Columbia Basin model, what are the plans to include Montana and British Columbia hydro? How can PNNL model without including the large reservoirs in Montana and British Columbia?
    - PNNL plans on getting to this in FY18 when it coordinates with other entities in getting data to feed the models.
- What does the probabilistic approach mean?

    - This means future looking scenarios. PNNL will be running climate ensembles and will capture uncertainty in those climate projections and propagate that throughout the system, then use a hybrid approach to expand that to additional ensembles.
- If the historical record is not stationary, how does that factor into the probabilistic analysis?
    - One of the primary purposes of the historic record is the ability to compare model results with observation and determine frequency distributions at certain locations.
    - Users will also be able to compare model output with measurements.
- From the perspective of some federal hydro operators, the longer-term climate simulations are of interest, but in some areas, operators are shielded from the hydrologic impacts because of their geographic location. Therefore, shorter-term planning horizons (weeks, months, years) would be a key topic of interest.
- Federal operators are interested in seeing how well the models knit together and how much value is returned in doing this work at the micro-fine grid scale. There are science questions to be answered to help inform the framework. Getting a start on answering these science questions will be quite useful.
- It would be useful to have shorter time scales and to do assessments on how the framework and different modeling pieces would play out (so that operators understand the utility it offers).
- Has there been any engagement or collaboration with the National Weather Service (NWS) and work going on in Tuscaloosa with the National Weather model?
    - PNNL acknowledged that there is opportunity around forecasts and data products, but it has not pursued collaboration with NWS at this point.
- Hydro operators have to predict hydro generation for 12 months out, but in reality, more than two months out, predictions are very inaccurate. That one year window is very crucial and predicting hydro generation based on climate is very important. Having an ensemble of different scenarios can help identify the low range vs. the high. Operators don't have the tools at this point to accurately predict 12 months out.
- Because of investors, operators must make predictions but these are usually inaccurate. Terms agreed to in licensing may be easier to achieve if the climate forecast is correct. It would be very useful if longer-term forecasting could be factored into the ensembles. The time horizon for licensing is 30-50 years, but the investment window is about 20 years.
- What does PNNL do with missing data (it is dropped from time to time)? Sometimes operators have to use what they have because it is all that is available, even though it is not accurate.
- The modeling framework can provide both short-term (24-48 hours) and long-term (annual forecasting and over a series of decades) value to its customers.
- NGO partners find this effort important and want to know how it can be useful to them.
- States think PNNL's framework could be very useful for state relicensing. Having something open source and detailed, as well as a common agreement around what constitutes an appropriate model is good.
- Bard College is currently working on a project to develop resources for homeowners who have a dam in their community. The ability to work with regulatory agencies, to have a common model, and to have a common idea of what operators are going to do would help remove a lot of uncertainty at the state level about whether to improve systems or not. Individual users are not always up to speed with this kind of resource. It would be good to have others in the industry, including regulatory agencies, all on the same page.

- State and federal agencies want to continue to work with PNNL so that they stay informed about outputs.

## Next Steps and Closing

- Next steps include convening this national group periodically (one-two times per year) via webinar or hybrid meetings like this one. A meeting will be convened with the Columbia Basin Group as early as October, as well as continued work on the modeling framework.
- Anna West thanked participants for their time and input. PNNL noted that it will try to continue organizing forums in which it brings stakeholders together, especially as it develops products to share with industry.

**Appendix: Workshop Agenda**

## *Advancing Modeling Tools for Assessment of Long-Term Energy/Water Risks for Hydropower Meeting*

Pacific Northwest National Laboratory

Colorado Convention Center, Room 103

Denver, Colorado

## Tuesday, June 27th 10:00am – 12:00pm

*Meeting Objectives:*

- Build common understanding of the project purpose and the relevant science
- Share findings from user feedback and gather additional feedback
- Provide suggestions for the project next steps (model development and regional approach)
- Gather input on project approach

### Meeting Agenda

| TIME | TOPIC |
|---|---|
| 10:00 - 10:15 | Welcome and Project Overview |
| 10:15 – 10:45 | Overview of Findings in User Needs Assessment |
| 10:45 - 11:45 | Project Framework and Discussion |
| 11:45- 12:00 | Next Steps and Closing |