NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Hydro Assets

Special Hydro Reporting Guidance

GADS Data Reporting Training Workshop

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Special Hydro Reporting Guidance

- Hydro Assets have unique attributes that sometimes fit with conventional reporting guidance and sometimes have attributes that are closer to Wind or Solar
  - Some Hydro units are capable of operating to their GDC/NDC on demand
    - Similar to a gas turbine, these units can be dispatched as needed
  - The output can be highly predictable from day to day
    - Their output can be scheduled into a market with some certainty
  - Some Hydro units are capable of operating at their GDC/NDC but are limited by permitted operating constraints (i.e. FERC license or other regulation)
    - Wind and Solar rely on the resource availability. i.e. the output is variable and not within the operator's control

Hydro DRI Guidance

- Hydro Assets have unique attributes that sometimes fit with conventional reporting guidance and sometimes have attributes that are closer to Wind or Solar
  1. Hydro Inspection Cause Code 7300
  2. Change in Operating Head
     a) Gross Maximum Capacity and Net Maximum Capacity (GMC and NMC)
     b) Gross Dependable Capacity and Net Dependable Capacity (NMC and NDC)
  3. Lack of Water for Peaking/Pulsing Units
  4. Lack of Water for Run of River Plants
     a) Lack of Water Amplification Code – WC - Water Condition
     b) Hydro Equations
  5. Tailwater/Tailrace Conditions
     a) Tailwater Too High or Too Low (cause code 9138 – High Water Level in Tailrace)
     b) Tailrace or Tailwater Issues (Cause Code 7180 – Tailrace)

Hydro Inspection Cause Code 7300

- Cause Code 7300 was added to cover periodic inspections
  - Many owners have inspections scheduled periodically. These are outages that are not specifically directed to a particular issue
  - These would be scheduled on a routine basis. i.e. every six months, every two years, every four years, as examples
  - These inspections can include some basic maintenance and repairs

Hydro Inspection Cause Code 7300

- There are Generator Inspection and Turbine Inspection cause codes in the list (4840 – generator and 7201 – turbine). These codes would be used if the outage work is specific to inspect these particular elements.
  - As an example, a unit taken down to inspect if excessive cavitation had occurred would be coded to 7201
  - 7300 is for an overall general inspection.
- Cause code 7300 is to be used exclusively with hydro assets. It is not to be used for fossil/steam, gas, reciprocating engines, or other conventional generating assets.
- If another issue is discovered that extends the outage, this would be handled similar to other planned outages
  - Move the outage to a Forced Outage with appropriate cause code
    - i.e. The inspection identifies that runner welding needs to occur, the outage would more to U3 (the outage could have extended over the six hours) and coded to 7010 - Runner cavitation damage

Hydro Inspection Cause Code 7300 Questions?

GMC and NMC

- For fossil units, parasitic and station loads can be up to 5% or more of the output.
  - Research was done and found that for most hydro plants, this was close to 0.1%
- Moving forward, this will default to 0%. For reporting purposes, the GMC and NMC for Hydro are considered the same.
  - GMC=NMC
    - There may be circumstances where a hydro plant has a relatively large station or parasitic load that needs to be accounted for.
    - In these cases, it is recommended that these values be manually entered into the GADS data. Don't rely on the default

GMC and NMC
Questions?

Change in Operating Head

- For Gas Turbines, GADS reporting requires reporting seasonal derates due to effects on output due to temperature changes.
- At many hydro stations, the dependable capacity is related to the head, or difference in water level of the forebay or reservoir to the tailrace.
  - This can be thought of as analogous to changes in temperature for Gas Turbines
- During normal operation, forebay levels may change daily or even hourly.
- For flood control, the forebay may be “drafted” to a low level and held there for several months in anticipation of snow melt or other high flow events

Change in Operating Head

- Even though these fluctuations can result in a representative decrease in output, it was concluded by the GADS User Group that these changes do not need to be taken into account when reporting capabilities for hydro units.

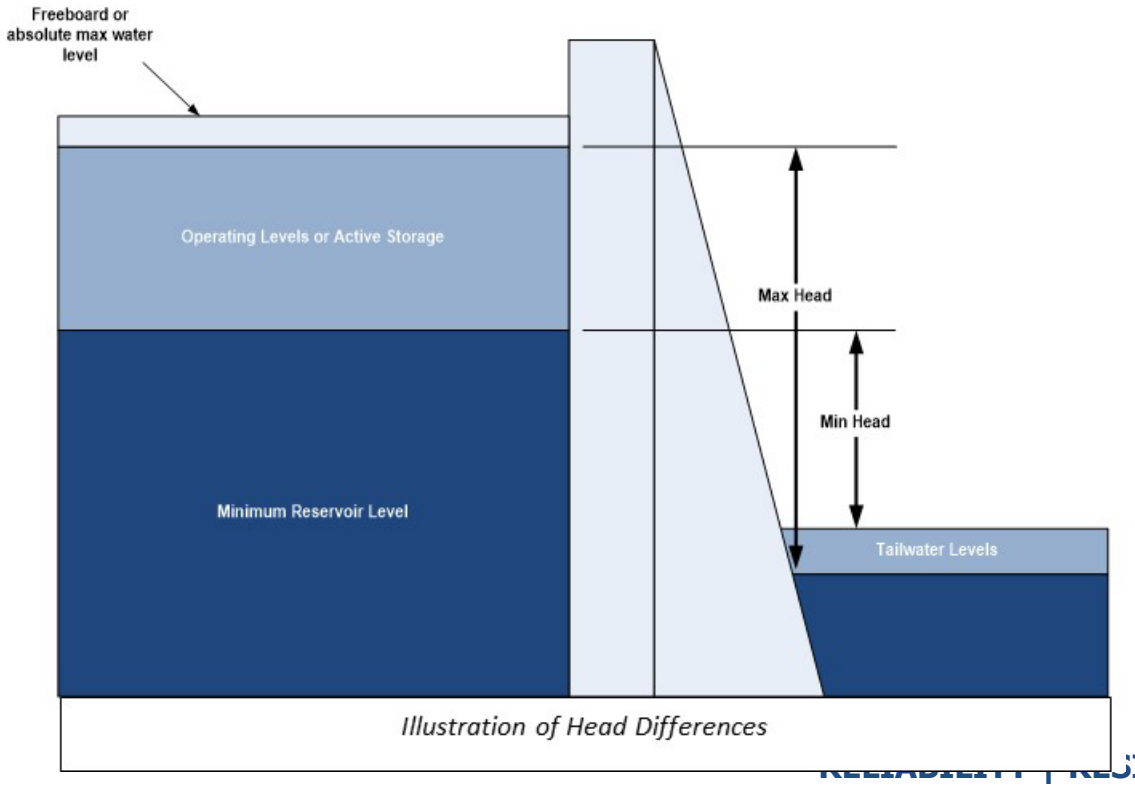
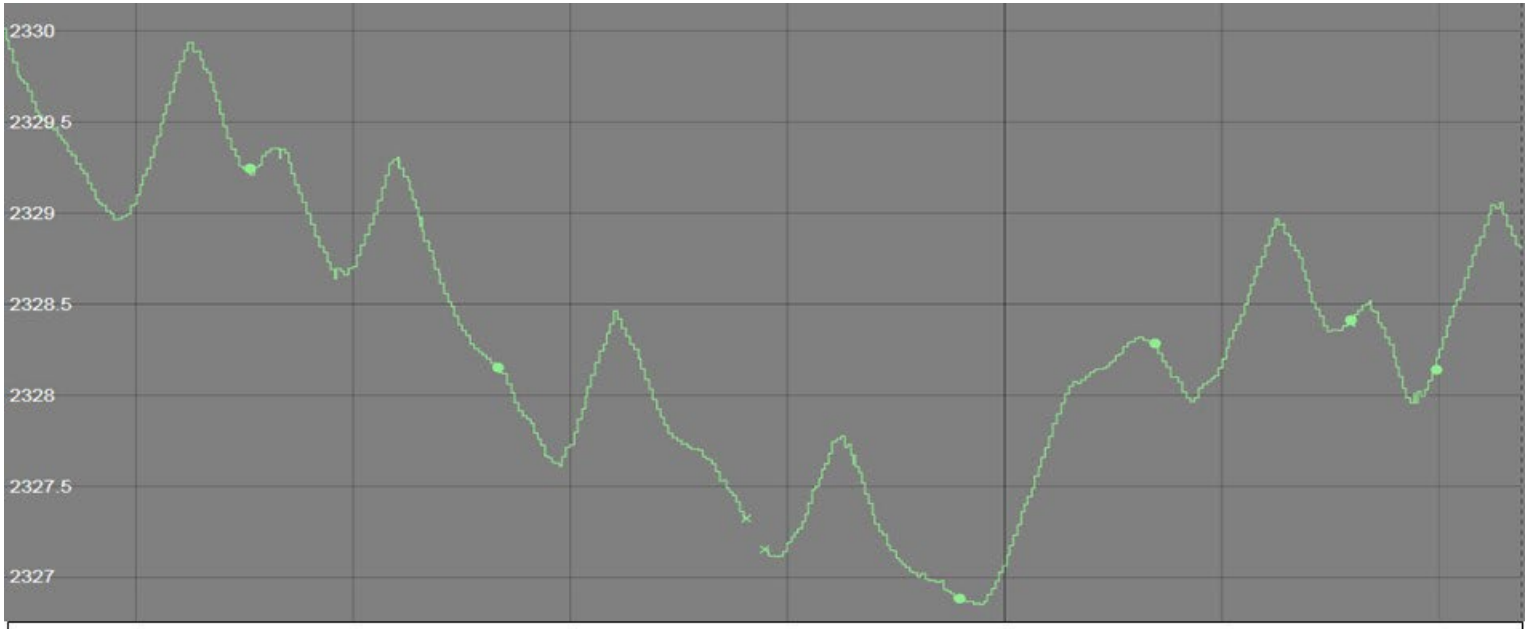


Illustration of Head Differences

Change in Operating Head

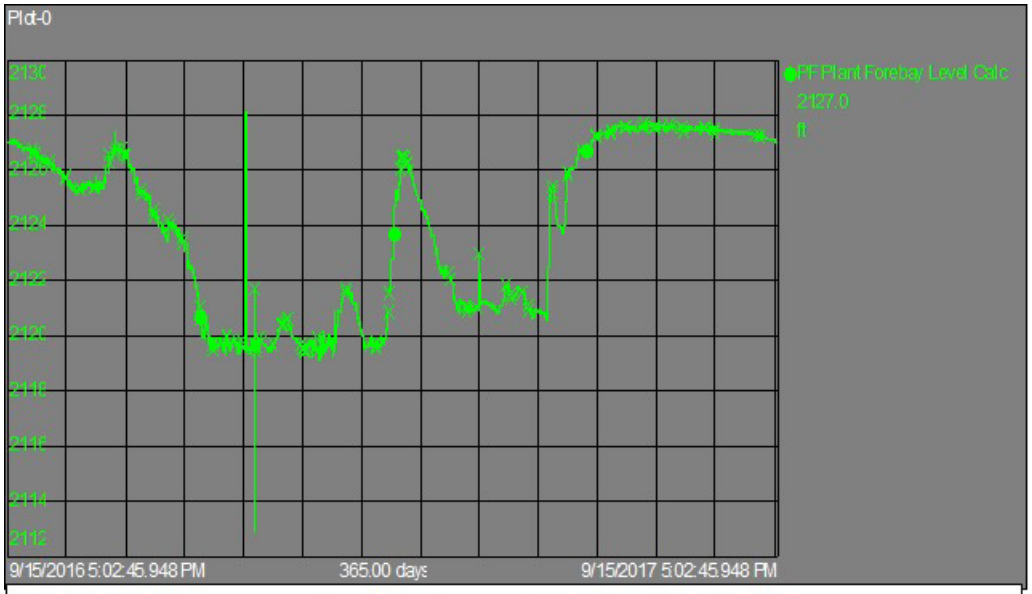
- The illustration below shows how a hydro plant can be operated over the course of a short period of time where the head can change – therefore the output of the unit/plant



Example of Weekly Head Change
(Each vertical line is one day)

Change in Operating Head

- Where flood control is the primary mission of a dam the reservoir is drafted, or partially emptied, to create storage for a future water surge. (This can be snow melt, rain storm or other weather event.)



Seasonal Change in Forebay Level
(each vertical line is one month)

- For these <u>seasonal</u> conditions that may last for a month or more, the owner is encouraged to report an estimated decrease in dependable capability.

Change in Operating Head Questions?

Lack of Water for Peaking/Pulsing Units

- Hydro plants that have active storage behind them and have a range of reservoir levels that they are allowed to operate within can be categorized as Peaking or Pulsing
  - This operation can also be described Shaping, Regulating, Load Following, etc.
- These plants may be shut down (or mostly shut down) during some parts of the day or week, and then run at nearly full output for some other parts of the day or week.
  - Another description can be when units are shut down so that water can be stored (or restored) for a later operation – that day or tomorrow or next week, etc.

Lack of Water for Peaking/Pulsing Units

- Below is an illustration of a Plant Peaking Operation

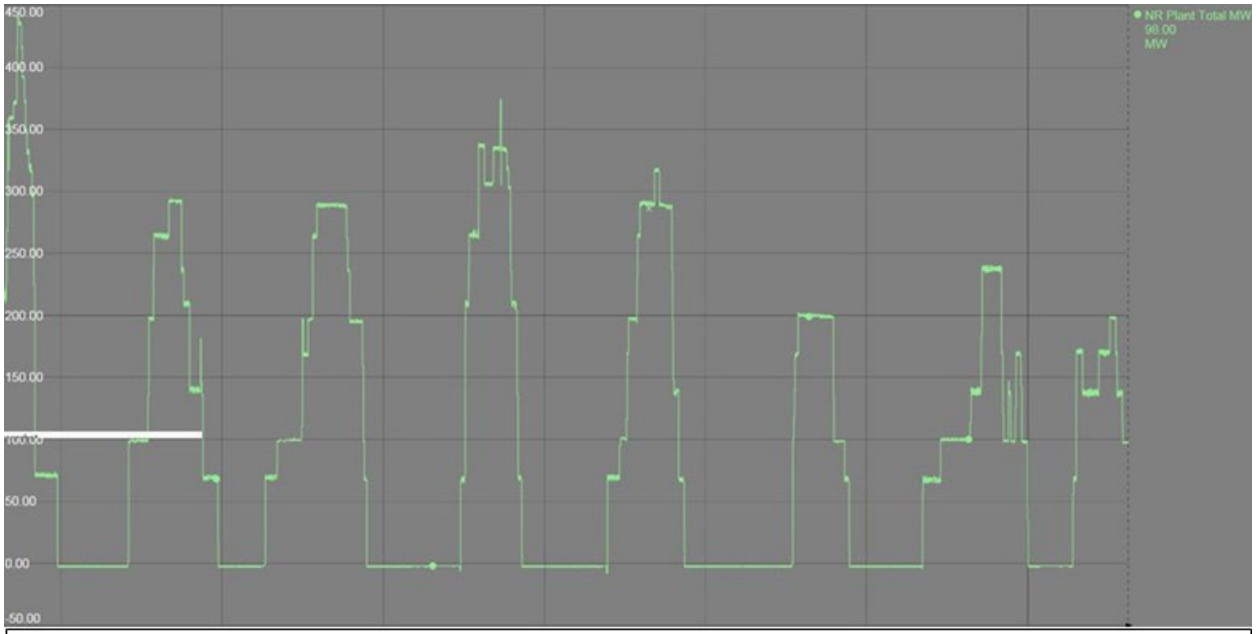


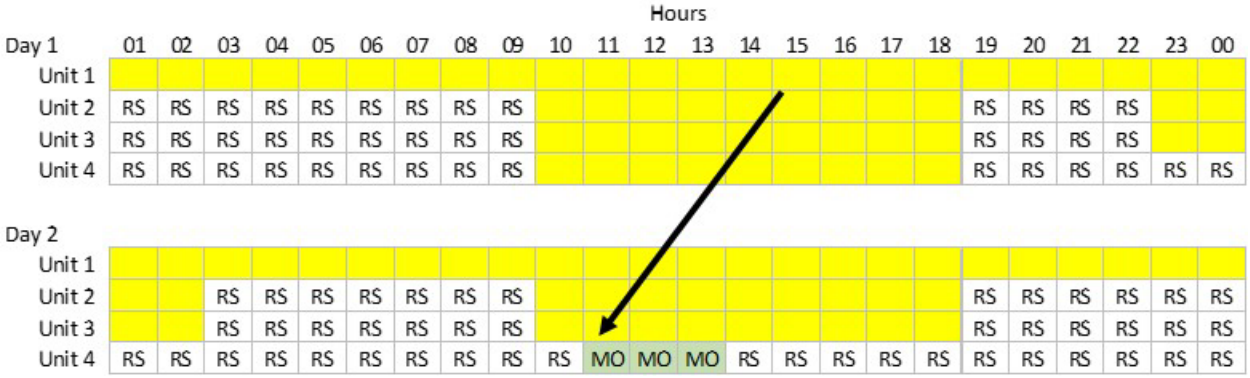
Illustration of a multiple unit Plant in a Peaking or Pulsing Mode
When units are shut down, they are placed in RS

- For this type of operation, when the unit is shut down, it should be put in as Reserve Shutdown (RS)

Lack of Water for Peaking/Pulsing Units

In this example, the unit 1 is run 24/7. Units 2, 3, and 4 are dispatched as indicated. Because this is a Peaking plant, when U2, 3, and 4 are shut down, they are coded as RS. As it happens, the decision was made that U4 would not be required for day 2. As it is, it had planned to be in RS for the entire day.

With the knowledge that the fourth unit will not be run that day, the decision is made to take the unit out of service to address some minor problems with sticking that is occurring on the unit brakes. The unit is cleared for this work at 1100 hrs and is returned three hours later at 1300 hrs



Even though the plan was not to run, this is still coded as MO, not PO or FO due to lack of water. It is incorrect to continue this as RS as the unit could not be run if requested.

Lack of Water for Peaking/Pulsing Units

- It is possible that a plant like this might go one or two days(or more) without any unit actually generating as its reservoir is re-filling.
  - However, these units would still be in Reserve Shutdown and they could be called to run.
- If a peaking plant is drafted for reasons (i.e. flood control) and the reservoir reaches a low limit and the reservoir must be maintained at that low level, the plant then enters a “run of river” mode and the events will also need to reflect that operating mode.
  - This is described in the next section.

Lack of Water for Run of River Plants

- Many hydro plants do not have active storage that allows the type of operation described in the Peaking/Pulsing type of plant operation.
- For many plants, a reservoir level is established as part of their FERC operating License or other Regulatory agency operating requirements.
  - In these cases, the output of the plant can be described as "whatever is coming into the reservoir, must continuously go out"

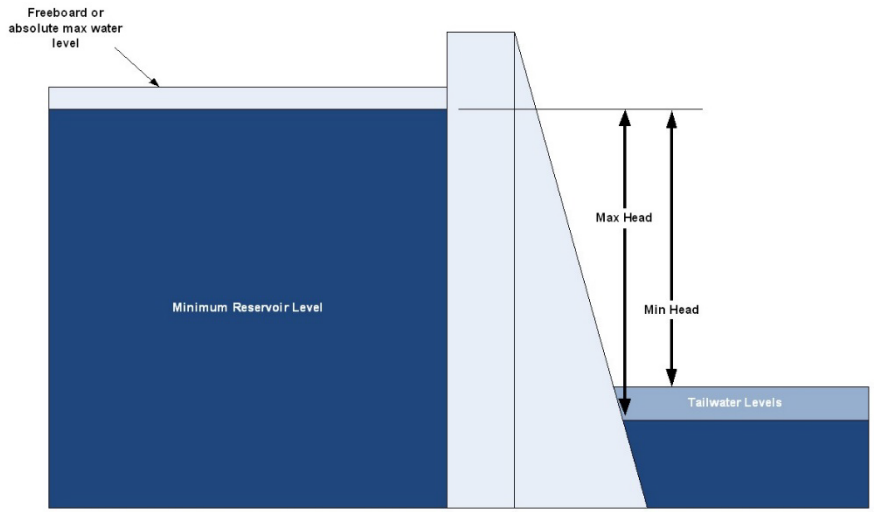
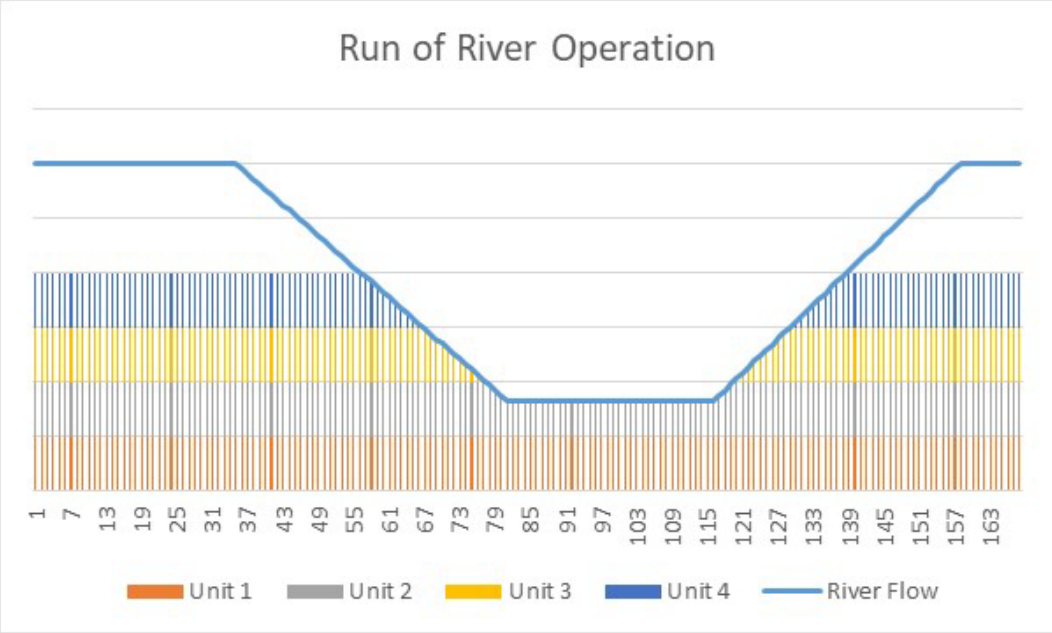


Illustration for Run of River Plant
Note the Reservoir Level has no latitude for fluctuation

Lack of Water for Run of River Plants

- For these plants, as the stream flow decreases, units are required to be backed off and shut down in order to keep the reservoir level (i.e. forebay) at a constant elevation.
- As a practical matter, many operations practice “swapping” units so that operating hours tend to balanced out between the units



Lack of Water for Run of River Plants

- When a unit must be shut down because there is insufficient water to run all the units and there is no reservoir that would allow the units to run if called upon,
  - These shut downs are to be categorized as a **Forced Outage U3 due to a lack of water**.

- This would be coded as U3 (Forced Outage that could have been delayed over the weekend) and cause code 9135 – Lack of Water.

Lack of Water for Run of River Plants

- There is a similar condition that can occur when units are shut down due to diversion of water to another channel for fish, wildlife, recreation, aesthetics, water supply, irrigation, or other purposes. In these types of operations, FERC License conditions or other regulatory requirements dictate that water priority is to be served to another use other than energy production.
  - This is a **Forced Outage due to a lack of water due to regulatory requirements**.

- U3 and cause code 9696 – Other miscellaneous operational environmental limits – hydro and pumped storage.
  - (Note: while 9696 is not precisely the description, it is representative for this event.)

Lack of Water for "Run of River Plants" Questions?

Lack of Water Amplification Code – WC

- With the evolution of GADS applied to Wind and Solar, the concept of "Resource Unavailable" has evolved. With run of river hydro, this is an analogous situation.

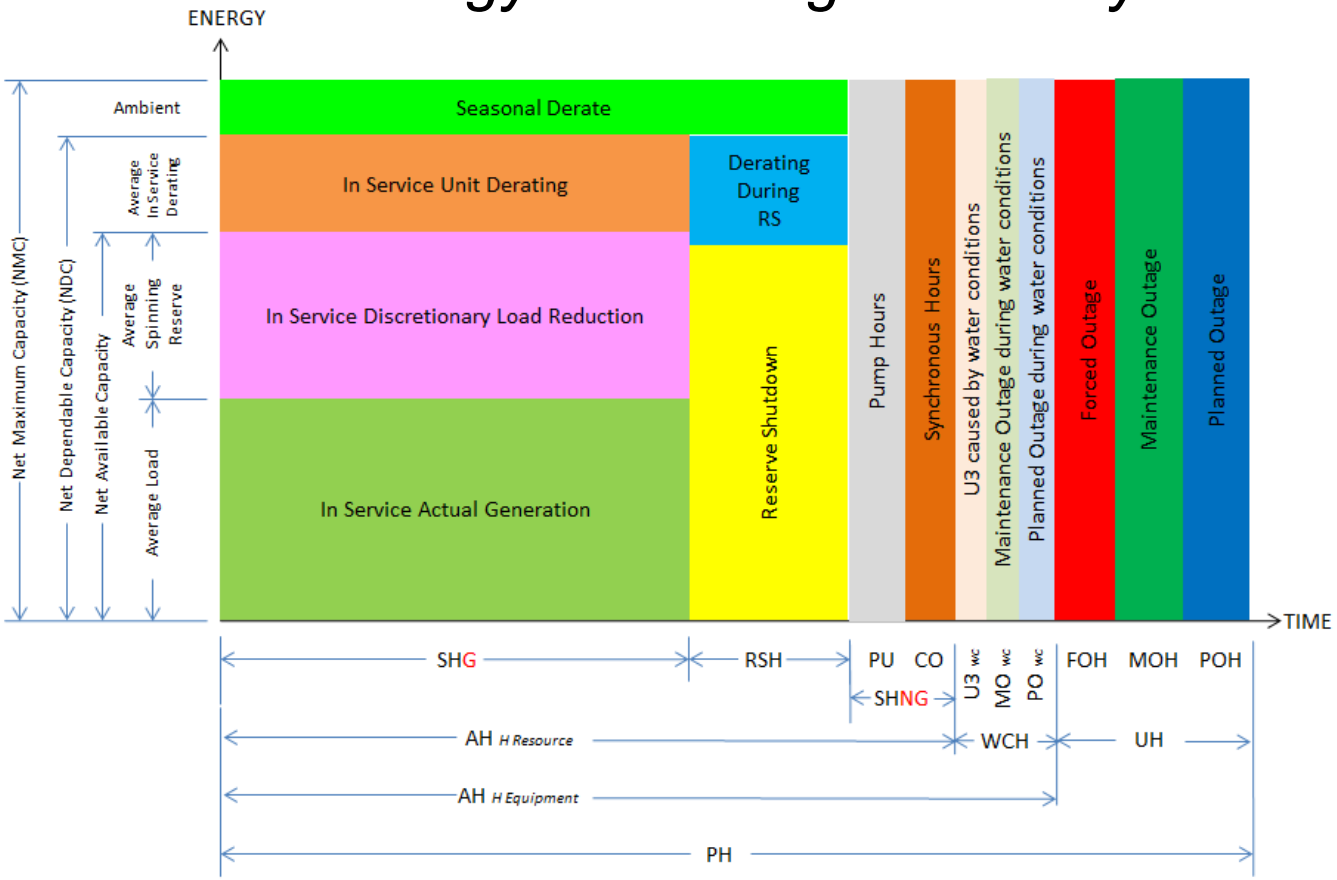
- Because Hydro is part of the conventional GADS system, it was determined that owners should use a special Amp Code – WC (for Water Conditions) to further identify this event.
  - U3 cause code 9135 – Lack of Water Amp Code WC
  - U3 cause code 9696 – Other miscellaneous operational environmental limits Amp Code WC

Lack of Water Amplification Code – WC

- The purpose is for the Owner to be able to report externally that the unit is in a FO condition due to lack of water.
  - The “Resource” is unavailable
- Additionally, for plant metrics purposes, those hours where the WC is applied, equations can be set up to remove those hours for internal plant reporting purposes.
  - The “Equipment” is available
- Calculations can be made that identify the status of the Resource and the status of the Equipment

Lack of Water Amplification Code – WC

Energy Time Diagram for Hydro



SHG – Service Hours Generating
SHNG – Service Hours Non-Generating
WCH – Water Condition Hours

Lack of Water Amplification Code – WC Questions?

Lack of Water Amplification Code – WC Equations

- As stated above, there are times for run of river projects when units are out of service due to a lack of water.
- However, these units could be operated so their capability from an equipment perspective should reflect the lack of water condition.
- The circumstances here mirror the concept of RUTH in the Wind GADS reporting.
  - In Wind, two sets of parallel equations were developed. One to report performance on the resource (includes RUTH hours), and one to report performance on the equipment (excludes RUTH hours).
- This same concept is currently being applied with Solar GADS as well.

Lack of Water Amplification Code – WC Equations

As an example, in conventional GADS the Availability Factor (AF) is defined as:

$$AF = \frac{AH}{PH} X100\%$$

AH – Available Hours

PH – Period hours

$$AH = RSH + SH + +Sync\ Cond\ Hours + Pumping\ Hours$$

Substituting

$$AF = \frac{RSH + SH + +Sync\ Cond\ Hours + Pumping\ Hours}{PH} X100\%$$

This is as defined in Appendix F of the GADS DRI.

Lack of Water Amplification Code – WC Equations

For run of river hydro, the Availability Factor from a ***Resource*** perspective would be identical

$$AF_{h\ Resource} =$$

$$\frac{RSH + SH + +Sync\ Cond\ Hours + Pumping\ Hours}{PH} X100\%$$

The *h Resource* – identifies the equation as a "hydro resource" equation.

WC Hours are not included

Lack of Water Amplification Code – WC Equations

Those hours that are separated by the WC amp code would also be considered available hours. With this stipulation, the Available Hours for **Equipment** would be:

$$AH_{h\ Equipment} = RSH + SH + Sync\ Cond\ hours + Pumping\ Hours + U3_{WC} + PO_{WC} + MO_{WC}$$

Substituting this into the equation for Availability Factor for hydro equipment:

$$AF_{h\ Equipment} = \frac{RSH + SH + Sync\ Cond\ hours + Pumping\ Hours + U3_{WC} + PO_{WC} + MO_{WC}}{PH} X100\%$$

The *h equipment* – identifies the equation as a "hydro equipment" equation.

WC Hours <u>are</u> included

Lack of Water Amplification Code – WC Equations

- The equation examples here are for illustration purposes of the concept of either removing the WC Hours to address the availability of the **Resource** for system analysis and planning purposes.
- The example also shows where you would add the WC hours to address the availability of the **Equipment** for plant performance monitoring and management
- Other Factors and Rates can be determined for hydro Resource or hydro Equipment using the logic in the illustraitons
- Finally, this concept is very similar to the “X Equations” that are detailed in Appendix F of the DRI

Lack of Water Amplification Code – WC Equations

- The benefits of this is that for equipment related performance metrics, it does not penalize the equipment availability if maintenance or planned work is done during low water times.
  - In other words, it provides an incentive to perform this work when you should perform this work

This method is intended to provide incentive to plant management to perform maintenance at those times when these activities should be performed, when there is no water to run the units.

Lack of Water Amplification Code – WC Equations

This does not apply to Peaking/Pulsing hydro plants!!

- Although water may be limited, the units are available for dispatch should system conditions call for them.
  - Units may not run for weeks because of dispatch choices and limited flow to fill a reservoir. This is still not a lack of water condition as if call, the unit could run.
    - An example is a sudden loss of generating unit and the need for the hydro to run all out for a while so the loss of generation can be accommodated with other sources.
- If you have a Peaking/Pulsing Plant, the outages apply as with other conventional GADS units

Lack of Water Amplification Code – WC Equations Questions?

Tailwater/Tailrace Conditions

- **Tailwater Too High (cause code 9138 – High Water Level in Tailrace)**
- There are operating conditions with hydro turbines that can occur where the tailwater elevation becomes too high and the turbine does not have enough head (i.e. elevation difference between the forebay and tailwater levels) to operate reliably and the unit is shut down. This is not a common issue but does come up with some plants.

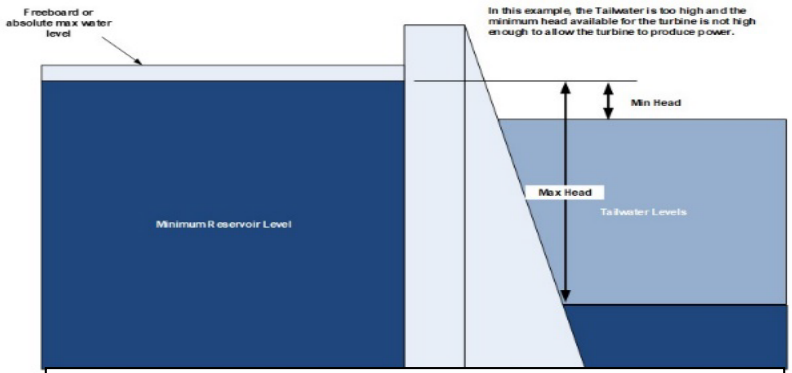


Illustration of High Tailwater Condition

- When this condition occurs, the shutdown should be coded as a forced outage, U3, and given the cause code 9138

Tailwater/Tailrace Conditions

- **Tailrace or Tailwater Issues (Cause Code 7180 – Tailrace)**
- Sometimes the tailrace is too low to allow backpressure to build up on the turbine discharge and can cause water pressure fluctuations and an unstable turbine.
  - While this condition can be alleviated with vacuum break valves or similar, a lack of tailwater can prevent the unit from being placed on-line due to the instability. This should be coded as U1 or U2, cause code 7180.

Tailwater/Tailrace Conditions

- **Tailrace or Tailwater Issues (Cause Code 7180 – Tailrace)**
- Another use for this cause code would be if there was construction in the tailrace area.
  - This could be to remove restrictions caused by debris in the tail channel. (I.e. a dredging project or debris removal project).
  - In these cases, These would typically be a Planned Outage (PO) or could be a Maintenance Outage (MO) if it is in response to a land slide or other natural event.
  - This should be coded as PO or MO, cause code 7180.
    - (If the condition forced the unit offline, it would be recorded as a U1, U2, U3)

Tailwater/Tailrace Conditions
Questions?

Questions and Answers