

V.3.3-RES-SNGL-SPEC-POWERGEN SINGLE RESERVOIR REGULATION OPERATION
SCHEME POWER GENERATION

Purpose

Scheme POWERGEN computes the generation discharge from a hydroelectric dam.

The generation outflows are affected by the inflows, rule curve elevations, maximum generation discharges of this dam and downstream dams, minimum outflow requirements, diurnal variation of power requirements, daily variations of power needs during the week and upper and lower limiting elevations.

Input Summary

<u>Keywords</u>	<u>Definition and Format</u>
POWERGEN <u>1</u> /	Input opening keyword for Scheme
<u>PARMS</u>	Parameter opening keyword for Scheme
[TOD]	Time of hydrologic day to bring pool to rulecurve elevation: <ul style="list-style-type: none">- integer- value between 0-24 inclusive- default is 0
DAILY	Daily distribution function: <ul style="list-style-type: none">- number of values = $24/\Delta t_{op}$ (Δt_{op} is the Operation time interval)- between 0.0 and 1.0; must sum to 1.0
[DOW]	Day of week to bring pool to rulecurve elevation: <ul style="list-style-type: none">- integer- value of 1-7 (where 1 = Sunday, 2 = Monday ...)
[WEEKLY]	Weekly distribution function (omit if DOW is not used) <ul style="list-style-type: none">- number of values = 7- between 0.0 to 1.0; must sum to 1.0
[MINQDAY]	Mean daily minimum discharge; default is 0.0
[MINQWEEK]	Mean weekly minimum discharge; default is 0.0
[MINQINST]	Minimum instantaneous flow; default is 0.0 if vary with time: <ul style="list-style-type: none">- 'j' dates followed by 'j' values of minimum discharge- dates- integer between 1 and 366 in ascending

Keywords

Definition and Format

		order
		- discharges
HUPPER		Upper limiting elevation; can be: <ul style="list-style-type: none">- constant value within ELVSSTOR curve <u>2</u>/- RULE or RULE+factor (no spaces between RULE, + and factor; factor > 0.0)- set of values<ul style="list-style-type: none">- 'j' dates followed by 'j' values of elevation- dates<ul style="list-style-type: none">- integer between 1 and 366 in ascending order- elevations within ELVSSTOR curve
HLOWER		Lower limiting elevation: <ul style="list-style-type: none">- same format as HUPPER- if rulecurve usage specified must be RULE or RULE-factor (no spaces between RULE, - and factor; factor > 0.0)
[DSMAXQ]		Downstream dam limiting discharge; default is QGENMAX
QGENMAX		Maximum constant generation discharge
[ELVSMAXQ]	<u>3</u> /	Pool elevation versus maximum generation curve: <ul style="list-style-type: none">- 'j' values of elevation followed by 'j' values of maximum generation discharge- elevations within ELVSSTOR curve in ascending order- discharges
[HEADVSQ]	<u>3</u> /	Head between pool and tailwater versus discharge curve (allowed only if ELVSMAXQ was not entered): if defined here: <ul style="list-style-type: none">- 'j' head values followed by 'j' values of discharge- heads in ascending order if referenced to original definition: <ul style="list-style-type: none">- name and level number of Scheme in which it was originally defined
[TWCURVE]	<u>3</u> /	Tailwater rating curve name: <ul style="list-style-type: none">- only allowed if HEADVSQ was entered- 8-character name- must be defined by FCININT DEF-RC command- must match name of any other tailwater rating curve used in this Reservoir Operation
[CONV]	<u>3</u> /	Convergence criterion between 0.01 and 1.0;

<u>Keywords</u>	<u>Definition and Format</u>
	default is 0.02 (omit if HEADVSQ is not used]
CURVE	Rulecurve definition: If defined here: <ul style="list-style-type: none"> - 'j' dates followed by 'j' values of elevation - dates - integer between 1 and 366 in ascending order - elevations within ELVSSTOR curve If referenced to original definition: <ul style="list-style-type: none"> - name and level number of Scheme in which it was originally defined
[RULETIME]	Time of hydrologic day rulecurve is set: <ul style="list-style-type: none"> - needed only if CURVE is defined in this Scheme - integer between 0 and 24 inclusive; default is 0
<u>ENDPARMS</u>	Parameter ending keyword for Scheme
[<u>CARRYOVER</u>]	Carryover opening keyword for Scheme: <ul style="list-style-type: none"> - needed only if carryover is entered
[OLDQ]	Time interval mean discharge values: <ul style="list-style-type: none"> - number of values = $24/\Delta T_{op}$ - defaults (all values) to general mean discharge carryover value
[<u>ENDCO</u>]	Carryover ending keyword for Scheme: <ul style="list-style-type: none"> - needed only if CARRYOVER was entered
ENDPOWER	Input ending keyword for Scheme

Notes:

- 1/ No time series information is needed to define this Scheme.
- 2/ ELVSSTOR is the elevation versus storage curve defined in the general parameter section.
- 3/ An elevation vs. maximum generation discharge curve is optional in this Scheme. However if it is desired it can be entered in one of two ways:
 - a. The curve can be entered directly by using the ELVSMAXQ keyword. In this case neither the HEADVSQ, TWCURVE nor the CONV keywords are needed or allowed.
 - b. The curve can be computed by using the head vs. generation curve (HEADVSQ keyword) and the tailwater rating curve (TWCURVE keyword). The convergence criterion (CONV keyword) is allowed in this situation but it is optional. In this

case the ELVSMAXQ keyword is neither needed nor allowed.

Input Examples:

This example implies the rule curve has been defined in the INDSRCHGE Scheme. Input for SUMINF is included because that utility is required for the POWERGEN Scheme.

```
POWERGEN(1)
PARMS
TOD      6
DAILY           0.0      0.30      0.40      0.30
DOW      2
WEEKLY    0.0      0.20      0.20      0.20      0.20      0.20      0.0
MINQINST          1.00
HUPPER      RULE+0.20
HLOWER      RULE-5.00
QGENMAX      30000.00
CURVE      INDSRCHGE(1)
ENDP
CARRYOVER
OLDQ      0.0      0.0      0.0
ENDCO
ENDPOWER
SUMINF(1)
PARMS
NORMQ      30000.00
ELTEST      190.00
ENDP
ENDSUM
```

Method

If the outflow is observed it is plugged directly into the continuity equation to compute the pool storage and the pool elevation.

If the outflow is proposed by the operator it is treated in the same way as observed except checking against limiting values is made and pertinent values are revised if needed.

If no observed or proposed generation discharge is available, outflow must be computed. The computation of outflow requires the execution of the inflow summation (SUMINF) utility which computes values needed by this Scheme such as cumulative inflow volumes and the existence of a flood situation as determined by the upper limit exceedance criteria in that utility.

If inflows are fairly large the upper limiting elevation will be equaled or exceeded even with full maximum power generation. Outflow will be set to the maximum generation discharge until the time when maximum pool storage is exceeded and the inflow recesses below the maximum generation discharge. The daily or weekly cycle power generation operation will then be used.

If inflows are not too large generation outflows are computed by bringing the pool elevation back to the rule curve either once a day at a specified time [TOD] or once a week on a specified day [DOW] and time [TOD].

When the pool is brought back to the rule curve once a day the daily outflow volume and the daily mean outflow required to bring the pool from its elevation at the beginning of the daily cycle to the rule curve elevation at the end of the daily cycle are computed. The daily mean outflow is lower limited by MINQDAY and FLOUT and upper limited by QGENMAX. (FLOUT is upper limited by QGENMAX.) FLOUT is a constant minimum outflow required to keep the pool from exceeding the upper limiting elevation during a forecast run. Both the daily outflow volume and the daily mean outflow will be revised if necessary. If the daily outflow volume is decreased due to the limiting condition of the daily mean outflow the pool cannot be brought back to the rule curve elevation at the end of the daily cycle.

The daily outflow volume is then distributed into time interval mean outflows (QOM) using the daily distribution fractions [DAILY]. The daily distribution fractions are determined from averaging the past generation discharge records. QOM is limited by MINQINST and QGENMAX. When QOM must be changed the excess or the deficit flow volume is distributed first into the remaining time interval until all QOM have reached their limits before it is carried into the next day.

Then pool storage is computed and the storage is checked against upper and lower limiting storage. Outflows are revised as required to ensure the pool doesn't exceed its limits and excess or deficit flow volumes are carried over to subsequent time intervals. Computation of outflows will be carried out from day to day until the end of the forecast run.

When the pool is brought back to the rule curve elevation once a week the weekly outflow volume and the weekly mean outflow required to bring the pool from its elevation at the beginning of the weekly cycle to the rule curve elevation at the end of the weekly cycle are computed. The weekly mean outflow is lower limited by MINQWEEK and FLOUT and upper limited by QGENMAX. (FLOUT is upper limited by QGENMAX.) Both the weekly outflow volume and the weekly mean outflow will be revised if necessary. If the weekly outflow volume is increased or decreased due to the limiting condition of the weekly mean outflow the pool cannot be brought back to the rule curve elevation at the end of the weekly cycle. The weekly outflow volume is then distributed into the daily flow volume using the weekly distribution fractions [WEEKLY]. The weekly distribution fractions are again determined from averaging the historical release records.

After computing the daily flow volume the outflow as described in the daily cycle is determined. Computation of outflows will be carried out from week to week until the end of the forecast run.

Unless the program is in another Scheme this power generation Scheme will be executed every time interval throughout the forecast run. The generation outflow might be observed, proposed by the dam operator or computed from the daily or weekly cycles described above. Once the outflow is known the beginning pool storage for the time interval and mean inflow and outflow are used in the continuity equation to compute the pool storage and elevation at the end of the

time interval.

User Guidelines

1. This power generation Scheme must always be accompanied by the execution of the inflow summation utility (SUMINF). SUMINF supplies information needed in POWERGEN while computing outflows including total inflow volume and the existence of a flood situation if the upper pool limit is exceeded.
2. Although dam operators often adjust the rulecurve the rulecurve adjustment utility (RULEADJ) should rarely be used for a power dam. Since there is almost always a diurnal and/or weekly variation in power requirements the difference in observed and rulecurve elevations would not be representative of the deviation from the rulecurve except at specific times. The difference would be representative only when the pool is brought back to the rulecurve which is once a day for the daily cycle or once a week for the weekly cycle. RULEADJ is strictly applicable only for power dams that keep the pool elevation constantly at the rulecurve elevation until inflow exceeds the maximum generation discharge. Even in this case the FILLSPILL or RULECURVE Scheme would be more appropriate and RULEADJ would be used with one of those Schemes rather than with the POWERGEN Scheme.