

Stakeholder Consultation Workshop on

Detailed Procedures for

SCUC, USD, and SCED

[To be submitted for approval of Hon'ble CERC]

Grid Controller of India Limited (GRID-INDIA)
(formerly known as POSOCO)

Background

- CERC (Indian Electricity Grid Code) Regulations, 2023 i.e. IEGC-2023
 - Includes chapters on SCUC, Unit Shut Down (USD), and SCED
 - Regulations 46(4)(i), 47(2), 46(4)(j), 46(5)(a), 46(5)(b), 49(2)(a)(iv), 49(2)(a)(x), 49(2)(a)(xi) of IEGC-2023
- SCUC – Security Constrained Unit Commitment
- SCED – Security Constrained Economic Despatch SCED Pilot Procedure - 2019 [LINK](#)
- USD – Unit Shut Down
- RSD – Reserve Shut Down {now obsolete, replaced by USD} RSD Procedure - 2017 [LINK](#)
- Reserve estimation procedures for TRAS and SRAS TRAS Reserve Requirement Procedure-2023 [LINK](#)
- This procedure supersedes the earlier procedures prepared for SCED, and RSD

Scope & Objectives

- Regional entity thermal generating stations or units
 - For which tariffs are determined under section 62 of the Act – mandated for SCUC/SCED
 - Other than Sec-62 thermal generating stations may opt to participate under SCUC/SCED
 - ❖ A thermal generating station which opts to participate in SCUC is mandated to participate in SCED
- **The objective of this procedure** is to lay down the roles of various entities and methodology for the operation of SCUC, USD, and SCED mechanisms
 - Achieve National Merit Order
- **The objective of SCUC** is to commit a generating station or unit thereof, for the maximisation of reserves in the interest of grid security.
- **The objective of SCED** is to optimise generation despatch and achieve National Merit Order after gate closure and RTM
 - Incrementing generation from the generating stations with cheaper charge
 - Decrementing commensurate generation from the generating station with higher charge
 - After considering the operational and technical constraints of generation and transmission facilities

Definitions

- **“Cold Start”** in relation to steam turbine means start up after a shutdown period exceeding 72 hours (turbine metal temperatures below approximately 40% of their full load values)
- **“Hot Start”** in relation to steam turbine, means the start up after a shutdown period of less than 10 hours (turbine metal temperatures below approximately 80% of their full load values)
- **“Warm Start”** means the start up after a shutdown period between 10 hours and 72 hours (turbine metal temperatures between approximately 40% to 80% of their full load values) in relation to steam turbine.
- **“Minimum Up Time”** means the minimum time for which a unit shall be kept on bar, once committed under SCUC.
- **“Minimum Down Time”** means the minimum shutdown duration that would be provided between de-synchronization and synchronization of a generator under SCUC.
- **SCUC-Up** means the incremental generation scheduled under the head “SCUC” in the scheduling system, in order to bring the schedule up to minimum turndown level.
- **SCUC-Down** means the decremental generation scheduled under the head “SCUC” in the scheduling system, in order to balance the SCUC-Up scheduled in other generating stations.

Sample Scheduling System - illustration

Schedule » Net Schedule

Net Schedule																
Date: 13-09-2023		Region: WEST		View: Seller												
Seller: VSTPS V		Revision No: 153		Show data												
Created On: 13-09-2023 17:21:37		Remarks: ConsoleApplication														
Time Block	Time Desc	ISGS	MTOA	STOA	LTA	DAM	GDAM	URS	AS	SCED	REMC	RTM	HPDAM	BUNDLE RE	Net Total	Grand Total
1	00:00-00:15	-463.750000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-463.750000	-463.750000
2	00:15-00:30	-463.750000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-463.750000	-463.750000
3	00:30-00:45	-463.750000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-463.750000	-463.750000
4	00:45-01:00	-463.750000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-463.750000	-463.750000
5	01:00-01:15	-463.750000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-463.750000	-463.750000
6	01:15-01:30	-463.750000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-463.750000	-463.750000
7	01:30-01:45	-463.750000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-463.750000	-463.750000
8	01:45-02:00	-463.750000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-463.750000	-463.750000
9	02:00-02:15	-463.750000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-463.750000	-463.750000
10	02:15-02:30	-463.750000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-463.750000	-463.750000
11	02:30-02:45	-463.750000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-463.750000	-463.750000
12	02:45-03:00	-463.750000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-463.750000	-463.750000
13	03:00-03:15	-463.750000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-463.750000	-463.750000
14	03:15-03:30	-463.750000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-463.750000	-463.750000
15	03:30-03:45	-463.750000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-463.750000	-463.750000
16	03:45-04:00	-463.750000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-463.750000	-463.750000
17	04:00-04:15	-463.750000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-463.750000	-463.750000
18	04:15-04:30	-463.750000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-463.750000	-463.750000

Key Roles & Responsibilities

- NLDC shall be the nodal agency for coordinating and overseeing SCUC, and SCED processes
- RLDC shall be the nodal agency for overseeing USD process in consultation with NLDC
- Generating stations shall provide necessary data and information to RLDCs and NLDC for scheduling and dispatch
- Beneficiaries shall facilitate NLDC, RLDCs and Generating stations to ensure proper implementation of SCUC, and SCED processes
- RPCs shall prepare Energy and Deviation Accounts of the SCUC and SCED participants based on variable charge or compensation charge, as the case may be, as per IEGC
- NOAR shall be the single point entry and the master repository for submitting variable charge/compensation charge applicable for SRAS, TRAS, SCUC, and SCED
 - Same variable charge/compensation charge shall be used for dispatch under all the mechanisms and/applications

Scheduling Timelines - selected

0600 hrs of D-1	DC/Pmax, Ramp rate, turndown level/Pmin for the next day
0700 hrs of D-1	RLDCs prepare the entitlements and share of each beneficiary
0800 hrs of D-1	Beneficiaries shall submit their requisitions/schedules from ISGS
0945 hrs of D-1	RLDCs shall prepare the injection and drawl schedules
1300 hrs of D-1	DAM-Energy cleared and Power Exchanges would convey DAM results to NLDC
1400 hrs of D-1	Information by NLDC about plants with Sch < TM
1400-1430 hrs D-1	Slot for revision by beneficiaries to maintain turndown level
1430 hrs of D-1	Bids for Tertiary Reserve Ancillary Services TRAS-DAM-Up/Down cleared by NLDC
1430 hrs of D-1	Injection and drawal schedules with NLDC
1500 hrs of D-1	SCUC run and information dissemination



SCUC Requirement Assessment

- In case of shortage of reserves despite efforts made to procure by stakeholders
- Dovetailed with TRAS procurement/assessment procedure
 - TRAS-DAM-Up-Cleared quantum shall be say "X" MW.
 - Block wise TRAS-RTM-Up reserves expected to be available (say "Y" MW)
 - ❖ Shall be considered as the minimum of the last 7 days data
- If the Total TRAS Reserve Requirement say "Z" MW is more than the total cleared MW in TRAS-DAM and TRAS-RTM (i.e., X+Y MW),
 - System would need additional reserves for such duration.
 - While calculating the TRAS Reserve Requirement "Z", factor
 - ❖ Reserves created due to action of SCUC in the previous 7 days
 - ❖ Reserves anticipated to be available in Section 62 plants
 - ❖ Advance reserves procured, and reserve position intimated by the states

Sources of SCUC Reserves

- Additional Up reserve required (R=Z-X-Y) MW committed from
 - **Cat#1: Units that are likely to go below their minimum turndown level**
 - **Cat#2: Units under Unit Shut Down**
- By 1400 hrs of D-1, NLDC/RLDCs publish a tentative list of generating stations likely to be scheduled below the minimum turndown level. **Format-1.**
- Beneficiaries of such stations, shall be permitted to revise their requisitions by 1430 Hrs of D-1
- After 1430 hrs of D-1 day, further reduction in drawal schedule shall not be allowed
- NLDC may schedule incremental power from the generating units by 1500 hrs of D-1. **Format-2.**
 - Bringing these units to technical minimum would create extra Up reserves
 - Scheduled as per merit order, lowest energy charge to the highest energy charge
 - Changes in drawal schedule shall not be considered between 1430 hrs to 1500 hrs

Formats for SCUC Cat#1 units

Format-1: Tentative list of generating stations, scheduled below the minimum turndown level

Time: 1400 hrs

Date <published on D-1 basis>: DD/MMM/YYYY

For Date "D": DD/MMM/YYYY

Sno	Name of generator (Multiple entries allowed)	From time block	To time block	Schedule (MW)	Turndown level (MW)	ECR (Paise/kWh)
1	Gen-A	10	20	225	275	330
2	Gen-A	25	35	180	275	330
3	Gen-B	5	96	200	275	375

Increase generation up to Minimum Turndown Level

Format-2: List of generating stations with incremental power scheduled to achieve minimum turndown level

Time: 1500 hrs

Date <published on D-1 basis>: DD/MMM/YYYY

For Date "D": DD/MMM/YYYY

Sno	Name of generator (Multiple entries allowed)	Time block	Schedule (MW) @1430 hrs	Revised Schedule (MW) @ 1500 hrs	Pmax (MW)	ECR (Paise/kWh)
1	Gen-A	10-20	225	275	500	330
2	Gen-A	25-35	180	275	500	330
3	Gen-B	5-96	200	275	500	375

Time Block	Total Up Reserves from Cat#1 units (MW)
1	0
2	0
....	
10	450
....
25	450

Hot, Warm, Cold Start timings – for algorithm

Start Type	Time (in hrs)
Hot	4
Warm	8
Cold	12
Cold + revive from wet preservation	18
Cold + all units under s/d	18

Type	Time (in hrs)
Minimum Up time: Coal	12
Minimum Up time: Gas	3
Minimum Down time	4

The total time available for the revival of the unit would be the duration between the time of instruction by NLDC/RLDCs and the target time for synchronization of the unit --- typically greater than the default timings

- State Regulations surveyed
- CERC Approved Procedure for RRAS – 2016 [LINK](#)
- Generators can submit a lower time limit than specified

SCUC from Cat#2 units

- If the entire incremental reserve ($R=Z-X-Y$) requirement is not fulfilled by Cat#1 units
 - New units have to be committed from Cat#2 units
- Three-day ahead block-wise inter-state generation requirement forecasted shall be considered including Up and Down reserves
- The system security constraints and power plant constraints would be considered
- Units under USD may be selected by the NLDC algorithm to come on bar under hot, warm and cold starts
- The list of units for the next day would be broadcasted in the NLDC website every day at 1500 hrs. [Format-3\(a\)](#).
- Units with longer startup would be informed in advance on a D-2 basis at 1000 hrs. [Format-3\(b\)](#).
- Advance intimation units would be factored while preparing the additional list

SCUC Broad Algorithm

Objective function

Minimize the 3 day-ahead power plant variable operation cost. The operation costs comprise of energy cost and startup cost.

Constraints

1. Meeting the 3 day ahead forecasted demand (requisition)
2. Maintaining the required spinning reserve
3. Honouring transmission constraints
4. Must RUN/ Must OFF units
5. Capacity and Ramp constraints
6. Minimum Up Time and Minimum Down Time
7. Crew constraint

MILP based optimization program

Heat rate neglected

New Inputs from WBES

Blockwise Unit Availability considering planned/forced outages

Suitable assumptions to be made for data

Outputs [by 1500 hrs]:

1. List of units to be brought on bar (SCUC-Up flag)
2. Units scheduled to at least 55%
3. Earmark reserves in each station where unit brought on bar under SCUC to the scheduling system
4. SCUC Up/Down MW

Formats of SCUC Cat#2 units

Units required on next day

Inform @1500 hrs on 14th Sep 2023
to bring units on 15th Sep 2023

D-1

Format-3(a): List of units that are required to come on bar on the next day

Time: 1500 hrs

Date <published on D-1 basis>: DD/MMM/YYYY

For Date "D": DD/MMM/YYYY

Sno	<Station Name>#<unit number>	Unit synchronization time	Unit synchronization date
1	Gen-A#1	0000 hrs	D
2	Gen-A#2	0800 hrs	D
3	Gen-A#3	1300 hrs	D
4	Gen-B#1	1600 hrs	D

Intra-day forecasts not considered for SCUC at present

9 hrs lead time

D-2

Format-3(b): Advance intimation of the list of units that are required to come on bar on the next two days

Time: 1000 hrs

Date <published on D-2 basis>: DD/MMM/YYYY

For Date "D": DD/MMM/YYYY

Sno	<Station Name>#<unit number>	Unit synchronization time	Unit synchronization date
1	Gen-A#1	1500 hrs	D-1
2	Gen-A#2	1600 hrs	D-1
3	Gen-A#3	0100 hrs	D
4	Gen-B#1	0200 hrs	D

Units given advance intimation

Inform @1000 hrs on 14th Sep 2023 to bring units on 15th Sep 2023 and 16th Sep 2023.

36 hrs lead time

Day-ahead SCED/SCUC

LP based optimization program

- To maintain load generation balance with SCUC, and create a feasible schedule factoring requisitions
- A 96 time block multi-period day-ahead SCED run at NLDC, starting 1500 hrs
- Where SCUC stations have to be scheduled SCUC-Up, commensurate reduction shall be done as SCUC-Down
 - Subject to technical constraints, following merit order
 - Separate head in the scheduling system, "SCUC"
- If "SCUC-Up flag" is set, downward requisition blocked from 1500 hrs
- The total MW reserves after SCUC+Multi-period SCED > greater than the Reserve Requirement --- soft constraint
- $\sum_{i=1}^n SCUC = 0$
- Run @ 1500 hrs, 2315 hrs
- Real time SCED takes over...

Key Inputs:

1. Unit commitment status
2. Earmarked Reserves
3. Changes in requisitions

Outputs:

1. SCUC Up/Down MW
2. Look-ahead feasible schedule

SCUC Support summary

- SCUC support will ensure the below from 1500 hrs of D-1
 - Schedule generator up to technical minimum (55%*Normative IC)
 - Reserves earmarked and blocked from sale/requisition
 - Downward revision restricted up to TM
 - Upward revision allowed upto DConbar-reserves earmarked
- SCUC units would be intimated twice daily to come on bar - @1000 hrs & @1500 hrs
 - 1000 hrs list is for advance intimation based on 1500 hrs of D-2 data
 - 1500 hrs list would be based on D-1 data, and would factor the 1000 hrs list
- Day-ahead multi-period SCUC/SCED will provide look-ahead schedules for the next day

Unit Shut Down (USD)

- T-GNA exigency buy-sell
- RTM buy-sell

- Units not brought on bar under SCUC
 - Operate at a level below the minimum turn down level or
 - Go under Unit Shut Down (USD)
- In case a generating station opts to go under unit shut down (USD) --- “arrange supply”
 - Obligation to supply its beneficiaries who had made requisition before 1530 hrs
 - by entering into a contract(s); or by arranging supply from any other generating station or unit thereof owned by such generating company; or
 - **rely on SCED** for arranging the schedule 30 minutes before dispatch
- The power scheduled from alternate supplier shall be reduced from the schedule of the generating station.
- In case of emergency conditions, for reasons of grid security, units under USD may be directed by NLDC/RLDCs to come on bar **Format-3(a) or Format-3(b).**
- Reserve quantum earmarked in units brought on bar under SCUC shall be used only by NLDC
 - Shall not be available for requisition by beneficiaries or sale by generating station

Security Constrained Economic Despatch (SCED)

- SCED shall run after RTM, 30 minutes before the actual dispatch period
 - Block by block SCED run every 15 minutes
 - After gate closure and RTM energy market clearing
 - SCUC-Up and SCUC-Down shall be evaluated/re-adjusted for every generator
 - ❖ Factoring the up revision by the beneficiaries, and
 - ❖ Any market sale transactions by the generator
- Generators to declare the energy charge, or the SCED Compensation Charge
- The objective function and the constraints for SCED similar to pilot project
- USD plants to submit standing consent to NLDC before gate closure for arranging supply
 - $P_{max} = \text{Schedule}$.
 - $P_{min}=0$
- NLDC shall accommodate USD under SCED subject to
 - Availability of reserves
 - Only If the energy charge or SCED Compensation Charge, is higher than that of the marginal generating station of SCED
 - To encourage generator to use market avenues, interlock to be designed in WBES
- No guarantee that SCED can provide the incremental schedule

Some Probable Scenarios for SCUC/SCED

Sno	Scenario	Requisition by Beneficiary	Obligation met from alternate source	SCUC	SCED
1	Low Requisition – Plant given SCUC-Up	<ul style="list-style-type: none"> • Yes – obligation met • Reserve locked • Down revision locked • Up revision allowed 	<ul style="list-style-type: none"> • No 	✓	✓
2	Previously under USD-Plant given SCUC-Up	<ul style="list-style-type: none"> • Yes-obligation met • Reserve locked • Down revision locked • Up revision allowed 	<ul style="list-style-type: none"> • No 	✓	✓
3	Low Requisition – Plant goes under USD Off bar DC	<ul style="list-style-type: none"> • No –obligation not met • Down revision allowed • Up revision allowed (up to 1530 hrs D-1) 	<ul style="list-style-type: none"> • Yes • Match requisition from alternate source 	X	✓
4	Unit Tripping DC not zero	<ul style="list-style-type: none"> • Yes- obligation not met • No revision allowed 	<ul style="list-style-type: none"> • Yes • Block change in requisition 	X	X
5	Unit Tripping DC = 0	<ul style="list-style-type: none"> • No revision allowed • No requisition, no schedule 	<ul style="list-style-type: none"> • No 	X	X

Accounting and Settlement

- SCUC - Deviation and Ancillary Services Pool Account.
 - Scheduling head "SCUC" would be used
 - Pay to the pool or receive from the pool @ energy charge
- SCED - SCED Pool Account
- As per the IEGC-2016 (fourth amendment) provisions [retained in IEGC-2023]
 - Startup cost settlement
 - Compensation due to Part Load Operation to be paid for SCUC and SCED
- SCED benefits sharing mechanism 50 (Beneficiaries) : 50(Sellers)
 - × 7 paise/kWh cap removed – for generator
 - × 60:40 split for SCED Up/Down removed – for generator

Thank You

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