

**Power System Operation Corporation Ltd.
National Load Despatch Centre (NLDC), New Delhi**

Dated: 18th April 2019

To: All SCED Generators
MS NRPC / WRPC / SRPC / ERPC / NERPC

Through: NRLDC / WRLDC / SRLDC / ERLDC / NERLDC

Reference: NLDC Communication dated 7th April 2019

Subject: Implementation of SCED Pilot – Fine Tuning of the SCED process and Issuance of Revised SCED Procedures

In compliance to the CERC Order dated 31st Jan 2019 in Petition No. 02/SM/2019, the Pilot on Security Constrained Economic Despatch (SCED) for Inter State Generating Stations pan India, was operationalized from 1300 Hrs on 01st April, 2019.

In the previous NLDC communication dated 7th April 2019, various complexities in terms of scheduling changes, synchronization of data, challenges in communication etc. were mentioned. A number of measures have been taken during the last few days to address these issues. The SCED program generates savings by increasing cheaper generation and decreasing costly generation wherever and whenever feasible honouring the given constraints including transmission constraints. However, infeasibility is always a possible outcome when solving an optimization problem and handling this in real time is a challenging task. Feedback is being received from the generators that sometimes the results appear to be counter intuitive. Such a situation generally arises in cases where adequate ramp is not available to meet the change in the schedules from one block to the next block. This in turn, leads to a case of solving an optimization problem with an infeasible solution.

In order to address these concerns and based on operational experience gained, the optimization algorithm has been improved so as to make it more robust to deal with infeasibility and ride through within the given constraints in real time. The updated version of the software has been deployed with effect from 14:45 hours of 18th April 2019.

SCED algorithm uses the net of regional transfer capability for the transmission constraint. However, the present scheduling methodology uses inter-regional scheduling on a corridor wise basis e.g., WR-SR, ER-NR, etc. Moreover, scheduling on the net of regional basis also requires implementation of the National DSM Pool for settlement which is yet to be done. Hence, in order to facilitate incorporation of the distribution of SCED schedules on the inter-regional corridors (para 9.2) and incorporate improvements in the algorithm (para 7.7), a revised version of the detailed SCED Procedures is hereby enclosed.

Regards,


18/04/19

(Debasis De)

Chief General Manager (I/c), NLDC

Copy: Secretary, CERC

Power System Operation Corporation Ltd.
National Load Despatch Centre (NLDC)



Procedure for Pilot
on
Security Constrained Economic Despatch for
Inter State Generating Stations pan India

Prepared in Compliance

to

CERC Order dated 31st January 2019

in

Petition No. 02 /SM/2019 (Suo-Motu)

Revision – 1: 18th April 2019

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1. Preamble

- 1.1. This Procedure is issued in compliance to CERC order dated 31st January 2019 in Petition No. 02/SM/2019 (Suo-Motu) in the matter of Pilot on Security Constrained Economic Dispatch (SCED) of Inter-State Generating Stations (ISGS) Pan India, hereinafter referred to as "**SCED Pilot**".
- 1.2. The objective of SCED is to optimize the despatch of the generation resources at inter-state level which are participating in the SCED Pilot and reduce the overall variable charges for production of electricity. The implementation of SCED is a step towards introduction of optimization techniques in the despatch processes at inter-state level in the Indian Power System.
- 1.3. All the words and expressions used in the Procedure shall have the same meaning as assigned to them in various CERC Regulations.
- 1.4. This procedure would be applicable during the period of implementation of SCED Pilot w.e.f **01st April 2019**.

2. Objective

- 2.1. The objective of the procedure is to lay down the roles, responsibilities, scheduling, despatch, accounting and settlement methodologies to be followed by the National Load Despatch Centre (NLDC), Regional Load Despatch Centres (RLDCs), State Load Despatch Centres (SLDCs), Regional Power Committees (RPCs), ISGS in the implementation of the SCED.

3. Scope

- 3.1. The Procedure shall be applicable to all the thermal ISGS that are regional entities participating in the Reserve Regulation Ancillary Services (RRAS) mechanism and whose tariff is determined or adopted by the CERC for their full capacity, hereinafter, referred to as **"SCED Generators"**. The SCED Generators would exclude multi-fuel based (gas stations using domestic gas, RLNG, liquid fuels) ISGS to begin with. The multi-fuel ISGS stations are being excluded in the pilot project as one physical station is using multiple fuel types (domestic gas, RLNG, liquid fuels) and therefore, there is an added complexity on account of unit commitment/open or closed cycle operation to be factored in real time.
- 3.2. The Procedure shall also apply to CTU, SLDCs, RLDCs, NLDC and RPCs.
- 3.3. The SCED Pilot envisages optimization for a despatch period of one time block of 15 minutes at a time repeated every 15-minutes over the day for 96 time blocks.

4. Role of National Load Despatch Centre (NLDC)

- 4.1. NLDC would develop and implement requisite software applications for the SCED Pilot and update it from time to time for all the SCED Generators honouring the existing scheduling practices prescribed in the Indian Electricity Grid Code (IEGC).
- 4.2. NLDC would run the SCED software application to generate the SCED schedules (up/down) for the SCED Generators and communicate the same to the RLDCs for incorporation in the schedules.
- 4.3. NLDC would maintain and operate a separate bank account in the name of "National Pool Account (SCED)" for settlement of payments to/from the SCED Generators.

- 4.4. NLDC would prepare a consolidated all India statement (daily/weekly/monthly) indicating the schedules on account of SCED.
- 4.5. NLDC would issue a consolidated "National SCED Weekly Statement" indicating the payment and receipts to/from all SCED generators which would be made available to the stakeholders through the NLDC website.

5. Role of Regional Load Despatch Centres (RLDCs)

- 5.1. The respective RLDCs would incorporate the SCED schedules as received from NLDC and maintain the relevant scheduling data during the operation of the SCED pilot (including but not limited to generating station-wise installed capacity, declared capacity, schedule, Un-Requisitioned Surplus (URS), generator wise Variable cost, RRAS, SCED schedules for up/down and requisitions from the generating stations).
- 5.2. The reconciliation of schedules on account of SCED would be done by RLDCs with the data provided by NLDC before forwarding to RPCs.

6. Role of Regional Power Committees (RPCs)

- 6.1. The RPCs would issue weekly SCED accounts along with the DSM, RRAS, FRAS and AGC accounts based on the data provided to them by the RLDCs.
- 6.2. The RPCs would issue monthly "Statement of Compensation due to Part Load Operation on Account of SCED" separately in its accounts for all SCED generators.

7. Scheduling & Despatch of ISGS under SCED

- 7.1. The existing schedule & despatch procedure in accordance with IEGC (*Part 6 - Scheduling and Despatch Code*) would continue for all entities.
- 7.2. NLDC would prepare the SCED schedules based on the following data:

- 7.2.1. Normative On bar declared capability
- 7.2.2. Injection schedule (latest revision)
- 7.2.3. Ramp Rates (as declared in RRAS)
- 7.2.4. Variable Charges (as declared in RRAS)
- 7.2.5. Technical Minimum (as per IEGC provisions)
- 7.2.6. Inter-Regional Transfer Margins

The Mathematical Formulation of the Economic Despatch Model used for SCED procedure is enclosed at **Annexure - I**.

- 7.3. A schematic of scheduling under SCED Procedure is placed at **Annexure - II** for better clarity and understanding.
- 7.4. The SCED software program would consider only the units on bar and unit commitment is not envisaged. Further, SCED would run after all schedule revisions as per the allowable time lines have been incorporated by the RLDCs and RRAS despatched by NLDC.
- 7.5. The SCED schedules, with the increment (up)/decrement values (down), for each SCED Generator in a particular time block would be intimated by NLDC to respective RLDCs, normally about one-time block in advance.
- 7.6. Triggering in of the SCED optimization (smooth take-off) and reverting to normal schedules (smooth landing) in case of any interruption of SCED algorithm due to any reason are issues that need to be taken care of.

The triggering in of the SCED optimization algorithm shall have least impact on the total schedules if at the time of triggering in, the schedules of the generators are close to optimized schedules. This would generally be the situation during peak hours. Likewise, in the case of an interruption, the impact of safe landing would be minimized with the generators reverting gradually to the base schedules as per the ramp rates.

In case of failure or interruption of the SCED software program or a communication failure for any reason, the schedules without SCED shall

become applicable. NLDC/RLDCs shall notify the same. In such a case, the SCED Generators shall come back to their schedules without SCED schedule as per their respective ramp rate. The mismatch in schedules after accounting for the generating station's ramp rate shall be taken care in the SCED implemented schedules by RLDCs in consultation with NLDC for the affected generators. After resolving the issues leading to interruption, SCED optimization algorithm shall be triggered in again.

- 7.7. Diversity in the regional load-generation patterns has given rise to the present scope of generation optimization through SCED. However, opposing ramping requirements of different regions also impose constraints in terms of overall ramping that is required for the optimization process. This may sometimes lead to an infeasible/non-converged solution while solving the SCED optimization problem.

In the event of an infeasible/non-converged solution by the SCED optimization algorithm within the given set of constraints, the classical method of relaxation of the constraints, incrementally in steps, and/or penalizing the objective function shall be attempted in order to find an optimal solution. The lessons learnt during the pilot phase would help in improving the optimization process nuances. Such small incremental relaxation of constraint(s), required to obtain an optimal solution, shall automatically be accounted for in the SCED implemented schedules and through the National Pool Account. Higher ramping capability of the participating generators will help in improving the optimization and the above mentioned issues.

- 7.8. RLDCs would incorporate the SCED schedule in the respective SCED Generator's schedule and provide a net injection schedule.

- 7.9. SCED schedules would be treated as deemed delivered. There would be no retrospective changes in the SCED schedules except in situations as mentioned in Para 7.7 and 7.8 above.
- 7.10. The schedules of the states/beneficiaries would not be changed under SCED and the beneficiaries would continue to be scheduled based on their requisitions from different power plants as per the existing practices.
- 7.11. A virtual SCED entity, VSCED-[Region] would be created in the scheduling process of the RLDCs which shall act as a counter-party to the SCED schedules for the SCED generators. For example, in the Northern Region, VSCED-NR shall be created. The virtual SCED entity, by its very nature, is not a physical entity bounded by meters and hence, shall not form a part of the Regional DSM Pool.
- 7.12. Applicable injection and withdrawal loss will be applied to SCED schedules as per the existing scheduling practice.
- 7.13. The URS available due to Regulation of Power Supply provisions as per the CERC Regulations would also be used for SCED procedure similar to RRAS.
- 7.14. The SCED Generator whose scheduling has been restricted due to transmission constraints shall be excluded from the SCED optimization process to begin with. However, later these stations can also be considered in the SCED optimization algorithm with revised constraints (maximum/minimum generation limits) for despatch. The concerned RLDC shall inform NLDC about such generators.

8. Data and Voice Communication

- 8.1. All SCED Generators would ensure the availability of real time updated data to the RLDCs. CTU would ensure reliable communication between the respective SCED Generators and RLDCs and between RLDCs and NLDC.

- 8.2. RLDCs would provide information related to SCED schedules of SCED Generators on their websites. The data display on RLDCs Website (for each SCED Generator) would be as per **Format SCED1**.

9. Energy Accounting & Settlement

- 9.1. Energy Accounting for SCED optimized schedules shall be done by the respective RPC on weekly basis along with the DSM, RRAS, FRAS and AGC accounts based on the data provided to them by RLDCs.
- 9.2. SCED schedules are also required to be incorporated in the inter-regional schedules for each region and accordingly, NLDC shall compute the impact of SCED schedules on the inter-regional schedules for all regions. The incremental change in the inter-regional schedules shall be communicated by NLDC to the respective RLDCs for incorporation in the net inter-regional schedules being given to the RPCs for the purpose of accounting.
- 9.3. NLDC would prepare a consolidated all India statement, daily/weekly/monthly indicating the schedules on account of SCED.
- 9.4. The variable charges (paise/kWh) declared by the generators for the purpose of Reserve Regulation Ancillary Services (RRAS) shall be considered in the SCED procedure.
- 9.5. NLDC would maintain and operate a separate bank account in the name of "National Pool Account (SCED)" for payments to/receipts from the SCED Generators. The details of the bank account would be displayed on the NLDC website.
- 9.6. For any decrement in schedule of SCED Generator due to SCED, the SCED Generator shall pay to the 'National Pool Account (SCED)' for the decrement in generation at the rate of its variable charges.

- 9.7. For any increment in schedule of SCED Generator due to SCED procedure, the SCED generator would be paid from the 'National Pool Account (SCED)' for the incremental generation at the rate of its variable charges.
- 9.8. The payments/receipts by/to the SCED Generators would be based on the **"Regional SCED Weekly Statement" (Format SCED2)** issued by the RPCs and the consolidated **"National SCED Weekly Statement" (Format SCED3)** issued by NLDC respectively. No separate bills shall be raised for this purpose.
- 9.9. NLDC would issue a consolidated **"National SCED Weekly Statement"** comprising of payment and receipts to/from all SCED Generators based on the Regional SCED Weekly Statements issued by the RPCs.
- 9.10. The concerned SCED Generator would pay the indicated charges for SCED decrement within seven (07) working days of the issue of statement of SCED by the RPC to the 'National Pool Account (SCED)'. Payments against SCED shall not be adjusted against any other payments by the SCED Generator.
- 9.11. The concerned SCED Generator shall be paid the indicated charges for SCED increment within ten (10) working days of the issue of consolidated **"National SCED Weekly Statement"** by the NLDC from the 'National Pool Account (SCED)'.
- 9.12. If payments by the SCED Generator, due under the SCED, are delayed beyond seven (7) working days from the date of issue of the **"Regional SCED Weekly Statement"** by the RPCs, the defaulting SCED Generator shall pay simple interest @ 0.04% for each day of delay.
- 9.13. If payments to the SCED generator, due under the SCED are delayed beyond ten (10) working days from the date of issue of the consolidated **"National SCED Weekly Statement"** by NLDC, the SCED Generator shall be paid simple interest @ 0.04% for each day of delay.
- 9.14. The RPCs would issue monthly "Statement of Compensation due to Part Load Operation on Account of SCED" (**Format SCED4**). The compensation for heat rate degradation to the SCED generators as per the statement issued by the

RPCs would be payable from the National Pool Account (SCED) within seven (07) working days of the issue of the monthly statement by the respective RPCs.

- 9.15. NLDC would issue monthly “National Statement of Compensation due to Part Load Operation on Account of SCED” (**Format SCED5**) on the compensation to be paid to the SCED Generator for heat rate degradation, from National Pool Account (SCED) based on Format SCED4 statement issued by respective RPCs.
- 9.16. NLDC shall maintain a record of all savings on accrual basis in the ‘National Pool Account (SCED)’ on a weekly basis. As mentioned in the CERC Order, the methodology of sharing of the savings accrued in the ‘National Pool Account (SCED)’ would be decided by CERC in due course.

10. Removal of Difficulties

- 10.1. Notwithstanding anything contained in this Procedure, NLDC/RLDCs may take appropriate decisions in the interest of System Operation. Such decisions shall be taken under intimation to CERC and the procedure shall be modified/amended, as necessary.
- 10.2. In case of any difficulty in implementation of this procedure, this procedure shall be reviewed or revised by POSOCO and submitted to the CERC for information.

Mathematical Formulation of Security Constrained Economic Despatch

Objective Function

- Minimize Pan India ISGS Variable Cost

Subject to Constraints

- Meeting Total Requisition by States from ISGS
- Transmission Constraints (ATC)
- Technical Minimum of Plants
- Maximum Generation (DC-on-bar)
- Ramp up/down rates

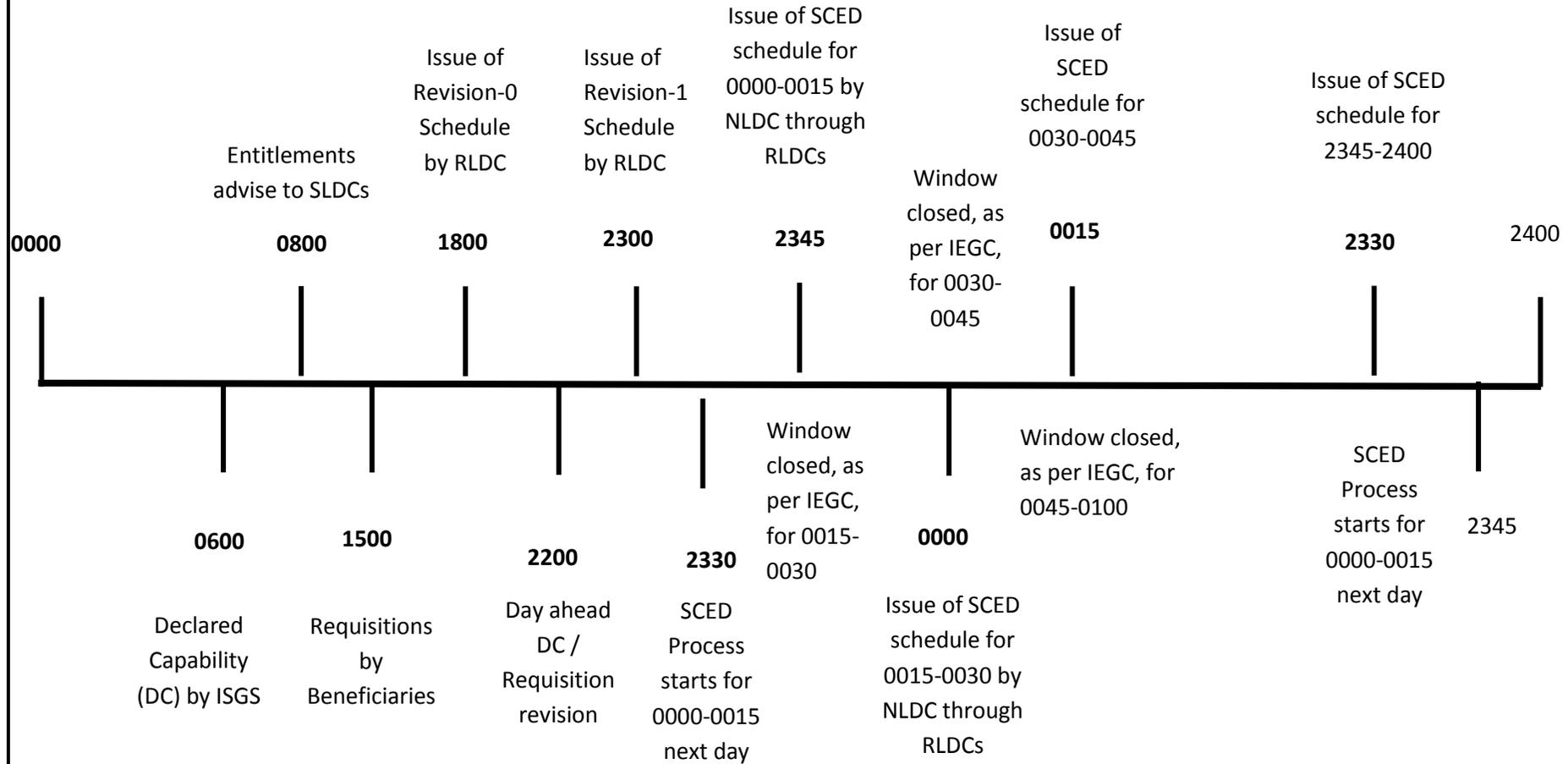
Minimise $\sum_{i=1}^k C_i P_i + \sum(\text{Violation Penalties}) \dots\dots\dots(1)$

- k = total number of Plants
- Where C_i is the variable per unit cost of the i^{th} Plant
- P_i is the optimised scheduled power of the i^{th} Plant
- *Violation Penalties* are computed based on constraint violations

Subject to

- $\sum_{i=1}^k P_i = \sum_{i=1}^k S_i - \text{Schedule violation} \dots\dots\dots(2)$
- $P_i \leq (\text{DC on bar}) \dots\dots\dots(3)$
- $P_i \geq P_{i,\text{min}} \dots\dots\dots(4)$
- $P_{i,t} \leq P_{i,t-1} + \text{Ramp up rate} + \text{Ramp up violation} \dots\dots\dots(5)$
- $P_{i,t} \geq P_{i,t-1} - \text{Ramp down rate} - \text{Ramp down violation} \dots\dots\dots(6)$
- $\forall r \in R, \sum_r (P_{i,r} - S_{i,r}) \geq \min((SCHIR_r - ATC_r), 0) - \text{ATC violation} \dots\dots(7)$
 - S -is the scheduled power
 - t -represents current time of execution
 - R -represents each of the regions viz., North, East, West, South and North East
 - ATC -is the Available Transmission Capability of each region R
 - $SCHIR$ -is the Scheduled Net Interchange of the region R
 - $P_{i,\text{min}}$ is the *technical minimum* for thermal power plants considered at 55% DC on bar or schedule whichever is less

Annexure II: Schematic of Scheduling Process under SCED Procedure





Format SCED2: ...RPC "Regional SCED Weekly Statement"

(To be issued by concerned RPC)

SCED Account For Week <<from date>> <<to date>>

***(+)** means payable from the 'National Pool Account (SCED)' to SCED Generator

/ (-) means receivable by 'National Pool Account (SCED)' from SCED Generator

S.N.	SCED Generator	Increment due to SCED scheduled to VSCED [Region] (MWHr) (A)	Decrement due to SCED scheduled to VSCED [Region] (MWHr) (B)	Charges To be Paid to SCED Generator from National Pool (SCED) (in ₹) (C) = (A) x V.C.	Charges To be Refunded by SCED Generator to National Pool (SCED) (in ₹) (D) = (B) x V.C.	Net Charges Payable (+) / Receivable (-) (in ₹) (E)* = (C) - (D)
1	SCED Generator 1					
2	SCED Generator 2					
....					
	Total					



Format SCED3: NLDC "National SCED Weekly Statement"

For Week <<from date>> <<to date>>

***(+)** means payable from the National Pool Account (SCED) to SCED Generator

/ (-) means receivable by National Pool Account (SCED) from SCED Generator

S.N.	SCED Generator	Region	Increment due to SCED scheduled to VSCED (MWHr) (A)	Decrement due to SCED scheduled to VSCED (MWHr) (B)	Charges To be Paid to SCED Generator from National Pool (SCED) (in ₹) (C) = (A) x V.C.	Charges To be Refunded by SCED Generator to National Pool (SCED) (in ₹) (D) = (B) x V.C.	Net Charges Payable (+) / Receivable (-) (in ₹) (E)* = (C) - (D)
1	SCED Generator 1	NR					
2	SCED Generator 2	WR					
....					
	Total						



Format SCED4: ...RPC "Statement of Compensation due to Part Load Operation on Account of SCED"

(To be issued by concerned RPC)

For Month:

SCED Generator	Decrement due to SCED (MWHr)	Compensation Amount Payable on account of SCED from National Pool Account (SCED) to SCED Generator (in ₹)
SCED Generator 1		
SCED Generator 2		
.....		
Total		



Format SCED5: NLDC "National Statement of Compensation due to Part Load Operation on Account of SCED"

For Month:

SCED Generator	Region	Decrement due to SCED (MWHr)	Compensation Amount Payable on account of SCED from National Pool Account (SCED) to SCED Generator (in ₹)
SCED Generator 1	NR		
SCED Generator 2	WR		
.....		
Total			