Malaysian Grid Code

Part VII: Scheduling & Dispatch Code
SDC1: Generation Scheduling

Ir. Mohd Yusrizal Mohd Yusof

Single Buyer Department

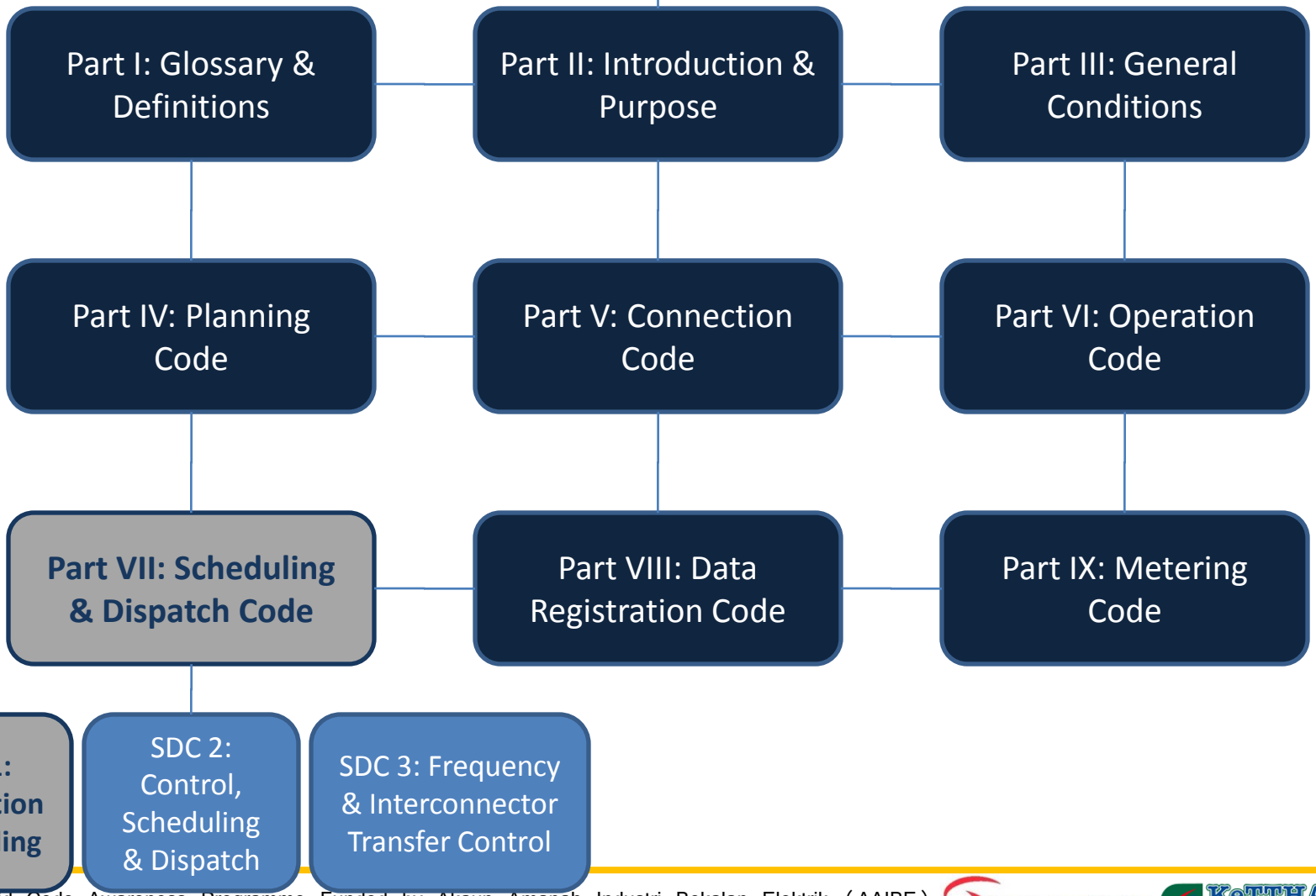
Tenaga Nasional Berhad

KeTTHA
KEMENTERIAN TENAGA, TEKNOLOGI HIJAU DAN AIR

Suruhanjaya Tenaga

The Malaysian Grid Code Awareness Programme Funded by Akaun Amanah Industri Bekalan Elektrik (AAIBE)

MALAYSIAN GRID CODE



SDC 1: Generation Scheduling

SDC 1.1 : Introduction

- Generation Scheduling : Scheduling of generators to meet demand, based on availability, parameters & cost, flexibility, transmission constraints , security and system losses
- The schedule should be based on least cost operation for the grid system within the limitations mentioned above

SDC 1: Generation Scheduling

SDC 1.1 : Introduction

No	Procedures	Affected Parties
1	Daily Availability Declaration	Generators, Single Buyer, GSO
2	SDP- Scheduling Dispatch Parameters for following Schedule Day	Generators, Single Buyer, GSO
3	Monthly, weekly, daily notification of power export availability/import request including price information	Interconnected parties, Single Buyer, GSO
4	Submission of certain network data by each User with a Network connected to the Transmission system to which Generating Units are connected (considerations for Network constraints)	Generators, Single Buyer, GSO
5	Submission of certain network data by each User with a Network connected to the Distribution Network to which Generating Units are connected (considerations for Network constraints)	Generators, Single Buyer, GSO

SDC 1: Generation Scheduling
SDC 1.1 : Introduction

No	Procedures	Affected Parties
6	The submission by Users of Demand Control information (OC4)	Generators, Single Buyer, GSO
7	Agreement on Power and Energy flows between Interconnected Parties by the Single Buyer following discussion with GSO	Generators, Single Buyer, GSO
8	The production of Least Cost Generation Schedule – unit commitment and generation Dispatch level	Interconnected parties, Single Buyer, GSO

SDC 1: Generation Scheduling

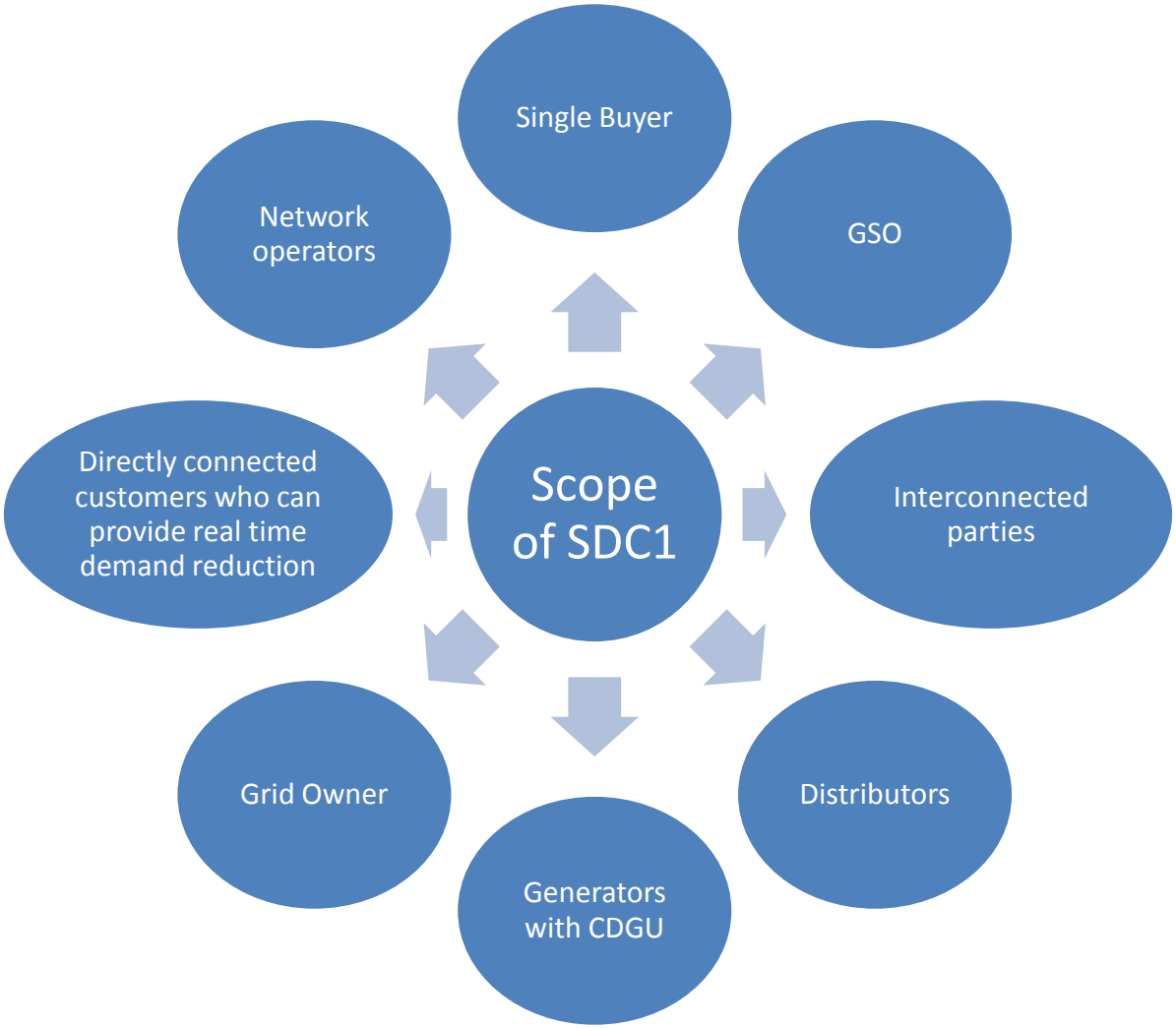
SDC 1.2 : Objectives

SDC1: To enable Single Buyer to prepare a schedule based on Least Cost Dispatch model. To include : Cost inputs, fuel constraints, hydro limitation and optimization of hydro-thermal

1. Ensures Integrity of the interconnected transmission system
2. Ensures security of supply
3. Ensures sufficient generating capacity to meet transmission system demand as often as practicable with appropriate margin of reserve
4. Enables preparation and issue of a Generation Schedule
5. Enables optimization of the total cost of Grid System operation over a specific period taking into account of scheduled and forced outages and factors 6, 7 and 8
6. Enables optimization of use of generating and transmission capacities
7. Enables use of energy from Hydro power stations to optimize system marginal cost with consideration for reservoir levels, riparian requirements and seasonal variations
8. Maintains sufficient fuel stocks, optimizes hydro reservoir depletion and meet fuel-contract requirement

SDC 1: Generation Scheduling

SDC 1.3 : Scope



SDC 1: Generation Scheduling

SDC 1.4.1 : Procedure (Applicability) : Normal Working Day

D-1 :

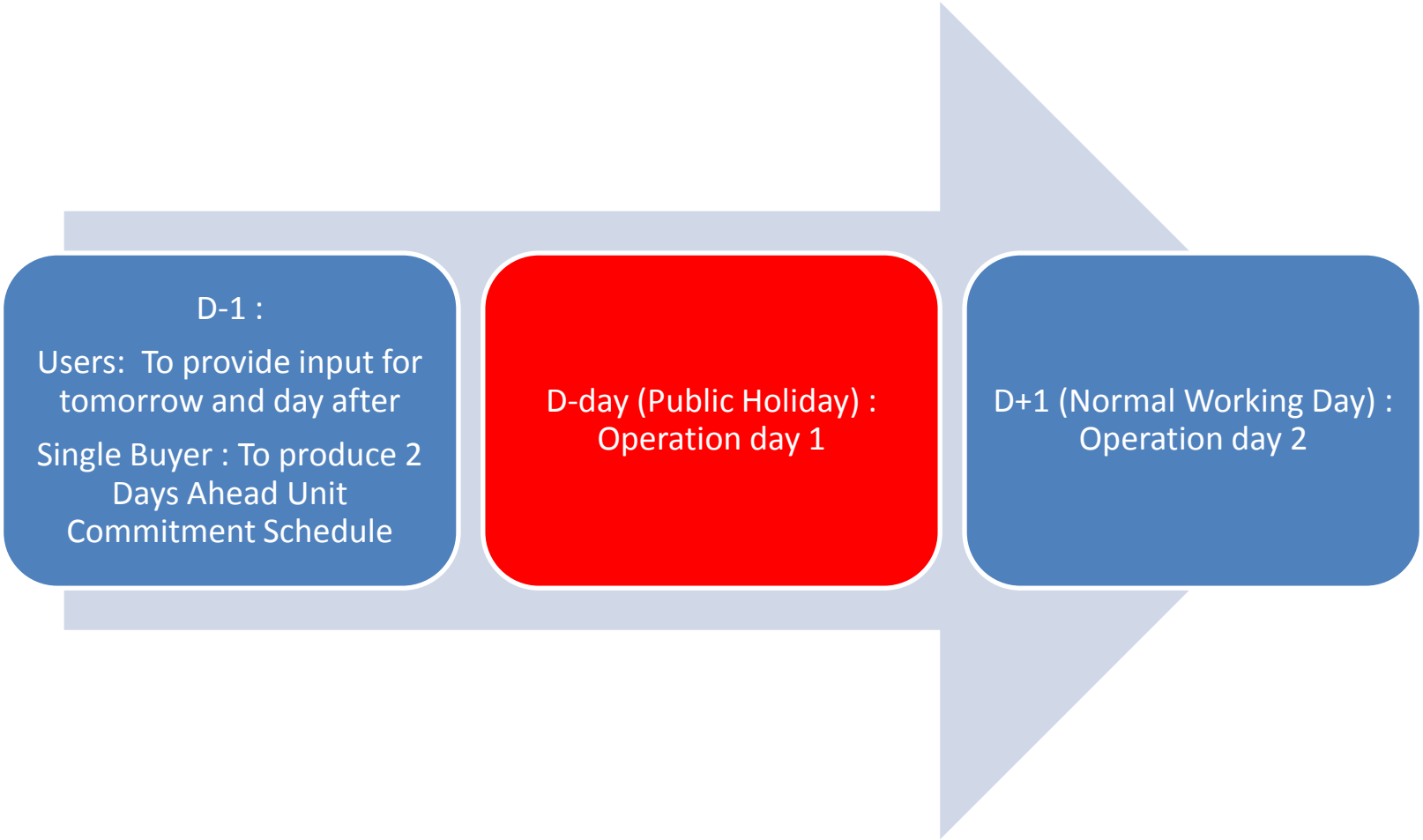
Users: To provide input for tomorrow

Single Buyer : To produce Day Ahead Unit Commitment Schedule

D-day (Normal Working Day) : Operation day

SDC 1: Generation Scheduling

SDC 1.4.1 : Procedure (Applicability) : 1 Day Public Holiday



SDC 1: Generation Scheduling

SDC 1.4.1 : Procedure (Applicability) : Weekends

D-1 :

Users: To provide input Saturday, Sunday and Monday

Single Buyer : To produce 3 Days Ahead Unit Commitment Schedule

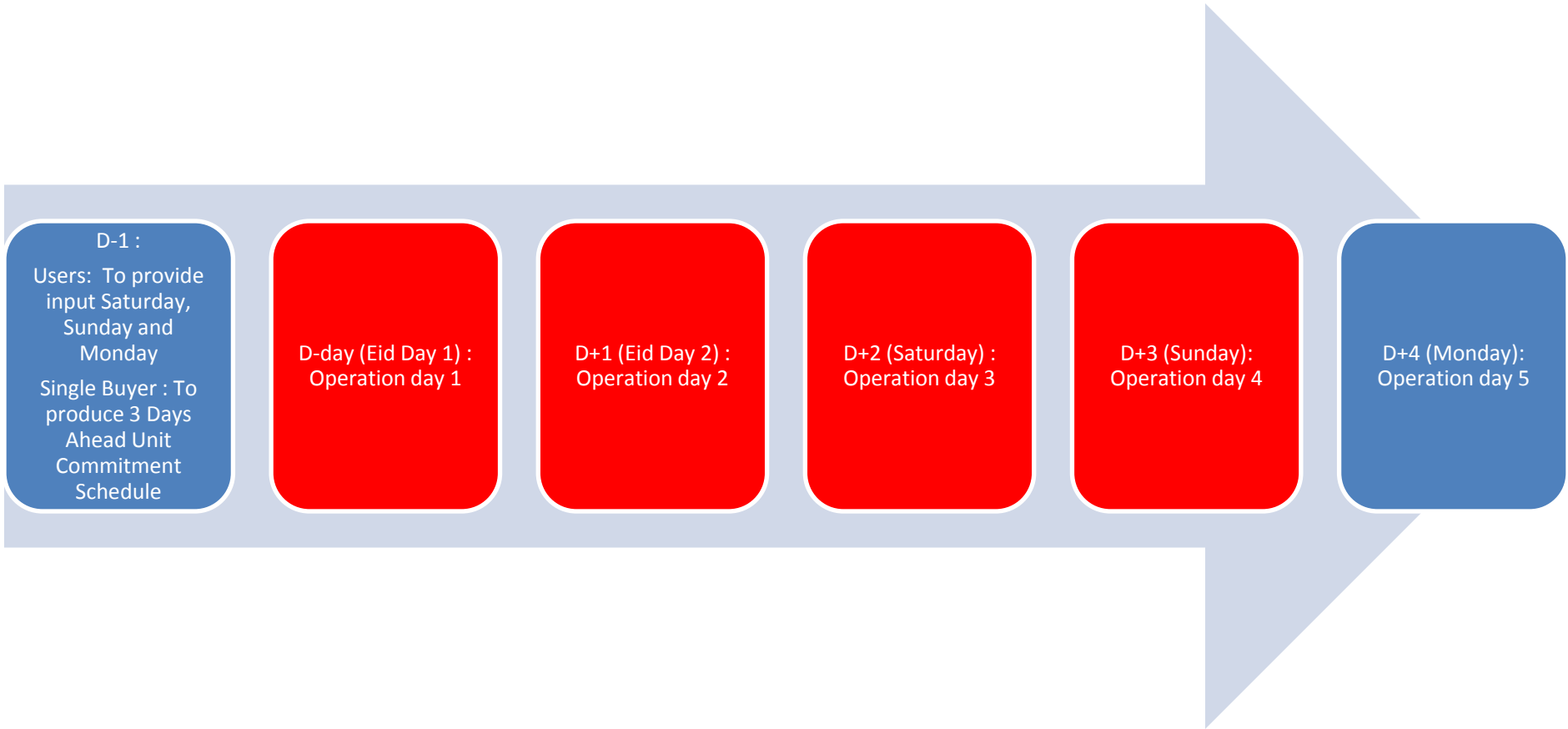
D-day (Saturday) : Operation day 1

D+1 (Sunday) : Operation day 2

D+2 (Monday) : Operation day 3

SDC 1: Generation Scheduling

SDC 1.4.1 : Procedure (Applicability) : Consecutive PHs+Weekends



Maximum of 4 non working days + 1 day after 4 consecutive non working days

SDC 1: Generation Scheduling

SDC 1.4.4: Least Cost Operation

- Day Ahead Plan: CDGUs on least system operating cost

- With considerations:
  - CDGU pricing : energy price only – fuel cost + VOR
  - Hydro Thermal optimization : hydro based on year-end lake level target.
  - Operational restriction or CDGU flexibility
  - Fuel constraints – gas, etc.
  - Max-min water-take for hydro CDGU for riparian
  - Energy export/import
  - Government fuel conservation policy
  - CDGU availability
  - Government fuel pricing policy

- Single Buyer to prepare :
  - Least cost unconstrained schedule
  - Least cost constrained schedule

SDC 1: Generation Scheduling

SDC 1.4.5: Unconstrained Schedule

SDC 1: Generation Scheduling

SDC 1.4.5: Constrained Schedule

The least cost constrained schedule will be deemed as the least cost schedule for the next day

GSO may deem it necessary to change the schedule after the issuance of the schedule due to various factors. Record of the changes should be kept by GSO for at least 12 months

SDC 1: Generation Scheduling

SDC 1.5: Other Relevant Data

- Generators to highlight risks on CDGU such as fuel supply interruption or plants problem by 1000hrs each day
- Temporary changes to Registered Data, supplementary services
- Highlight details of re-commissioning /retesting plans
- Distributors to also highlight any constraints on its network to the Single Buyer

SDC 1: Generation Scheduling

SDC 1.6: Data Validity Checking

- Availability data declaration, Generation Scheduling & Dispatch Parameters and other relevant Generator data will be checked with Data Validity and Default Rules
- Data could be automatically amended if the data do not meet the requirements of the rules
- Failure to submit data by 1000hrs on each scheduling day, could result to utilization of previous data
- User is responsible in ensuring data is up-to-date and to notify Single Buyer of any changes

SDC 1: Generation Scheduling

Daily Practice : Implementation

10 am:

1. DAD submission by all generators
2. Load Forecast submission

12 noon:

1. Submission of first draft for Daily System Security Assessment

3 pm:

1. Input from DSSA, review , ready for submission

5 pm :

1. Submission of full day ahead schedule to NLDC
2. Submission of day ahead schedule for each generator

(Day after) 8 am :

1. Updated Availability data from NORMS
2. Updated load forecast
3. Updated 8 am-12 midnight plan

(Day after) 9 am :

1. Docket meeting
2. Discuss current day and review previous day

SDC 1: Generation Scheduling

Least Cost Concept

Minimize Cost:

Cost = Generator Fuel & VOM cost

+ Generator Start Cost

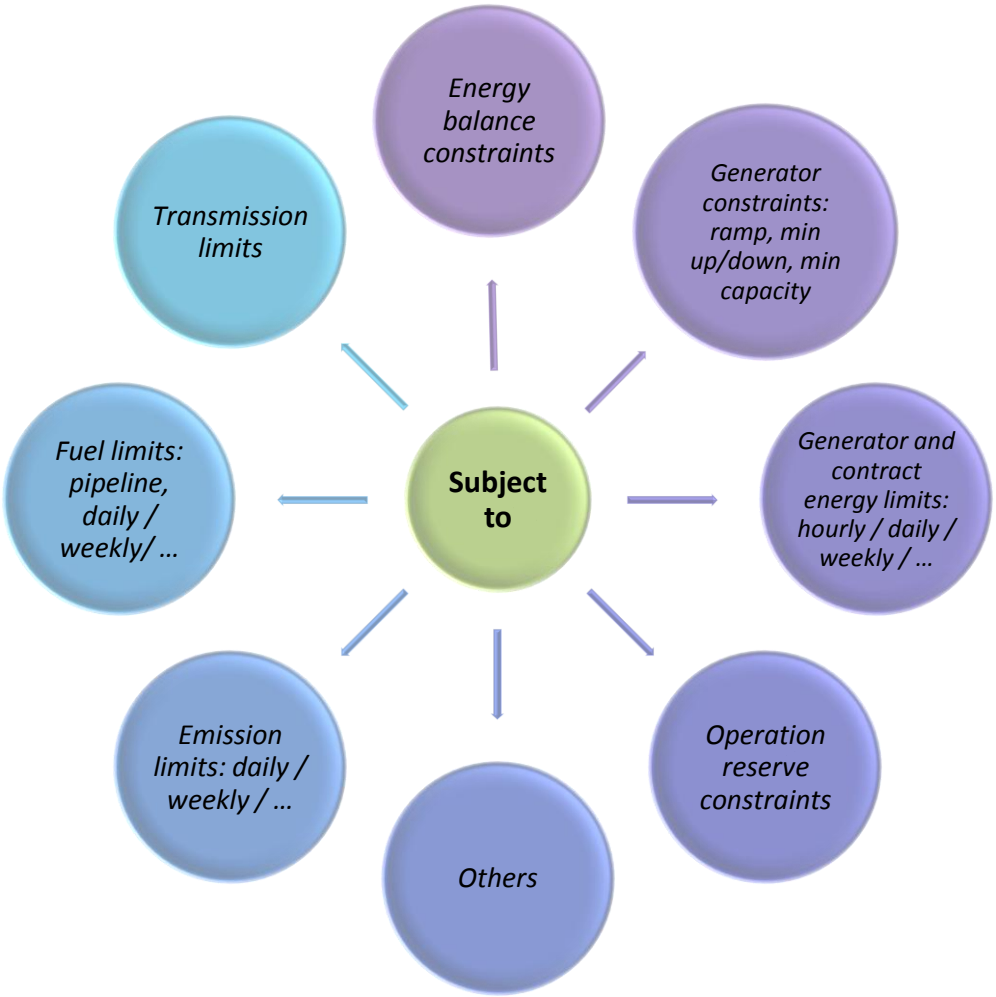
+ Contract Purchase Cost – Contract Sale Saving

+ Transmission Wheeling

+ Energy / AS / fuel / capacity market purchase cost

– Energy / AS / fuel / capacity market sale revenue

- The objective is to minimize generation cost, within various limitations/constraints
- The strategy is to pick the cheapest possible combination of generating units to serve the demand at all times



SDC 1: Generation Scheduling

Input-Output

Inputs:

- Heat Rate
- Demand forecast
- Planned/Forced Outages/Availability
- Gas Allocation
- Hydro Energy
- Scheduled commitment
- Co-generation
- Import-Export
- Energy cost (Fuel +VOR)
- Start-up cost
- Ramp-up/down rate
- Min up time, min down time
- Synchronizing time

Optimization

Outputs:

- Generation Schedule
- Gas Nomination
- Average cost
- Marginal cost

A unit commitment economic dispatch software (PLEXOS) based on mixed integer and dynamic programming method is utilized to solve this complex problem

SDC 1: Generation Scheduling

Merit Order vs. Computer Simulation

- Traditionally, merit order list is utilized as a tool for dispatching.
- With advancement in computer technology, simulation software is now available to help us solving the unit commitment and dispatching
- Merit order: A ranking list of power plants, from the lowest cost per unit to the highest cost per unit (RM/kWh) at the maximum supply level of all plants

SDC 1: Generation Scheduling

Discussion

Assume a grid system with the following units:

	Capacity	Heat rate (kJ/kWh)				VOR
Unit	MW	100%	75%	50%	25%	RM/MWh
A1	50	10100	10500	11200	NA	13.0
A2	40	10700	11200	11700	NA	13.5
B1	35	7700	8100	8600	NA	19.8
B2	40	7000	7600	8000	8200	16.2
C1	15	12000	12360	12731	15000	12.0
C2	15	11000	11330	11670	13800	11.5
D1	12	12500	12875	13261	14600	10.0
D2	10	10600	10918	11246	11583	11.0
D3	12	12500	12875	13261	14600	12.5
Total capacity	229					

SDC 1: Generation Scheduling
Discussion

The total energy cost = Fuel + VOR are as follows:

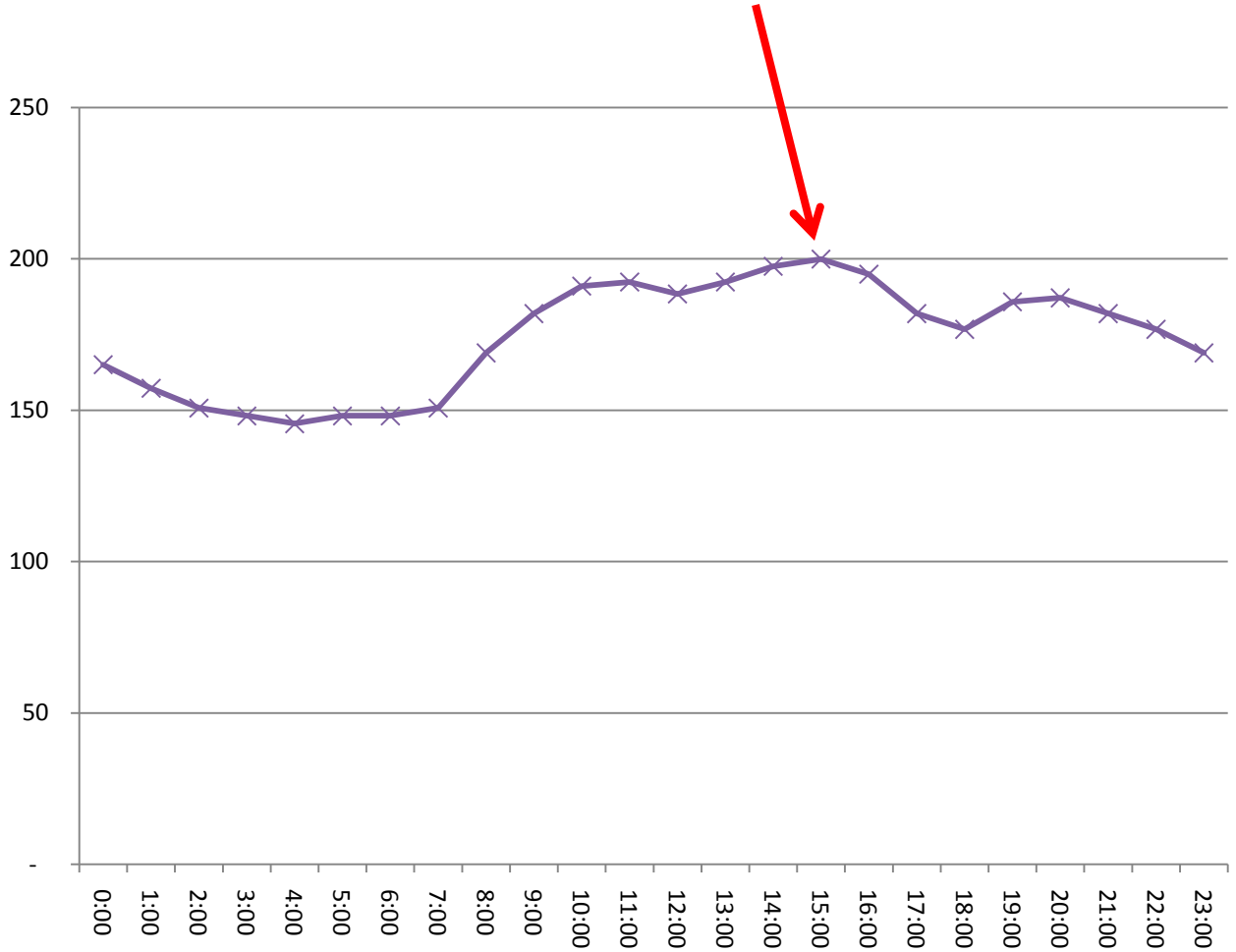
	Capacity	RM/mmbtu		Fuel cost/kWh				Energy cost/kWh			
Unit	MW	Fuel	fuel price	100%	75%	50%	25%	100%	75%	50%	25%
A1	50	coal	14.38	0.14	0.14	0.15	0.00	0.15	0.16	0.17	0.00
A2	40	coal	16.00	0.16	0.17	0.18	0.00	0.18	0.18	0.19	0.00
B1	35	gas	25.00	0.18	0.19	0.20	0.00	0.20	0.21	0.22	0.00
B2	40	gas	25.00	0.17	0.18	0.19	0.19	0.18	0.20	0.21	0.21
C1	15	gas	25.00	0.28	0.29	0.30	0.36	0.30	0.30	0.31	0.37
C2	15	gas	25.00	0.26	0.27	0.28	0.33	0.27	0.28	0.29	0.34
D1	12	gas	25.00	0.30	0.31	0.31	0.35	0.31	0.32	0.32	0.36
D2	10	gas	25.00	0.25	0.26	0.27	0.27	0.26	0.27	0.28	0.29
D3	12	gas	25.00	0.30	0.31	0.31	0.35	0.31	0.32	0.33	0.36

The Merit Order list is as follows:

	Capacity	Total cost
Unit	MW	RM/kWh
A1	50	0.15
A2	40	0.18
B2	40	0.18
B1	35	0.20
D2	10	0.26
C2	15	0.27
C1	15	0.30
D1	12	0.31
D3	12	0.31

SDC 1: Generation Scheduling
Discussion

Assume system demand as follows (200 MW MD at 1500hrs):



SDC 1: Generation Scheduling
Discussion

Dispatch based on merit order:

Unit	MW Dispatched	Capacity	Energy Cost/kWh	Total Cost
A1	50	50	0.151	7533.67
A2	40	40	0.176	7031.00
B2	40	40	0.182	7283.07
B1	35	35	0.202	7079.26
D2	10	10	0.262	2621.85
C2	15	15	0.272	4082.45
C1	10	15	0.314	3140.00
Total	200			38771.30

Cost = RM0.314/kWh @67% capacity

Second option (pick D1 instead of C1):

Unit	MW Dispatched	Capacity	Energy Cost/kWh	Total Cost
A1	50	50	0.151	7533.67
A2	40	40	0.176	7031.00
B2	40	40	0.182	7283.07
B1	35	35	0.202	7079.26
D2	10	10	0.262	2621.85
C2	15	15	0.272	4082.45
D1	10	12	0.305	3050.00
Total	200			38681.30

Cost = RM0.305/kWh @83% capacity

Savings of 0.2% of the total cost

Although Merit Order could still be used as an indication tool, utilization of software will allow various combinations to be assessed, hence resulting to a better cost optimization

SDC 1: Generation Scheduling

Future plan

- Single Buyer will reconfirm on all generators submission for the purpose of updating the software
- We will also request for additional outstanding inputs, start-up time, ramp-up/down, minimum stable operating level etc. (within the limits specified under the Malaysian Grid Code)
- We request full co-operation from all generators to ensure correct data, hence resulting to better modeling
- Inputs to improve our processes are always welcomed
- Our aim is to optimize the total system cost and prepare a useable schedule for GSO
- Having a good plan will allow us to anticipate future problems better, hence preparing a contingency plan well ahead to ensure lights is always on.

THANK YOU

mmohdyus@ tnb.com.my

KeTTHA
KEMENTERIAN TENAGA, TEKNOLOGI HIJAU DAN AIR

Suruhanjaya Tenaga

The Malaysian Grid Code Awareness Programme Funded by Akaun Amanah Industri Bekalan Elektrik (AAIBE)

Please use white font colour here

Items	ICON
General Conditions	 or 
Planning Code	 
Connection code	
Operating Code	

Please use white colour font here

Items	ICON
Scheduling & Dispatch	
Data Registration	
Metering	 or