Schedule and Dispatch Codes

Also include Metering Codes

16 June 2014

Sabah dan Labuan Grid Code Awareness Programme Funded by Akaun Amanah Industri Bekalan Elektrik (AAIBE)

Objectives

- To provide awareness about the Sabah & Labuan Grid Codes.
- To understand the Electricity Supply Industry (ESI) structure of Sabah
- To facilitate cooperation within all grid participants to realize safe, reliable and economic operation of the grid system
- To understand compliance and derogation issues

Dispatch Code

- Schedule and Dispatch Plan
- Control, Schedule and Dispatch
- Frequency and Transfer Control

SDC1. SCHEDULING AND DISPATCH CODE NO. 1

SDC1 sets out the procedure for;

(a) The weekly notification by the **Power Producers to the LDC of the Availability of** any of their **CDGU in an Availability Notice;**

(b) the daily notification to the **LDC** of whether there is any **CDGU** which differs from the last Generating Unit Scheduling and Dispatch Parameters (SDP), in respect of the following Schedule Day by each Power Producer in a SDP Notice;

(c) The weekly notification of **Power export availability or import requests and price** information by **Interconnected Parties to the Single Buyer;**

(d) the submission of certain **Network data to the LDC,** by each Network Operator or User with a Network directly connected to the Transmission Network to which Generating Units are connected *(to allow consideration of Network constraints*);

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SDC1. SCHEDULING AND DISPATCH CODE NO. 1 (cont…)

(e) the submission of certain Network data to the **LDC,** as applicable by each Network Operator or User with a Network directly connected to the Distribution Network to which Generating Units are connected (*to allow consideration of distribution restrictions*);

(f) the submission by **Network Operators and Users to the LDC of Demand Control** information (in accordance with OC4);

(g) agreement on Power and Energy flows between Sabah or Labuan and Interconnected Parties by the Single Buyer following discussions with the GSO;

(h) the production of a **Merit Order and Energy Balance Statement, to include the Transfer Level, for use in the production of the schedules;**

(i) the production by the **GSO** in consultation with the Single Buyer of the schedule**,** based on the **Merit Order and Energy Balance Statement and subsequent issue** by the **GSO** of an **Indicative Running Notification (IRN) on a weekly basis** as a statement of which **CDGU** may be required. Amendments to this **IRN** to be delivered on a daily basis as described in SDC1.4.

SDC1.2 OBJECTIVES

To enable the **Single Buyer and GSO to prepare a schedule based on a least cost dispatch model** (or models) which, amongst other things, models variable costs, fuel take-or-pay costs and reservoir contents change and river flow rates and allows hydro/thermal optimisation and is used in the Scheduling and Dispatch process and thereby ensures:

(a) the integrity of the interconnected Power System**;**

(b) the security and quality of supply;

(c) that there is sufficient available generating Capacity to meet Power System Demand as often as is practicable with an appropriate margin of reserve;

(d) to enable the preparation and issue of an **Indicative Running Notification;**

(e) optimise the total cost of Power System operation**;**

SDC 1 Objectives cont…

(f) optimum use of generating and transmission capacities;

(g) maximum possible use of **Energy from hydro-power stations taking due account** of river flow rates and reservoir contents and seasonal variations, and which is based upon long term water inflow records and provides an 80% probability level of achievement; and

(h) to maintain sufficient solid and liquid fuel stocks and optimise hydro reservoir depletion to meet fuel-contract minimum-take by the end of the calendar year and in accordance with monthly nominations.

This schedule contains the **Merit Order** which details those CDGUs that will be loaded, in accordance with their league table position in the Merit Order, to meet incremental blocks of Demand across specified time periods. Thus base load, mid range, peak loading and Operating Reserve will be specified, amongst other things.

Illustration of Unit Commitment

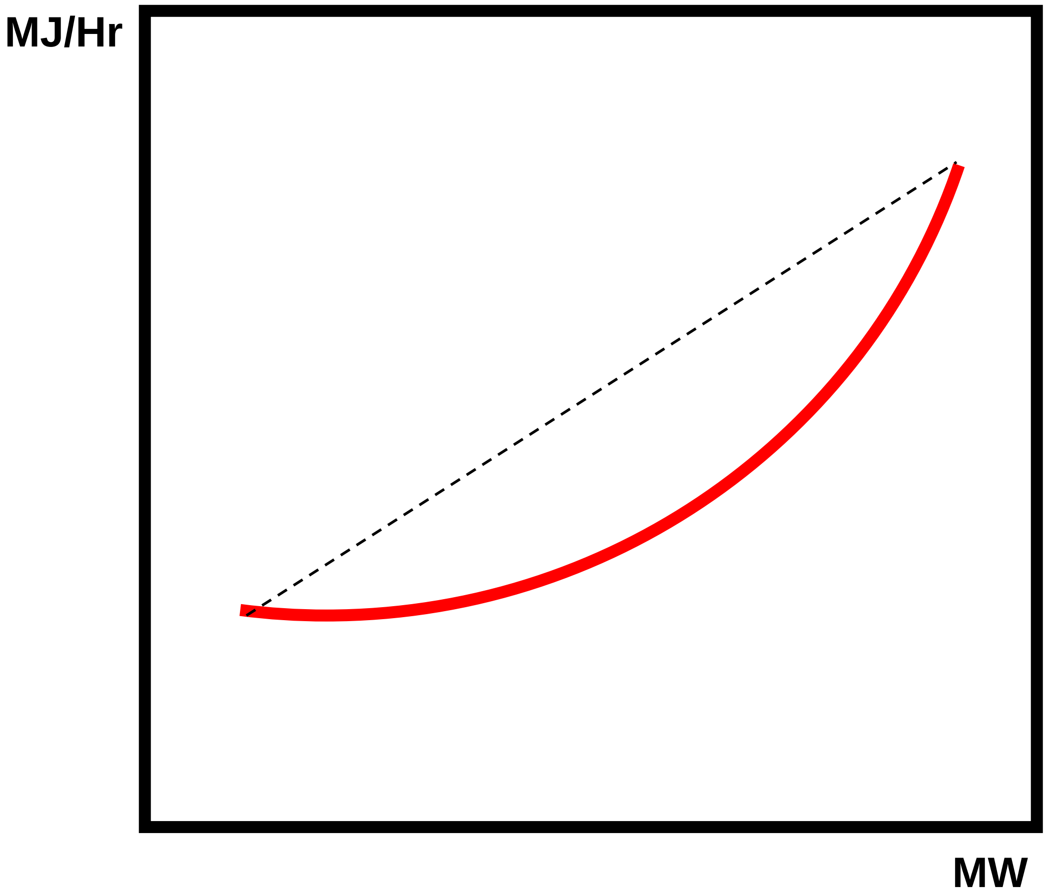
- Heat Rate
- Unit Commitment
- Process of unit commitment

Generator Cost Curves

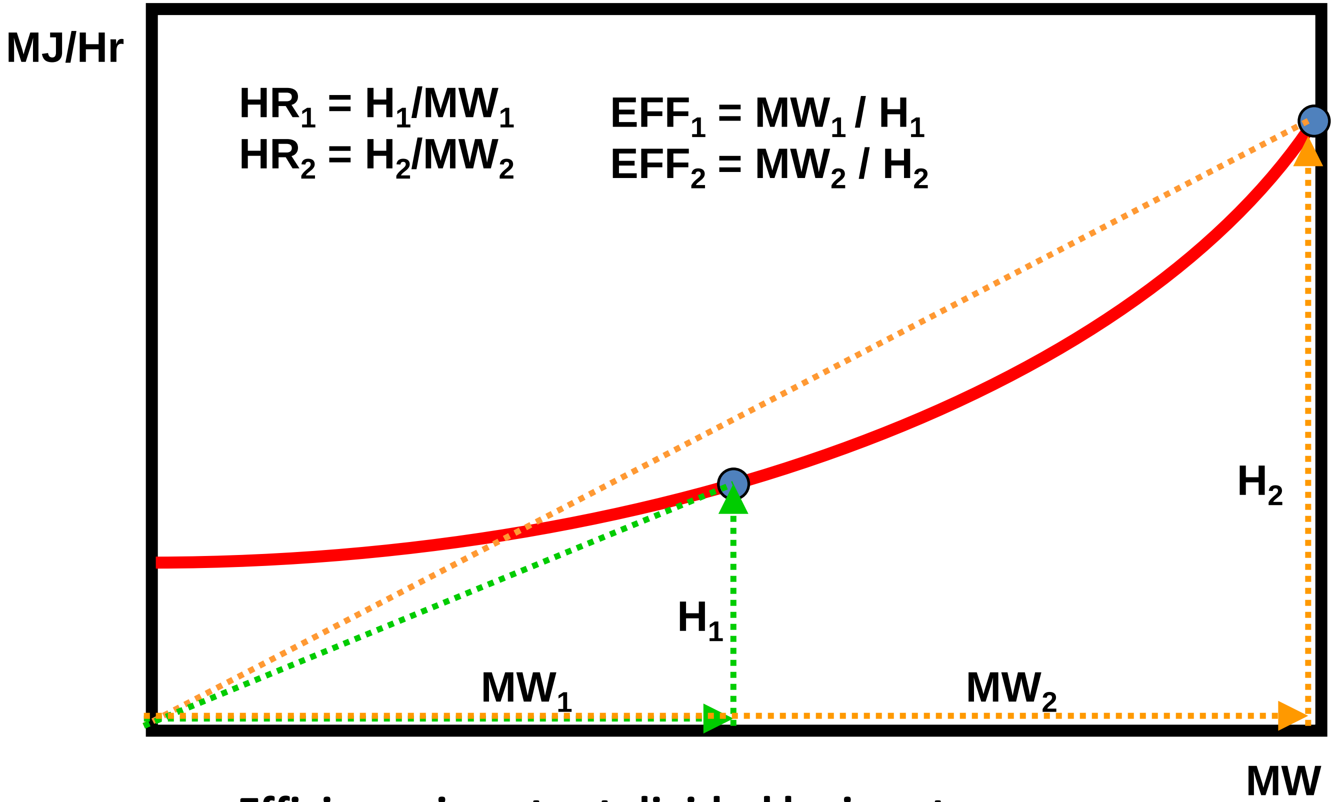
- **Input-output (IO) curve**:
  - Shows relationship between MW output and energy input in Mbtu / hr (or MJ/hr)
- **Fuel-cost curve:**
  - Input-output curve scaled by a fuel cost expressed in $ / Mbtu (or $/MJ)
- **Heat-rate curve:**
  - Shows relationship between MW output and energy input (Mbtu / MWhr or MJ/MWhr)
- **Incremental (marginal) cost curve:**
  - Shows the cost to produce the next MWhr

Input – Output Curve

- The I/O Curve describes the fuel input heat energy to the plant in MJ/Hr or MBTU/Hr, versus the output energy in MW.



Heat Rate



- **Efficiency is output divided by input**
- **Heat Rate is input divided by output**

Heat Rate = (MJ/Hr)/MW =1 /(MWHr/MJ)
=1/ Efficiency

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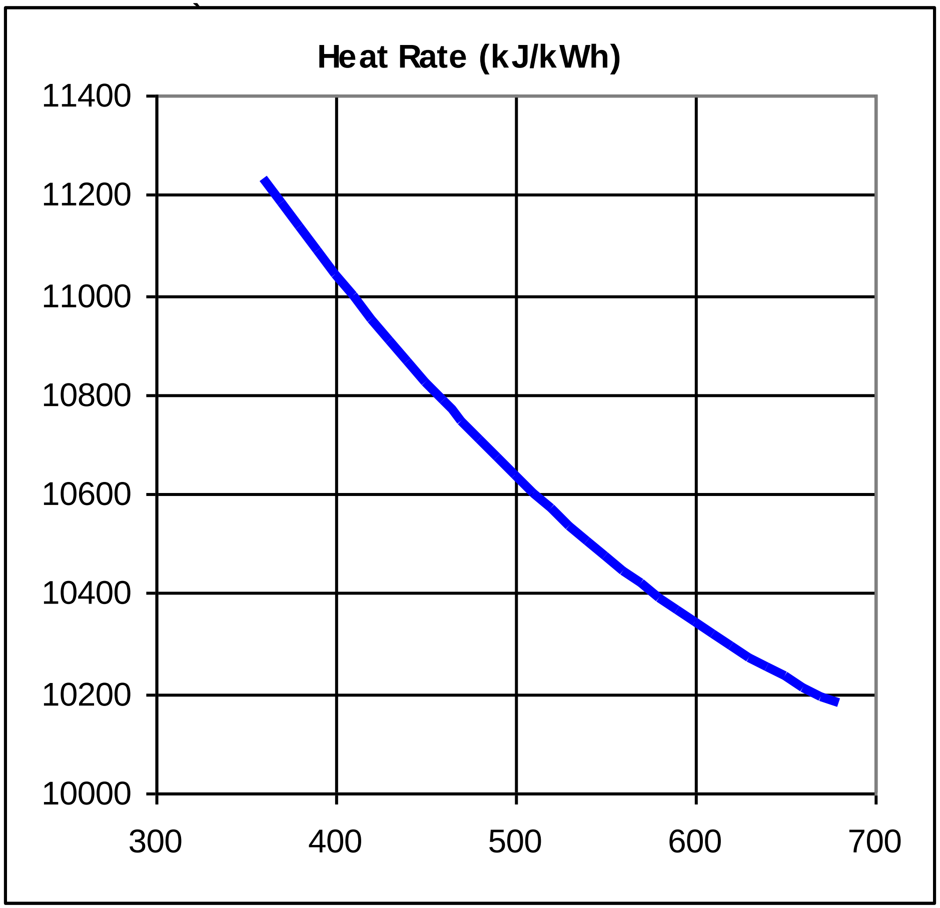
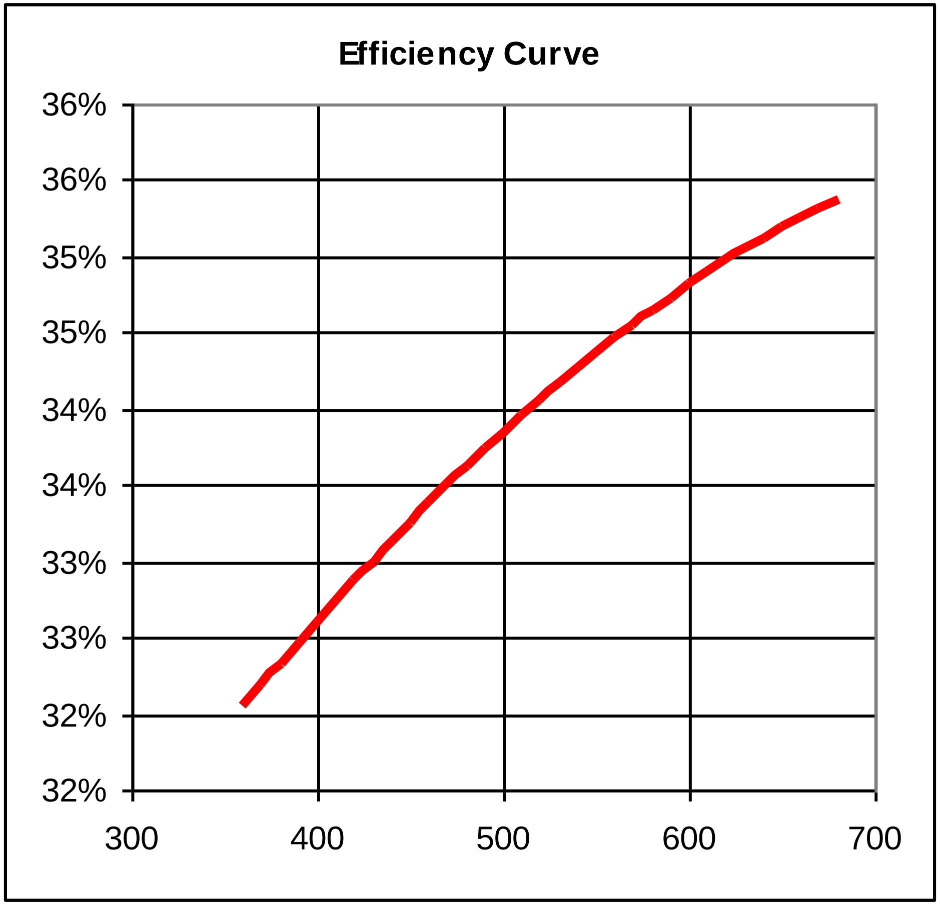
Efficiency vs. Heat Rate Curves





- **Heat rate and efficiency differs at different load levels.**

Efficiency and Heat Rate (2)

- Typical ranges
  - Gas Turbines 27% to 30%
  - Steam 30% to 35% (about 40% for supercritical)
  - Combine Cycle 40% to 60%
- Heat Rate
  - Inverse of efficiency in kJ/kWh
  - Typical figures
    - Gas Turbines 12,000 kJ / kWh
    - Steam 10,000 kJ / kWh
    - Combine Cycle 8,000 kJ / kWh

Example of Generation Cost Calculation

If the heat rate is 8554 kJ/kWh, and the fuel cost is 10 RM/GJ, what is the cost of generation in sen/kWh?

Generation Cost

= MW X Heat Rate X Fuel Cost

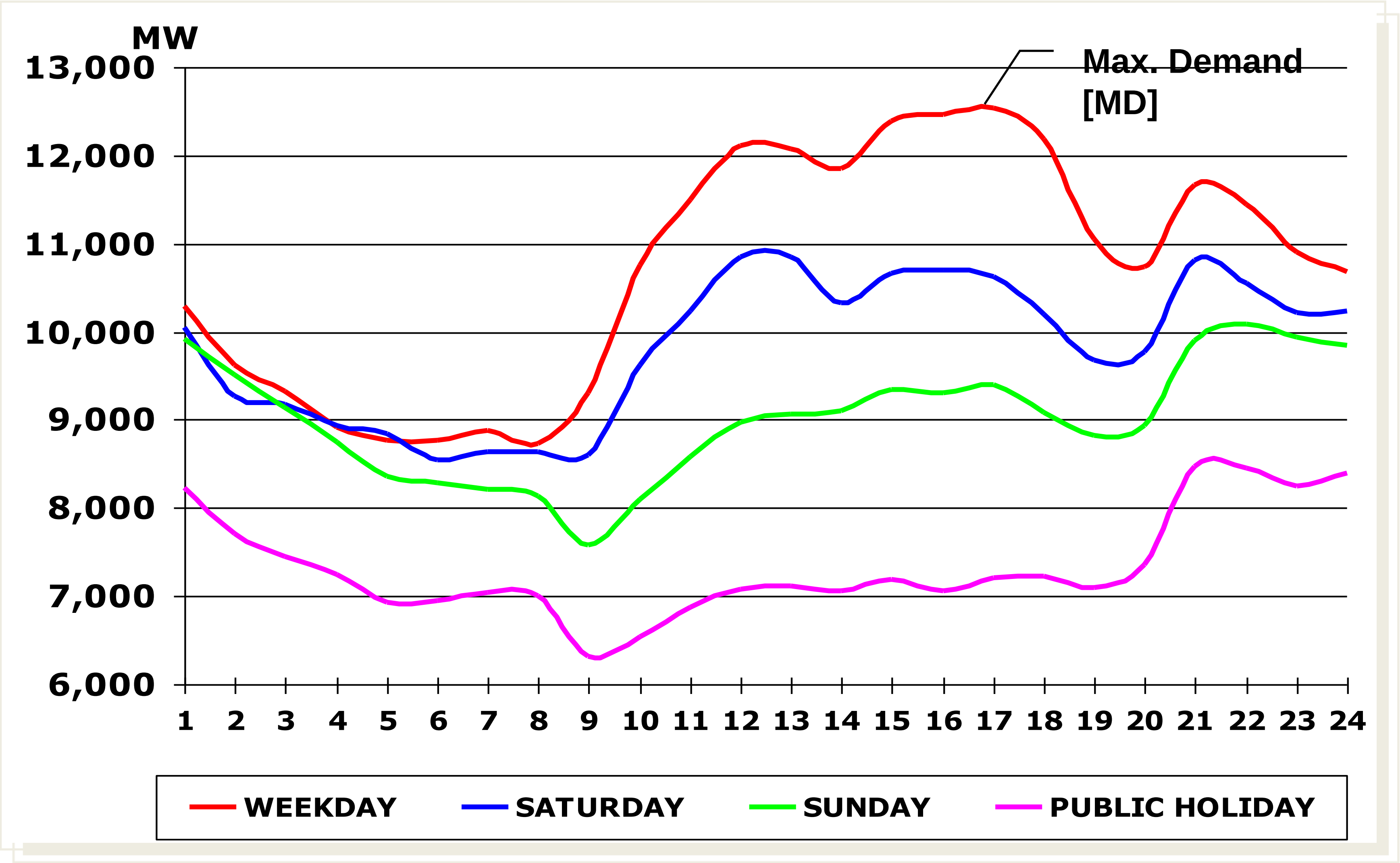
= 1 MW X (8554 kJ/kWh) X (10 RM/GJ X 1GJ/1,000,000kJ x1000kW/MW)

= RM 85.54 / MW per hour

= 8.554 sen / kWh

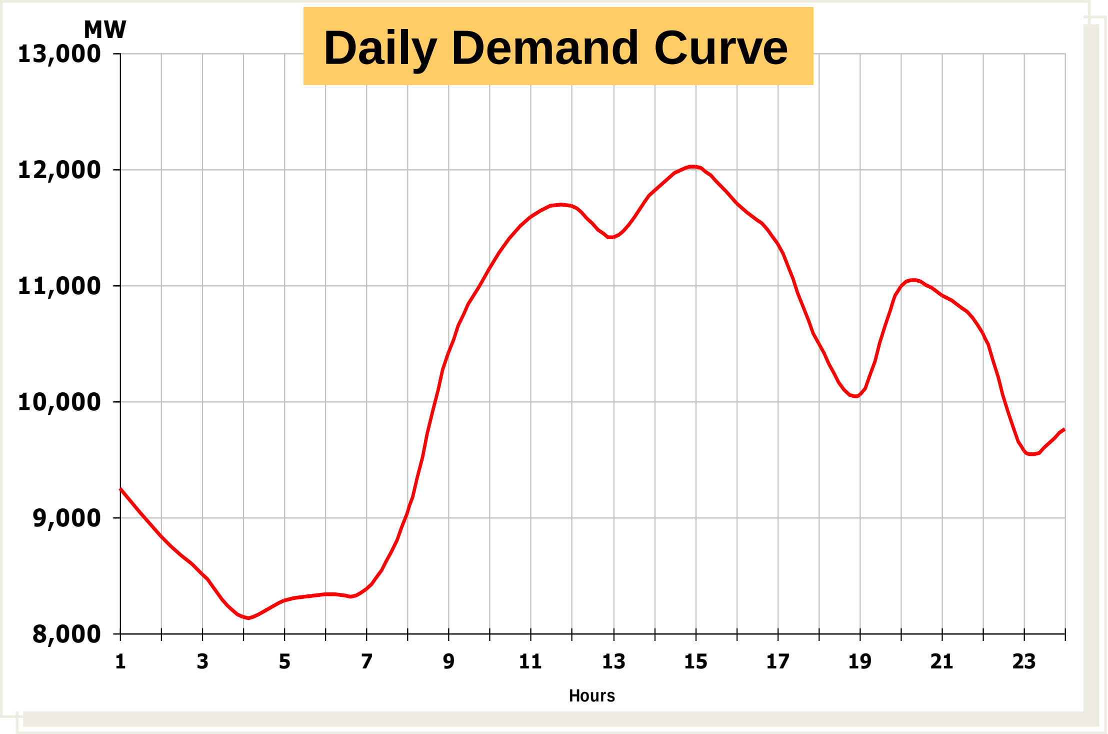
- For reference
  - 1 Btu (British thermal unit) = 1054 J
  - 1 MBtu = 1x10^6 Btu
  - 1 MBtu = 0.29 MWh, 3.44 MBtu = 1 MWh

What are Demand Curves ?



What is the basic principle?

- Demand is not static but changes with time.
- Energy cannot be stored and must be despatched when needed.
- Need to maintain sufficient generation reserves



1. ***The objective is to continuously match generation and electricity demand at the least cost.***

2. ***If there is imbalance, it is indicated by change in frequency changes and tie line power flow.***

Simple Example of Unit Commitment

Unit Commitment
What are the Objective Function?

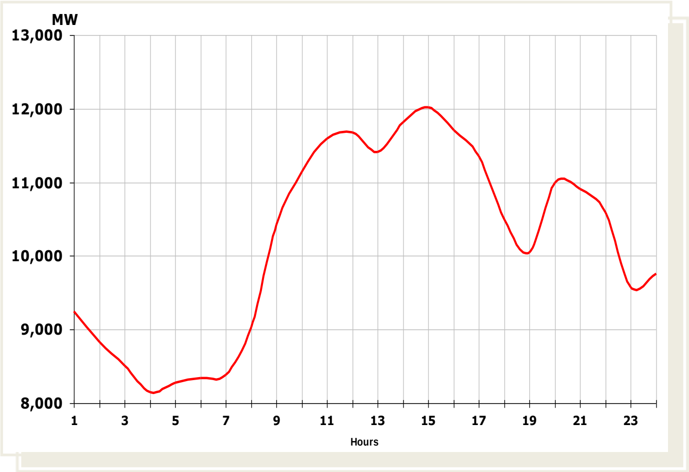
To meet Demand at minimal production cost which can be sustained over time:

- Annual and monthly Generator outage planning: Generators must submit 3 year ahead rolling Annual Schedule Outage Plan to SB and GSO, also firm up month ahead and week ahead outage plan
- "Week ahead and day ahead" Unit commitment program is used to calculate schedule based on generator availability, day ahead to week ahead demand curve forecast. The output is a half hourly on/off schedule.

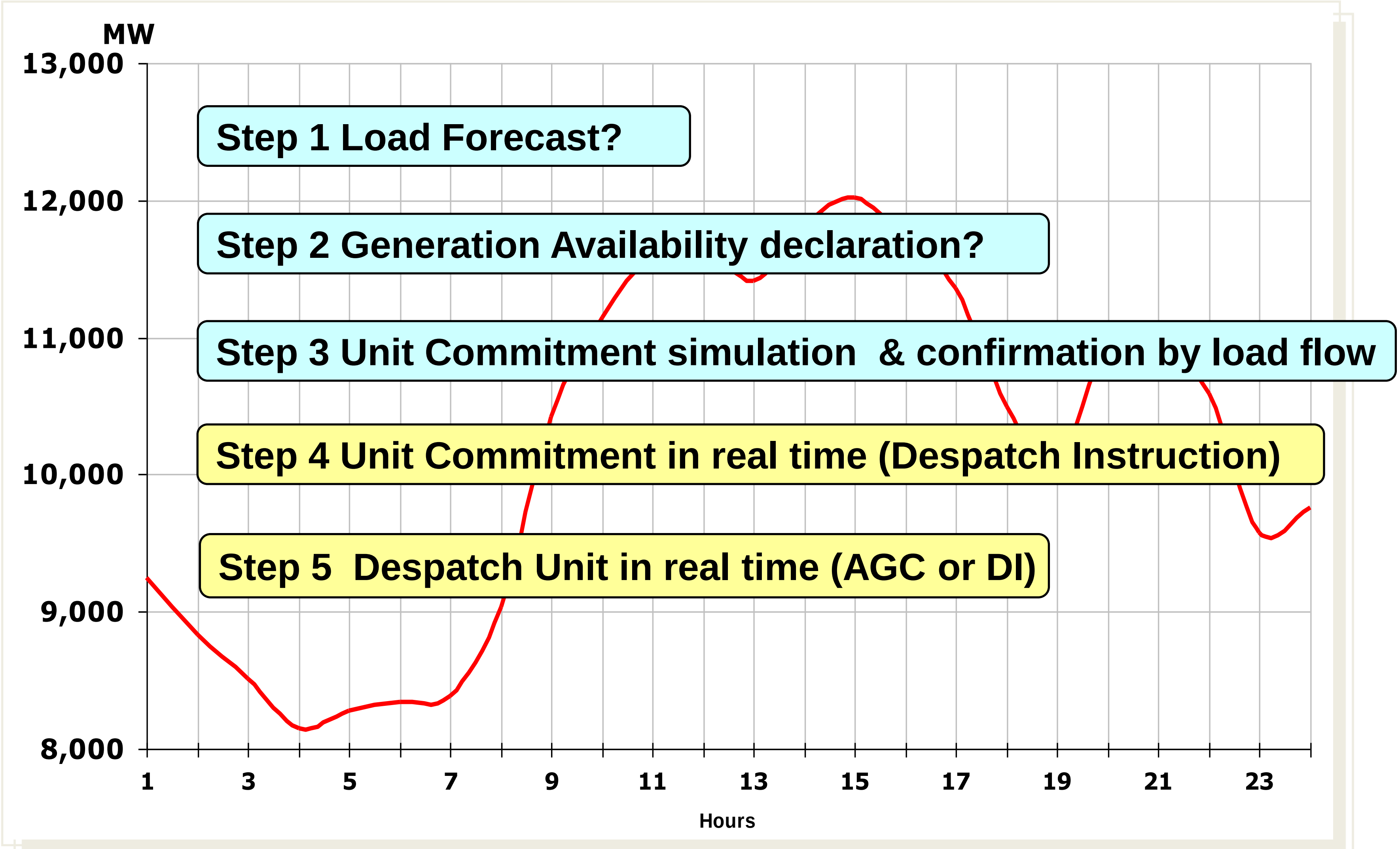
Planning

Real time

- Commit / de-commit (start up or shut down) Unit generation according to schedule subject to minor adjustment due to changes in conditions and constraints.
- Perform economic despatch based on heat rate curve and incremental heat rate



Generation Production Unit Commitment
What is the process?



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Unit Commitment (UC)

- Unit Commitment is the scheduling of a set of generating unit to be: ***on, off, or in standby*** for a given a period of time to meet least production cost over sustainable period (normal a week or at least a day basis).

- “Commit" a generating unit is to "turn it on" that is, to bring the unit up to speed, synchronize it to the system, and connect it so it can deliver power to the network.

- The problem with "commit enough units and leave them on line" is one of economics.

- A great deal of money can be saved by turning units off (de-committing them) when they are not needed.

- The computational procedure for making such decisions is called unit commitment, and a unit when scheduled for connection to the system is said to be committed.

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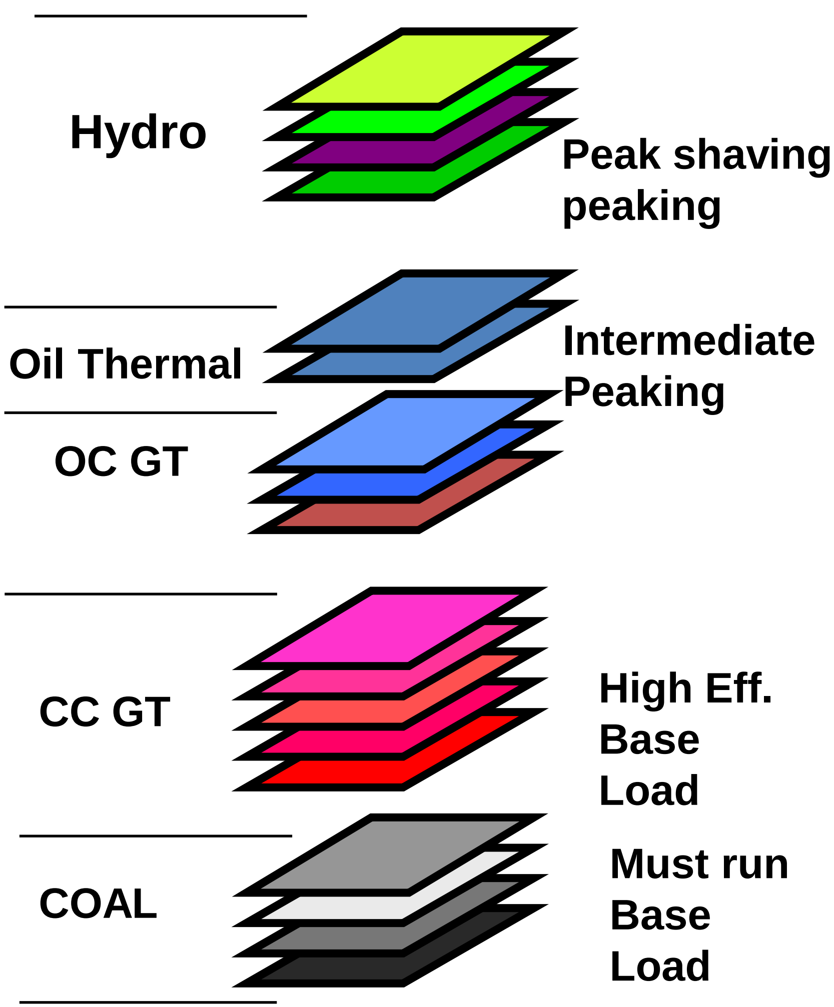
Unit Commitment vs Merit Order Process

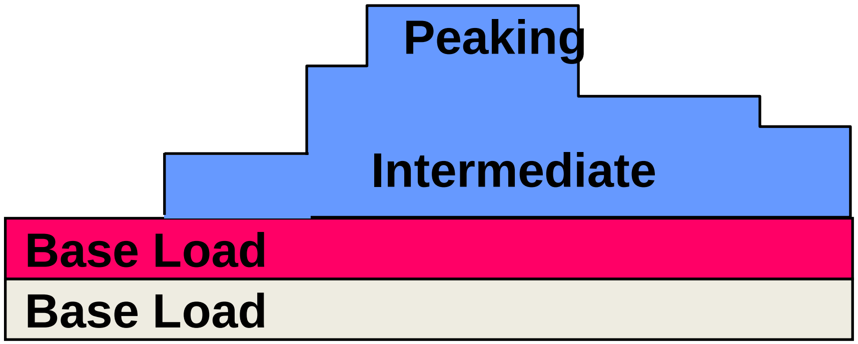
Merit Order Stack



Before the availability of computer program, a simplistic method is to use merit order stacking.

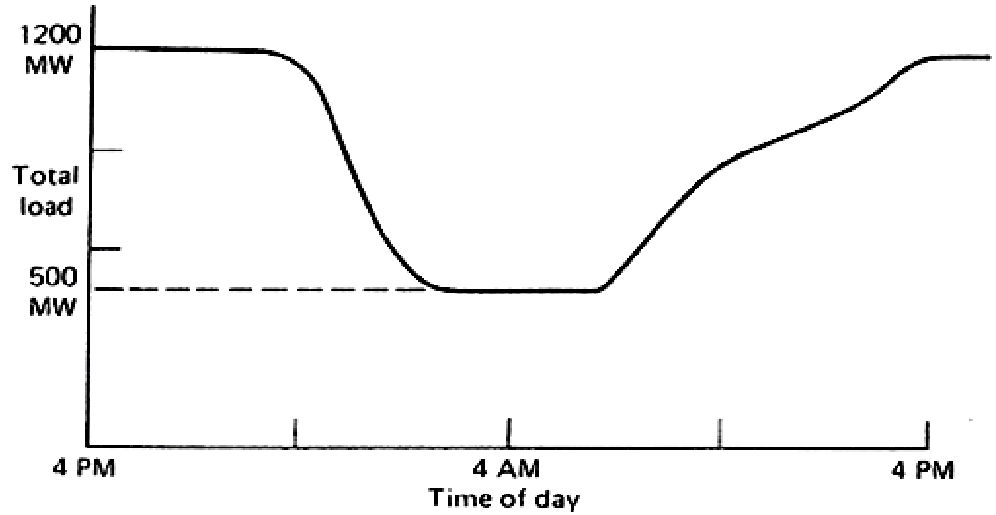
The principle is to despatch the most efficient plant first.

This is not efficient as other generation costs, constraints and incremental heat rate curve are not considered.

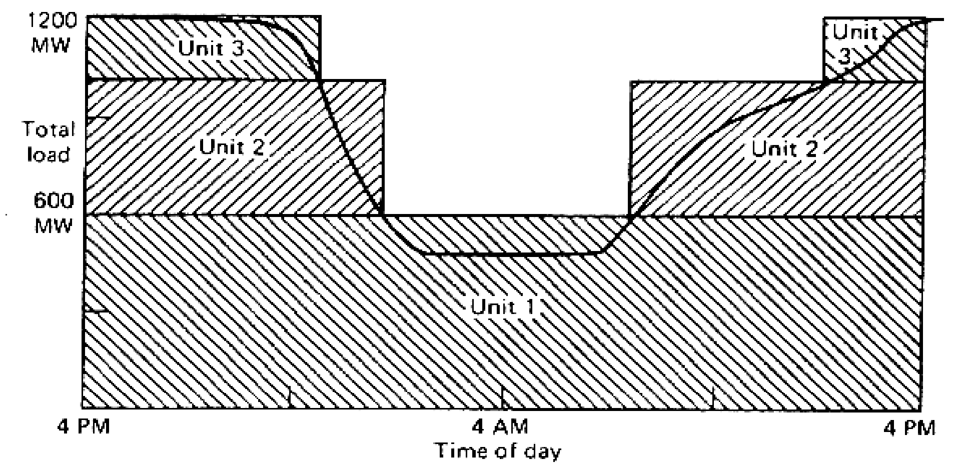


A Simple Example

a) Simple “Peak-Valley” Load Pattern



b) Unit Commitment Schedule Using Shut-Down Rule



A Simple Example

Unit 1:

- PMin = 250 MW, PMax = 600 MW
- $C1 = 510.0 + 7.9\ P_1 + 0.00172\ P_1^{\ 2}$ \$/h

Unit 2:

- PMin = 200 MW, PMax = 400 MW
- $C2 = 310.0 + 7.85\ P_2 + 0.00194\ P_2^{\ 2}$ \$/h

Unit 3:

- PMin = 150 MW, PMax = 500 MW
- $C3 = 78.0 + 9.56\ P_3 + 0.00694\ P_3^2$ \$/h

What combination of units 1, 2 and 3 will produce **550 MW** at minimum cost?

How much should each unit in that combination generate?

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Cost of various combination

1	2	3	P_{min}	P_{max}	P_1	P_2	P_3	C_{total}
Off	Off	Off	0	0	Infeasible			
Off	Off	On	150	500	Infeasible			
Off	On	Off	200	400	Infeasible			
Off	On	On	350	900	0	400	150	5418
On	Off	Off	250	600	550	0	0	***5389***
On	Off	On	400	1100	400	0	150	5613
On	On	Off	450	1000	295	255	0	5471
On	On	On	600	1500	Infeasible			5617

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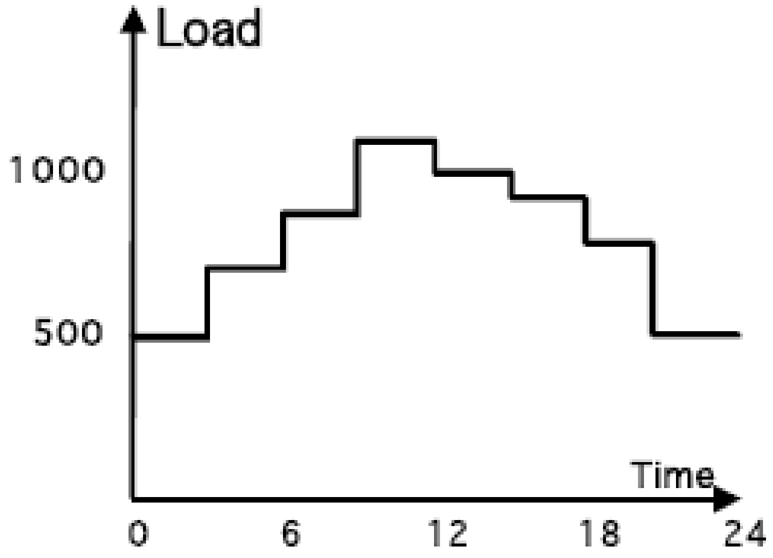
Observations on the example:

- Far too few units committed: Can’t meet the demand
- Not enough units committed: Some units operate above optimum
- Too many units committed: Some units below optimum
- Far too many units committed: Minimum generation exceeds demand
- No-load cost affects choice of optimal combination

Another Example

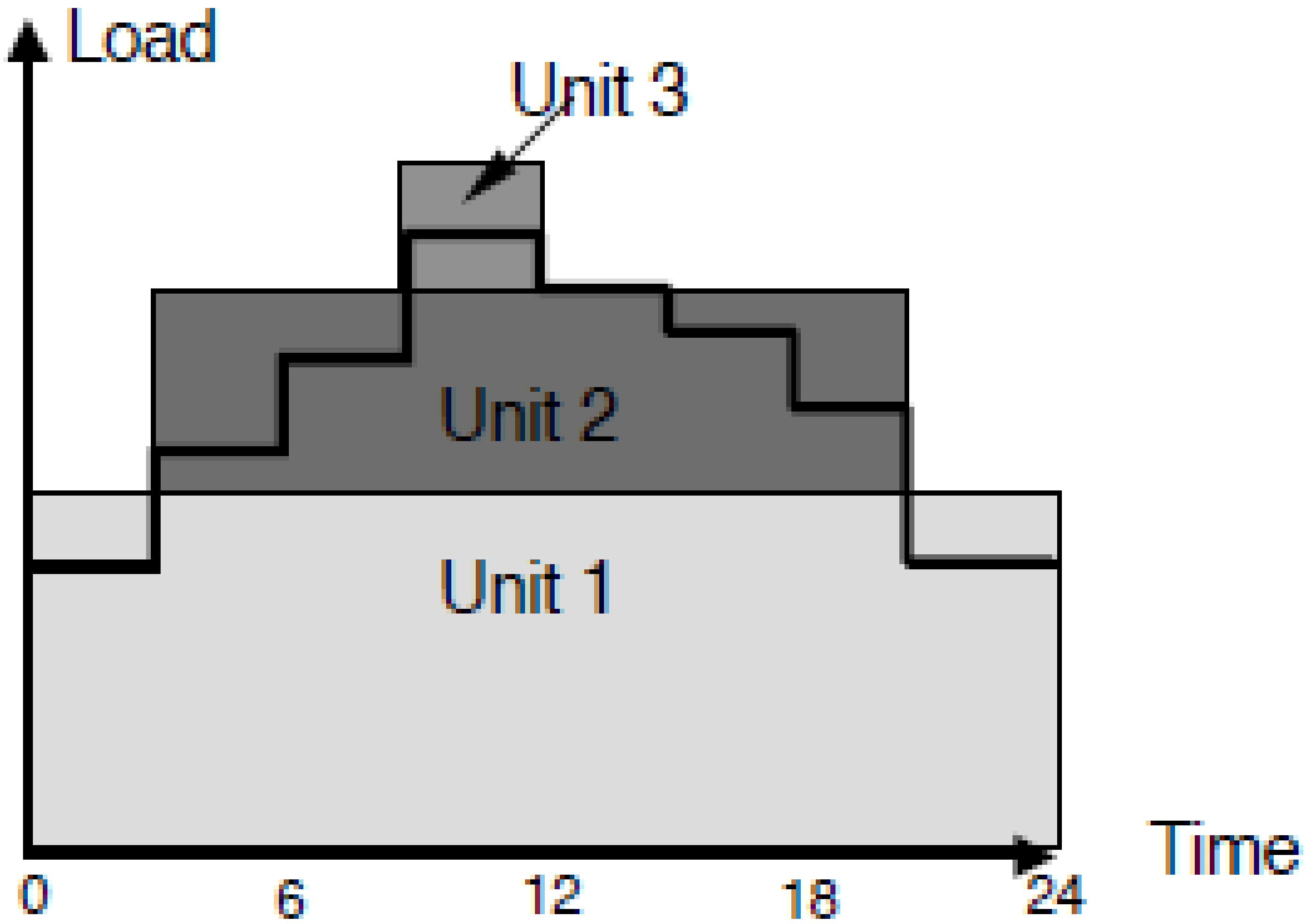
- Optimal generation schedule for a load profile
- Decompose the profile into a set of period
- Assume load is constant over each period
- For each time period, which units should be committed to generate at minimum cost during that period?



Optimal combination for each hour

Load	Unit 1	Unit 2	Unit 3
1100	On	On	On
1000	On	On	Off
900	On	On	Off
800	On	On	Off
700	On	On	Off
600	On	Off	Off
500	On	Off	Off

Matching the combinations to the load



Unit Commitment Solution methods

- If the number of generating units is N, for the total period of M intervals, the maximum number of possible combinations is $(2N - 1)^M$, which can become a astronomical number to consider.
- For example, take a 24-h period (e.g., 24 one-hour intervals) and consider systems with 5, 10, 20, and 40 units. The value of $(2N - 1)^{24}$ becomes the following.

N	$(2^N --- 1)^{24}$
5	6.2×10^{35}
10	1.73×10^{72}
20	3.12×10^{144}
40	(Too big)

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Unit Commitment Solution

- Many methods can be used for solving the unit commitment problem. The methods include:
  - **Lagrange Multiplier Method**
  - **Lambda Iteration Method**
  - Gradient Methods - Gradient Search
  - Newton's Method
  - Piecewise Linear Cost Functions Method
  - **Dynamic Programming**
  - Base Point and Participation Factors Method
  - Artificial Intelligent Method

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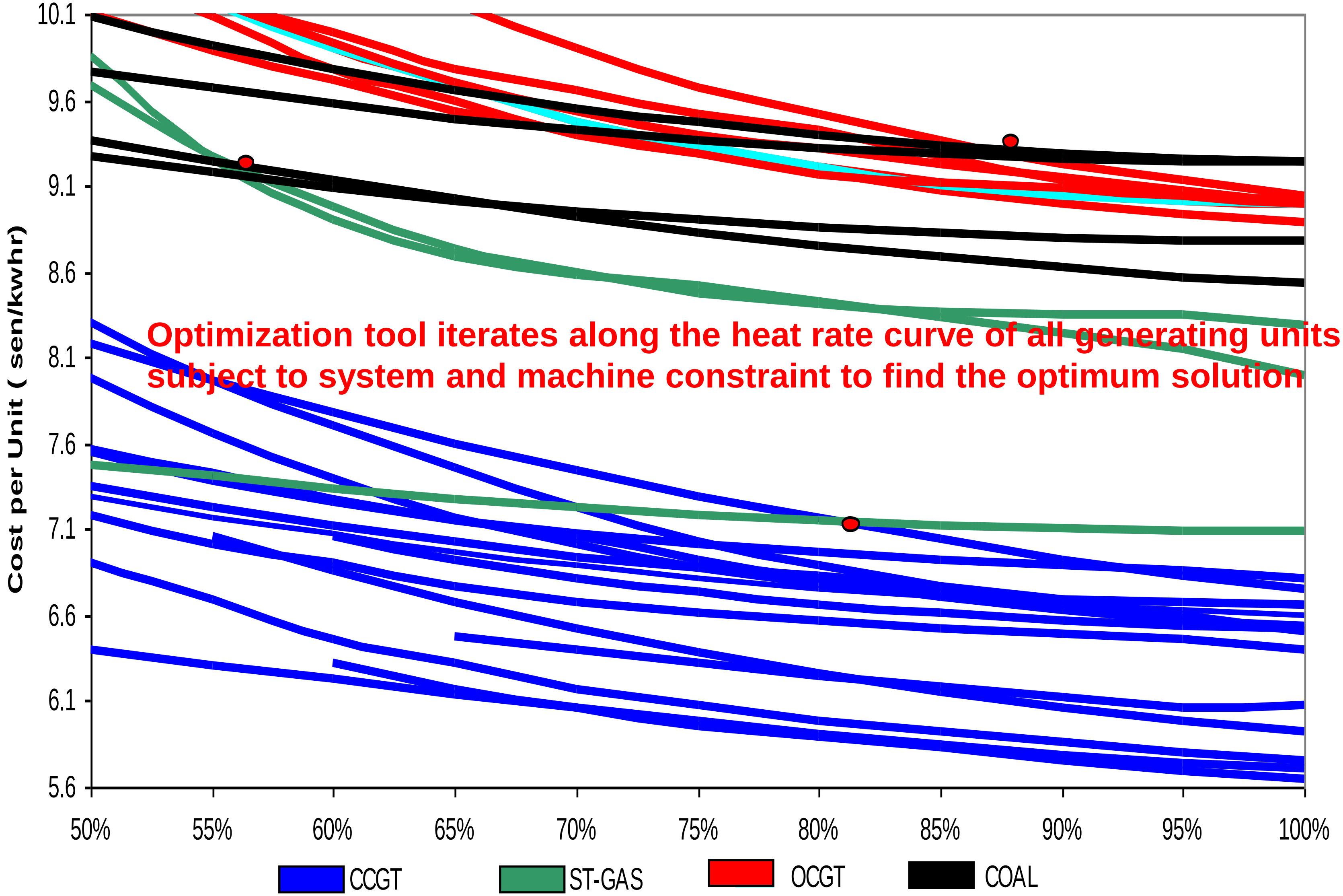
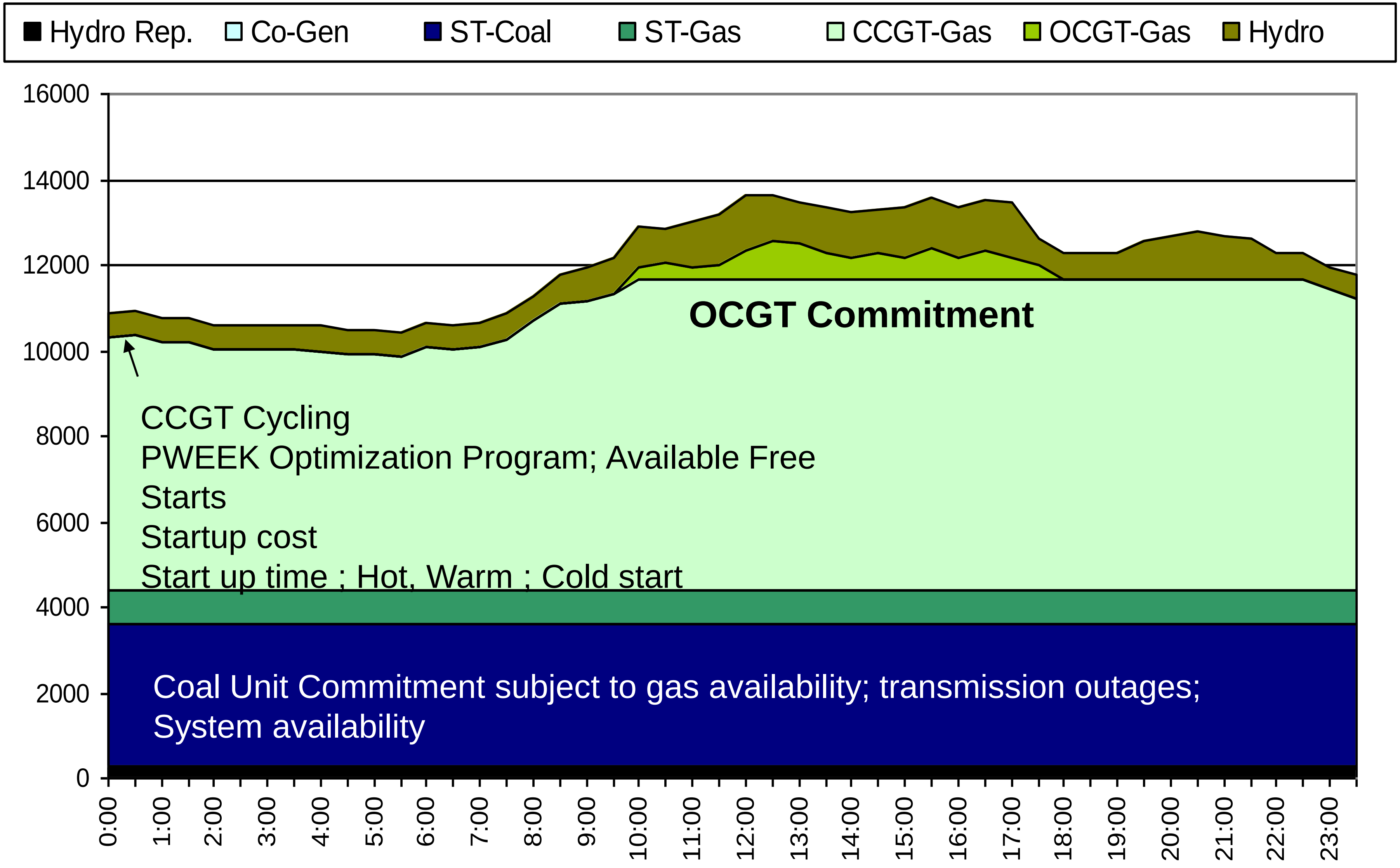
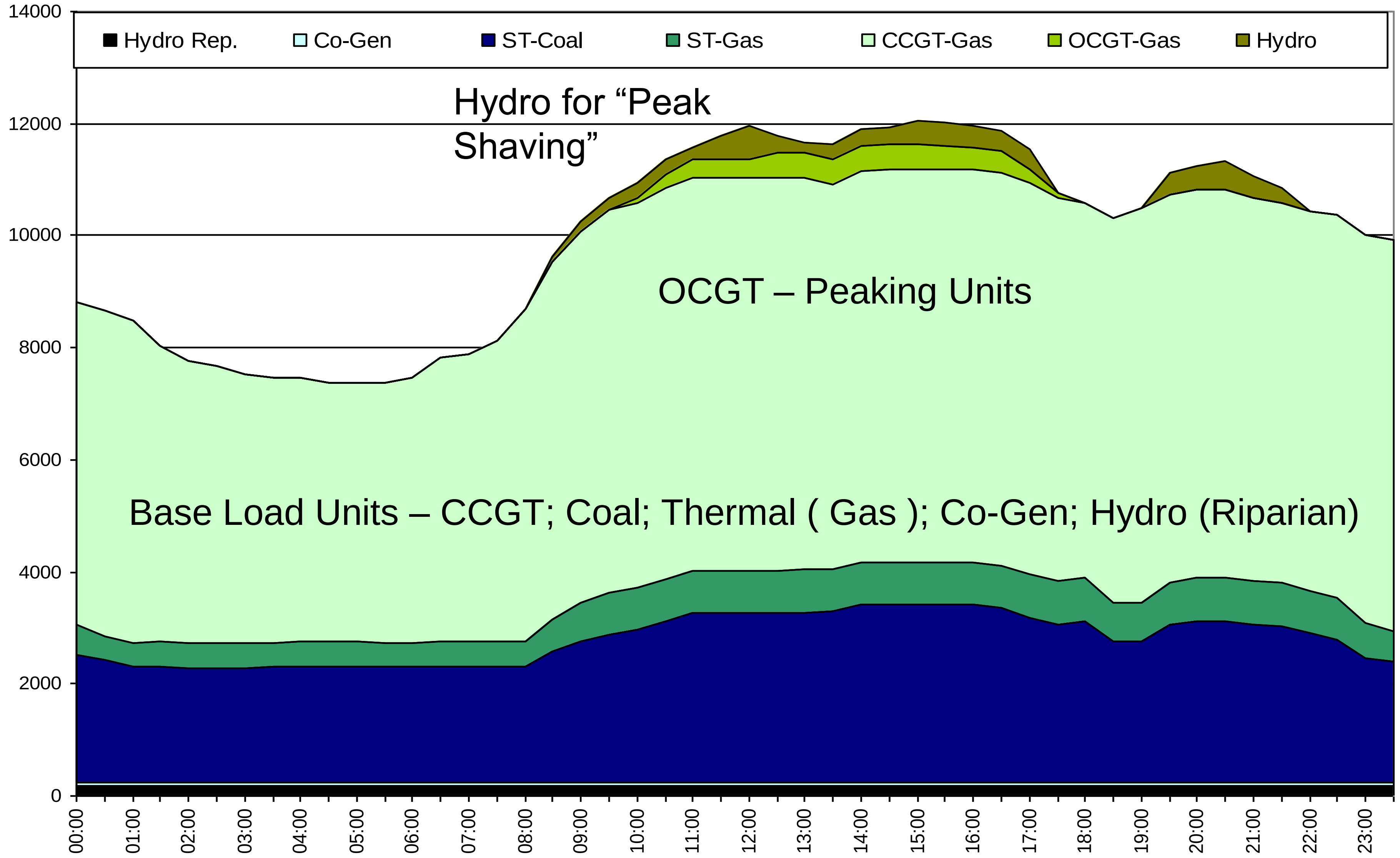
Graph: Total Cost for Generating Units By Plant Type



Graph: Unit Commitment by Plant Type



Graph: Generation Despatch by Fuel Type



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Unit Commitment Considerations

- Unit dependable capacity
- Unit availability (start & end time)
- Time reqd. for notice to synchronise
- Unit minimum generation
- Heat rate and incremental heat rate curve
- Fuel cost & Fuel constraints
- Variable operating rate (VOR)
- Minimum shutdown time
- Ramp rate
- Start up Costs
- Spinning reserve requirement

For hydro generators amount of available water and cost of replacement
Gas turbines can be constraints by gas pressure & gas availability

Flexible Plants

- Power output can be adjusted (within limits)
- Examples:
  - Thermal Units:-
    - Coal-fired
    - Oil-fired
    - Open cycle gas turbines
    - Combined cycle gas turbines
  - Hydro plants with storage
- Status and power output can be optimized

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Inflexible Plants

- Power output cannot be adjusted for technical or commercial reasons
- Examples:
  - Nuclear
  - Run-of-the-river hydro
  - Renewables (wind, solar,…)
  - Combined heat and power (CHP, cogeneration)
- Output treated as given when optimizing

Unit Constraints

- Minimum up time
  - Once a unit is running it may not be shut down immediately:
- Minimum down time
  - Once a unit is shut down, it may not be started immediately
- If $X_i(t) = 1$ and $t_i^{up} < t_i^{up,min}$ then $X_i(t+1) = 1$
- If $X_i(t) = 0$ and $t_i^{down} < t_i^{down,min}$ then $X_i(t+1) = 0$

Unit Constraints

- Maximum ramp rates
  - To avoid damaging the turbine, the electrical output of a unit cannot change by more than a certain amount over a period of time:

Maximum ramp up rate constraint:

$$\Rightarrow \quad P_i(t+1) - P_i(t) \le \Delta P_i^{up,\max}$$

Maximum ramp down rate constraint:

$$\Rightarrow \quad P_i(t) - P_i(t+1) \le \Delta P_i^{down,\max}$$

1 %-3% per minutes for most thermal plants

System Constraint: Reserve Capacity

- Unanticipated loss of a generating unit or an interconnection causes unacceptable frequency drop if not corrected
- Need to limit maximum generation of large generating unit below its full capacity during trough period
- Need to increase production from other units to keep frequency drop within acceptable limits
- Rapid increase in production only possible if committed units are not all operating at their maximum capacity

$$\sum_{i \in C(t)} P_i^{\max} \geq L(t) + R(t)$$

$R(t)$: Reserve requirement at time t

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How much reserve?

- Protect the system against "credible outages"
- Deterministic criteria:
  - Capacity of largest unit or interconnection
  - Percentage of peak load
- Probabilistic criteria:
  - Takes into account the number and size of the committed units as well as their outage rate
- SESB ?

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Types of Reserve

- Spinning reserve
  - Primary
    - quick response for a short time
  - Secondary
    - slower response for a longer time
  - High frequency
    - ability to reduce output when frequency is high
- Scheduled or off-line reserve (standby)
  - Unit that can start quickly (e.g. gas turbines)
- Other sources of reserve
  - Pumped hydro plants
  - Demand reduction
- Reserve must be spread around the network

Cost of Reserve

Reserve has a cost even when it is not called

- More units scheduled than required
  - Units not operated at their maximum efficiency
  - Extra start up costs
- Must build units capable of rapid response
- Cost of reserve proportionally larger in small systems
  - Important driver for the creation of interconnections between systems

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Crew Constraints

- It may not be possible to start more than one generating unit at a time in a power station because of the number of people required to supervise the start-up
- Less of a problem than it use to be thanks to automation

Emission Constraints

- Amount of pollutants that generating units can emit may be limited
- Pollutants:
  - SO_2, NO_x
- Various forms:
  - Limit on each plant at each hour
  - Limit on plant over a year
  - Limit on a group of plants over a period

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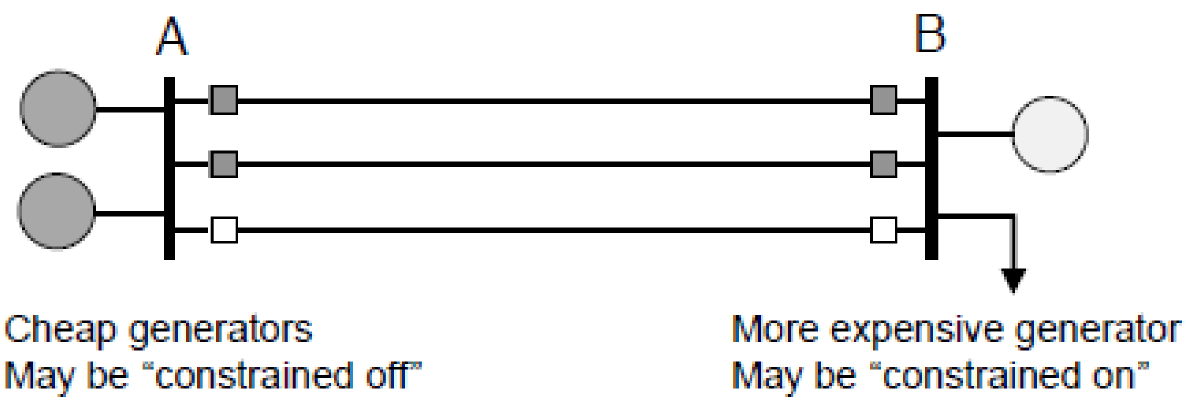
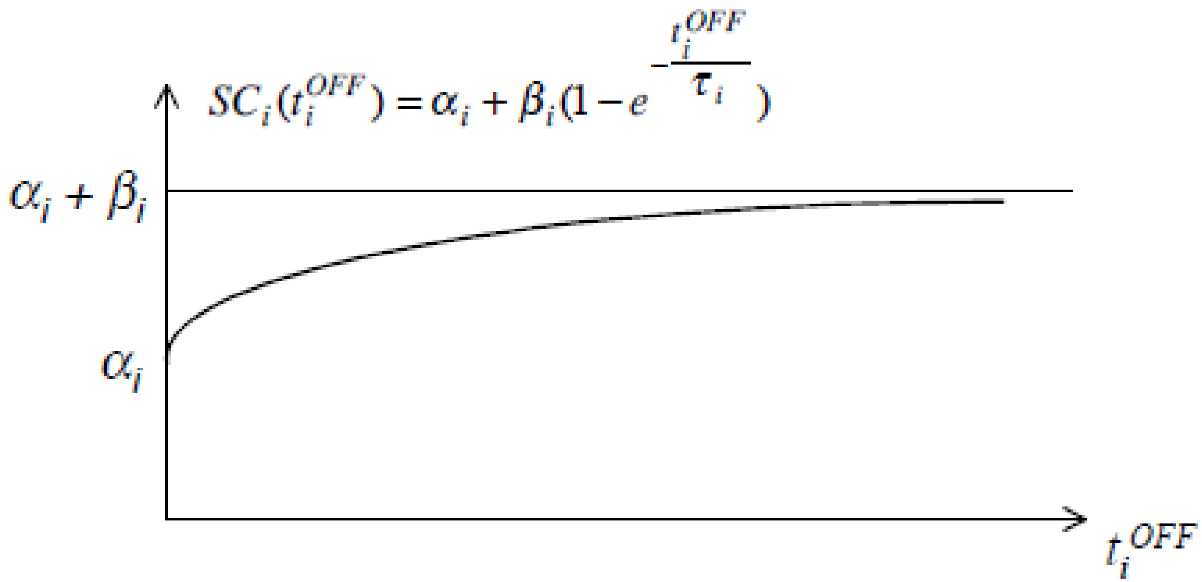
Network Constraints

- Transmission network may have an effect on the commitment of units
  - Some units must run to provide voltage support
  - The output of some units may be limited because their output would exceed the transmission capacity of the network



Start-up Costs

- Thermal units must be "warmed up" before they can be brought on-line
- Warming up a unit costs money
- Start-up cost depends on time unit has been off



Coal plant – 160k, CCGT-- 10k, Hydro/ OCGT –free start

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Start-up Costs

- Need to “balance” start-up costs and running costs
- Example:
  - Diesel generator/ OCGT: low start-up cost, high running cost
  - Coal plant/CCGT: high start-up cost, low running cost
- Issues:
  - How long should a unit run to “recover” its start-up cost?
  - Start-up one more large unit or a diesel generator to cover the peak?
  - Shutdown one more unit at night or run several units part loaded?

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Gas Constraint

- The gas allocated per day may be limited
- Generator cannot be operated at full load when gas pressure is low
- If it is anticipated that gas curtailment will be implemented the next day, reduce the gas usage on the current day and saved for the next day. Save hydro for the gas curtailment day.
- Dispatch more hydro or operate based load plant at higher load during trough period during gas curtailment day.
- Gas pipe line acts as a reservoir of gas stored at high pressure.

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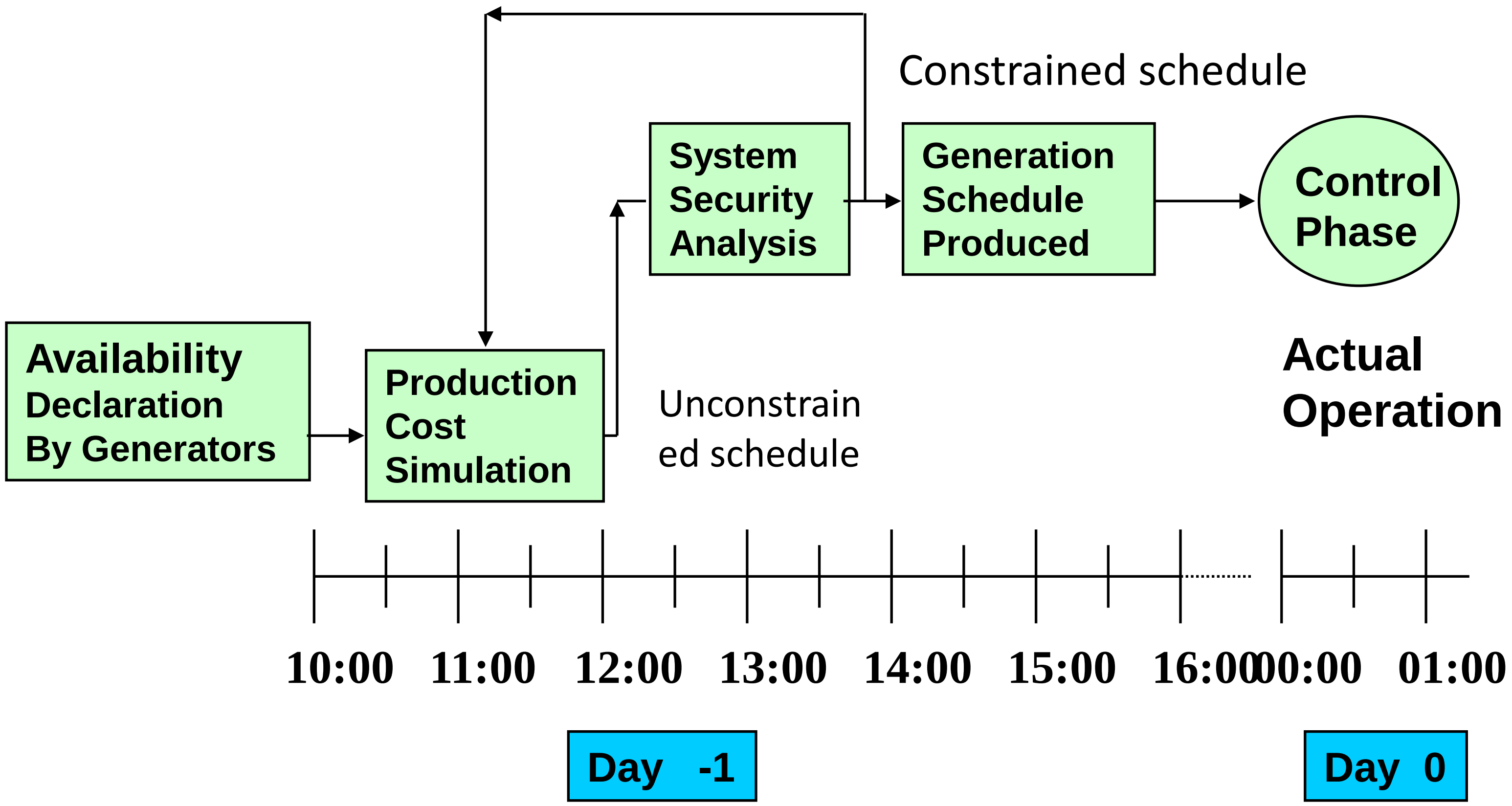
The Generation Schedule Day



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Weekly Production Plan

TITLE	Weekly Production Plan

<u>Assumptions/Methodologies:</u>

1) One-week ahead load forecast as provided by System Planning.
2) One-week ahead planned generator outages as provided by O&PP's Production Studies section.
3) Minimum SR = 1,000MW.
4) Thermal units not scheduled: P[illegible] U4, U5, U6
5) Planned hydro energy for K[illegible] as provided by O&PP.
6) EGAT tracsaction : Mon-Sun 24hrs export 370MW
7) Y[illegible] PG will shutdown from 2/5 until 23/5/2005
8) PD1 : Reliability Run

	Forecast	
	MD	Energy
Saturday	10710	228.6
Sunday	9630	206.4
Monday	12370	245.3
Tuesday	12380	250.7
Wednesday	12390	250.9
Thursday	12360	250.8
Friday	12150	249.2
Saturday	11220	232.1
Sunday	9640	206.5

Week 20, 2005		Saturday 07-May	Sunday 08-May	Monday 09-May	Tuesday 10-May	Wed 11-May	Thursday 12-May	Friday 13-May	Saturday 14-May	Sunday 15-May
Schedule for:										
CCGT	# of GTs for cycling			2@SC[illegible]	2@S[illegible]	2@S[illegible]	2@SC[illegible]	2@SCF[illegible]	2@SC[illegible]	
	# of GTs on standby									2@SGRI
OCGT		10x	2x	15x	16x	17x	17x	15x	10x	3x
Planned hydro energy	K[illegible]R	4.77	3.00	4.88	5.00	5.00	5.00	4.95	4.74	3.00
	TM[illegible]R	0.72	0.72	1.12	1.34	1.35	1.32	0.90	0.72	0.72
	PG[illegible]U	0.60	0.30	0.80	0.80	0.80	0.80	0.80	0.60	0.30
Average gas cons.	TNB	516	475	691	691	691	685	662	638	611
	[illegible]+IPP	806	771	843	851	852	834	796	744	618
	Total	1323	1246	1534	1542	1543	1519	1458	1383	1230

Remarks

<u>**Unit outages:**</u>

JI[illegible]G U1	26/3 - 9/5
K[illegible]P station	22/4 - 14/5
P[illegible]G U6	10/5 - 13/6
PL[illegible]S GT13	14/5 - 17/6
CE[illegible]S GT6	30/4 - 7/5
SF[illegible]G GT2	01/5 - 25/5
C[illegible]S GT3	7/5 - 10/7
P[illegible] GT12	8/5
G[illegible]R GT1	6/5 - 8/5
P[illegible] GT1B	7/5 - 8/5
JC[illegible] U4	10/2 - 11/6

Weekly total	Average	Wkday ave
32.56	4.65	4.97
7.47	1.07	1.21
4.90	0.70	0.80

<u>Average gas cons. (Kerteh=JDA)</u>

Constrained	1458 mmscfd
Unconstrained	1443 mmscfd

Section	Production Studies	Prepared by	[illegible]	Date	13-May-05	File location:	\\prodsvr\Production\Reports\WeeklyPlan\2005
Unit	O&PP	Checked by	[illegible]	Revision		File name:	WeeklyPlan05Wk20.xls
Department	System Planning						

* Includes test energy carried out after long outage

** Includes gas commissioning test

Weekly Production Plan

TITLE	Weekly Production Plan

Assumptions/Methodologies:

1) One-week ahead load forecast as provided by System Planning.
2) One-week ahead planned generator outages as provided by O&PP's Production Studies section.
3) Minimum SR = 1,000MW.
4) Thermal units not scheduled: P[illegible] U4, U5, U6
5) Planned hydro energy for K[illegible], T[illegible] & P[illegible] as provided by O&PP.
6) **EGAT tracsaction : Mon-Sun 24hrs export 370MW**
7) **Y[illegible] PG will shutdown from 2/5 until 23/5/2005**
8) **PD1 : Reliability Run**

	Forecast MD	Forecast Energy
Saturday	10710	228.6
Sunday	9630	206.4
Monday	12370	245.3
Tuesday	12380	250.7
Wednesday	12390	250.9
Thursday	12360	250.8
Friday	12150	249.2
Saturday	11220	232.1
Sunday	9640	206.5

Week 20, 2005		Saturday 07-May	Sunday 08-May	Monday 09-May	Tuesday 10-May	Wed 11-May	Thursday 12-May	Friday 13-May	Saturday 14-May	Sunday 15-May
Schedule for:										
CCGT	# of GTs for cycling			2@SC[illegible]	2@S[illegible]	2@S[illegible]	2@S[illegible]	2@SCF[illegible]	2@SC[illegible]	
	# of GTs on standby									2@SGRI
OCGT		10x	2x	15x	16x	17x	17x	15x	10x	3x
Planned hydro energy	K[illegible]R	4.77	3.00	4.88	5.00	5.00	5.00	4.95	4.74	3.00
	TM[illegible]R	0.72	0.72	1.12	1.34	1.35	1.32	0.90	0.72	0.72
	PG[illegible]U	0.60	0.30	0.80	0.80	0.80	0.80	0.80	0.60	0.30
Average gas cons.	TNB	516	475	691	691	691	685	662	638	611
	[illegible]+IPP	806	771	843	851	852	834	796	744	618
	Total	1323	1246	1534	1542	1543	1519	1458	1383	1230

Remarks

Unit outages:

JI[illegible]G U1	26/3 - 9/5
K[illegible]P station	22/4 - 14/5
P[illegible]G U6	10/5 - 13/6
PL[illegible]S GT13	14/5 - 17/6
CE[illegible]S GT6	30/4 - 7/5
SF[illegible]G GT2	01/5 - 25/5
C[illegible]S GT3	7/5 - 10/7
P[illegible] GT12	8/5
G[illegible]R GT1	6/5 - 8/5
P[illegible] GT1B	7/5 - 8/5
JC[illegible] U4	10/2 - 11/6

Planned hydro energy	Weekly total	Average	Wkday ave
K[illegible]R	32.56	4.65	4.97
TM[illegible]R	7.47	1.07	1.21
PG[illegible]U	4.90	0.70	0.80

Average gas cons. (Kerteh+JDA)

Constrained	1458	mmscfd
Unconstrained	1443	mmscfd

Section	Production Studies	Prepared by	[illegible]	Date	13-May-05	File location:	[illegible]/Production/Reports/WeeklyPlan/2005
Unit	O&PP	Checked by	[illegible]	Revision		File name:	WeeklyPlan05WK20.xls
Department	System Planning						

* Includes test energy carried out after long outage

** Includes gas commissioning test

Example of Unit Commitment Schedule

Friday
06-May-05

HOUR	--	1	--	2	--	3	--	4	--	5	--	6	--	7	--	8	--	9	--	10	--	11	--	12	TOTAL
LOAD	9609	9316	9178	9035	8954	8843	8631	8603	8566	8487	8470	8512	8643	8629	8587	9124	10061	10679	11088	11295	11562	11875	11953	11654	248600
EGATDC	-350	-350	-350	-350	-350	-350	-350	-350	-350	-350	-350	-350	-350	-350	-350	-350	-350	-30	-30	-30	-30	-30	-30	-30	-5680
	724	724	724	724	724	724	724	724	724	724	724	724	724	724	724	724	724	724	724	724	724	724	724	724	17376
Unit 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	100	100	100	750
Unit 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	130	150	150	150	900
Unit 3	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	29	40	40	40	40	500
	74	74	24	20	20	20	20	20	20	20	20	20	20	20	20	20	74	74	74	74	74	74	74	74	1400
	33	33	33	33	33	33	33	33	33	33	21	33	33	33	33	33	33	33	33	33	33	33	33	33	786
	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	50	50	50	50	500
	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	384
	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	1368
	149	149	149	149	149	149	149	149	149	149	149	149	149	149	149	149	149	149	149	149	149	149	149	149	3576
	149	149	149	149	149	149	149	149	149	149	149	149	149	149	149	149	149	149	149	149	149	149	149	149	3576
	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	3096
	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	3096
	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	3096
	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	3096
	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	3024
	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	3024
	152	152	152	152	152	152	152	152	152	152	152	152	152	152	152	152	152	152	152	152	152	152	152	152	3648
	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	83	70	95	95	95	95	95	95	95	2074
	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	2904
	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121	2904
	642	456	447	439	415	387	377	377	376	373	372	373	378	377	376	461	642	642	690	690	690	659	657	664	14189
	642	456	447	439	415	387	377	377	376	373	372	373	378	377	376	461	642	642	690	690	690	656	643	643	14130
	263	263	229	166	150	150	150	150	150	150	150	150	150	150	150	180	287	287	287	287	287	287	287	287	5968
	260	260	225	166	150	150	150	150	150	150	150	150	150	150	150	180	285	287	287	287	287	287	287	287	5962
	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	213	200	229	232	235	246	253	200	5099
	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	212	200	228	232	233	240	246	200	5082
	394	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	422	400	422	422	422	422	422	350	9153
	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	7680
	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	3840
	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	3840
	213	213	213	213	213	202	164	159	152	138	138	143	166	164	156	213	213	213	213	213	213	213	213	213	4838
	213	213	213	213	213	202	164	159	152	138	138	143	166	164	156	213	213	213	213	213	213	213	213	213	4838
	213	213	213	213	213	202	164	159	152	138	138	143	166	164	156	213	213	213	213	213	213	213	213	213	4838
Unit N	213	213	213	213	213	202	164	159	152	138	138	143	166	164	156	213	213	213	213	213	213	213	213	213	4838

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Unit Commitment vs Merit Order

- Heat rate and efficiency differs at different load levels.
- Traditional merit order despatch considers only the heat rate at maximum load.
- Incremental cost despatch considers heat rate at all points, hence yields better system economics.
- Unit commitment takes into account all generation costs, constraints and usually study for a day to a week basis.
- Unit commitment is about how to shut down and start up plants to give the least production costs
- Normally, 1-3% of saving can be achieved in UC program.
- **Cost differential** can be quantified, and **fuel usage** is known.

With the tremendous computing power available now, incremental heat rate can be used for load despatching

SDC1.4.1 Preparation of the Week Ahead Plan

At the week ahead stage, the GSO will prepare a **Merit Order** and submit to the **Single Buyer for approval** together with an Energy Balance Statement, which will be compiled to illustrate the fuel use and hydro-CDGU use planned for the week ahead and take into account transfers to or from Interconnected Parties**.**

- The **preliminary schedule** will be an "Unconstrained Schedule" for the maximum forecast Demand and the minimum forecast Demand **for the week ahead.**
- A **second schedule**, the "Constrained Schedule", will be prepared by the GSO and will show how the CDGUs are proposed to be Dispatched and loaded at the maximum forecast Demand and the minimum forecast Demand taking account of the known limitations of the Transmission or Distribution Networks.
- This **Constrained Schedule** is then the statement by the GSO, in accordance with the Single Buyer's approved Merit Order and Energy Balance Statement, to Power Producers, of which CDGU may be required for the Schedule Days (SD1 of Week1 to SD7 of Week 1) starting with Monday of the week ahead being SD1 of Week 1.

SDC1.4.1

These arrangements are further detailed below.

- **(i) Merit Order**
  - A least cost **Merit Order** will be compiled by the GSO and submitted to the Single Buyer for approval once a week for the week commencing on the following Monday from the submitted CDGU information (using fuel-take or pay data, reservoir levels and Availability declarations made in a week ahead Availability Notice).
- **(ii) Unconstrained Schedule**
  - The GSO will produce an Unconstrained Schedule from the Merit Order, starting with the CDGU at the head of the Merit Order and the next highest CDGU that will:
  - in aggregate be sufficient to match at all times the forecast Power System Demand (derived under OC1) together with such Operating Reserve (derived from OC3); and as will
  - in aggregate be sufficient to match minimum **Demand levels allowing** for later **Demand.**

SDC1.4.1

- **(iii) Constrained Schedule**
  - From the Unconstrained Schedule the **GSO will prepare a Constrained Schedule,** which will optimise overall operating costs and maintain a prudent level of **Power System security.**
- **(iv) Final Schedule**
  - Before the issue of the **Indicative Running Notifications, the GSO may consider** it necessary to adjust the output of the Final Schedule.
- **(v) Content of Indicative Running Notification**
  - The information contained in the **Indicative Running Notification will indicate,** on an individual **CDGU basis, the period, Loading and declared fuel for which it is** scheduled during the following week.

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SDC1.4.1 Factors considered in the Merit Order and Energy Balance Statement

(a) The matching of any Large Consumer's contracted (Active and Reactive) requirements for Energy and Demand to the Loading of a CDGU, at the required MW and Mvar, as contained in an energy sales contract. Such energy sales contract to be approved by the Single Buyer, such that the net output of the contracted CDGU matches the Large Consumer's energy sales contract, including System losses between contracted CDGU and Large Consumer, whilst also meeting the Large Consumer's own (Active and Reactive) Demand requirements;

(b) Hydro/thermal optimisation, including any operational restrictions or **Generating Unit operational inflexibility;**

(c) Minimum and maximum water-take for hydro **CDGU** (to be optimised where necessary by the GSO) (to be stated in the **Energy Balance Statement);**

(d) Minimum and maximum fuel-take for thermal **CDGU (to be optimised** where necessary by the **GSO) (to be stated in the Energy Balance Statement);**

SDC4.1 Factors considered in the Merit Order and Energy Balance Statement (cont…)

e) The export or import of Energy across the Interconnector (to be stated in the **Energy Balance Statement);**

f) Requirements by the State or Federal Government to conserve certain fuels (to be stated in the **Energy Balance Statement);**

g) The Availability of a CDGU as declared in **a week ahead Availability Notice;**

h) The start up price of each thermal-**CDGU; and**

i) The additional cost of carrying added **Spinning Reserve resulting from** the operation of an excessively large **CDGU (such cost shall be** considered as additional running cost allocated to that **CDGU's variable** operating costs).

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SDC1.4.6 Generation Data Submitted Week Ahead

Monday **SD1** Week 0	Tuesday **SD2** Week 0	Wednesday **SD3** Week 0	Thursday **SD4** Week 0	Friday **SD5** Week 0	Monday **SD1** Week 1
Power Producers prepares **SDP** and **Availability Notices**	**GSO** receives **SDP** and **Availability Notices** by 10:00 hours	**GSO** submits by 10:00 hours the **Merit Order** to the **Single Buyer** for approval by 16:00 hours	**GSO** prepares a Constrained Schedule and discusses with **Single Buyer** by 10:00 hours	**GSO** issues **IRN** by 10:00 hours	**GSO** issues **Dispatch** instructions based on **IRN** issued on **SD5**

Unconstrained Schedule to consider

a) the requirements as determined by the **GSO for voltage control and** Mvar reserves;

b) in respect of a CDGU the MW values registered in the current Scheduling and Dispatch Parameters (SDP);

c) the need to provide an Operating Reserve, as specified in OC3;

d) CDGU stability, as determined by the GSO following advice from the Power Producer and registered in the SDP;

e) the requirements for maintaining frequency control (in accordance with SDC3);

f) the inability of any **CDGU** to meet its full Spinning Reserve capability or its Non-Spinning Reserve capability**;**

g) Operation of a Generating Unit over periods of low Demand to provide in the GSO's view sufficient margin to meet anticipated increases in Demand later in the current Schedule Day (SD1) or following Schedule Day (SD2); and

h) Transfers to or from Interconnected Parties (as agreed and allocated by the Single Buyer).

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Constrained Schedule Considers

a) **Transmission Network and Distribution Network constraints;**

b) testing and monitoring and/or investigations to be carried out under OC10 and/or commissioning and/or acceptance testing under the CC;

c) **System tests being carried out under OC11;**

d) any provisions by the **GSO under OC7 for the possible islanding of the Power System that require additional Generating Units to be Synchronised as a contingency action; and**

e) re-allocation of **Spinning Reserve and Non-Spinning Reserve to take** account of the possibility of islanding.

Final Schedule Considers

a) changes to Availability and or SDPs of CDGU notified to the LDC after the commencement of the Scheduling process;

b) changes to the GSO's Demand forecasts (for example due to unexpected weather);

c) changes to the Transmission Network and/or Distribution Network constraints emerging from the iterative process of Scheduling and Network security assessments;

d) changes to CDGU requirements following notification to the GSO of the changes in capability of a Generating Unit to provide additional services as described in SDC2;

e) changes to any conditions which in the reasonable opinion of the GSO could impose increased risk to the Power System and could therefore require an increase in the Operating Reserve; and

f) known or emerging limitations and or deficiencies of the Scheduling process.

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SDC 1.4

- **SDC1.4.1 Preparation of the Week Ahead Plan**
- **SDC1.4.2 Issue of Indicative Running Notification**
  - issue a weekly Indicative Running Notification in writing to Power Producers with CDGUs by 10:00
- **SDC1.4.3 Data Requirements**
  - to be supplied by a Power Producer not later than 10:00 hours on the Tuesday
- **SDC1.4.4 Day Ahead Amendment of Availability Notice**
  - no later than the Notice Submission Time each day
- **SDC1.4.5 Availability of a Generating Unit**
- **SDC1.4.6 Generation Data Submitted Week Ahead**
- **SDC1.4.7 Power Station Own Consumption**

SDC1.4.5-1.4.7

- **SDC1.4.5-**The **Power Producer shall use reasonable endeavours to ensure that it does not at any**time declare by issuing to the **LDC or allowing to remain outstanding an Amended** Availability Notice or a **SDP Notice which declares the Availability or SDP of a CDGU at** levels or values different from those that the **CDGU could currently achieve.**

- **SDC 1.4.6(i) Generating Units Scheduling and Dispatch Parameters (SDPs) -**The weekly **Availability, cost information, and revisions to "Registered Operating** Characteristics" for a **CDGU in respect of the week beginning on the Schedule Day commencing on Monday (SD1 of Week 1) shall be submitted by the Power Producer by the Notice Submission Time of 10:00 hours on Tuesday of Week 0.**

- **SDC1.4.7 Power Station Own Consumption-** Once per month, each **Power Producer must, in respect of each of its Power Stations,** submit in writing to the **LDC details of the CDGU works consumption of electricity since** the last submission.

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Suruhanjaya Tenaga KeTTHA KEMENTERIAN TENAGA, TEKNOLOGI HIJAU DAN AIR

SDC1.5 USER NETWORK DATA

SDC1.5.1 Week Ahead Notice

- To enable the **GSO to prepare the Constrained Schedule, it is necessary for all Users with HV Networks to provide data on any changes to its Network that, in the GSO's** reasonable opinion, could result in a **CDGU being constrained during that schedule** period.

- Therefore, by not later than the **Notice Submission Time of 10:00 hours each Tuesday of** Week 0, each **User with a HV Network will submit to the LDC in writing, confirmation of** the following in respect of the next **Availability period:**

  – (a) Constraints on a **User's Network, which restrict in any way the operation of a CDGU, which the GSO may need to take into account in preparing the** Constrained Schedule; and

  – (b) **User requirements for voltage control and Mvar, which the LDC may need to** take into account for **Power System security reasons.**

a) in the case of steam turbines the synchronising times for the various levels of warmth and in addition the time from synchronisation to **Dispatched Load; and**

b) in the case of hydro sets and also gas turbines, the time from initiation of a start to achieving **Dispatch Load.**

a) Minimum Generation in MW;

b) Governor Droop (%); and

c) Sustained Operating Capability.

a) Minimum Take (MW.hr) per **Schedule Day; and**

b) Maximum Take (MW.hr) per **Schedule Day.**

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SDC1 – APPENDIX A: GENERATION SCHEDULING AND DISPATCH PARAMETERS-cont…

a) Minimum on-time;

b) Minimum off-time;

c) Loading blocks in MW following Synchronisation;

d) Maximum **Loading rates for the various levels of warmth and for up to two output ranges** including soak times where appropriate;

e) Maximum De-**Loading rates for up to two output ranges;**

f) The MW and Mvar capability limits within which the **CDGU is able to operate as shown in** the relevant Generator Performance Chart;

g) Maximum number of on-**Load cycles per 24 hour period, together with the maximum Load** increases involved; and

h) In the case of gas turbines and Diesels only, the declared **Peak Capacity. Sufficient data** should also be supplied to allow the **LDC to temperature correct this impaired Capacity** figure to forecast ambient temperature.

a) the procedure for the **LDC to issue Dispatch instructions to Power Producers in** respect of their **CDGUs;**

b) the procedure for the **Single Buyer to coordinate and manage trading with Interconnected Parties; and**

c) the procedure for optimisation of overall **Power System operations by the GSO for** the **Scheduled Day.**

SDC2.4 PROCEDURE

- **SDC2.4.1 Information Used**
  - The information which the **Single Buyer, and GSO shall use in assessing weekly or daily,** as appropriate, which **CDGU to Dispatch will be the Availability Notice, the Merit Order** as derived under SDC1 and the other factors to be taken account listed in SDC1, **Generating Unit Scheduling and Dispatch Parameters, and 'Generation Other Relevant** Data' in respect of that **CDGU, supplied to the LDC by the Power Producers, and to the Single Buyer.**

- **SDC2.4.2 Re-Optimisation of the Constrained Schedule**
  - The **GSO will run Dispatch software to re-optimise the Constrained Schedule when, in its** reasonable judgement, a need arises.

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Additional factors

Taken into account in agreeing changes to the Constrained Schedule are:

a) those where a **Power Producer has failed to comply with a Dispatch** instruction given after the issue of the **Indicative Running Notification;**

b) variations between forecast **Demand and actual Demand including** variations in **Demand reduction actually achieved by Users;**

c) the need for **Generating Units to be operated for monitoring, testing or** investigation purposes under OC10 or at the request of a **User under OC10** or for commissioning or acceptance tests under OC11;

d) requests from the **Single Buyer for an increase or decrease in Transfer Level;**

e) requests from the **Single Buyer for a change to the operation of a specific CDGU;**

f) changes in the required level of **Operating Reserve, as defined by the GSO;**

g) System faults; and

h) changes in the weather; These factors may result in some **CDGUs being Dispatched out of Merit Order.**

SDC2.5 DISPATCH INSTRUCTIONS

- **SDC2.5.1 Introduction**
- **SDC2.5.2 Scope of Dispatch Instructions for CDGUs**
- **SDC2.5.3 Form of Instruction**
- **SDC2.5.4 Action required from Power Producers**

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SDC2.5.1 Dispatch Instruction

- Dispatch instructions relating to the Scheduled Day can be issued by the LDC at any time during the period beginning immediately after the issue of the Indicative Running Notification in respect of that Scheduled Day. The LDC may, however, issue Dispatch instructions in relation to a CDGU prior to the issue of an Indicative Running Notification containing that Generating Unit.

- The **LDC will make available the latest Indicative Running Notification to the Power Producers as soon as is reasonably practicable after any re-optimisation of the** Constrained Schedule.

- The **LDC will issue Dispatch instructions directly to the Power Station's Approved Person** for the **Dispatch of each CDGU.** On agreement with the GSO, the LDC may issue Dispatch instructions for any CDGU which has been declared available in an Availability Notice even if that Generating Unit was not included in an Indicative Running Notification. Dispatch instructions will take into account Availability Notice and Generating Unit Operating Characteristics.

- The **GSO through the LDC will use all reasonable endeavours to meet the Transfer Level** requested by the **Single Buyer.**

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Dispatch Instructions

Active Power Dispatch (Most frequent) & others are as follows:

a) time to **Synchronise;**

b) provision of **Spinning Reserve;**

c) provision of **Non-Spinning Reserve;**

d) Reactive Power (instructions may include Mvar output, target voltage levels, tap changes, maximum Mvar output, or maximum Mvar absorption);

e) operation in **Frequency Sensitive Mode;**

f) operation at **Maximum Continuous Rating (MCR)** or Peak Capacity;

g) future **Dispatch requirements;**

h) request for details of **Generating Units step-up transformer tap positions;**

i) instructions for tests;

j) emission or environmental constraints;

k) operation as a “Transfer Level Control Generating Unit”; and

l) details of adverse conditions, such as bad weather.

SDC2.5.3 Form of Instruction

- Dispatch instructions may be given by telephone, facsimile or electronic message from the LDC**.**
- Instructions will require formal acknowledgement by the Power Producer and recorded by the LDC in a written Dispatch log.
- When appropriate electronic means are available, Dispatch instructions shall be confirmed electronically. Power Producers shall also record all **Dispatch instructions in a written Dispatch log.**
- Such Dispatch logs and any other available forms of archived instructions, for example**,** telephone recordings, shall be provided to the **Regulator's investigation team pursuant** to OC6 when required.
- Otherwise, written records shall be kept by all parties for a period not less than 4 years and voice recordings for a period not less than 3 months.

SDC2.5.4 Action required from Power Producers

The following actions are required by each **Power Producer;**

a) each Power Producer will comply with all Dispatch instructions correctly given by the LDC;

b) each Power Producer must utilise the relevant Dispatch parameters when complying with Dispatch instructions; and

c) in the event that a Power Producer is unable to comply with Dispatch instructions, it must notify the Dispatcher immediately.

SDC2.6 EMERGENCY CONDITIONS

- To preserve Power System security under System Stress or emergency conditions, the LDC, or a local network control centre (which would be required if, for example, the LDC loses communication with Users), may issue **Emergency Instructions** to Power Producers**.** This may request action outside of the Scheduling and Dispatch Parameters, other relevant data or notice to Synchronise.

- A Power Producer is required to use all reasonable endeavours to comply with Emergency Instructions, but when unable to do so the Power Producer must inform the LDC immediately

SDC3 FREQUENCY AND TRANSFER CONTROL

SDC3 sets out the procedure that the **GSO and RSO will use** to direct control of the Frequency, the “Frequency Control”.

These will be controlled by**;**

a) the automatic response of **CDGUs in Frequency Sensitive Mode;**

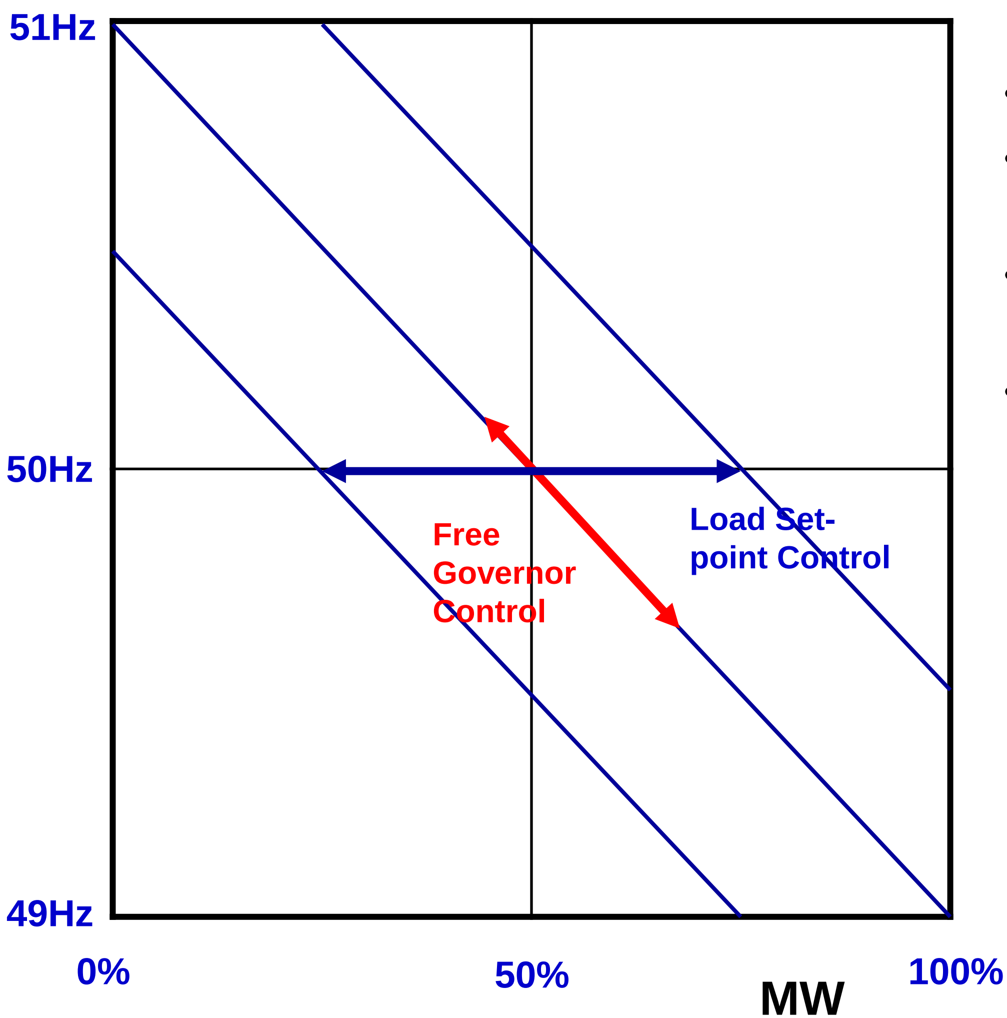
b) Dispatch of CDGUs by the GSO and RSO or RDCs;

c) Demand Control, carried out by the RDCs; and

d) the management of the Transfer Levels between the Power System and Interconnected Parties by the GSO and RSO.

In addition, it sets out the procedure by which the GSO will direct international transfers of Energy and Active Power, known as the Transfer Level, across the Interconnector.

Free Governor Vs Load Set-point Control



Purpose of Speed Governor

- Control of the turbine start-up and shutdown sequences
- Synchronisation of the turbine with the grid
- Control of the active power supplied by the generator to an interconnected network
- Control of network frequency on an isolated electrical network
- Protection of the unit against overspeed in case of load rejection

Free Governor Response = MW/sec

Load Set-point Control Response = MW/min

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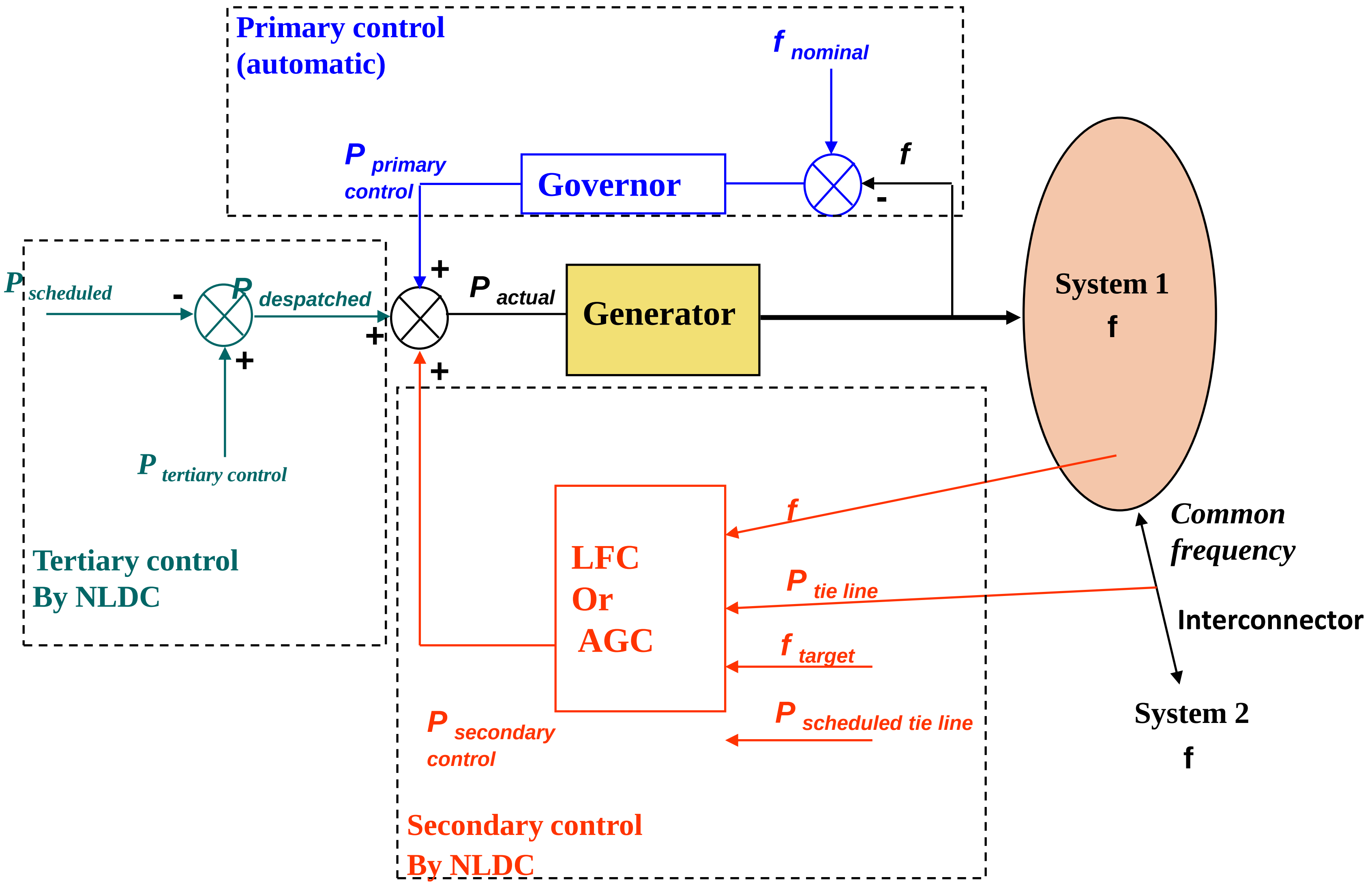
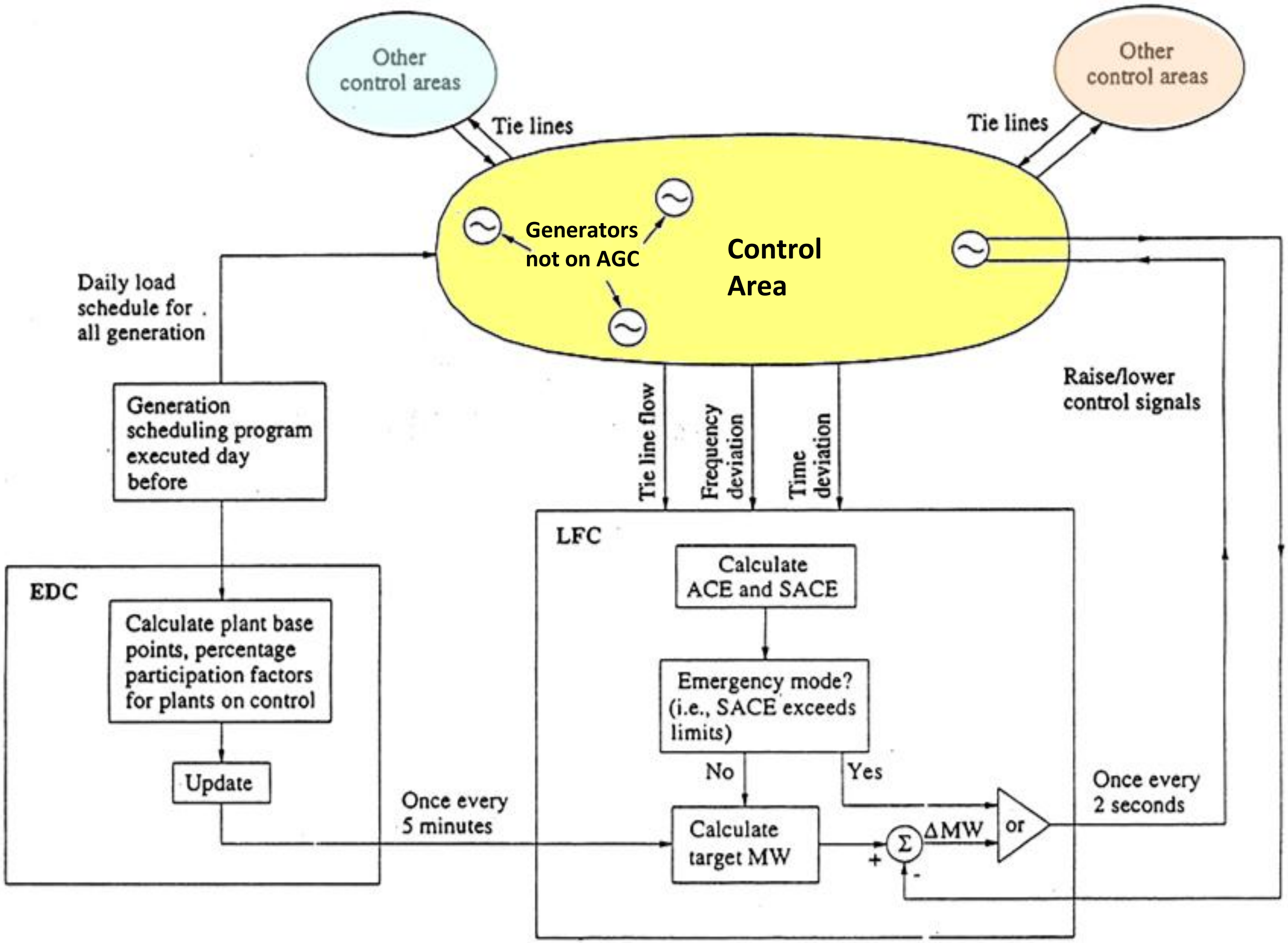
SDC3.4 PROCEDURE

- **SDC3.4.1 Frequency Response from Power Stations**
  - At Power Stations designated Regulating Power Stations by the Single Buyer each CDGU shall be available for Primary Reserve frequency regulation including High Frequency Response when required by the GSO or RSO.
  - At Power Stations not designated Regulating Power Stations each CDGU shall provide Secondary Reserve frequency regulation including High Frequency Response when required by the GSO or RSO.
- **SDC3.4.2 Instructions**
  - Coordination of instructions will be the responsibility of the GSO and RSOs.
- **SDC3.4.3 Low Frequency Relay Initiated Response from CDGUs**
- **SDC3.4.4 Low Frequency Relay Initiated Response from Demand**

Three Levels of Frequency Control



Functional Block of a Typical AGC



3.4.3 &3.4.4 Low Frequency Responds from Generator and Demand

CDGUs with the capability of low frequency relay initiated response may be used in the following modes:

(a) Synchronisation and generation from standstill;

(b) generation from zero generated output;

(c) increase in generated output.

The **GSO and RSOs** will agree the **low frequency relay settings** to be applied to CDGUs with the Power Producers.

The **GSO and RSOs** may use Demand with the capability of low frequency relay initiated Demand reduction for establishing its requirements for frequency control. The GSO and RSOs will specify the low frequency relay settings and the amount of Demand reduction to be made available.

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SDC3.5 ELECTRIC TIME

Time error correction (between local mean time and electric clock time) shall be performed by the GSO and RSOs by making an appropriate offset to the target Power System frequency. The GSO and RSOs shall be responsible for:

(a) monitoring and recording of electric time error;

(b) instructing actions to correct electric time error;

(c) maintaining (as far as it is able) the electric time error within ± 20 seconds.

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SDC3.6 TRANSFER REGULATION (INTERCONNECTED POWER SYSTEM ONLY)

- With respect to each **Interconnector, it is normal by mutual agreement for one party to provide** the Transfer Regulation, by controlling the level of **Power flows with its area generation control** SCADA system.
- Consequently the Transfer Regulation Party, being the **GSO or Interconnected Party, shall carry out Transfer Regulation to a tolerance of □ 20 MW of the agreed Transfer Level** with a regulation error measured at the MW going through zero at least once in every 10 minute period.
- If, at any time, the **Transfer Level error exceeds 20 MW, the Transfer Regulation Party shall take** such steps as are reasonably necessary to correct the error within 15 minutes, utilising any means the Transfer Regulation Party considers appropriate.
- For the avoidance of doubt, each party shall be responsible for the generation of the necessary **Reactive Power** at its end of the Interconnector with the result that **no transfer** of Reactive Power is required across the Interconnector between the GSO and the interconnector Party.

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The End of Schedule and Dispatch Code

- Cover submission of availability data and Preparation of Week ahead Schedule Plan
- Control and Dispatch instructions
- Frequency and Transfer Control, demand control

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The End

- End of Schedule and Dispatch Codes

METERING CODE (MC)

The objectives of the Metering Code are to establish the:

(a) standards to be met in the provision, location, installation, operation, testing and maintenance of **Metering Installations;**

(b) obligations of the parties bound by the Metering Code in relation to ownership and management of **Metering Installations and the provision and use of Meter data; and**

(c) responsibilities of all parties bound by the Metering Code in relation to the storage, collection and exchange of **Meter data.**

The Metering Code applies to all exit points from and entry points to the **Transmission Network and the** metering of **Generating Units equal to or greater than 1 MW connected to a Distribution Network or a Rural Network.**

MC4 REQUIREMENTS (1)

- **MC4.1 FISCAL METERING**
- **MC4.2 LOCATION**
- **MC4.3 OWNERSHIP**
  - MC4.3.2 Another Party May Own Metering if Agreed in Writing Between Parties
- **MC4.4 METERING INFORMATION REGISTER**
- **MC4.5 ACCURACY OF METERING AND DATA EXCHANGE**
  - MC4.5.1 Applicable Standards
    - (i) Metering Installation
    - ii) Data Exchange
  - MC4.5.2 Overall Accuracy Requirements for Fiscal Metering
  - MC4.5.3 Metering Equipment Accuracy Classes

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MC4 REQUIREMENTS (2)

- MC4.6 ADDITIONAL METERING
- MC4.7 ACCESS TO METERING DATA
- MC4.8 TESTING
- MC4.9 SECURITY
- MC4.10 DISPUTES
- MC4.11 COMMISSIONING OF METERING INSTALLATIONS
- MC4.12 OPERATIONAL METERING

MC4.8 TESTING

- The owner of a **Fiscal Metering installation will undertake calibration testing upon request by the Associated User.** In addition the owner will undertake routine testing of the Meters every year and of the CTs and VTs every 5 years.

- Where, following a test, the accuracy of the **Metering Installation is shown not to comply with** the requirements of this Metering Code, the owner will at its own cost:

  (a) consult with the **Single Buyer and the Associated Users with regards to the errors** found and the possible duration of the existence of the errors; and

  (b) make repairs to the **Metering Installation to restore the accuracy to the required** standards.

- The cost of routine testing must be met by the owner of the **Metering Installation.**

MC 4.8 Meter Testing (cont…)

- In regard to all testing, such work will only be undertaken by a person holding a valid Certificate of Registration as an Electrical Services Contractor issued with endorsement for meter testing, which may include a **Network Operator or User or their contractors.**

- **Where a User is the owner** of **Fiscal Metering and undertakes testing of this Fiscal Metering, then such testing may be** witnessed by a representative of the **Single Buyer, Network Operator and/or Associated User, if** the **Single Buyer, Network Operator and/or an Associated User makes a written request to do** so.

- Where such a test is undertaken outside the routine pre-planned maintenance periods, then the **User concerned shall provide a minimum of 5 Business Days notice of such tests to the Single Buyer and any Associated User. Where such a test is part of the routine pre-planned** maintenance process then the **User concerned shall provide a minimum of 20 Business Days** notice of such tests to the **Single Buyer and any Associated User**

MC4.12 OPERATIONAL METERING

- **Operational Metering is required for the real time operation of a Power System.** Because operational requirements differ from fiscal requirements, **Operational Metering does not** necessarily have the same requirement for accuracy of measurement that **Fiscal Metering has.**

- However, **Operational Metering is critical for the efficient, safe and timely operation of the Power System by its GSO or RSO.** Therefore, the **GSO or RSO has the right to install Operational Metering so as to provide such** operational information in relation to each **Generating Unit and each Power Station as the GSO** or **RSO may reasonably require to perform its duties in accordance with the Grid Code,** ordinances and license conditions.

- Such information required by the **GSO or RSO, in accordance with this MC4.12, shall be limited to** that required for support and implementation of the relevant unit dynamic modelling and spinning reserve monitoring. Such information shall be presented continuously to SCADA, event.

The End

- End of Metering Code

THANK YOU

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Suruhanjaya Tenaga

Sabah dan Labuan Grid Code Awareness Programme Funded by Akaun Amanah Industri Bekalan Elektrik (AAIBE)