A Half-Day Seminar on The New Deregulated Electricity Market in Singapore

28 March 2003, Friday at 2.00 p.m. to 5.00 p.m.

EDB Learning Centre, 2nd Level
2985 Jalan Bukit Merah, Singapore 159457

Objective

With the liberalization of the energy market, changes are expected in the way electricity is procured. This seminar will provide an insight of what was the past trend, the present and the future. It will provide a simple approach to evaluate the various electricity packages, so that end users can make an informed decision when they buy electricity in the new supply market, The seminar will also discuss the technical value-added services competitive electricity retailers can offer.

Programme

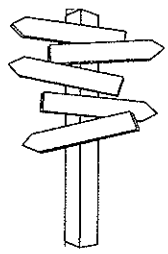
1.30 p.m.	Registration
2.00 p.m.	Welcome Address by Association of Consulting Engineers Singapore
2.00 p.m.	Singapore Electricity Industry - The Past, The Present and The Future by Mr. Tung Ho Kok, General Manager, Tuas Power Supply Pte Ltd
2.30 p.m.	Electricity Market Deregulation - Electricity Cost and Energy Efficiency by Mr. Ben Lau, Senior Manager (Supply Business), Tuas Power Supply Pte Ltd
3.00 p.m.	TEA BREAK
3.20 p.m.	Electricity Supply Packages and Buying Process by Mr. Lim Sam San, Manager (Marketing), Tuas Power Supply Pte Ltd
3.50 p.m.	Electricity Supply and Technical Value Added Services by Mr. Neo Poh Hua, Manager (Technical Services), Tuas Power Supply Pte Ltd
4.20 p.m.	Questions and Answers
5.00 p.m.	End

THE PAST, THE PRESENT AND THE FUTURE

TUAS POWER

THE NEW ELECTRICITY MARKET (NEM)

To provide direction and roadmap
as guiding posts for the power industry



- ***Mission*** - To ensure that Singapore enjoys the most competitive utility rates in the world



- ***How?*** - Economic reform in electricity industry should first be achieved through industry restructuring over a period of time and through a series of steps

INDUSTRY RESTRUCTURING

Step One : Regulatory Unbundling

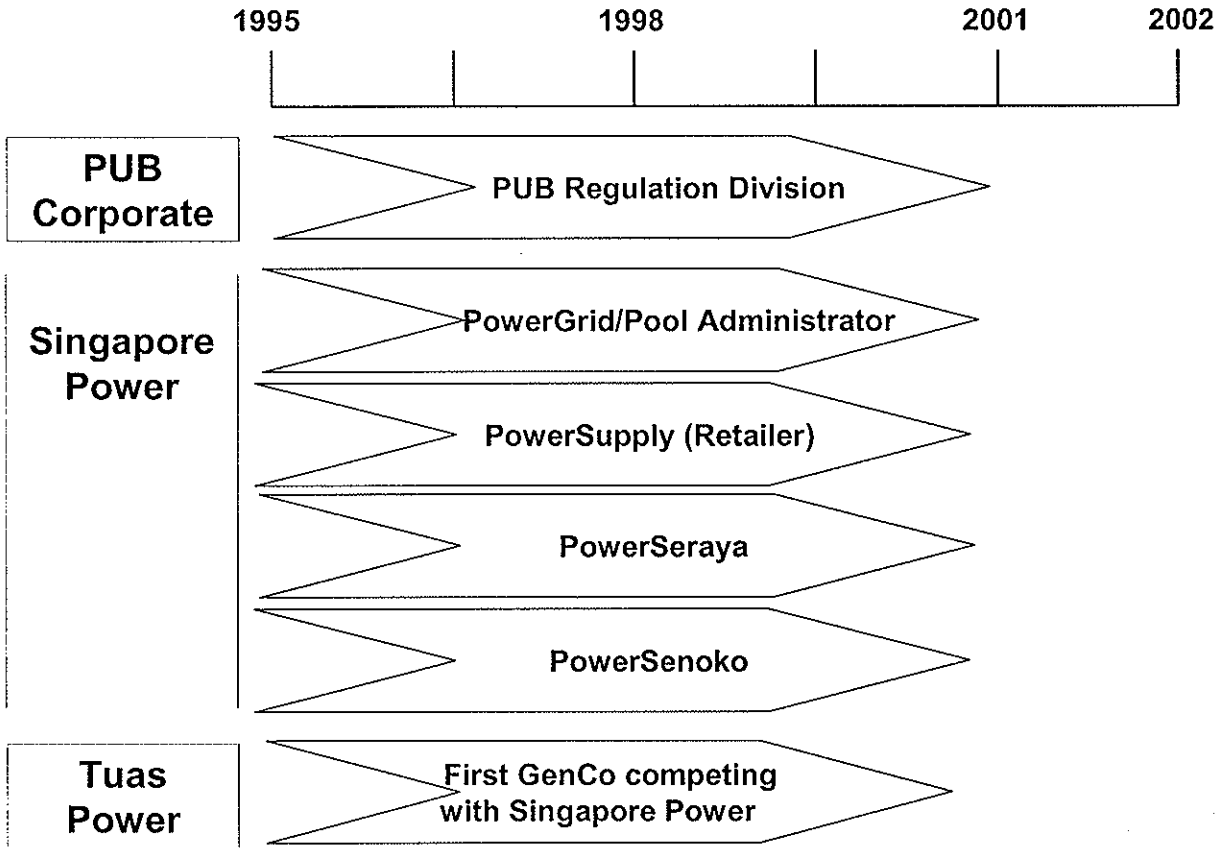
Optimal structure and processes to:

- Put in place a competitive framework
- Continue to maintain security of supply
- Introduce competition & offer choice to consumers
- Maximise returns from privatisation of generation assets by government

MAJOR MILESTONES: THE PAST

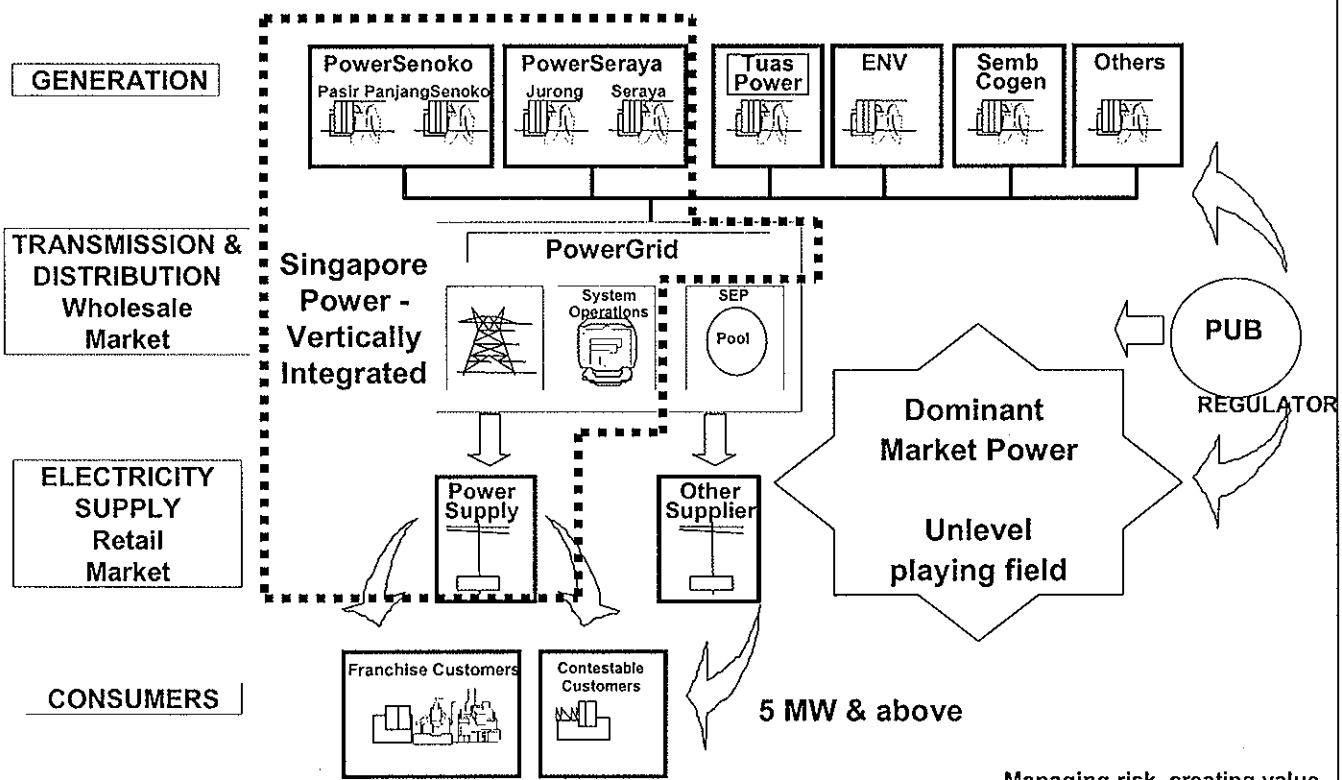
- 1995 Oct • Public Utilities Board (PUB) corporatises in preparation for liberalised power market
- 1998 Apr • Singapore Electricity Pool (SEP) starts, very large consumers (>5MW) become contestable
- 2000 Mar
- 2001 Apr
- Jul
- Jul
- 2003 Jan

Market Evolution Roadmap



Managing risk, creating value

The Electricity Market - Dominant Market Power & Unlevel Playing Field



Managing risk, creating value

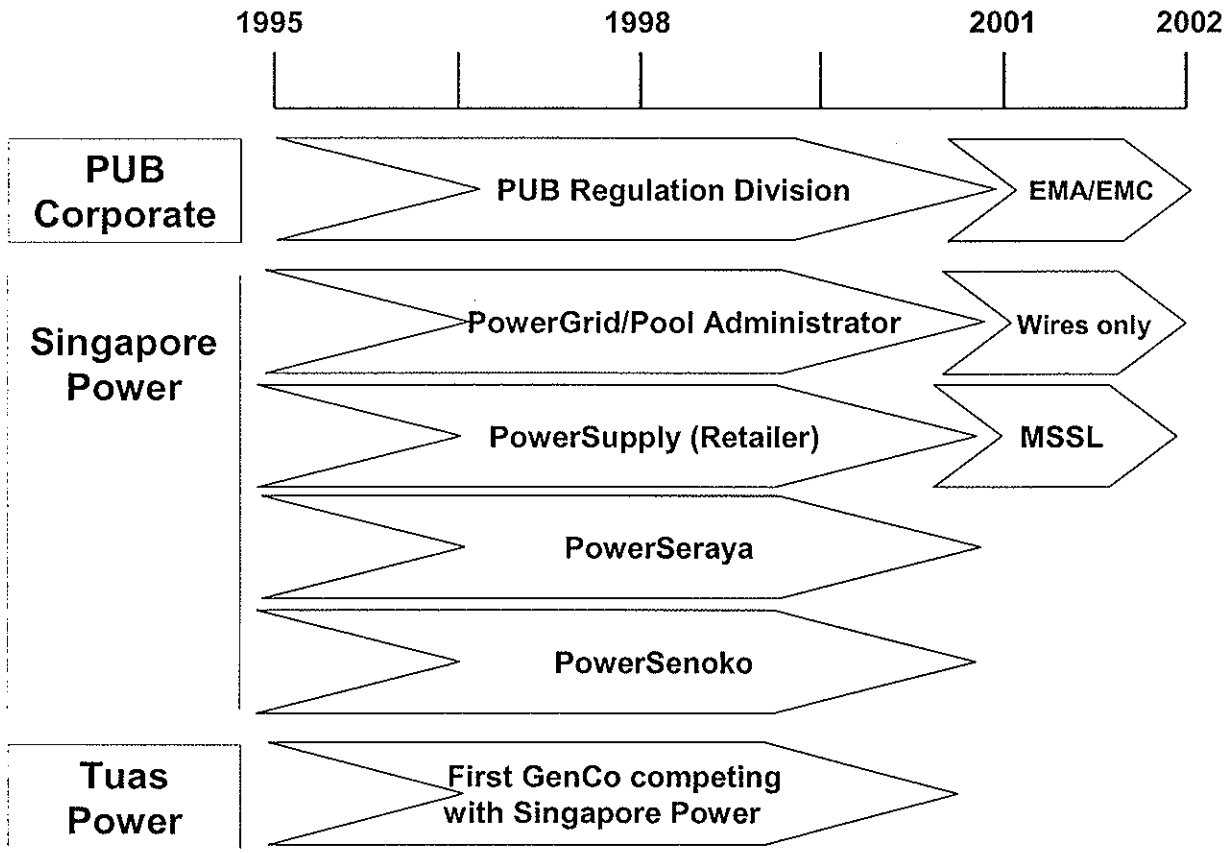
MAJOR MILESTONES: THE PRESENT

- 1995 Oct • Public Utilities Board (PUB) corporatises in preparation for liberalised power market
- 1998 Apr • Singapore Electricity Pool (SEP) starts, very large consumers (>5MW) become contestable
- 2000 Mar • Govt decision on further liberalisation of electricity industry
- 2001 Apr • Energy Market Authority (EMA) formed to replace PUB (Regulation)
- Jul • Energy Market Co. (EMC) formed to run SEP and later, NEM
- Jul
- 2003 Jan

Step Two: Functional Unbundling

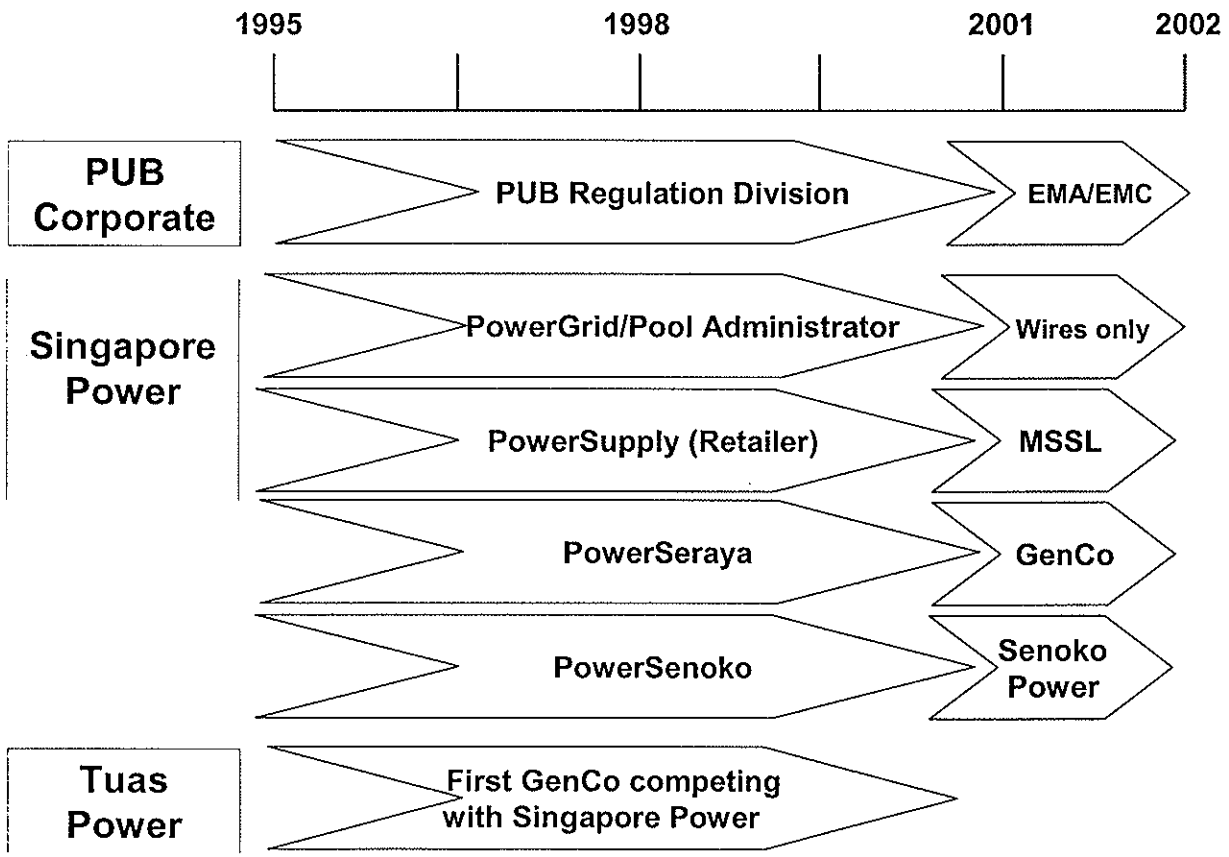
Monopoly and competitive elements of the electricity and gas industries should be separated **fully** and at the ownership level

Market Evolution Roadmap



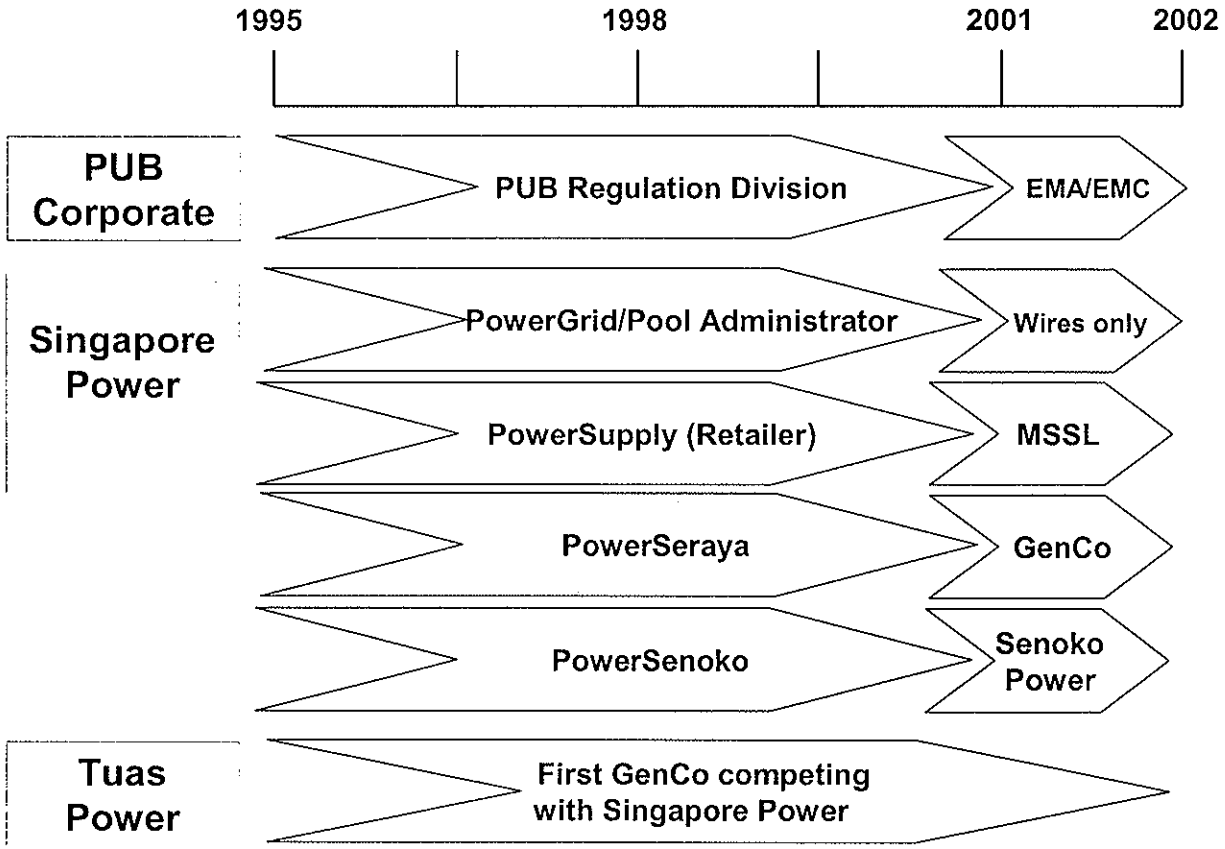
Managing risk, creating value

Market Evolution Roadmap



Managing risk, creating value

Market Evolution Roadmap



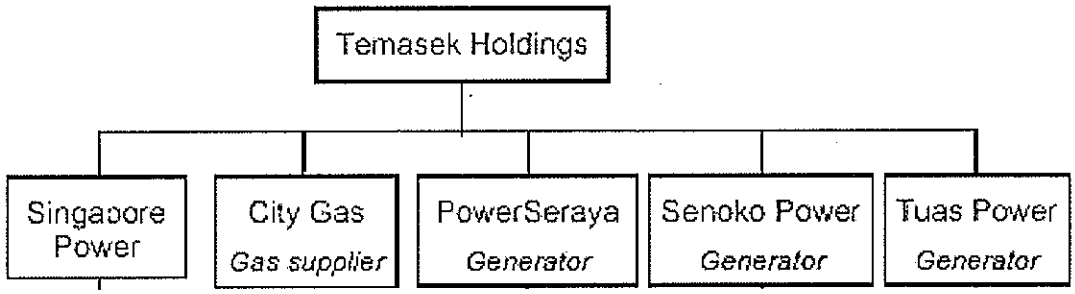
Step Two: Functional Unbundling

Monopoly and competitive elements of the electricity and gas industries should be separated fully and at the ownership level

Temasek Holdings

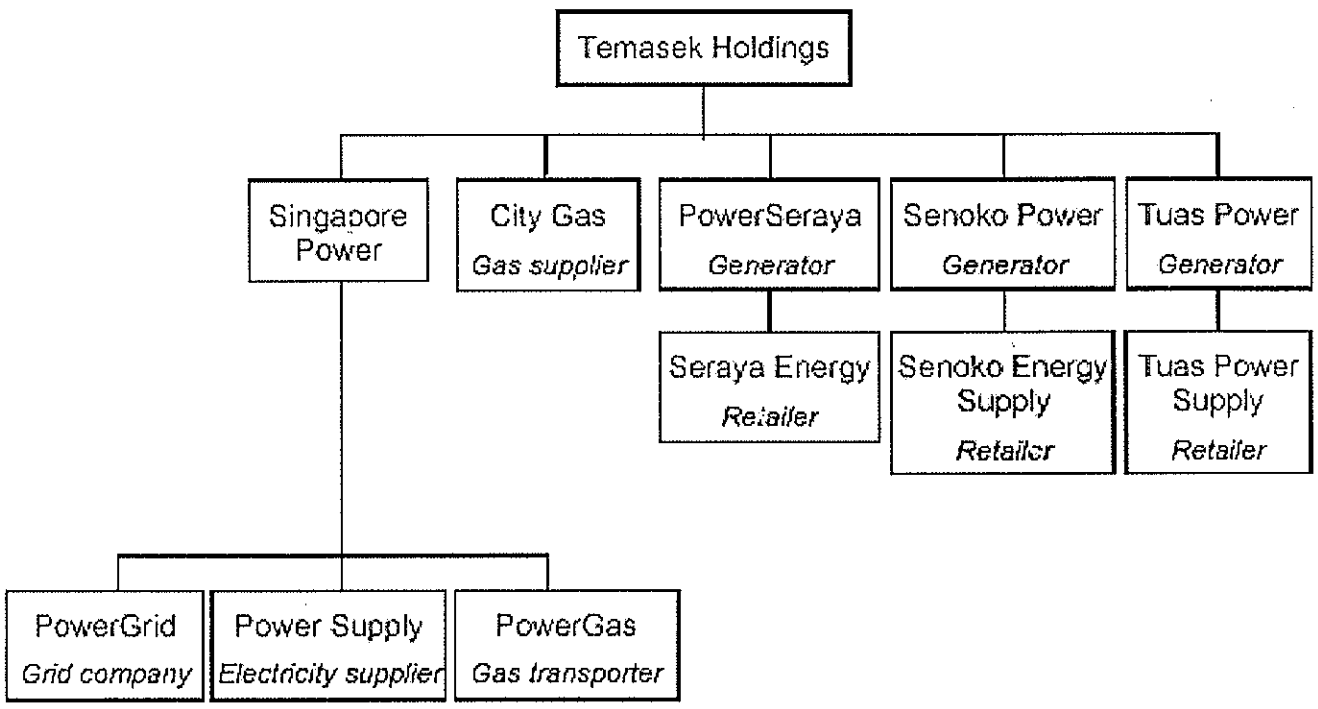
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Monopoly and competitive elements of the electricity and gas industries should be separated fully and at the ownership level



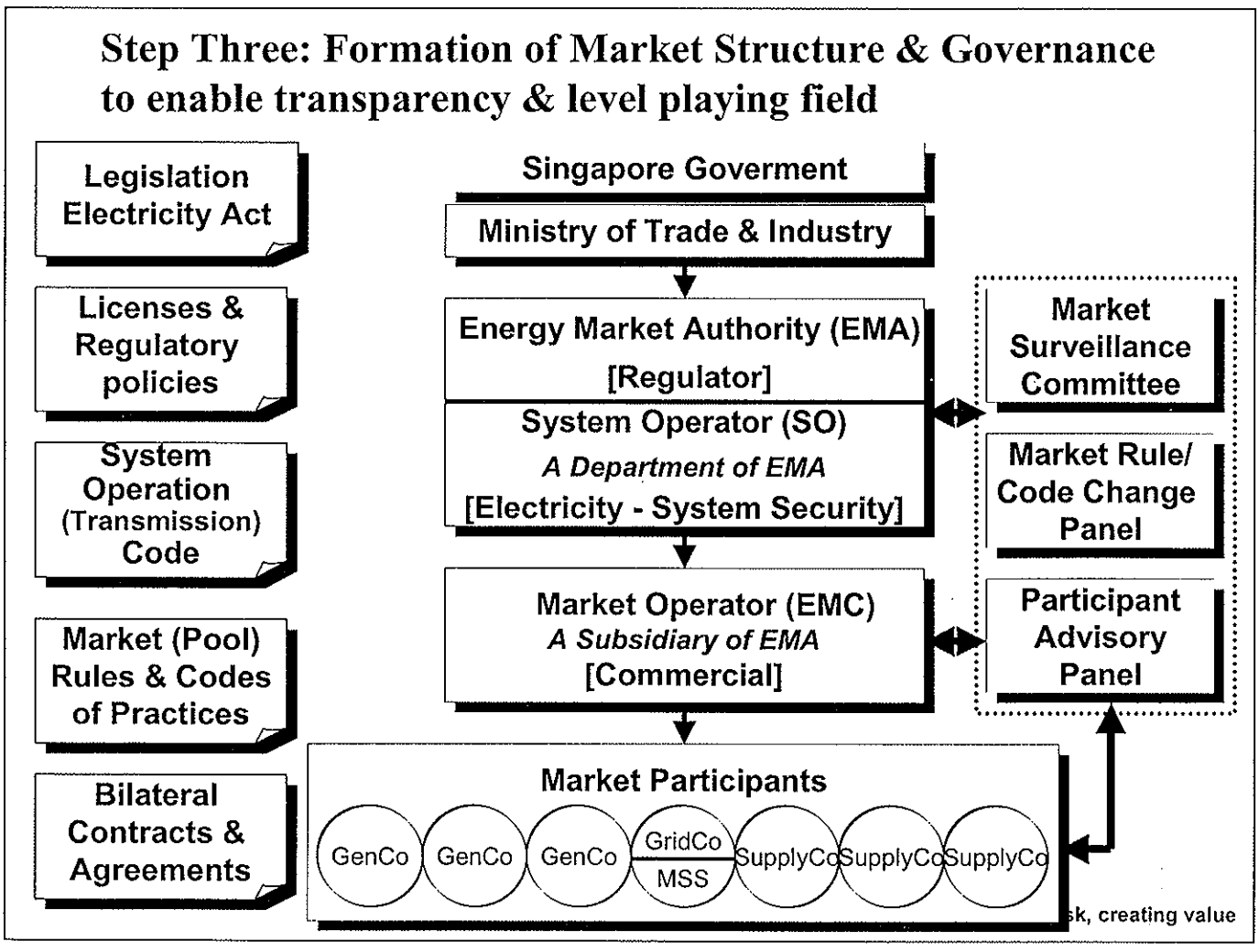
Step Two: Functional Unbundling

Monopoly and competitive elements of the electricity and gas industries should be separated fully and at the ownership level



Step Three

Formation of Market Structure & Governance to enable transparency & level playing field



Generation Companies

- Generate Electricity
- Compete by bidding into the Pool

Market Operator

- Market Operation (EMC)

Supply (Retail) Companies

- Sale of electricity to consumers

Industrial Regulator (EMA)

- Issue of Licenses
- Regulate Electricity Industry
- System operation

Market Service Support Company (Ex-Power Supply)

- Meter Reading
- Customer Registration & Transfer
- Customer Connection & Termination
- Testing & Inspection
- Wholesale settlement
- Supply to Non-Contestable Customers
- Not allowed to do Competitive Business
- Supplier of last resort

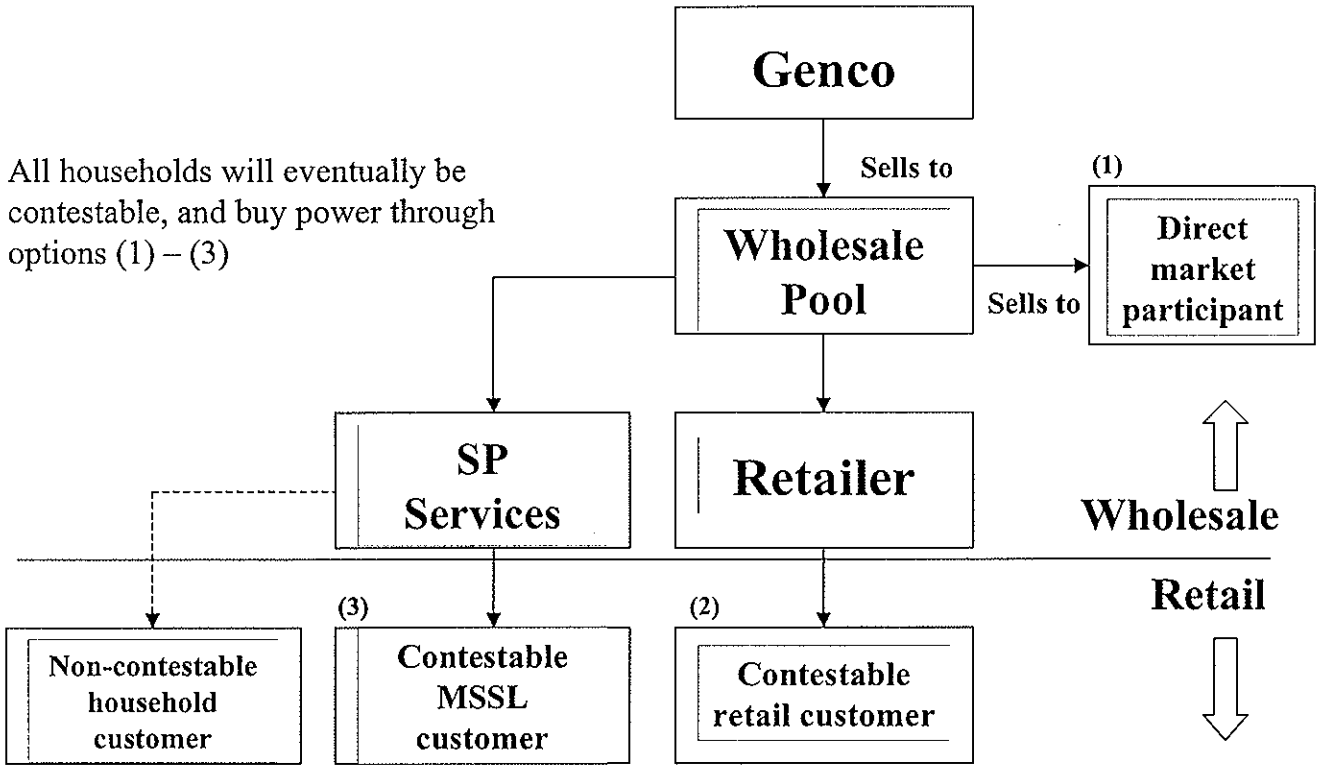
Transmission Licensee

- Responsible for the health of the network

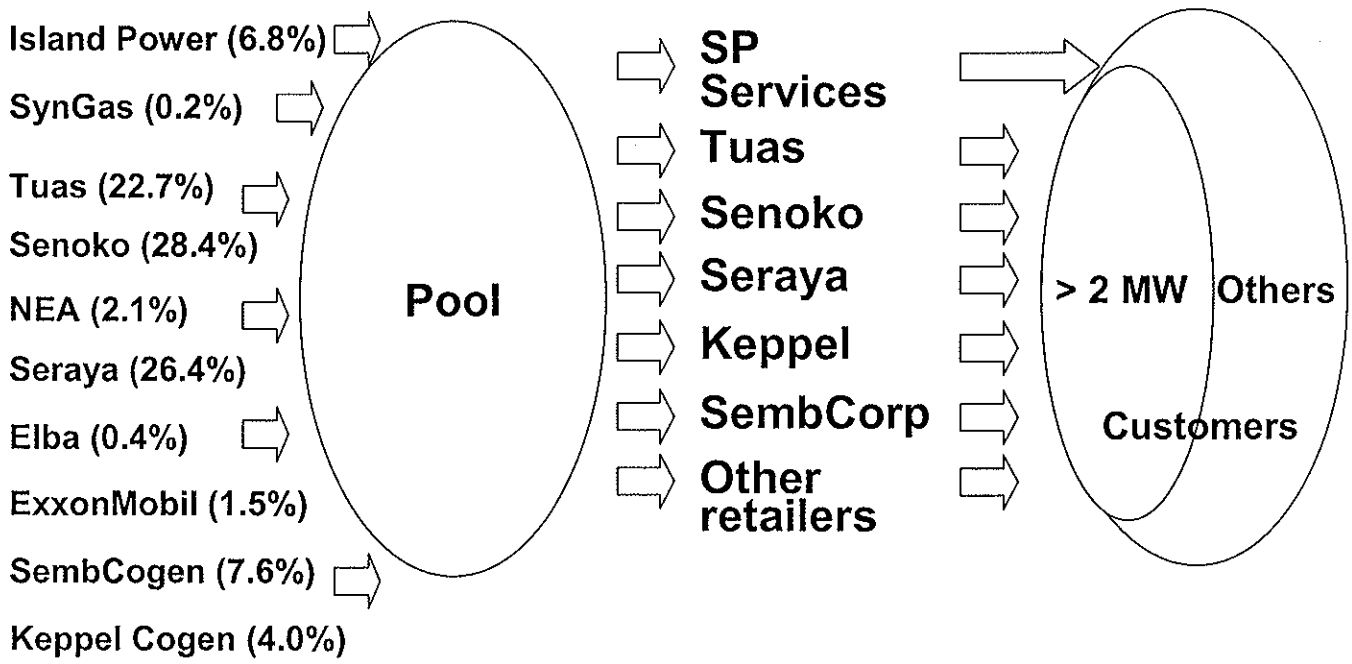
MAJOR MILESTONES: THE FUTURE

• 1995 Oct	•	Public Utilities Board (PUB) corporatises in preparation for liberalised power market
• 1998 Apr	•	Singapore Electricity Pool (SEP) starts, very large consumers (>5MW) become contestable
• 2000 Mar	•	Govt decision on further liberalisation of electricity industry
• 2001 Apr	•	Energy Market Authority (EMA) formed to replace PUB (Regulation)
• Jul	•	Energy Market Co. (EMC) formed to run SEP and later, NEM
• Jul	•	Large customers (>2MW) become contestable
• 2003 Jan	•	NEM opens

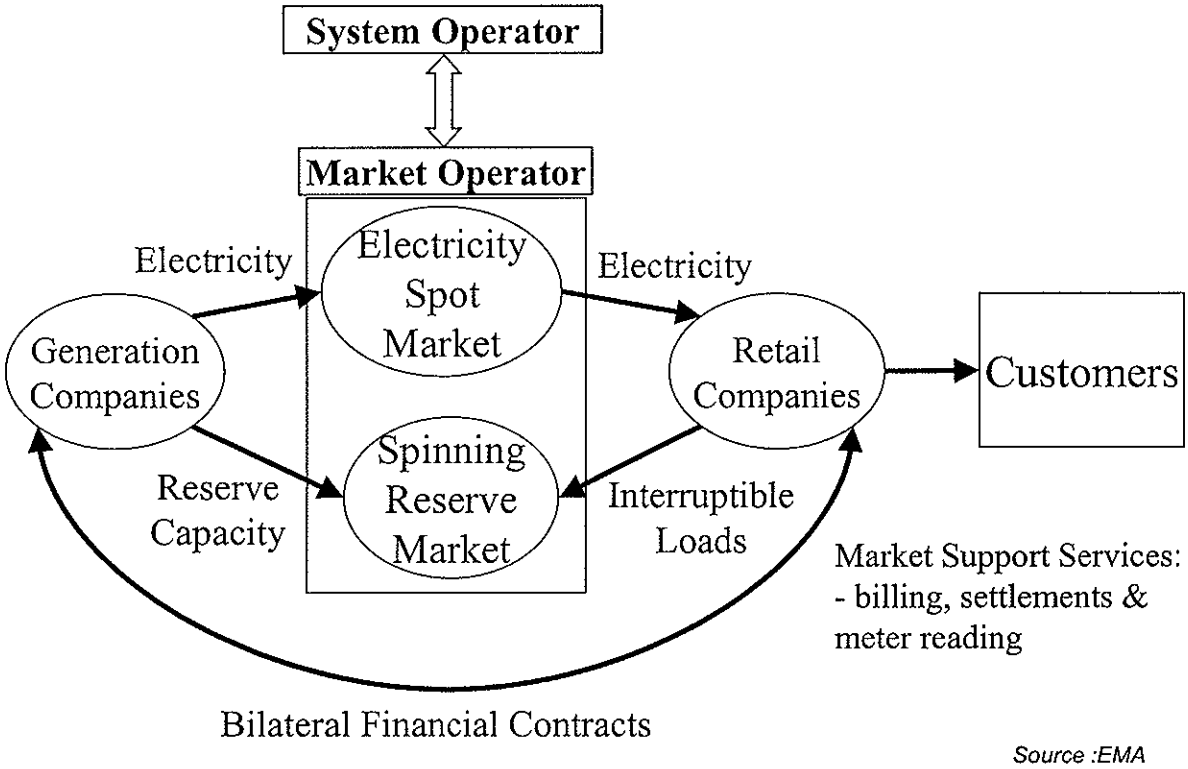
Structure of contestable market (retail & wholesale)



New Electricity Market - competitors



Structure of the Wholesale Electricity Market

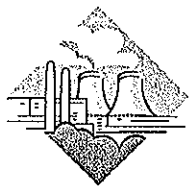


Source :EMA

Participants in the Electricity market

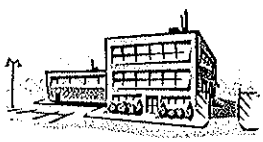
Who are They ?

Generator



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Customer



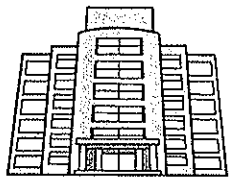
EMC/PSO PowerGrid

POWERGRID SUPPLY

ENERGY MARKET AUTHORITY

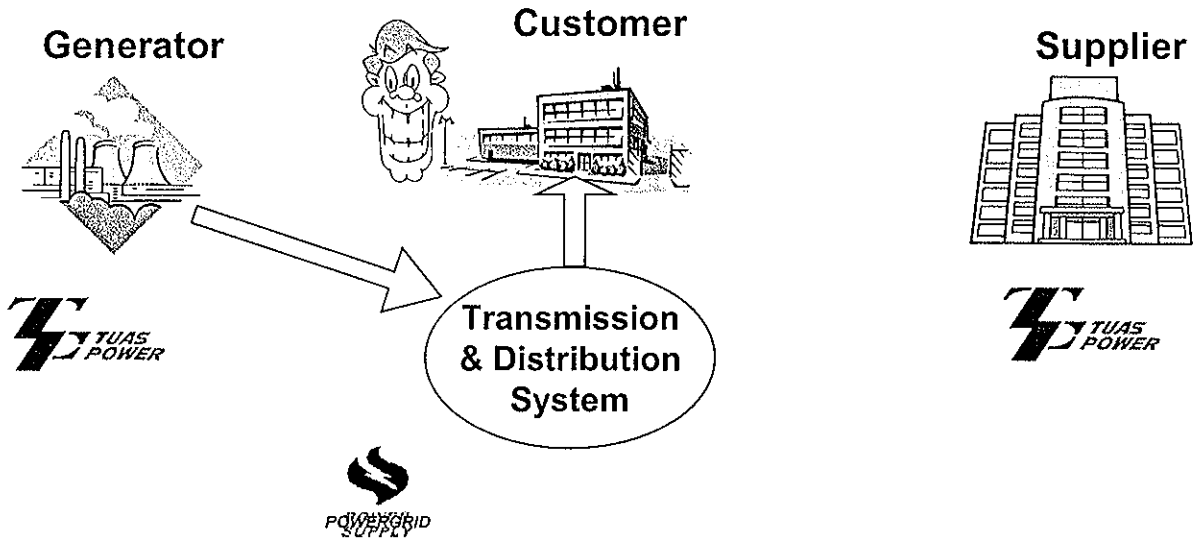
EMC

Supplier



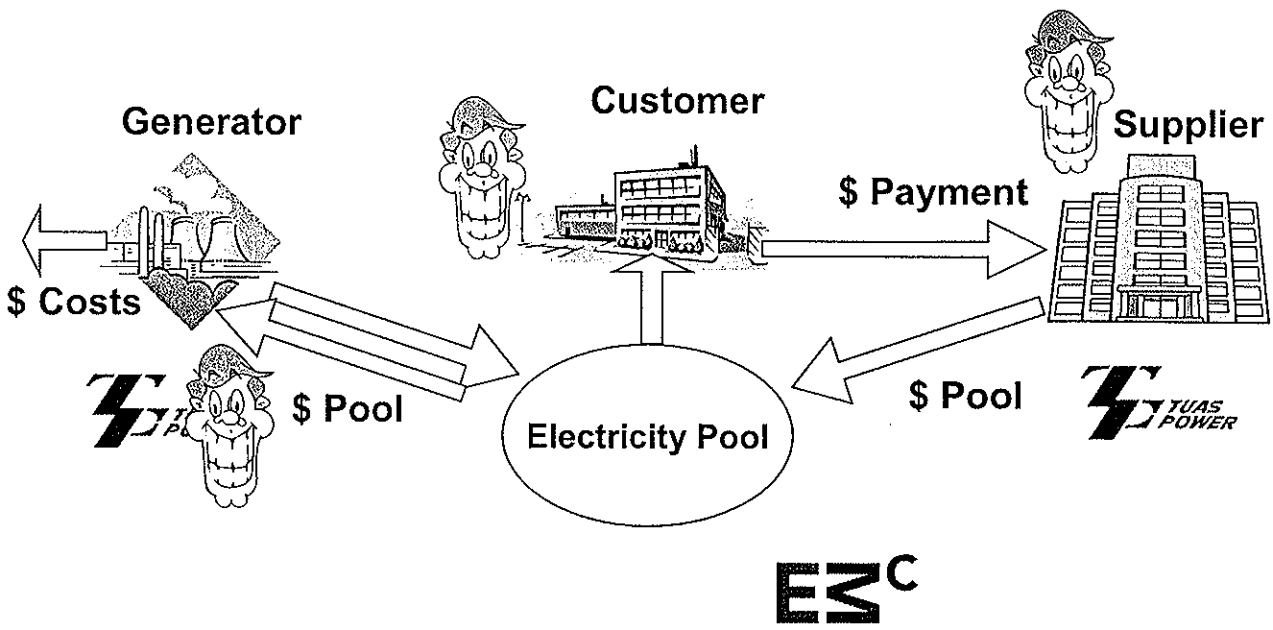
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Electricity Flow in the Electricity market



Managing risk, creating value

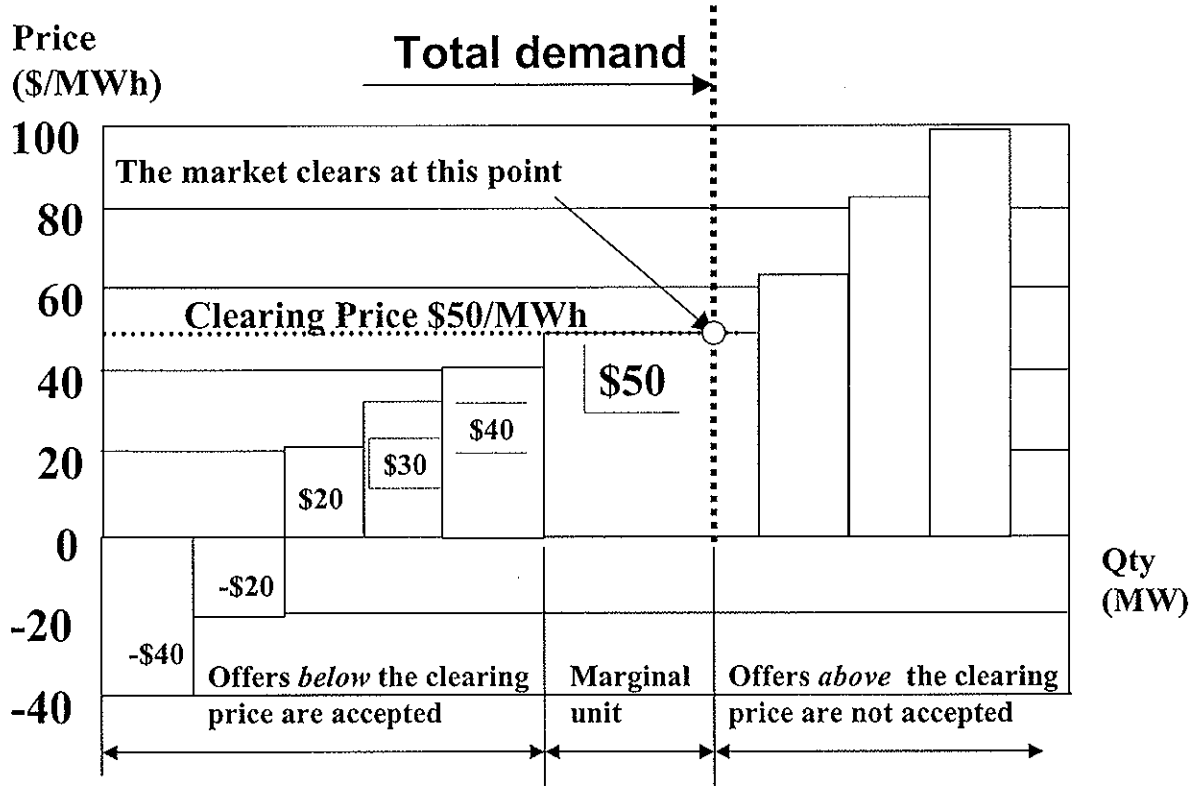
Cash Flow in the Electricity Market



EMC

Managing risk, creating value

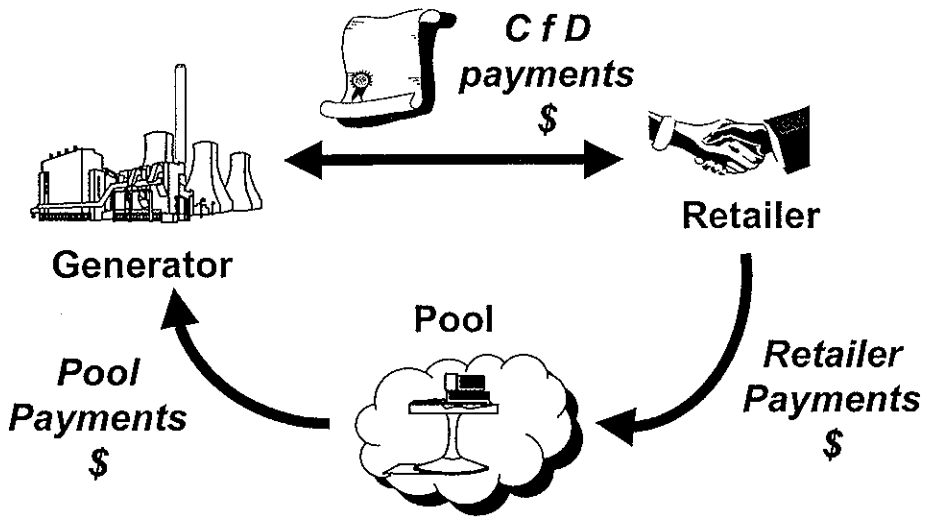
Bidding and Market Clearing Example



Company A Company B Company C

Retailers Manage Pool Prices Risk

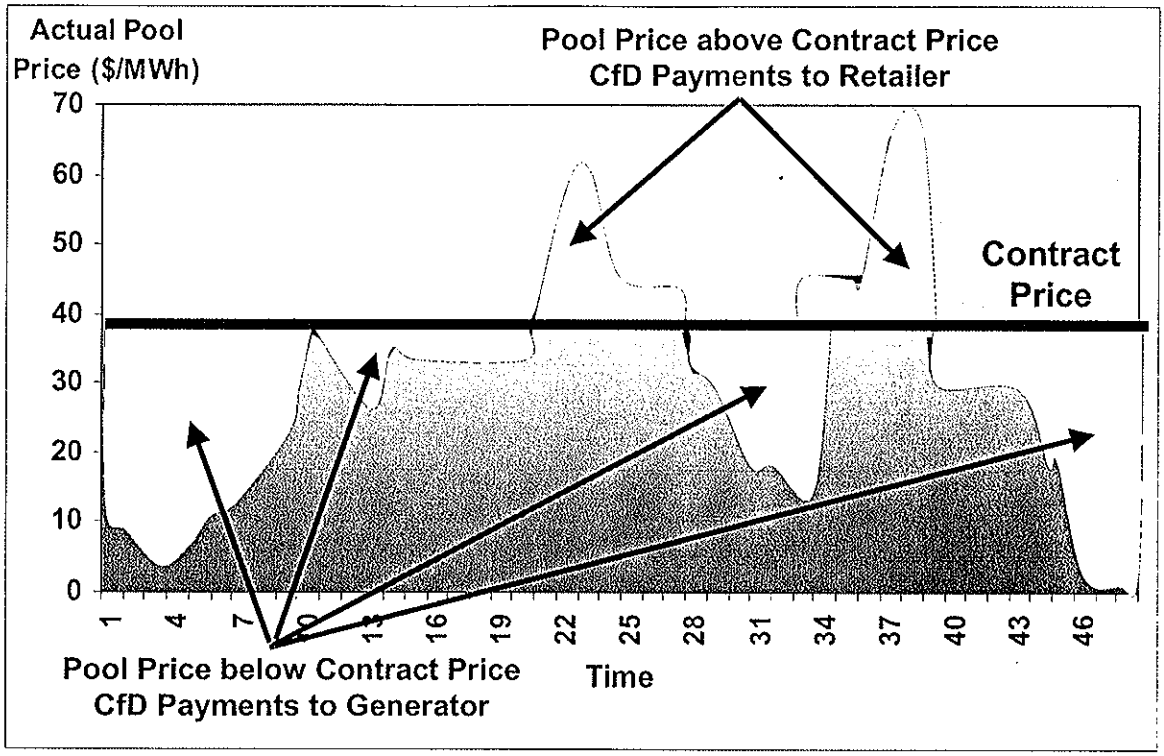
❖ Contracts for Differences (CfDs)



➢ CfD - Bilateral contract between generator and retailer that fix the price of electricity for an agreed volume of electricity

- ✓ Bypass the Pool
- ✓ Aim to manage volatility in actual pool prices

Contracts for Differences (CfDs)



Step Four: Introduce Retail Choice/Competition

Non-Contestable
(Monthly Bill ≈ < S$3,200)

Contestable Customers
(Monthly Bill ≈ > $3,200)

No Choice

3 Choices

Regulated Tariff

Retailers

MSSL

Directly from Pool

Choices of Contestable Consumers

Contestable Consumers

CHOOSE

Buy electricity indirectly from Wholesale Market through SP Services Limited (MSSL)

Buy electricity from a licensed retailer, like Tuas Power

Buy electricity directly from Wholesale Market as market participant

SP Services

CONTACT

EMC

No action is required and you will be buying electricity indirectly from the Wholesale Market through MSSL

- **Choose a retailer**
- **The retailer initiates the transfer process**

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- **Apply to EMA for a wholesale licence**
- **Register with EMC as a market participant**

WHEN WILL THE RETAIL MARKET OPEN ?

Phase I

June 2003

- HT & EHT consumers
- LT consumers with annual consumption exceeding 240,000 kWh

(average monthly bills>$3200)

Phase II

6 months after Phase I opens

- LT consumers with annual consumption exceeding 120,000 kWh

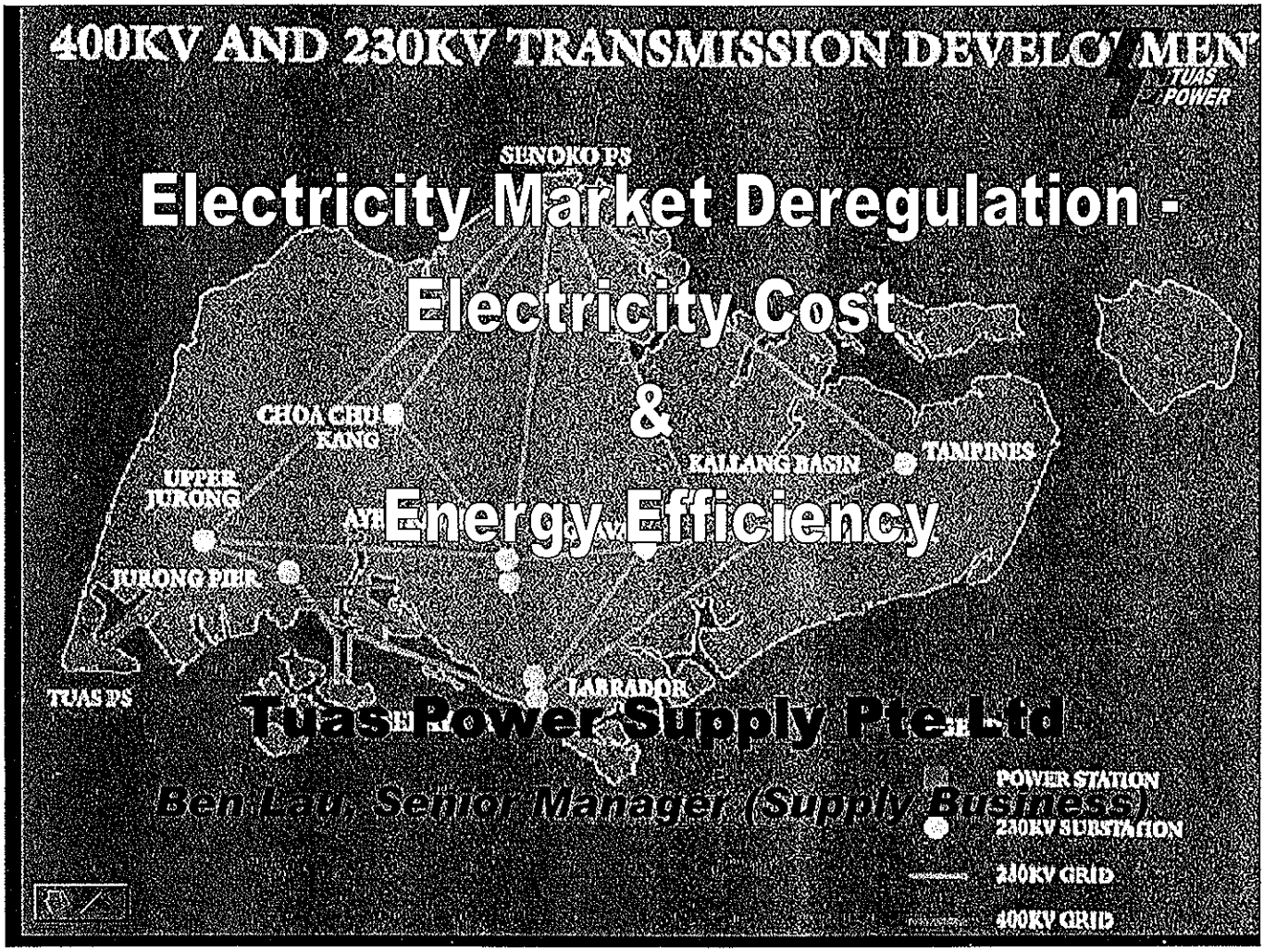
(ave monthly bills >$1500)

Phase III

Scheduled 2004

- Landlords & Tenants
- Households & remaining consumers

Thank You

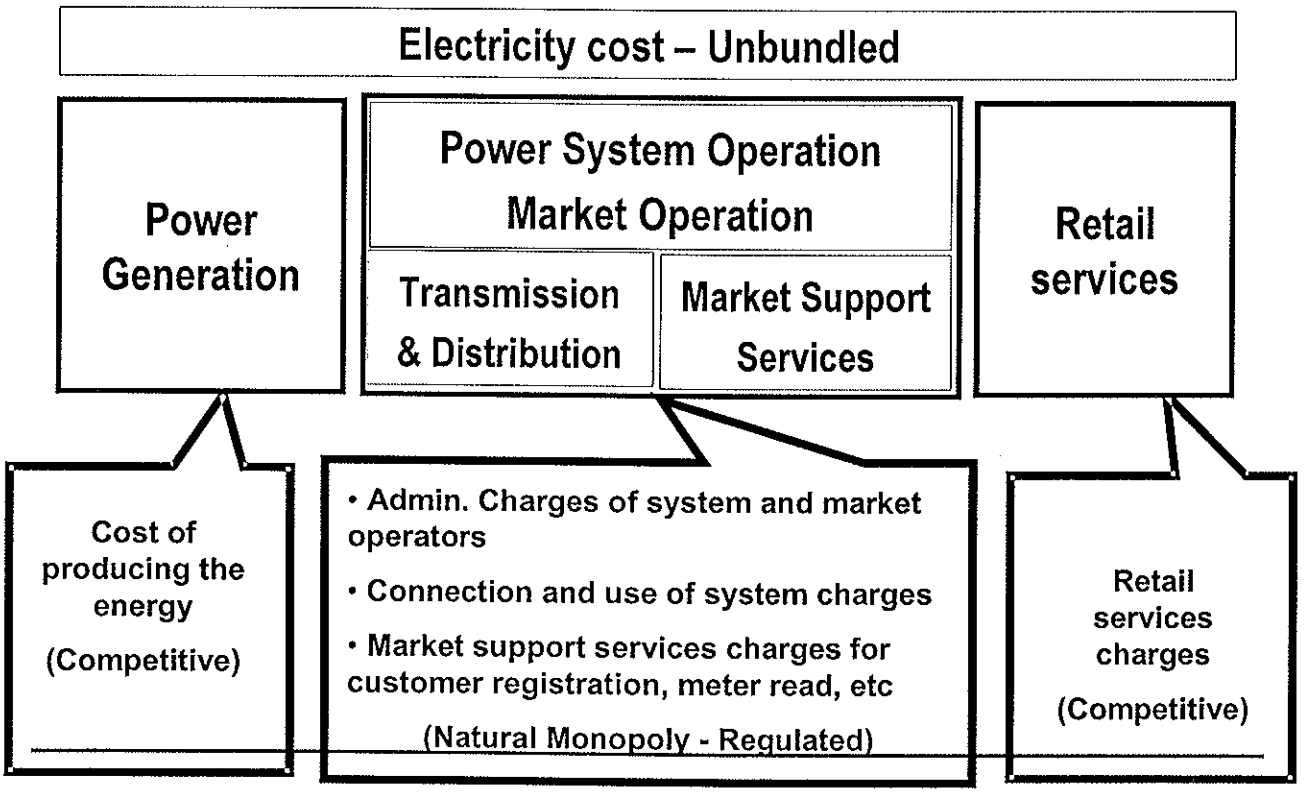


Electricity Market Deregulation
Electricity Cost and Energy Efficiency

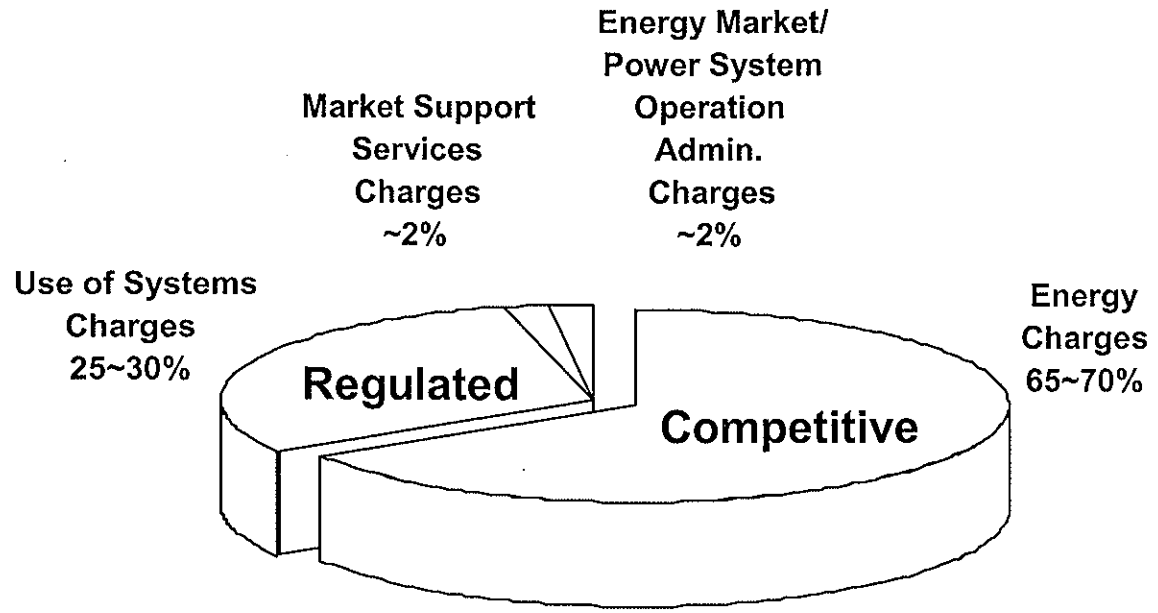
- Understand Electricity Cost
- Deregulation & Energy Efficiency

Understand Electricity Cost

Unbundling the Electricity Cost



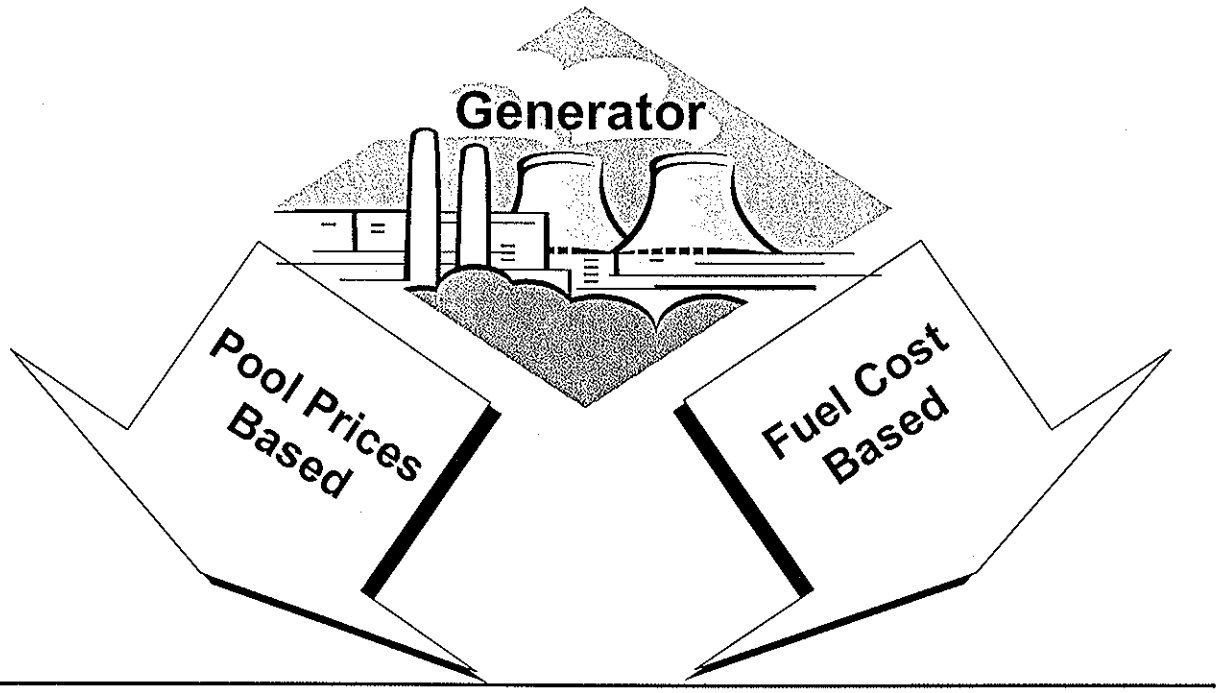
Electricity Cost Breakdown



Understand Electricity Cost
a. Electricity Generation Cost

Electricity Generation Cost

Pool Prices Based Vs Fuel Cost Based



1. Electricity Generation Cost
a. Pool Prices Based

Generation Cost – Pool Prices Based

- Pool prices are market spot prices for energy component of total electricity cost
- Determine by demand & supply of electricity every ½ hourly
- Pool Prices are volatile

Component of Pool Prices For the New Market

Energy Prices = (USEP + MFP + HEUC + MEUC)

Uniform Singapore Electricity Prices

Half hourly Uniform Energy Prices (weighted average of nodal prices)

Market Regulation Prices

Half hourly prices for balancing the system supply and demand

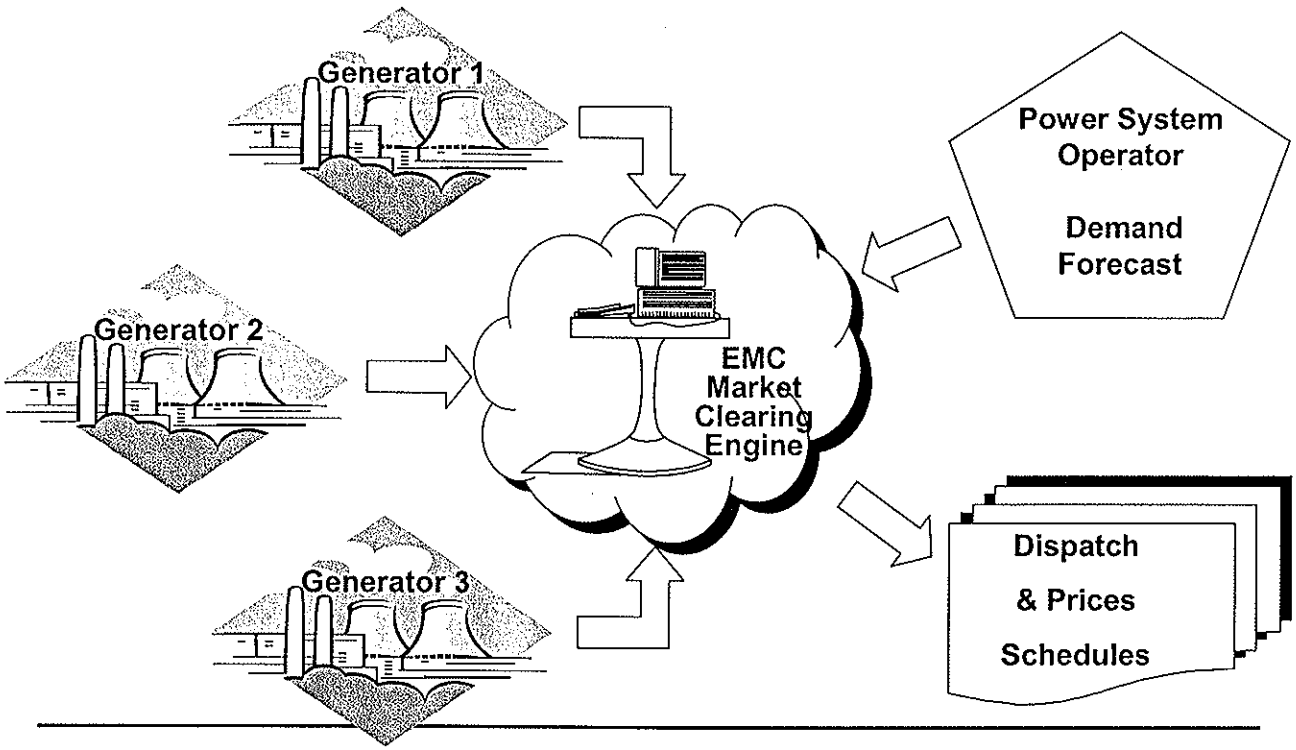
Half Hourly Energy Uplift Charges

For reconciling imbalance in energy, reserve, transmission rights & inter-connection flow

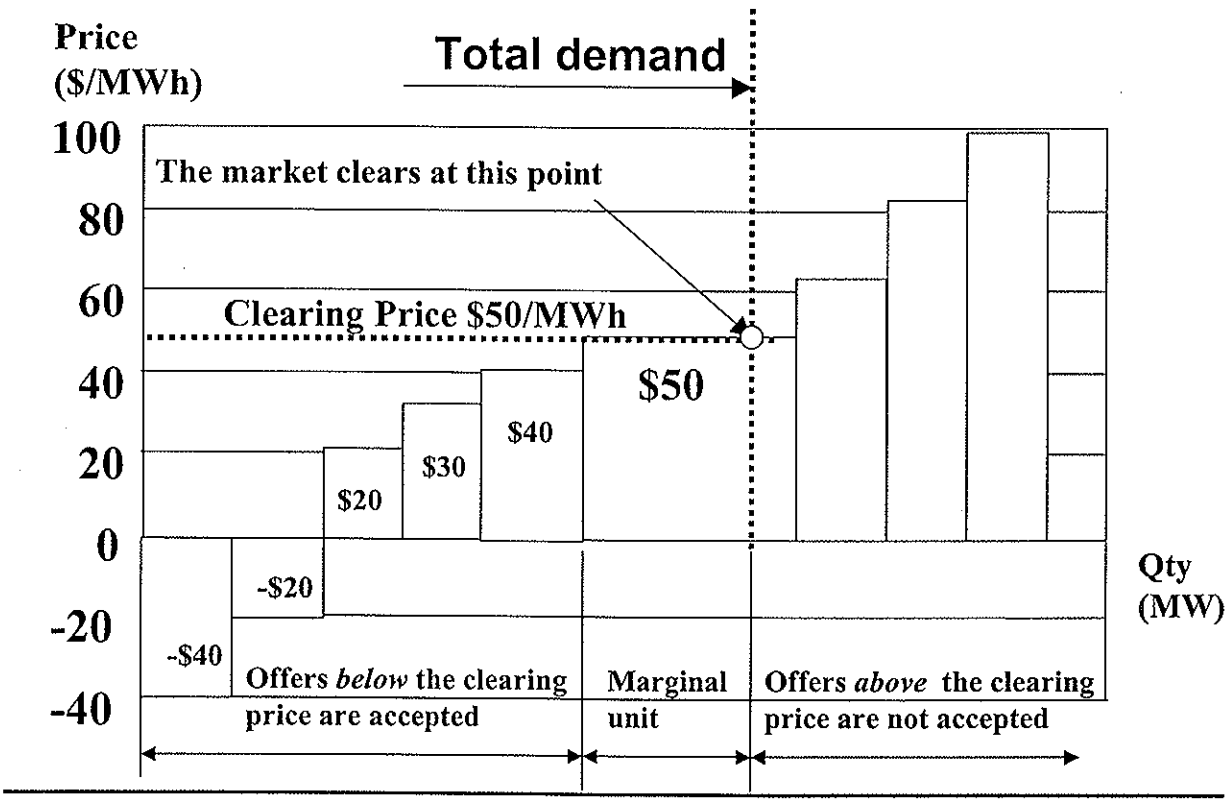
Monthly Energy Uplift Charges

For recovery cost of ancillary services contracts & disputes/compensations

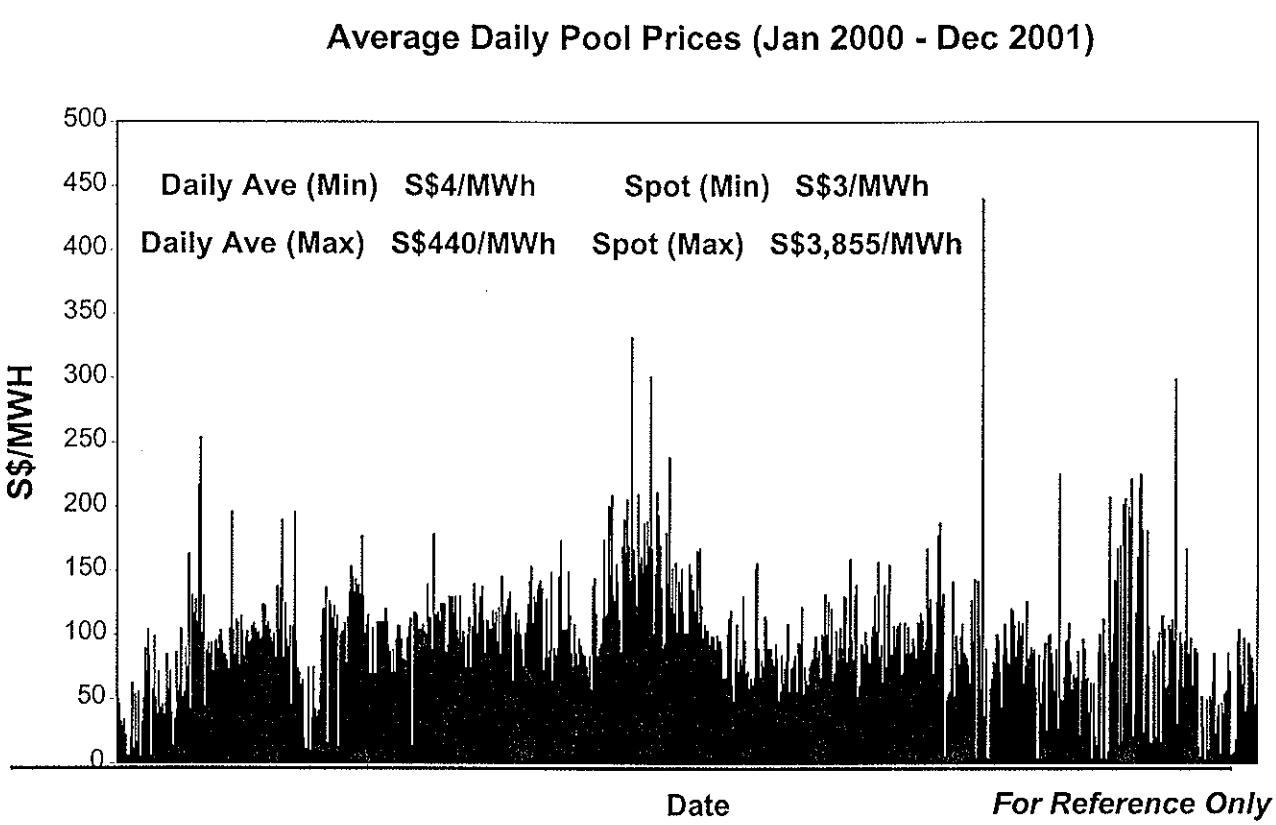
Generators Complete to Sell Electricity to the Pool



Daily Average Pool Prices (2000/01)

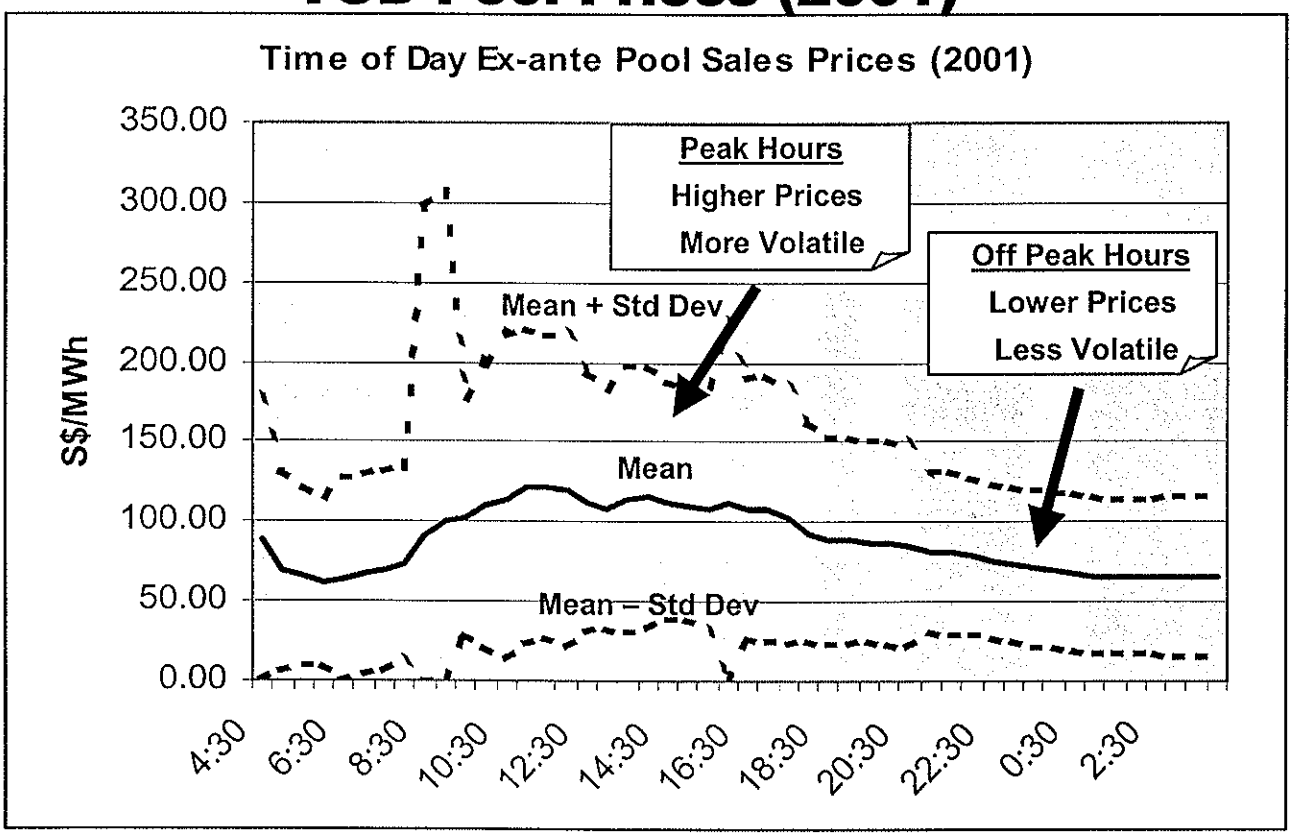


Daily Average Pool Prices (2000/01)



For Reference Only

Variations of TOD Pool Prices (2001)



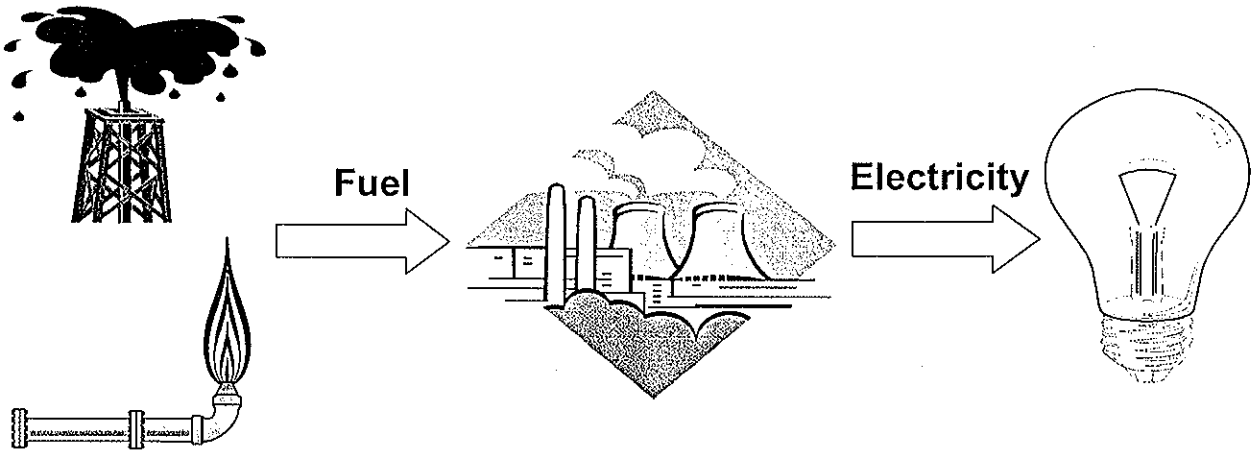
For Reference Only

1. Electricity Generation Cost
b. Fuel Cost Based

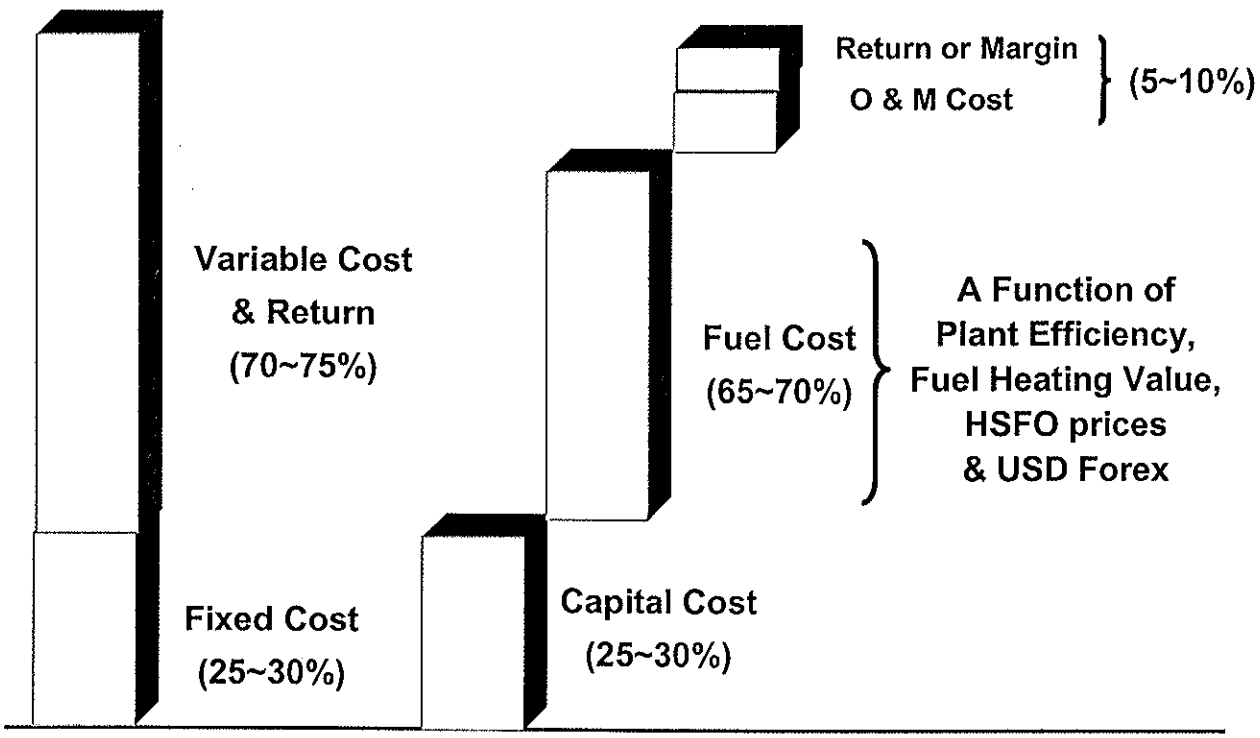
Generation Cost – Fuel Cost Based

- Generation cost is plant specific, plant type (steam, CCP, GT), capital cost, age of the plant, plant efficiency, fuel type (HSFO, natural gas), heating value of fuel, etc
- Generation cost is depended on fuel cost & USD forex
- Fuel Prices & USD forex can be volatile also

Generation Cost - Fuel Cost Based

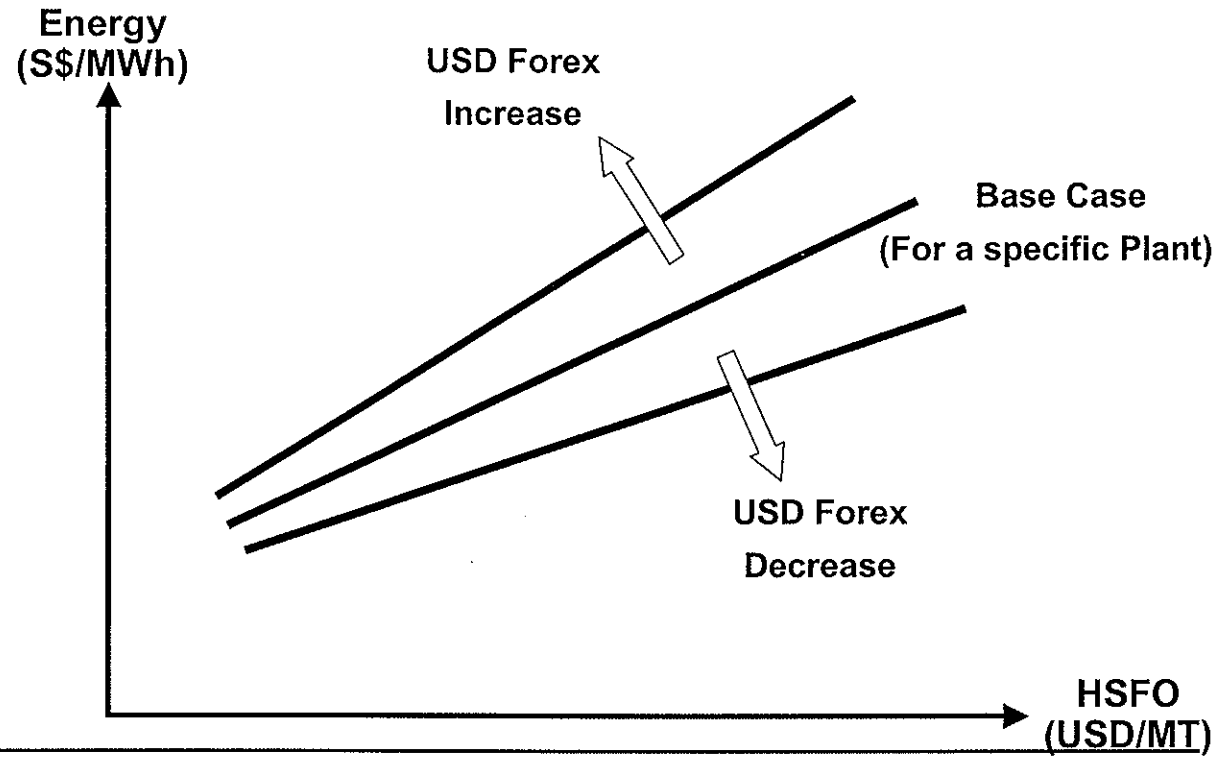


Components of Generation Cost



Tuas Power Supply's Estimation Only

Generation Cost – Fuel Cost Based



2. Electricity Transmission Cost

Transmission Cost Classification

❑ Transmission Costs are regulated

❑Customer Specific Costs

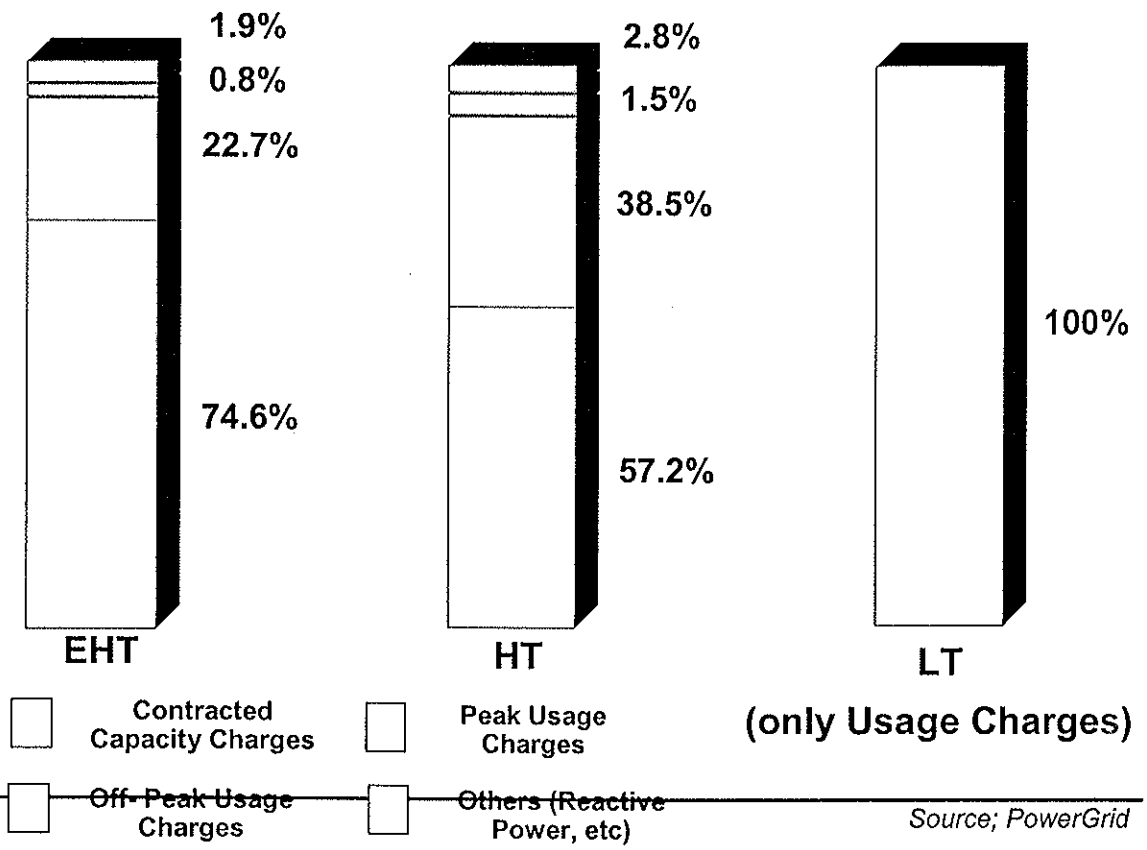
- ❖ Costs of reserving customer specific capacity
- ❖ Costs which can not be shared with other customers
- ➢ Cost Driver: Customer capacity requirement
- ➢ Cost Recovery: Customer contracted capacity charge

❑System Costs

- ❖ Costs which can be shared amongst customers based on usage (kWh)
- ❖ System built primarily to cater for peak usage
- ➢ Cost Driver: Mainly peak usage
- ➢ Cost Recovery: Mainly peak period charge

Source; PowerGrid

Components of Transmission Cost



Source; PowerGrid

3. Other Costs
- MSS Charges
- EMC & PSO Admin Charges
- Retail Services Cost

MSS Charges (1)

- Market Support Services (MSS) Charges are regulated – two components
  - Recurring Charges
  - Non-recurring Charges

MSS Charges (2)

❖ Recurring Charges

- Meter reading and data management
- MSS basic services – account management & customer service
- Billing & collection
- Billing data aggregation
- Telephone line charges for remote metering
- Recovery of costs for MSSL Retail Market System
- Regular (monthly) provision of raw metering data through CD-ROM or e-mail

For Reference Only

MSS Charges (3)

❖ Non-recurring Charges

- Consumer registration or transfer services
- Retailer registration
- Manual meter reading
- Supply of historical consumption data
- Charges for failed transaction (payable by retailer)
- Other transactions – account closure, involuntary or voluntary temporary disconnection and billing option charge
- Ad hoc provision of raw metering data through CD-ROM or e-mail

For Reference Only

EMC & PSO Administrative Costs

- EMC & PSO admin charges are regulated

- Payable by the market participants (both generators and loads) – Costs to generators and retailers

- To recovery the administrative costs incurred by EMC & PSO for their operation of the power system and market system respectively

For Reference Only

Retail Services Cost

- Retail Services Cost

  - Operating expenses – mainly manpower cost

  - Financing costs – settled payment with EMC daily and payment received from consumers according to the payment terms in the supply agreements

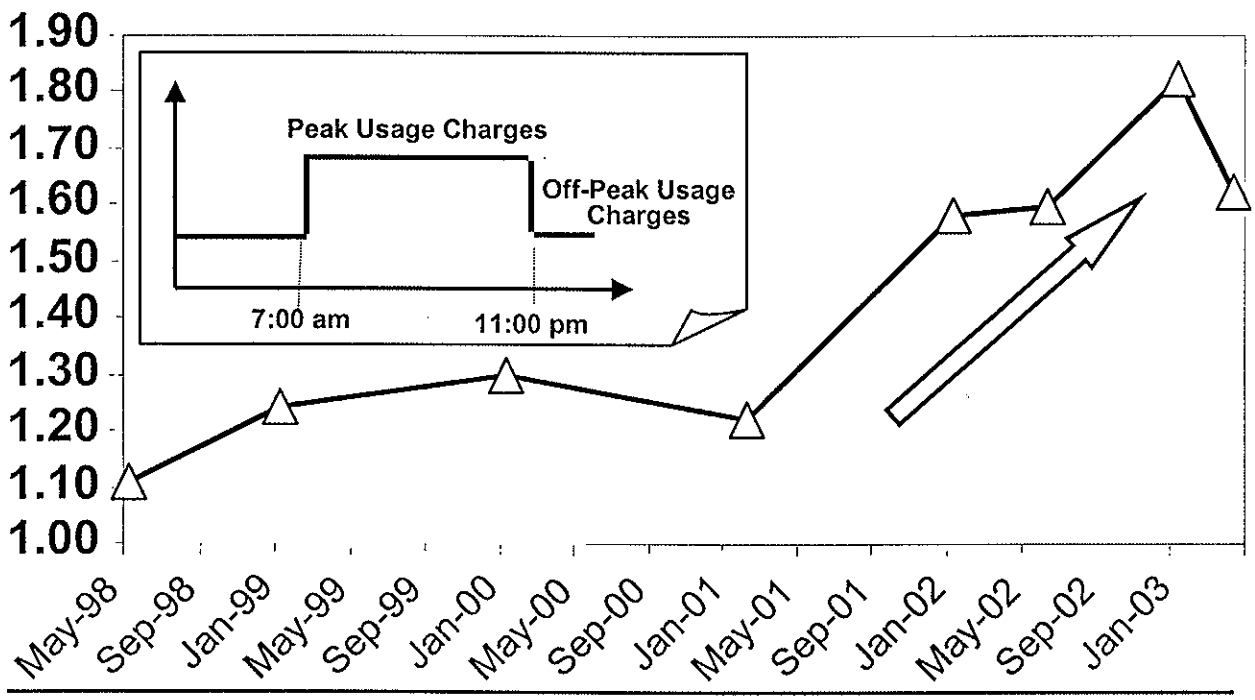
  - Recovery of IT system costs for customer and billing services

  - Bundled in the energy charges offered by the retailers

Deregulation & Energy Efficiency

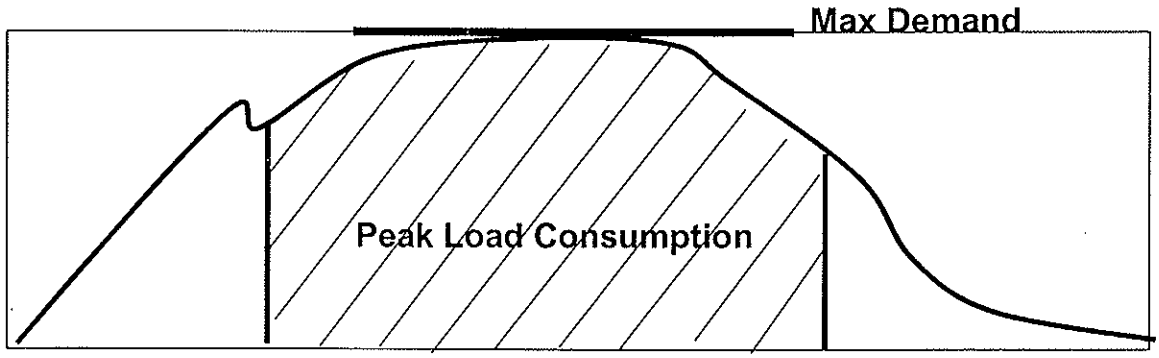
Electricity Prices

Peak / off Peak Prices Ratio



Load Profiles

Load Factor & % Peak Load

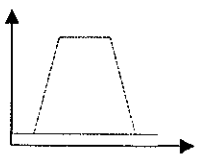
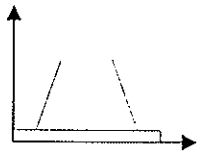
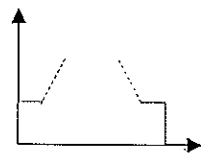
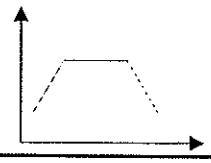


$$\text{Daily Load Factor} = \frac{\text{Actual Consumption in kWh}}{\text{Max Demand in kW} * 24 \text{ hrs/day}}$$

$$\%\ \text{Peak Load} = \frac{\text{Peak Load Consumption in kWh}}{\text{Total Consumption in kWh}}$$

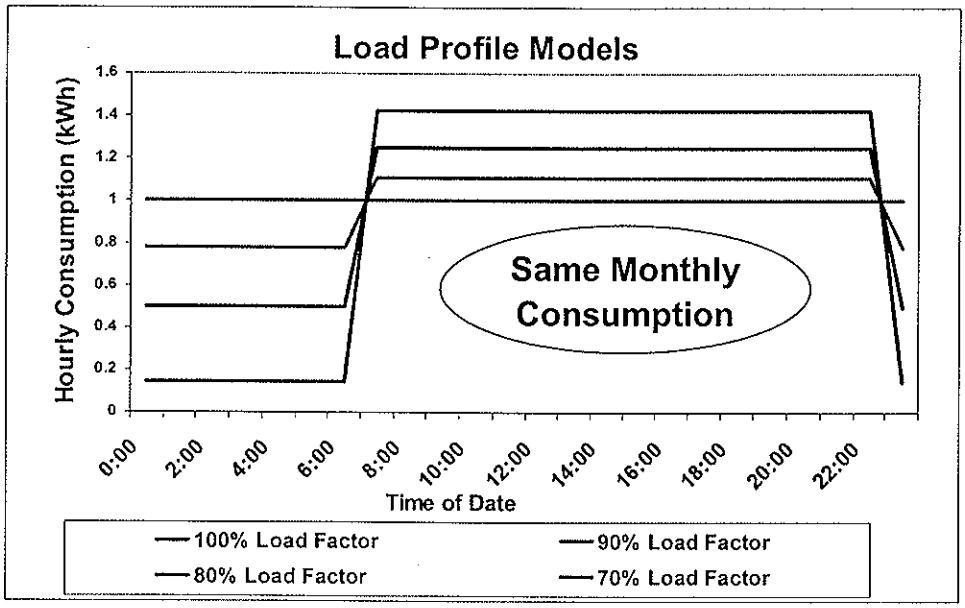
Lower Load Factor
Higher % Peak Load
} ⇨ **Higher Electricity Cost**

Typical Load Profiles

Types of Premises	Load Profile	Load Factor	% Load Load
❖ Offices/Shopping Mails		< 60%	> 90%
❖ Universities/Institutions		60 ~ 65%	85 ~ 90%
❖ Hotels		75 ~ 80%	80 ~ 85%
❖ General Manufacturing		80 ~ 85%	75 ~ 80%

For Reference Only

Load Profile Models



Load Profile Models
Electricity Cost Evaluation (1)

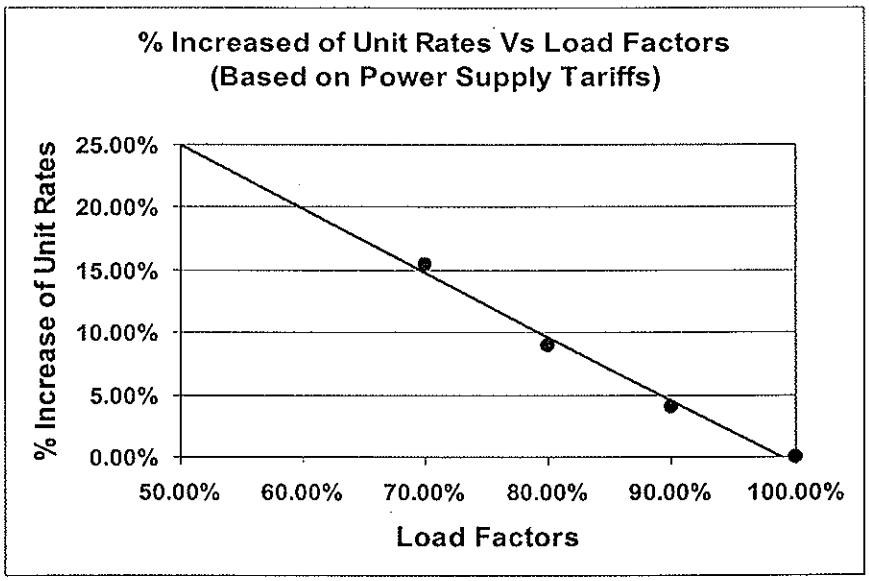
Power Supply October 02 Tariffs			
Contracted Capacity Charges	9.01	$/kW/month	
Peak Usage Charges (7am-11pm)	12.98	Cents/kWh	} Peak/Off Peak Ratio
Off-Peak Usage Charge (11pm-7am)	8.07	Cents/kWh	} = 1.61

Monthly Payment (30 days)	Consumption kWh/Month	CC S$/Month	Peak S$/Month	Off-Peak S$/Month	Total S$/Month
100% Load Factor	720	9.01	62.30	19.37	90.68
90% Load Factor	720	10.01	69.23	15.06	94.30
80% Load Factor	720	11.26	77.88	9.68	98.83
70% Load Factor	720	12.87	89.01	2.77	104.64

Assumptions:

Max demand equal to the contracted capacity and no reactive power charged

Load Profile Models
Electricity Cost Evaluation (2)



Load Profiles	Unit Rate Cents/kWh	% Increased %
100% Load Factor	12.59	-
90% Load Factor	13.10	3.99%
~~80% Load Factor~~	~~13.73~~	~~8.98%~~
70% Load Factor	14.53	15.40%

Review Electricity Requirements

- ❖Consumption quantity (kWh)
- ❖Max. demand (kW)
- ❖Load profiles (load factors, peak consumption, etc)
- ❖Operation modes (7 days X 24 hrs, 6 days X 12 hrs, 5 days X 8 hrs, etc)
- ❖Current and projected consumptions

- ✓Total cost = CC/UCC + Unit rate * Qty
- ✓Contracted capacity charges
- ✓The better the load profile (close to flat load), the lower the unit rate
- ✓Off peak hours, Saturday afternoons and Sundays, Pool prices are generally lower
- ✓Better planning and budgeting

Energy Management – The Driving Forces

Demand Side Management

- Energy conservation for cost savings
- Optimization of operation for higher plant utilization and efficiencies

Economic Forces

- Rising energy cost & price volatility increasing uncertainty for industry
- New framework provides room for optimization of energy assets, e.g. UOS charges, high peak prices

Rationale

- ✓ **Reasonable investments**
- ✓ **Short lead time**
- ✓ **Short payback period**

Environmental Pressure

- Developed countries to adapt to a future greenhouse constraint; UN Convention Framework for Climate Change & Kyoto Protocol

Evolving Regulations

- Government incentives for improving energy consumption – ENV/NEA, EDB, EMA
- Energy de-regulation creating uncertainties

Energy Management Strategies

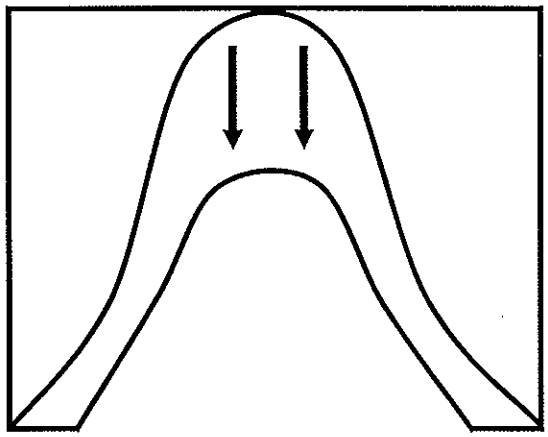
❑ **Objective: To Reshape the Load Profiles for Cost Savings**

✓ **Energy Conservation Strategy**

✓ **Peak Shaving Strategy**

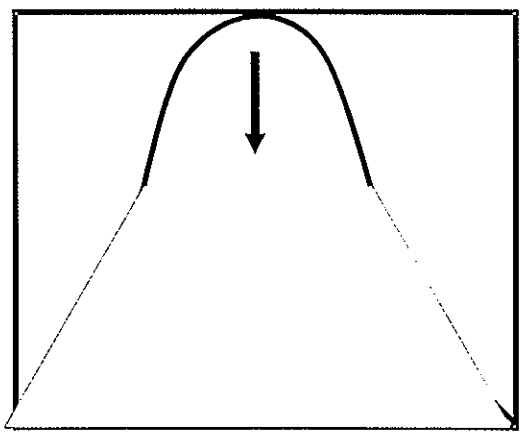
✓ **Load Shifting Strategy**

Energy Conservation Strategy

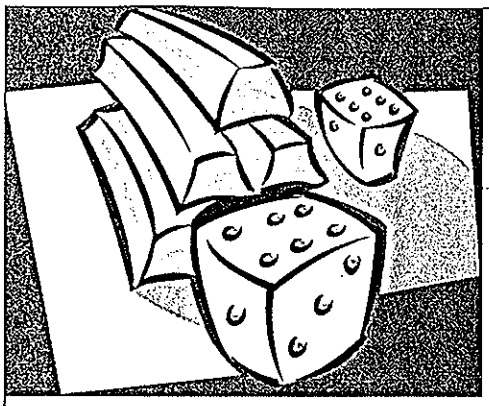


- Reduce maximum demand
- Reduce kWh consumption
- Reduce lighting load
- Install efficient air-conditioning equipment
- Optimize facilitates operation

Peak Shaving Strategy



- Reduce maximum demand
- Load shed non-critical equipment during peak period
- Self generation facility to produce electricity for self consumption

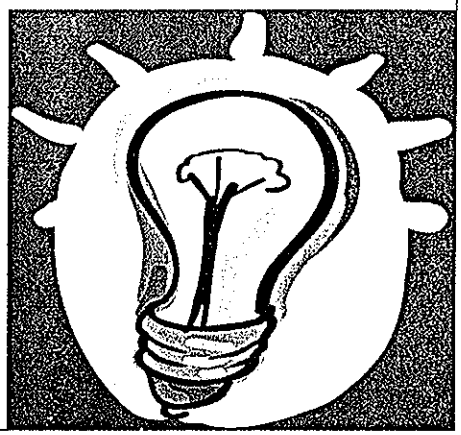


Tuas Power Supply Pte Ltd

EVALUATION OF ELECTRICITY SUPPLY PACKAGE

Lim Sam San

Manager (Marketing)



AGENDA

EVALUATION OF ELECTRICITY SUPPLY PACKAGE

- **FUNDAMENTALS OF ELECTRICITY PRODUCTS**
- **FUNDAMENTALS OF ELECTRICITY PRICING**

FUNDAMENTALS OF ELECTRICITY PRODUCTS

- Customer Choices
- Pool Prices Based
- Fuel Cost Based
- Summary

CONSUMER CHOICES 1

- Direct Purchase from Pool
  - Market Participant License
  - Pool prices
  - Market Participation (e.g. Reserve Market)

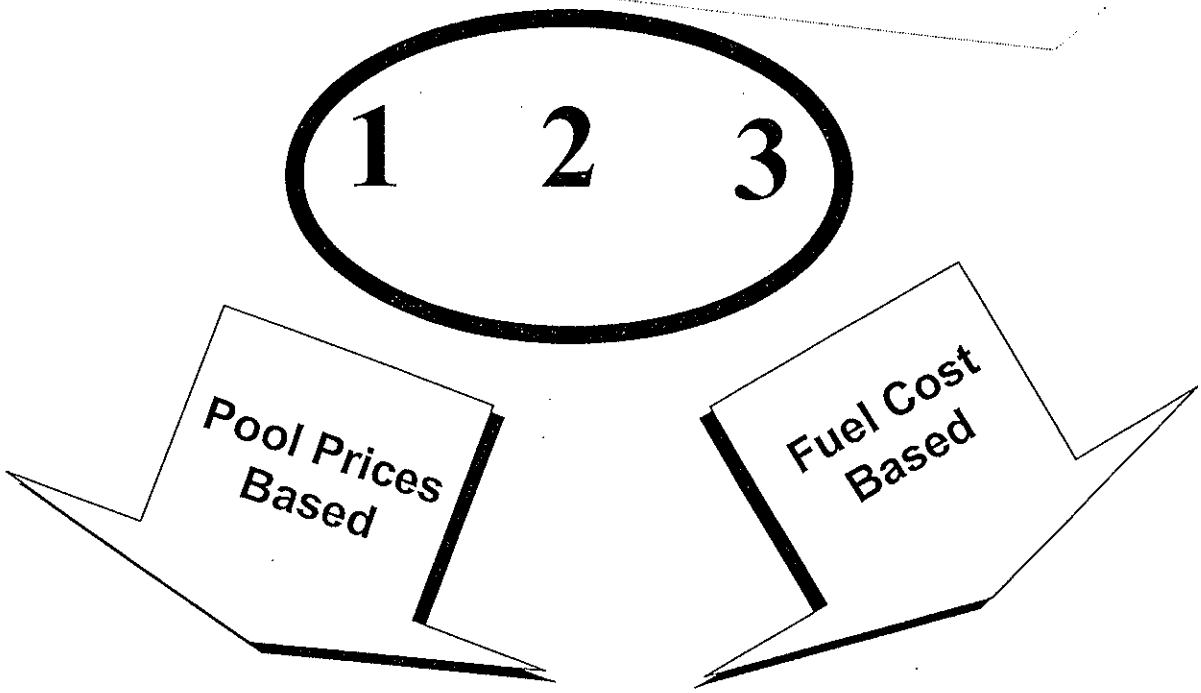
CONSUMER CHOICES 2

- Purchase from Retailer
  - Different Pricing Schemes
  - Different Terms

CONSUMER CHOICES 3

- Indirect Purchase from Pool vie MSSL
  - Default Service Provider
  - Conditions of Services
  - Pool prices
  - Right to Disconnect

COST OF ELECTRICITY IN SINGAPORE

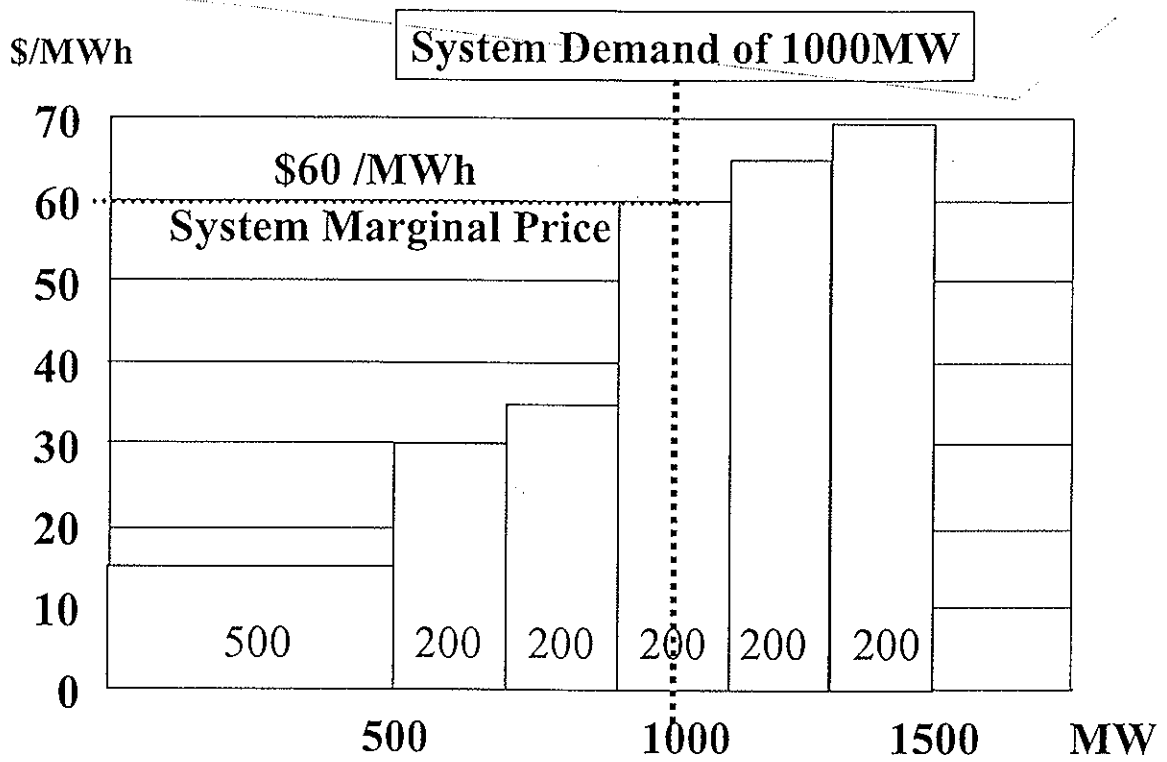


POOL PRICES BASED

- Pool prices are spot prices for electricity

- Determine by demand & supply of electricity every ½ hourly

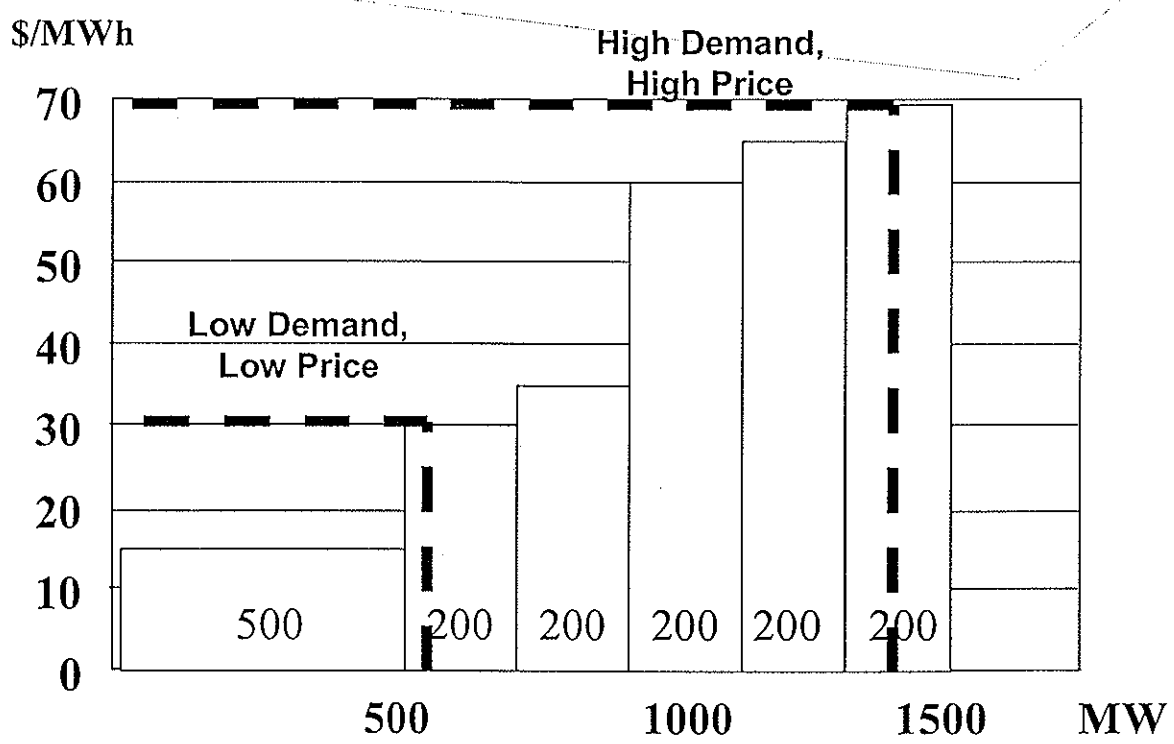
POOL PRICES BASED



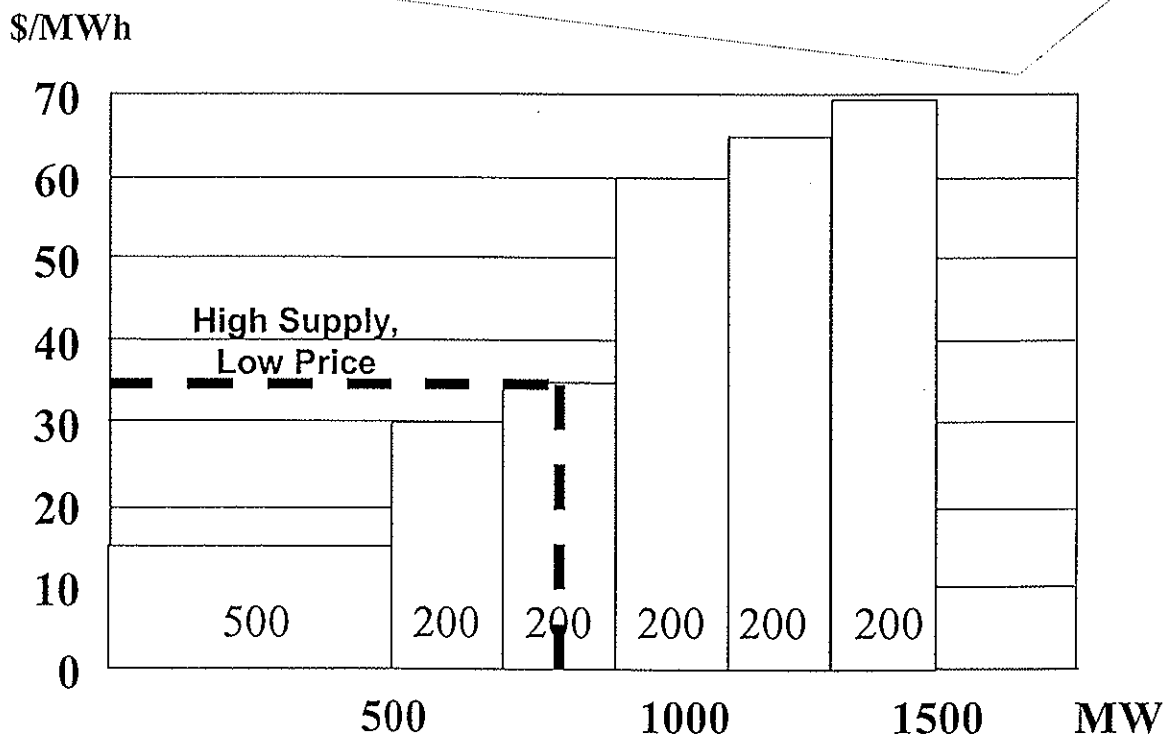
POOL PRICES BASED

- Pool prices are used:
  - Purchase of electricity
  - Indices for derivatives trading

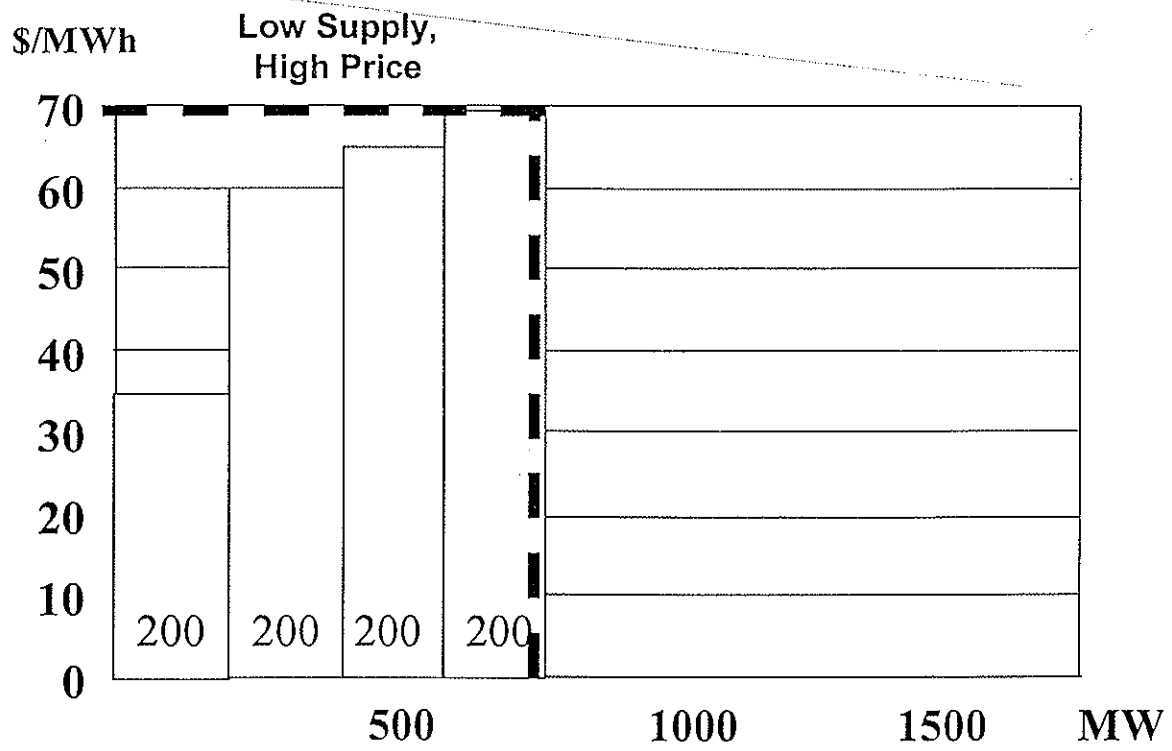
POOL PRICES BASED



POOL PRICES BASED

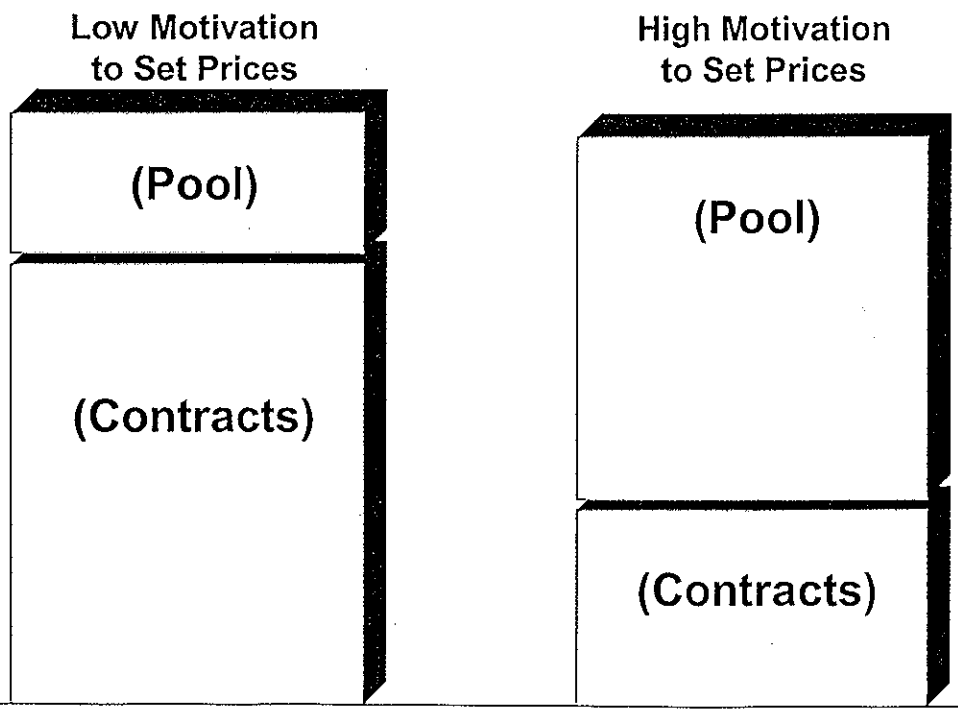


POOL PRICES BASED



POOL PRICES BASED

- GenCo Revenue



POOL PRICES BASED

- Examples
  - Pool prices + 1.0 ¢/kWh
  - 10 ¢/kWh at Pool Price of $100/MWh

    (Pool Prices ±$1/MWh ⇒ ±$0.5 ¢/kWh)
  - Pool prices + 2.5 ¢/kWh

    (Cap at $120, Floor at $80)

POOL PRICES BASED MARKET

- Low liquidity in Singapore (market is premature)
- Low take up rate
- Take up with certain insurances

FUEL COST BASED

Cost of electricity = f(Fuel Cost , FOREX)

- Majority of electricity generated with Fuel Oil or Natural Gas
- Fuel Oil & Natural Gas are procured based on HSFO 180 cSt

FUEL COST BASED (INDEXED)

- 10 ¢/kWh at US$135/MT

  (HSFO ±US$1/MT ⇒ ±0.05 ¢/kWh)
- Pay 10.5 ¢/kWh if actual month HSFO is US$145/MT
- Pay 9.5 ¢/kWh if actual month HSFO is US$125/MT
- Mark to market
- Is fuel cost going to fall?

FUEL COST BASED (FIXED)

- 10 ¢/kWh through out the entire term of agreement
- Short validity date (e.g. within a day)
- Volume Risk (e.g. 10 ¢/kWh for the 1st 1,000 kWh of each hour)
- Penalty for premature termination

FUEL COST BASED (CASE STUDY)

- 10MW consumer finalize contract Sep 01

  10 ¢/kWh

- 2MW consumer finalize contract Nov 01

  8.5 ¢/kWh

?

SUMMARY

Electricity Procurement ⇒ Position Taking

Managing Risks, Creating Value

FUNDAMENTALS OF ELECTRICITY PRICING

- Evaluation of Time Tiers
- Evaluation of Fuel Index Pricing Products
- Evaluation of Fixed Pricing Products
- Index vs Fixed
- Now vs Later
- Conclusion

TIME TIERS

A

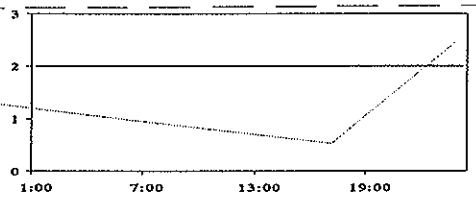
Tier 1	0700 – 2300	10 ¢/kWh
Tier 2	0000 – 0700 2300 – 2400	7 ¢/kWh

B

Tier 1	0900 – 1700	12 ¢/kWh
Tier 2	0500 – 0900 1700 – 2100	9 ¢/kWh
Tier 3	0000 – 0500 2100 – 2400	6 ¢/kWh

TIME TIERS

Example 1: 7 x 24 Operation



Tier 1	10 ¢/kWh	67%
Tier 2	7 ¢/kWh	33%

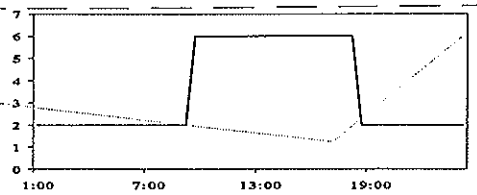
A = 9 ¢/kWh

Tier 1	12 ¢/kWh	33%
Tier 2	9 ¢/kWh	33%
Tier 3	6 ¢/kWh	33%

B = 9 ¢/kWh

TIME TIERS

Example 1: 9 to 5 Operation



Tier 1	10 ¢/kWh	81%
Tier 2	7 ¢/kWh	19%

A = 9.43 ¢/kWh

Tier 1	12 ¢/kWh	57%
Tier 2	9 ¢/kWh	24%
Tier 3	6 ¢/kWh	19%

B = 10.14 ¢/kWh

TIME TIERS

- **Single rate product includes premium**
- **Saving through Operational shift**

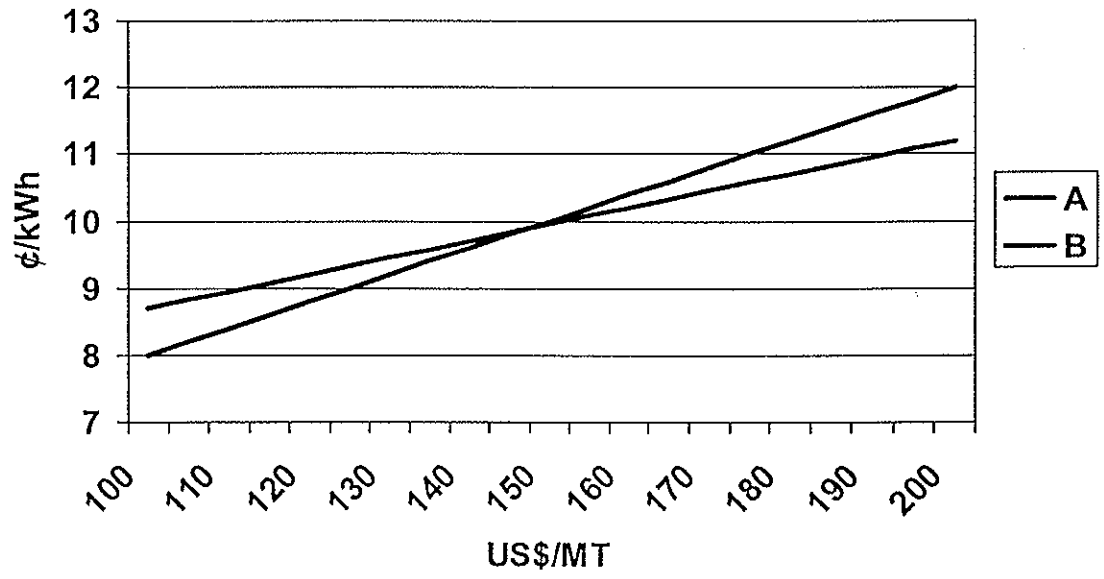
FUEL INDEXED PRICING

A 4.0 + 0.04 x HSFO

B 6.2 + 0.025 x HSFO

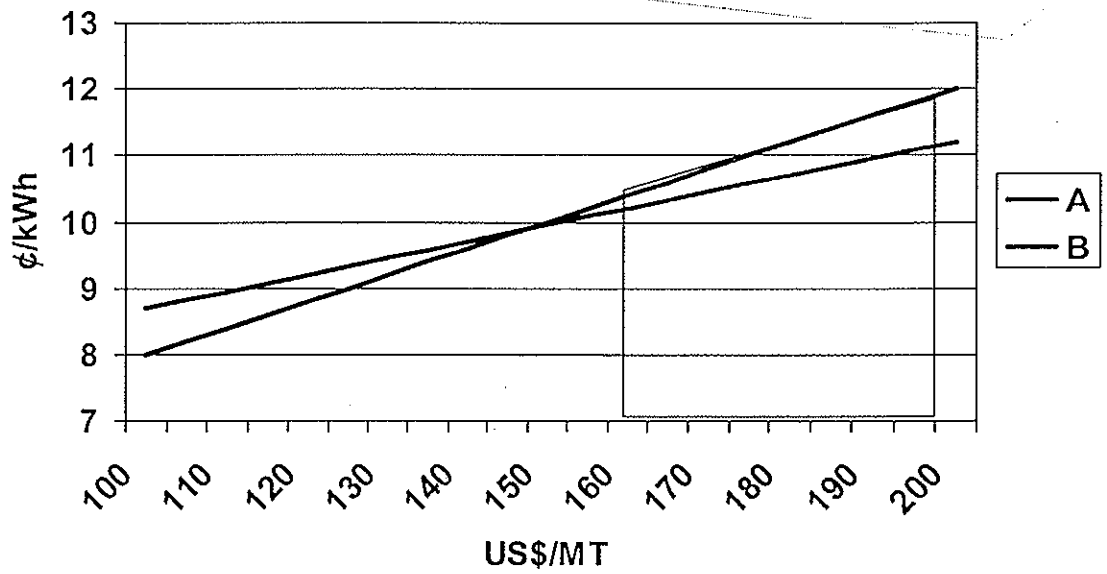
FUEL INDEXED PRICING

A vs B



FUEL INDEXED PRICING

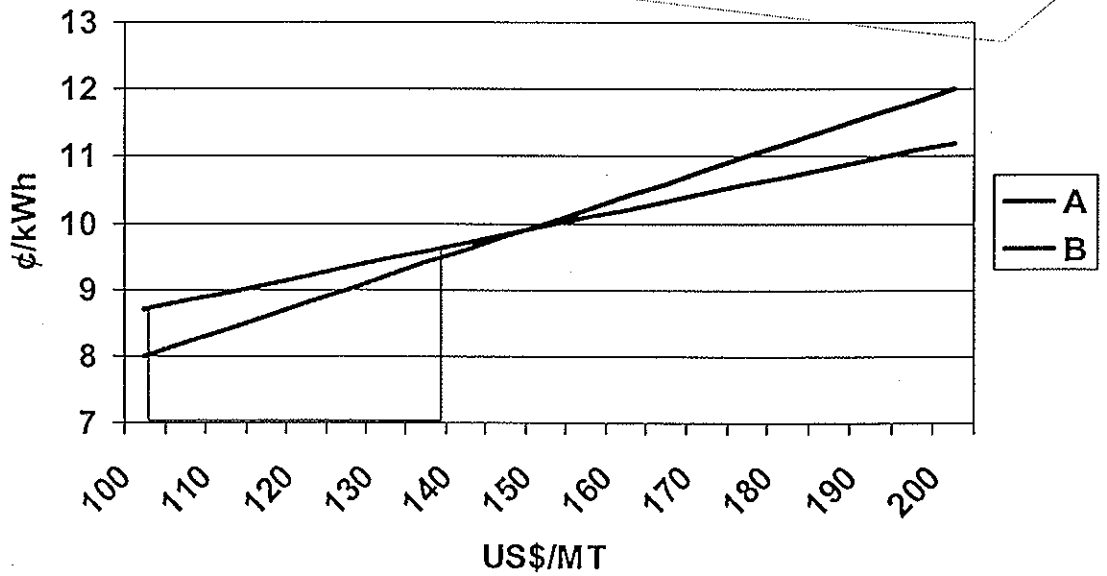
A vs B



- If Fuel expected to be 160 – 200
- B is better

FUEL INDEXED PRICING

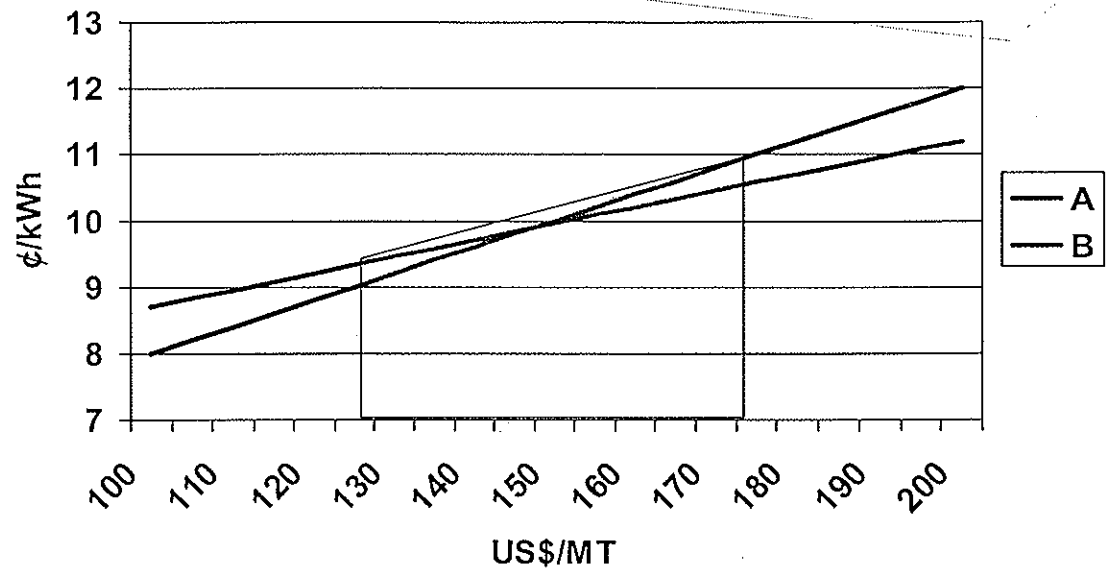
A vs B



- If Fuel expected to be 100 – 140
- A is better

FUEL INDEXED PRICING

A vs B



- If Fuel expected to be 130 - 180
- Compare area under each line, B is better

FIXED PRICING

- Price fixed based on Forward Fuel Cost

Example:

Forward Traded: 11 Nov 2002

Electricity Cost: 4 + 0.04 x HSFO

2003	Q1	Q2	Q3	Q4
HSFO	137	133	130	127
¢/kWh	9.48	9.32	9.2	9.08

FIXED PRICING

- Falling Fuel Market → lower price for longer term
  - 3 months – 9.48
  - 6 months – 9.40
  - 12 months – 9.27
- Situation reverse in Rising fuel market

FIXED vs INDEX

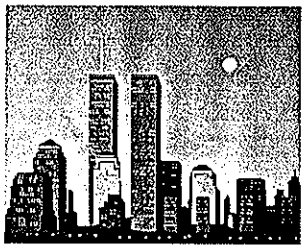
- Expectation of Fuel Market
- Expected to weaken → Index
- Expected to strengthen → Fixed

CONCLUSION

Electricity Procurement ⇒ Position Taking

Managing Risks, Creating Value

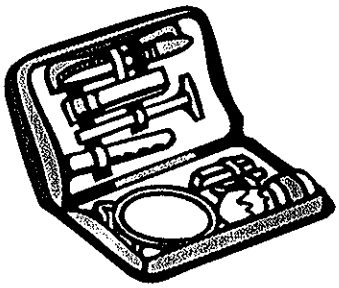
THANK YOU



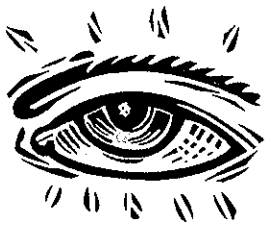


ELECTRICITY SUPPLY AND TECHNICAL VALUE ADDED SERVICES

Neo Poh Hua, Manager (Technical Services)







AGENDA

- Buying Electricity From Retailer and Grid (UOS) Charges
- Technical Value-added Services
- Electricity Supply To Landlord-tenants (Customer With Master-meter)
- Direct Supply Of Electricity By Generating Sets To On-site Loads (Customers With Embedded Generation)

BUYING ELECTRICITY FROM RETAILER AND GRID (UOS) CHARGES

BUYING ELECTRICITY FROM A RETAILER

- Do you need to lay new cables ?
  - No
- Will there be power supply interruption ?
  - No
- Any different in the quality of power ?
  - No
- Payment to retailer for the electricity consumed
  - Yes

BUYING ELECTRICITY FROM A RETAILER (CONT'D)

- Retailer does not own the T&D networks, a "non-wire" supply business
- Electricity is a commodity trading business
- In the long run, electricity prices will stabilizes
- Customers will want retailer to
  - Manage risks and create value
  - Provide better services

VALUE ADDED SERVICES

- E-Services
  - Download meter data
  - Compare pool prices
  - Generate reporting
- Technical Services
  - Conditioning Monitoring Services
  - Energy Management Services
  - Power Quality Solutions
  - Metering, Billing & Payment Collection Services for master-sub metered customers

USE OF SYSTEM (UOS)

- Contracted Capacity Charge ($/kW/Month)
- Uncontracted Capacity Charge ($/kW/Month)
- Reactive Power Charge (cents/kVarh)
- Peak and Off-Peak Period Charge (cents/kWh)

UOS CHARGES BY POWER GRID LTD

- Contracted Capacity Charge payable
  = Declared Contracted Capacity x Contracted Capacity Charge
- UnContracted Capacity Charge payable
  = (Maximum Demand – Declared Contracted Capacity) x UnContracted Capacity Charge
- Reactive Power Charge payable
  = (kVArh – 62% of kWh) x Reactive Power Charge
- Peak Period Charge payable
  = Peak kWh consumed x Peak Period Charge
- Off Peak Period Charge payable
  = Off-Peak kWh consumed x Off-Peak Period Charge

DECLARED CONTRACTED CAPACITY

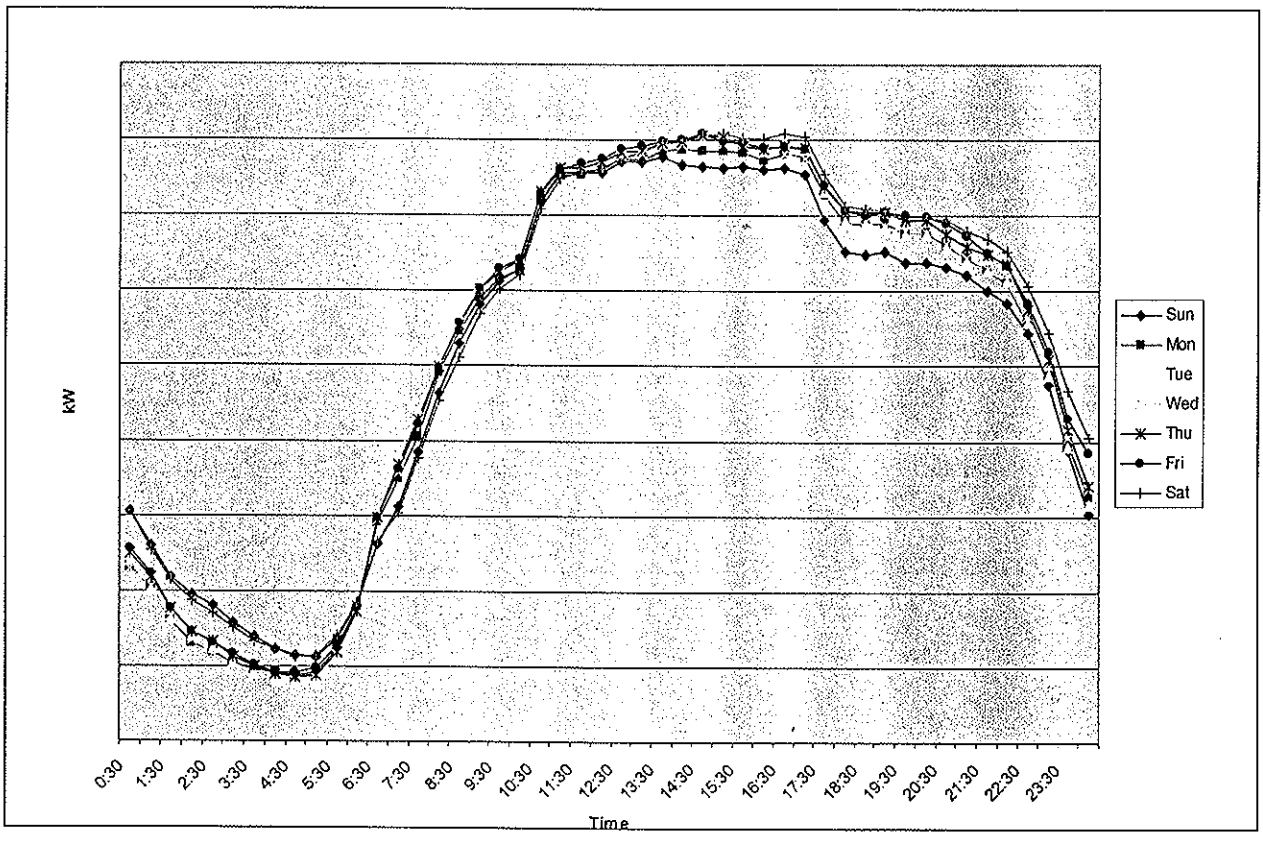
- New development
  - Design & development stage
  - Not to over declared the CC even though system is design for future capacity
- Existing building
  - Re-declared, if require, to optimize the CC to avoid the unContracted Capacity charge

BINDING PERIOD
(Power Grid Ltd's Requirement)

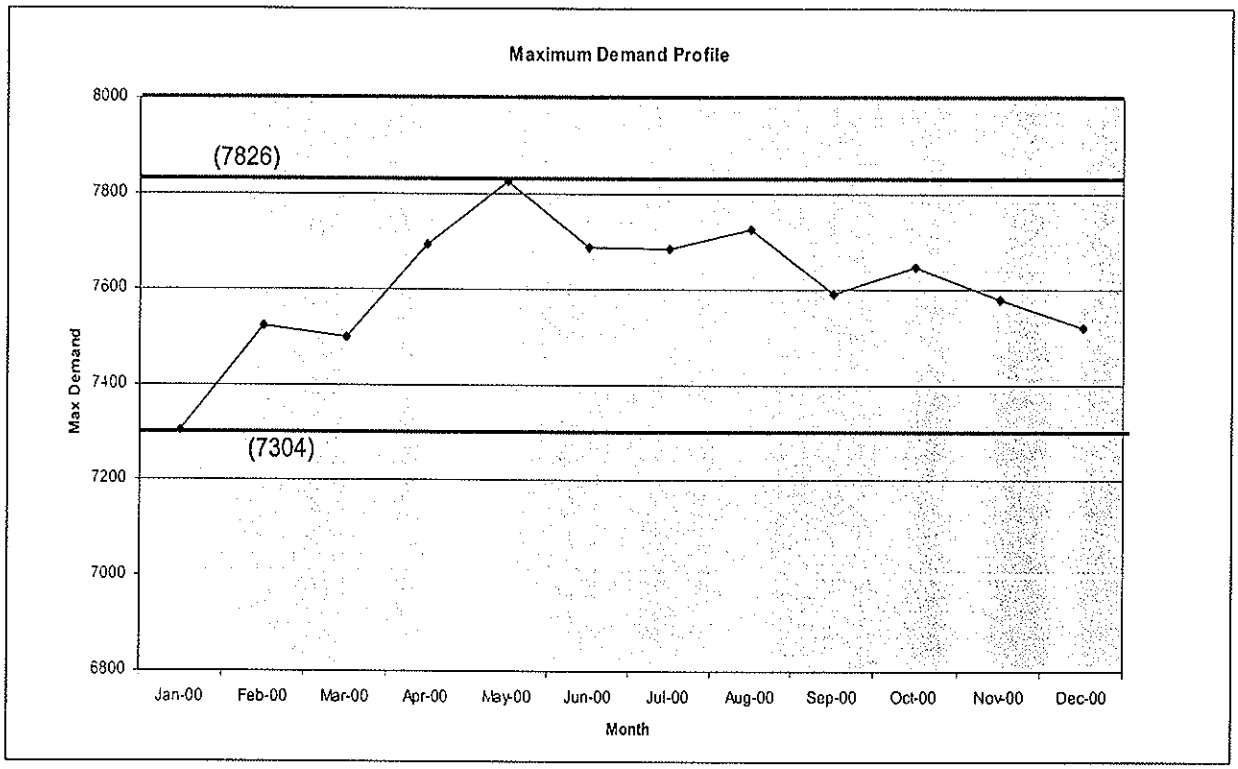
- Declared Contract Capacity – 1 year or 5 years period depending on the contract agreement.
- Within the period, you can only increase, but not decrease the contract capacity. 1 Month notice is required.
- You can re-declared (upward or downward) your contract capacity after the 1 year or 5 years period, re-declared CC will be binding for 1 year.

OPTIMIZATION OF CONTRACTED CAPACITY

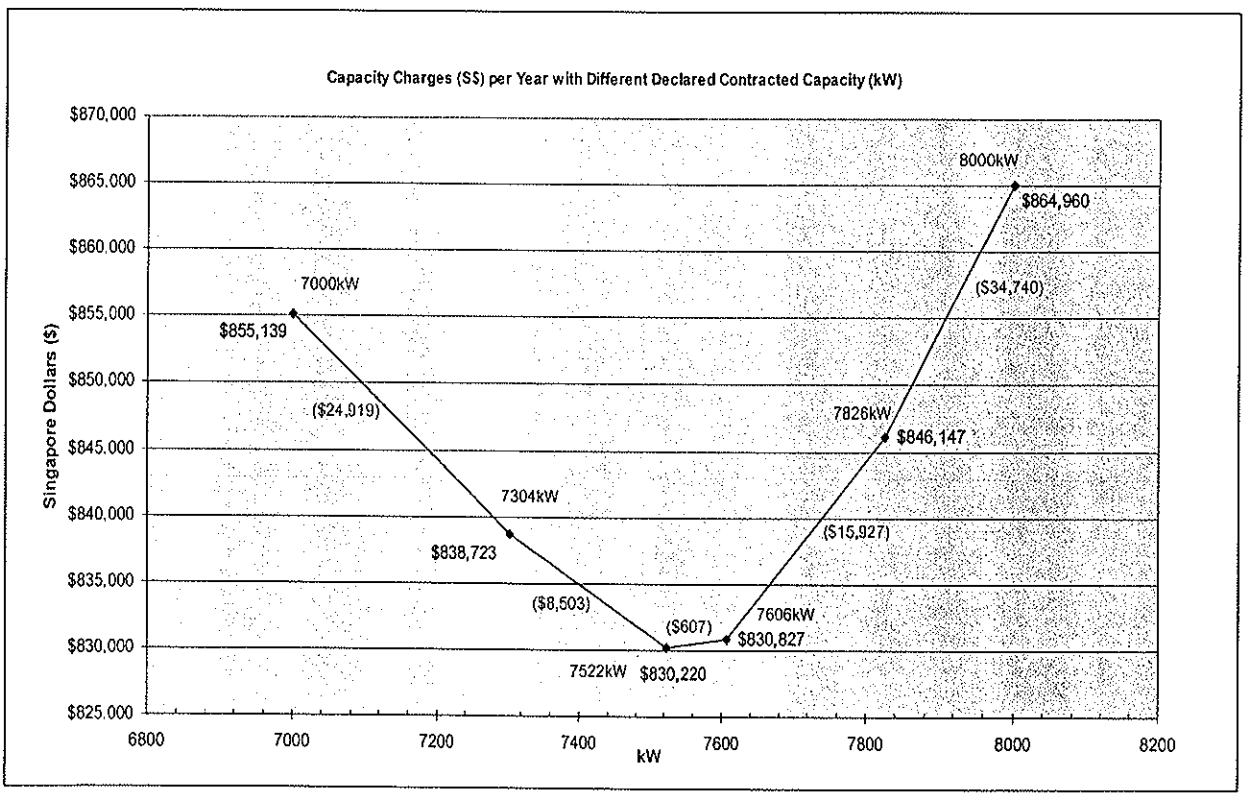
KW DEMAND PROFILE



HISTORICAL MONTHLY MAX DEMAND



CC OPTIMIZATION



TECHANICAL

VALUE-ADDED SERVICES

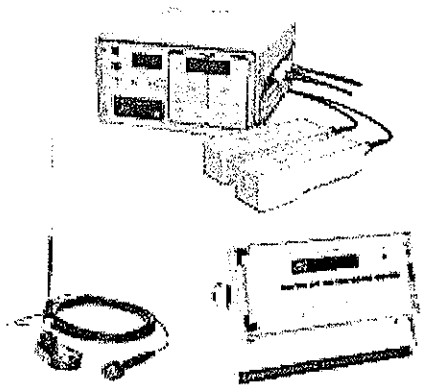
CONDITION MONITORING SERVICES

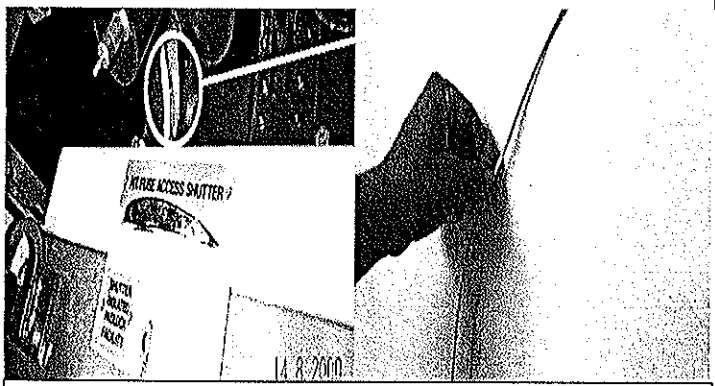
- Partial Discharge Measurement with Ultrasonic Inspection
- Infra-Red Thermographic Analysis with Ultrasonic Inspection
- Dissolved Gas Analysis (DGA) for Mineral Oil Transformer
- Transformer Oil Quality Test (dielectric strength, water content & acidity)

ADVANTAGES OF CONDITION MONITORING

- Non-intrusive technique
- No shutdown is required
- Early warning of developing faults
- Prevention of major failure of equipment

PARTIAL DISCHARGE MEASUREMENT

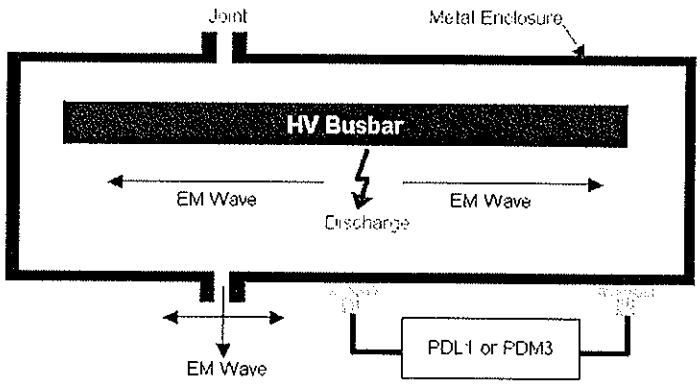




- Equipment : *22 kV switchgear's PT compartment*
- PDL reading : ***63 dB***
- Cause : *Weed grew inside PT compartment*
- Reason : Lack of routine maintenance
- Recommendation : To implement routine PD detection & maintenance

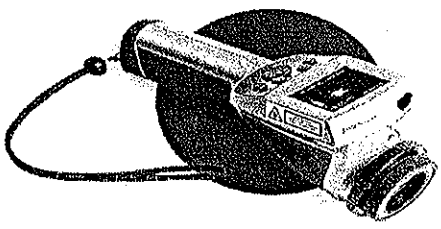
BASIC PRINCIPLE OF PDL/PDM

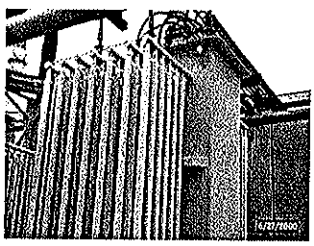
- When PD activity occurs within HV equipment, it generates EM waves
- EM waves transferred capacitively to the metal enclosure
- EM waves propagate inside the metal enclosure and escape through openings (such as air gap around covers, gaskets)
- When EM waves propagate outside, they impinges on the outside of metal enclosure

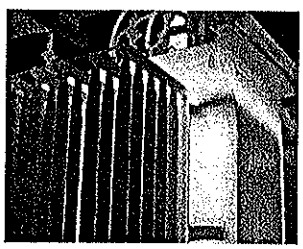


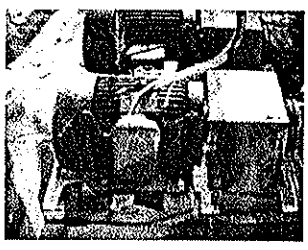
- This produces a transient in the earth potential of the metal enclosure
- This TEV (Transient Earth Voltage) is only a few volts & lasts only a short time with a risetime of a few nano-seconds
- PDL and PDM are designed to measure the TEV
- Magnitude of PD signal is measured with one probe placed on the metal part
- Location of PD signal is determined with two probes placed on the metal part

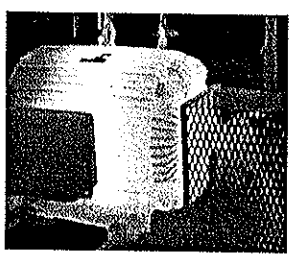
INFRA-RED THERMOGRAPHIC ANALYSIS

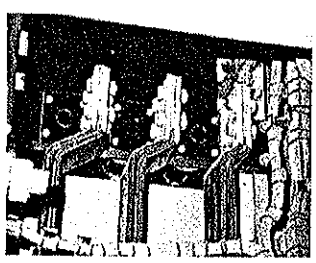


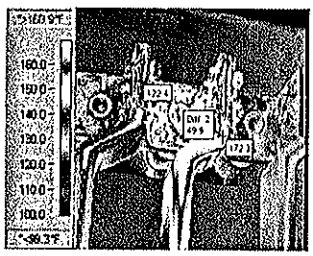








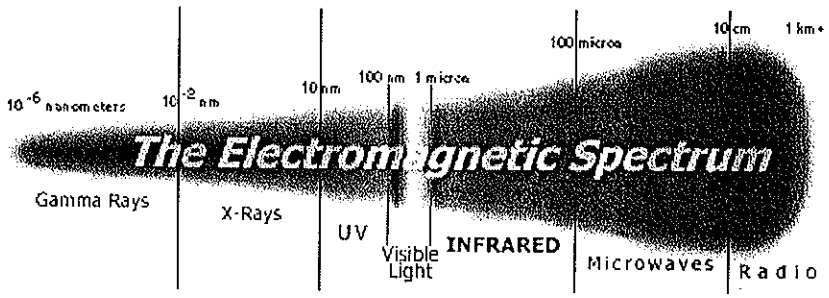




Infrared SEES what we can't see

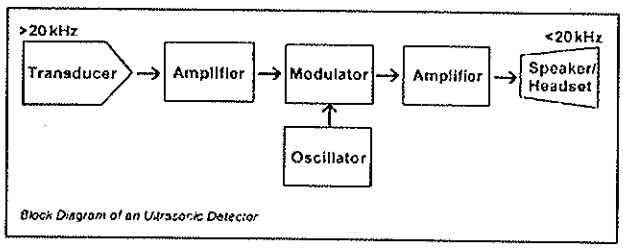
THERMAL ENERGY

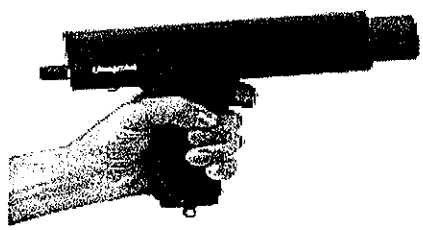
- Thermal energy is transmitted in the infrared wavelength (1 micron to 100 microns).
- Thermal energy is closely related to visible light in that it travels in a wave.
- The human eye can only see the narrow middle band of visible light that encompasses all the colors of light in the rainbow.



ULTRASOUND INSPECTION

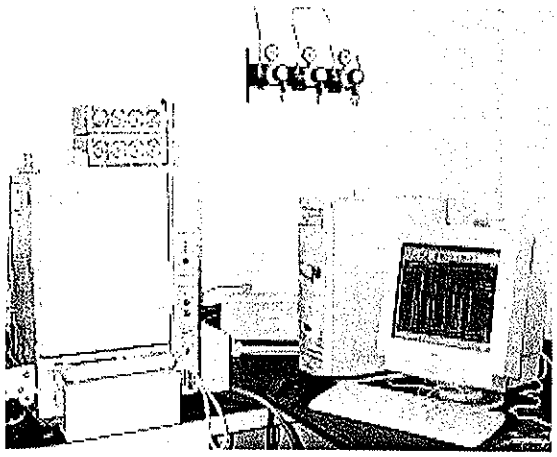
- Human ear can detect frequencies between 20Hz and 20kHz
- Frequencies above 20kHz are call Ultrasonic
- Most equipment produce ultrasound when problems develop or failures occur
- Ultrasonic frequencies are short wave and directional





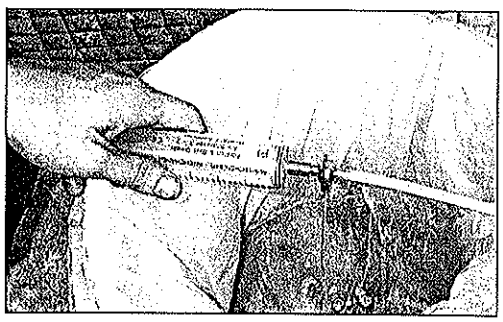
Ultrasonic HEARS what we can't hear

DISSOLVED GAS ANALYSIS (DGA)



DGA is a laboratory test to identify the *type* and *quantity* of the dissolved gases in the transformer oil sample.

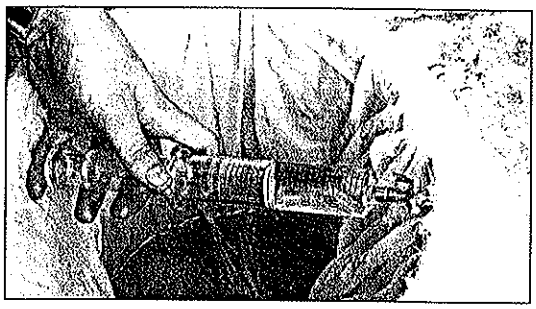
Oil Sampling by Glass Syringe



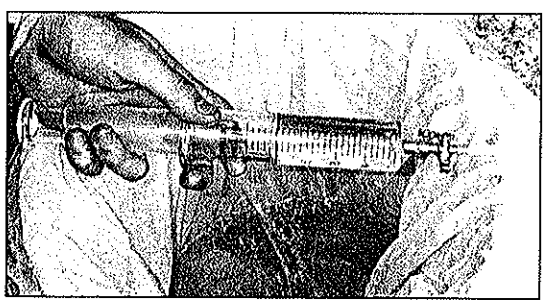
1. Flushing of Sampling Valve and Tube



3. Pushing Oil Out of Sampling Syringe



2. Flushing of Sampling Syringe



4. Collecting 50 ml of Oil into Sampling Syringe

Recommended Safe Fault Gas Levels in Mineral Oil-filled Transformer (max., ppm) IEC 60599

Gas	IEC (≥ 10 MVA)	IEC (≤ 10 MVA)
Hydrogen (H_2)	*60 - 150*	*100*
Carbon Monoxide (CO)	*540 - 900*	*200*
Carbon Dioxide (CO_2)	*5100 - 13000*	*5,000*
Methane (CH_4)	*40 - 110*	*50*
Ethylene (C_2H_4)	*60 - 280*	*50*
Ethane (C_2H_6)	*50 - 90*	*50*
Acetylene (C_2H_2)	*3 - 50*	*5*



POWER QUALITY SOLUTIONS

- **Harmonics**
  - **System reconfiguration or install harmonics filters**
- **Voltage dips**
  - **Improved equipment immunity**
  - **Installing mitigation equipment (UPS, DVR, etc.)**

LOAD SEGREGATION

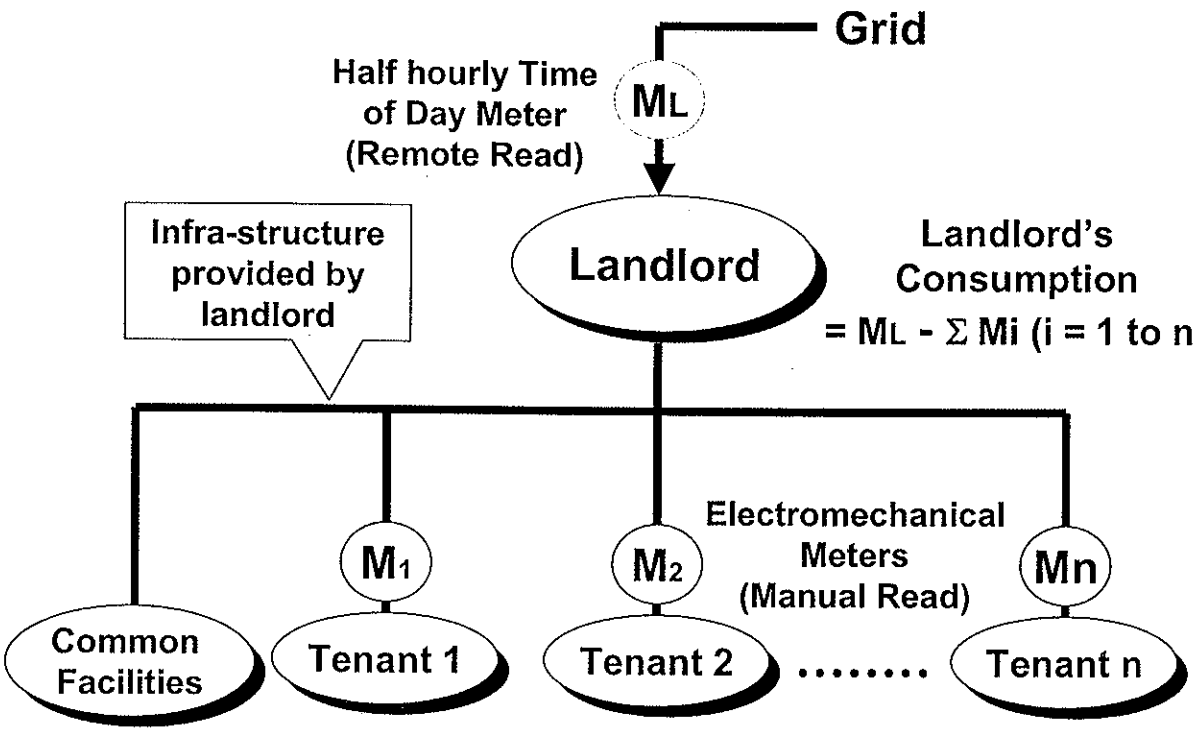
- Normal load
- Essential Load
- Critical Load (Sensitive Load)
  - High tech industries
  - Consider to segregate the critical load for future installation of mitigation equipment, if required

ELECTRICITY SUPPLY TO LANDLORD-TENANTS (CUSTOMER WITH MASTER-METER)

ELECTRICITY CONSUMERS

- Sole Building Owner
- Multiple Owners/Landlord & Tenants
  - (Master-metered Consumers)

TYPICAL ARRANGEMENT OF ELECTRICAL SYSTEM FOR LANDLORD-TENANTS



TYPICAL MASTER-METERED CONSUMERS

- Multi-tenanted commercial buildings – e.g. shopping centers, office buildings
- Multi-tenanted industrial buildings – e.g. flatted factories, warehouses
- Tenanted non-industrial institutions – e.g. hotels, hospitals, universities, polytechnics

CONTESTABILITY TO LANDLORD-TENANTS

- Master-metered accounts (landlords)
  - Contestable only when electricity market is fully liberalized
  - Landlord can apply to EMA for consideration on a case-by-case
- Why?
  - Landlord's electricity consumption is the total premise consumption minus the total tenants consumption
  - Landlord meter is Time of Day (half hourly) but most tenants are electro-mechanical meters

COST OF ELECTRICITY FOR LANDLORD

- Landlord pay supplier based on agreed energy cost + UOS charges = **L**
- Landlord to collect agreed rates from Tenants = **T**
- Electricity cost of landlord = **L – T**

METERING REQUIREMENTS

- Landlord's Meter
  - Supplied by Power Grid
  - Remote reading
  - Half hourly interval consumption
- Tenants' Meters
  - Retailer leases the meters on behalf of landlord
  - Landlord installs new meters (for new tenants after switching to supplier)

SUPPORT SERVICES FOR LANDLORD - TENANTS

- Meter Reading, Billing (Invoicing) and Payment Collection (2 Options)
  - Managed by landlord
  - Engaged the retailer to provide the required services on behalf of the landlord

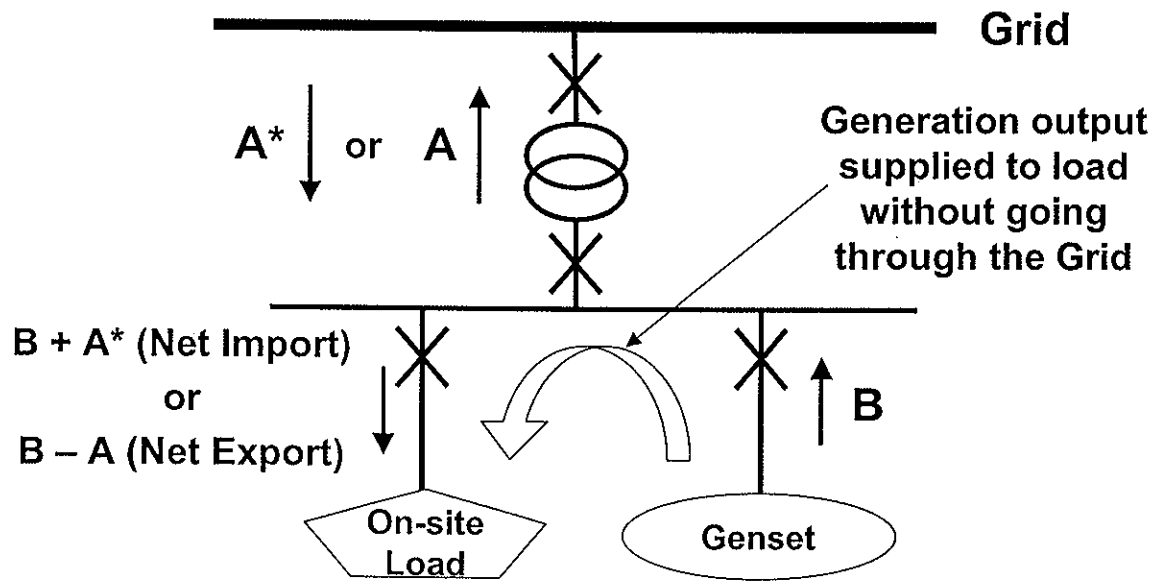
CONTRACTED CAPACITY OF THE PREMISE

- Before switching to supplier
  - Landlord's declared contracted capacity is the net capacity excluding tenants' consumption
- During and/or after switching to supplier
  - Landlord may need to increase the declared contracted capacity to include tenants consumption in order to manage the un-contracted capacity

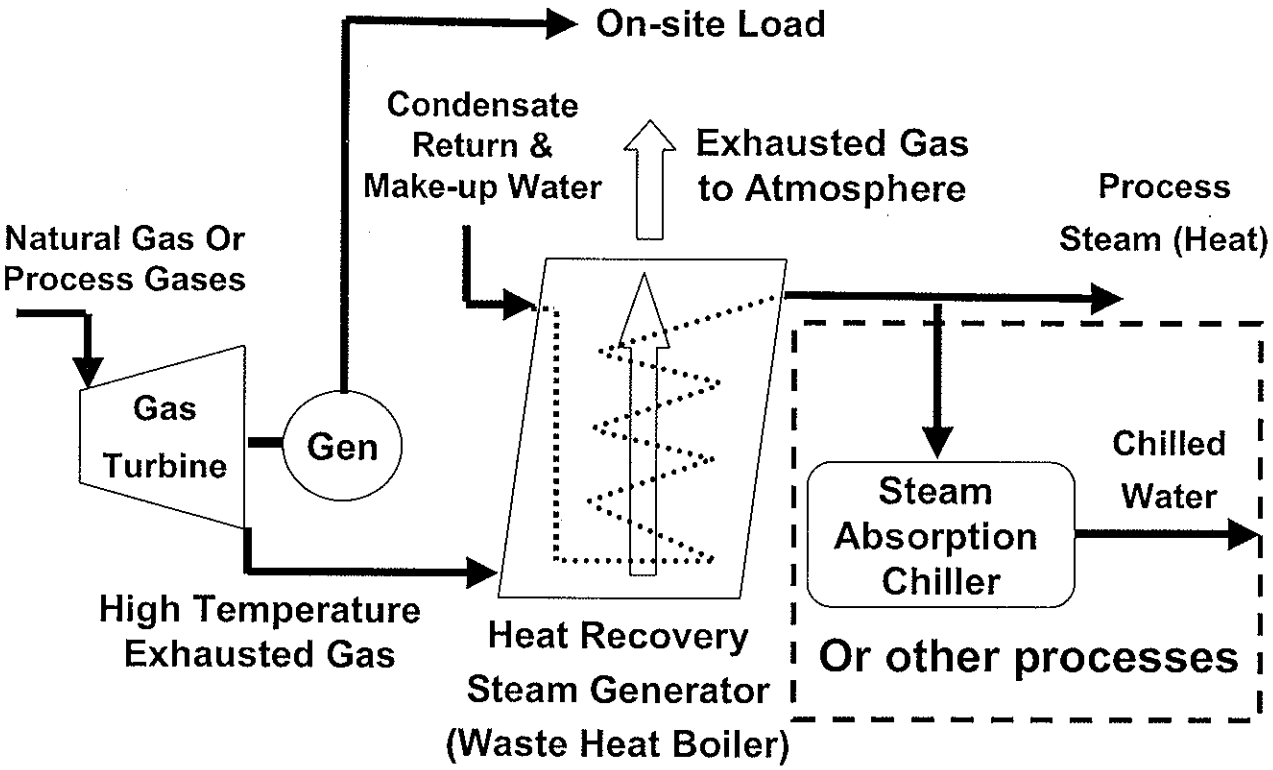
DIRECT SUPPLY OF ELECTRICITY BY GENERATING SETS TO ON-SITE LOADS (CUSTOMERS WITH EMBEDDED GENERATION)

WHAT IS 'DIRECT SUPPLY OF ELECTRICITY BY GENERATING SET TO ON-SITE LOAD' ?

- A generating set may supply part of its generation output directly to an on-site load without going through the transmission system (Grid)



COGENERATION PLANT – AN EXAMPLE



EMA POLICY ON EMBEDDED GENERATION CONDITIONS FOR SUPPLYING ON-SITE LOAD

- The genset, the land on which on-site load and genset are situated, and the facility constituting the load must be majority owned by the same company
- The genset and load must be located at the same land
- Cable between genset and load cannot be connected between two separate plots of land
- The company must hold an electricity license
- The genset shall be registered at the wholesale market according to the Market Rules

REGISTRATION OF GENERATION FACILITIES UNDER MARKET RULES

- Capacity = or > 10 MW (Registered as generation facility)
  - *Centrally scheduled - dispatched based on "offers" into market*
  - *Metered on a half hour basis*
  - *Settled in the wholesale market - based on nodal energy price*

- Capacity 1- 10 MW (Registered as generation settlement facility)
  - *Self Scheduled (but may choose to be treated exactly like a > 10 MW generator for centrally scheduled)*
  - *Metered on a half hour basis*

- Capacity = or < 1 MW (Not Registered or Settled in Wholesale Market)
  - *Self scheduled*
  - *Settled in the retail market - based on monthly meter readings*

TECHNICAL REQUIREMENTS ON GENERATING SET TO SUPPLY ON-SITE LOAD

- For net exporter which does not required transmission system resources (not going to take any electricity from the Grid), Circuit Breakers must be interlocked to prevent taking supply from the Grid

- For net exporter which required back-up from the Grid or net importer, it is required to enter into a contract with Power Grid to obtain its back-up supply. Power Grid will impose technical requirements and use of system charges for the back-up supply as appropriate

CONSIDERATIONS WHEN EMBARKING ON EMBEDDED GENERATION (1)

- Current and projected electricity and process heat consumption requirements (for cogeneration)
- Maximum demand and generation capacity
- Back-up requirements and/or planned load shedding operation
- Net exporter or net importer
- Licensing and permitting
- Participation in the wholesale market for electricity trading

CONSIDERATIONS WHEN EMBARKING ON EMBEDDED GENERATION (2)

- Cost-benefit for equipping embedded generation and/or cogeneration
- Capital and financing costs, payback period, NPV and IRR / WACC
- Sources, availability, specification and cost of fuel
- Operation and maintenance of the facilities and costs
- Use of System Charges for back-up supplies

  (which can be higher for back-up as compared with the charges for normal supplies)
  - *Contracted Capacity Charge*
  - *Un-Contracted Capacity Charge*
  - *Un-Contracted Standby Capacity Charge*
  - *Reactive Power Charge*

TUAS POWER

Thank You