ENSURING RELIABLE AND SECURE ELECTRICITY SUPPLY AT LEAST COST

DO WE NEED “BASE LOAD POWER?”

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RELIABLE, LOW COST POWER IS CRITICAL FOR OUR ECONOMIC DEVELOPMENT

• From our recent history we know that unreliable power supply (load shedding) and high electricity prices have a devastating impact on the economy and ultimately on people’s lives.
  – It is no coincidence that we now have one of the highest unemployment rates in the world and our economic growth per capita is stalled, etc.
  – We now know from direct observation and recent data that soaring electricity costs and load shedding are key contributors to our economic malaise.
• The question, therefore, of how we combine our available energy resources to ensure an:
  – adequate, reliable electricity supply
  – at least cost
is absolutely critical.
POWER SYSTEM PLANNING IS TECHNICALLY COMPLEX, BUT THE PRINCIPLES ARE SIMPLE

• Simply put, the objective of power sector planning is to meet demand by:
  1. electing a combination of resources from the many options available to us
     • **generation**: Hydro, Coal, Nuclear, Gas, CSP, PV, Wind, etc.
     • **storage**: Pumped storage, flywheels, batteries, capacitors, molten salt, etc.
     • **demand-side**: instantaneous, very short-term, short-term, medium term, long-term.*
  2. in order to provide the required security of supply (mathematically specified)
  3. at the least possible cost.

• A given level of security of supply can be achieved by many different resource combinations, but most will not be least cost.
  – i.e. it is possible to have the same security of supply with one combination of resources, but pay more for it than with another combination.

• Many different resource combinations can provide low cost power, but most will not provide the required security of supply level.
  – i.e. it is possible to have resource combinations, even very low cost ones that do not meet the required security of supply level.

ONLY A FEW CLOSELY RELATED POWER SYSTEM RESOURCE STRATEGIES WILL BE BOTH LEAST COST AND SUFFICIENTLY RELIABLE

System resource combination strategies

- Adequate reliability
- Least cost

The sweet spot: A power system resource strategy that is both least cost and reliable
EXAMPLE: MEETING DEMAND ON A TYPICAL DAY

• Assume a green fields system (we build everything from scratch)
ANY POWER SYSTEM MUST MEET DEMAND THAT VARIES OVER TIME
HISTORICALLY, BASED ON OUR RESOURCE AND TECHNOLOGICAL ENDOWMENTS WE MAXIMISED INFLEXIBLE (COAL) BASE GENERATION TO PROVIDE LEAST COST POWER...

Base load generators alone cannot economically meet demand.

Run generators flat-out to achieve least cost energy on the system and fill as much of the area under demand curve.

Cheapest energy is achieved by maximising use of plant being run flat-out (inflexibly) – hence “base load generation”
HISTORICALLY, INFLEXIBLE (COAL) BASE GENERATION WAS COMBINED WITH MORE EXPENSIVE, DISPATCHABLE FLEXIBLE RESOURCES TO PROVIDE LEAST COST POWER

There was never an inherent technical requirement for “base load” power to provide security of supply. Maximising coal generation capacity that could be run flat out (in “base load” mode) was simply an economic strategy to minimise total system cost under a given technological and resource endowment. If new variable technologies are now the cheapest source of bulk power there is no need for “base load” power anymore.

Coal units can be designed to be flexibly operated. But…

...historically they only produced least cost power when used in “base load” mode. They are thus economically inflexible.
HOW DO WE MEET DEMAND WITH NEW, LOWER COST, VARIABLE RESOURCES?

System with Variable Base Generation

Time of day

System Load

GW

00:00 01:00 02:00 03:00 04:00 05:00 06:00 07:00 08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00
WITH THE NEW TECHNOLOGIES WE MAXIMISE INFLEXIBLE VARIABLE BASE GENERATION TO PROVIDE LEAST COST POWER...

As with base load, Variable generators alone cannot economically meet demand.

In this example variable base generators provide the bulk (same kWh) of the energy at lower cost.

Fill as much of the area under curve with cheapest energy resource available (variable base generators in this case).
VARIABLE BASE GENERATION IS COMBINED WITH MORE EXPENSIVE, DISPATCHABLE FLEXIBLE RESOURCES TO PROVIDE LEAST COST POWER

Dispatchable flexible resources are used to bridge the gap and meet demand.

In the past base generation was maximised to provide the low cost kWhs on the system. Now this role is taken over by cheaper variable resources (In this example providing the same kWhs)
IN THIS EXAMPLE THE SAME AMOUNT OF DISPATCHABLE RESOURCES ARE USED (KWH), BUT WITH A DIFFERENT PROFILE
OPTIMISED VARIABLE BASE GENERATION

Optimised System with Variable Base Generation

Time of day

GW

00:00 01:00 02:00 03:00 04:00 05:00 06:00 07:00 08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00

System Load
The low cost of variable resources means that it now makes economic sense to increase the variable resources on the system to displace some of the more expensive dispatchable resources.
OPTIMISED VARIABLE BASE GENERATION

Dispatchable supply needed = 76 GWh
# EXAMPLE COST SUMMARY

<table>
<thead>
<tr>
<th></th>
<th>System with Inflexible Base Generation</th>
<th>System with Variable Base Generation</th>
<th>Optimised System with Variable Base Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost per MWh</td>
<td>GWh per day</td>
<td>GWh per day</td>
<td>GWh per day</td>
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<tr>
<td>Base load</td>
<td>120</td>
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<tr>
<td>Dispatchable</td>
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<tr>
<td>Wind (variable)</td>
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<td>-</td>
<td>358</td>
</tr>
<tr>
<td>Solar (variable)</td>
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<td>-</td>
<td>122</td>
</tr>
<tr>
<td>Total Energy (MWh)</td>
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<td>636</td>
</tr>
<tr>
<td>Weighted Price (c/kWh)</td>
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<td>140</td>
<td>94</td>
</tr>
</tbody>
</table>

*Inflexible Base Generation option is ~75% more expensive than Optimised Base Generation*
SECURITY OF SUPPLY:
HOW DO WE DESIGN A SYSTEM TO MEET THE REQUIRED SHORT-TERM SECURITY OF SUPPLY?

• What do we do if:
  – “The wind does not blow”
  – “The sun does not shine”
  – One or more large units (e.g. ~ 794MW Medupi, 900MW Koeberg) trip?
  – Plant maintenance or refurbishment outages overrun
  – A coal conveyer breaks
  – Flooding affects coal handling and supply into power stations
  – Extreme ambient temperatures significantly reduce dry cooling power output
  – Long transmission import lines fail (e.g. Cahora Bassa)
  – Etc, etc.

• As we know:
  – the actual capacity available from base load resources always varies.
  – and so does the actual capacity available from variable resources.
IRRESPECTIVE OF THE TYPE OF RESOURCES DEPLOYED, THE SOLUTION TO PROVIDING SECURITY OF SUPPLY IS THE SAME

• The problem is stochastic in nature.
  – i.e. it involves random risk – actual outcomes are not predictable, but the overall probabilities can be mathematically described.
• As always in such circumstances the solution is to take out an optimal level of insurance, e.g.:
  – Ensure an appropriate reserve margin
  – Reduce plant specific risk by holding an appropriately diversified portfolio
  – etc.
• NB: The insurance strategy itself should be optimised to:
  – deliver the specified security of supply
  – at the least cost
  – This is a technical process based on empirical data and statistical modelling
  • e.g. the “Plexos modelling” undertaken to produce the IRP.
  • This is not an opportunity for rent seeking
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Least cost

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