African Utility Week

SOUTH AFRICA’S LEAST-COST PLANNING OPTIONS AS A CASE STUDY FOR AFRICAN COUNTRIES

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Introduction

- This is a time when the power sector planning challenge is even greater than before
  - Disruptive technological change
  - Climate change and other environmental imperatives
  - The problem of uncertainty
  - Conflicting policy objectives?
    - System resilience
    - Socio economic development
    - Jobs, etc.
    - Environmental
    - Vested interests – politics.
- What are the implications of these challenges for planning?
- The nature and scope of planning will partly depend on the characteristics of the power sector in each country.
  - But, the principles remain applicable
- Examples from the South African case will be used to illustrate the points.

A power sector plan amounts to a set of investment decisions

- A power plan is a set of high level investment decisions with
  - expected costs; and
  - expected benefits
- But neither of these are certain
  - The future is unknowable
  - Humans suffer from “Bounded rationality”
  - The challenge therefore is one of:
    - decision making under uncertainty

Uncertainty

- **Risk:** contingencies (states of nature) known and probabilities objectively assigned
- **(Technical) Uncertainty:** either future contingencies can not all be known, or probabilities can not be objectively assigned.
- **Ignorance:** neither all contingencies nor probabilities are known   Stirling (1998)
- We don't know what it is that we don't know
  - The problem is bigger than what we think it is and is therefore generally underestimated
  - Bounded rationality in the context of uncertainty:
    - Research in behavioural economics: humans are not particularly well adjusted to dealing with uncertainty and probabilistic processes.

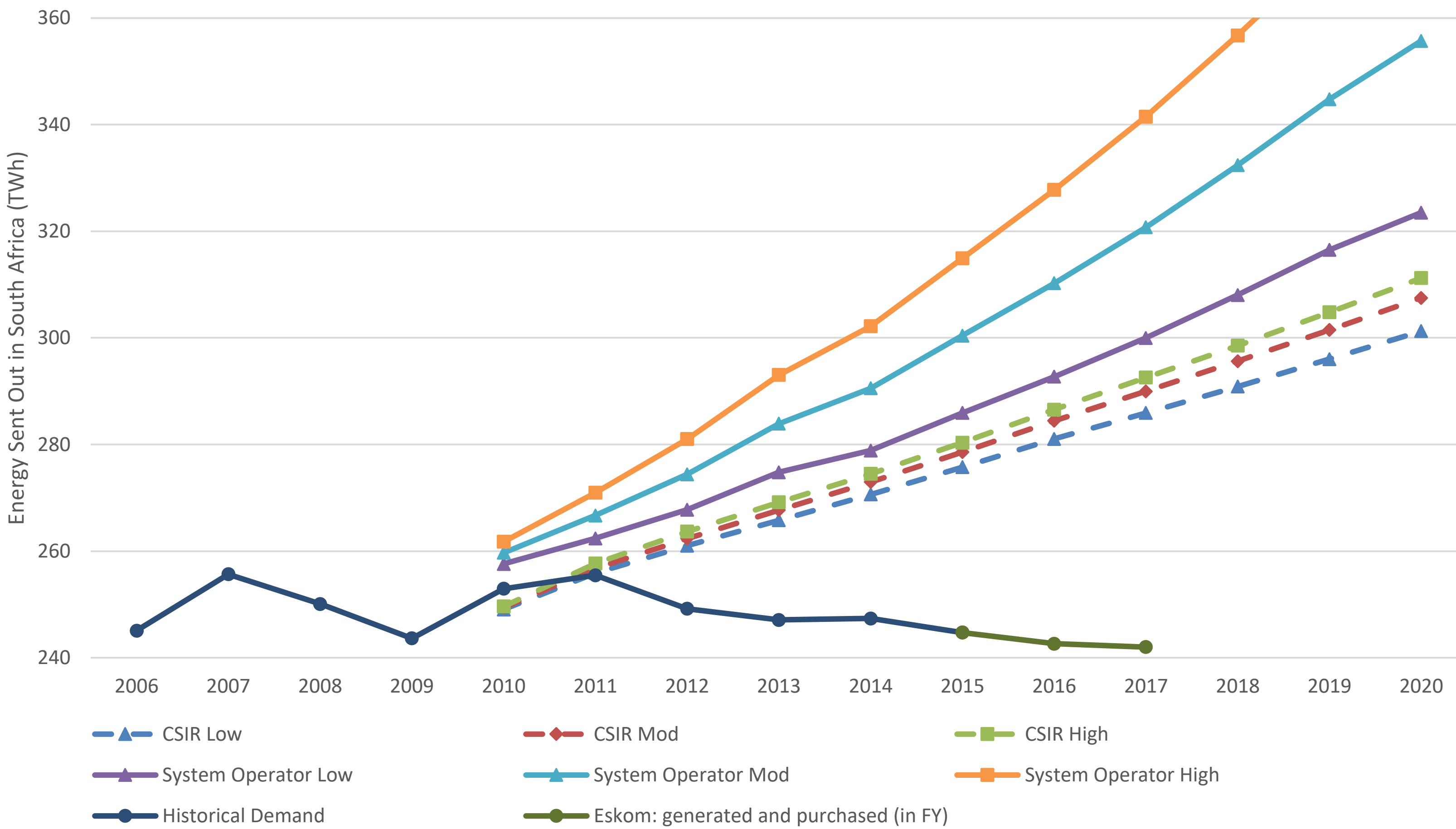
SA's Power Generation Planning Process

- The DOE remains responsible for the development of The Integrated Resource Plan (IRP)
- Based on a least cost optimisation model
- Process
  1. Adoption of planning assumptions (incl. demand forecasts)
  2. Modelling and scenario planning
  3. Risk adjustments
  4. Public consultation
  5. Cabinet approval and publication
- NERSA generation licence applications must show compliance with the IRP.

SA 2010 IRP Results

	New build options							
	Coal (PF, FBC, imports, own build)	Nuclear	Import hydro	Gas – CCGT	Peak – OCGT	Wind	CSP	Solar PV
	MW	MW	MW	MW	MW	MW	MW	MW
2010	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	300
2013	0	0	0	0	0	0	0	300
2014	500[1]	0	0	0	0	400	0	300
2015	500[1]	0	0	0	0	400	0	300
2016	0	0	0	0	0	400	100	300
2017	0	0	0	0	0	400	100	300
2018	0	0	0	0	0	400[4]	100[4]	300[4]
2019	250	0	0	237[3]	0	400[4]	100[4]	300[4]
2020	250	0	0	237[3]	0	400	100	300
2021	250	0	0	237[3]	0	400	100	300
2022	250	0	1 143[2]	0	805	400	100	300
2023	250	1 600	1 183[2]	0	805	400	100	300
2024	250	1 600	283[2]	0	0	800	100	300
2025	250	1 600	0	0	805	1 600	100	1 000
2026	1 000	1 600	0	0	0	400	0	500
2027	250	0	0	0	0	1 600	0	500
2028	1 000	1 600	0	474	690	0	0	500
2029	250	1 600	0	237	805	0	0	1 000
2030	1 000	0	0	948	0	0	0	1 000
Total	6 250	9 600	2 609	2 370	3 910	8 400	1 000	8 400

UNCERTAINTY: IRP 2010 demand forecasts and outcomes



UNCERTAINTY: Medupi power station cost overruns

Date	Capacity	Cost	Basis	Source
Jan-07	4500MW	R52bn	Incl. IDC, Excl. FGD	*Eskom*
Oct-07	4800MW	R78.6bn	Incl. IDC, Excl. FGD	*Eskom*
Nov-09	4764MW	R124.4bn	Incl. IDC, Excl. FGD	*Eskom*
Apr-11	4764MW	R98.9bn	Excl. IDC, Excl. FGD	*Eskom*
Jul-12	4764MW	R91.2bn	Excl. Transmission, FGD, other and IDC	*Eskom*
Jul-13	4764MW	R105bn	Excl. IDC	*Eskom*
Mar-16	4764MW	R145bn	Excl. IDC	*Eskom*
Final cost	4764MW	> R200bn	All inclusive	*Own estimates*

Disruptive technological changes provide new challenges and opportunities

- Clean and low cost renewables.
  - Countries such as Mexico, Saudi Arabia, etc. are already realising prices below 30 ZARc/kWh.
  - Embedded generation has become cost competitive against retail tariffs.
- Digitisation of the power system.
  - Smart meters.
  - Prosumers.
  - Community based peer-to-peer power trading - block chain technology, etc.
    - e.g Bangladesh
- Energy storage.
  - Storage costs are rapidly declining.
  - Embedded and grid-scale levels.
  - Electric Vehicles.
    - SA: 2018 Nissan Leaf claims a range of 378 km!
    - At 10kWh/100km and falling prices EVs are rapidly becoming competitive against ICE vehicles.
- Etc

These changes result in a new power sector techno-economic paradigm

- Economies of scale have almost disappeared.
  - A large turbine is now 7.5MW (wind) not 800MW (steam); and
  - A large power project is now 140MW not 4800MW.
- The cheapest sources of generation (renewables) will produce variable output.
  - Complementary dispatchable mid-merit resources will be valuable; and
  - Inflexible base load resources will lose value.
- Decentralisation.
  - Hundreds of utility scale projects will now be spread throughout the network; and
  - Embedded demand side resources (demand or generation based) will proliferate.
- System balancing.
  - Digitally based market and pricing based mechanisms will play a much bigger role in order to effectively coordinate a multitude of resources;
  - The role of centralised command-and-control will reduce (but not disappear).
- In general the action will move from the centre to the periphery.
  - Greater energy democracy and choice.

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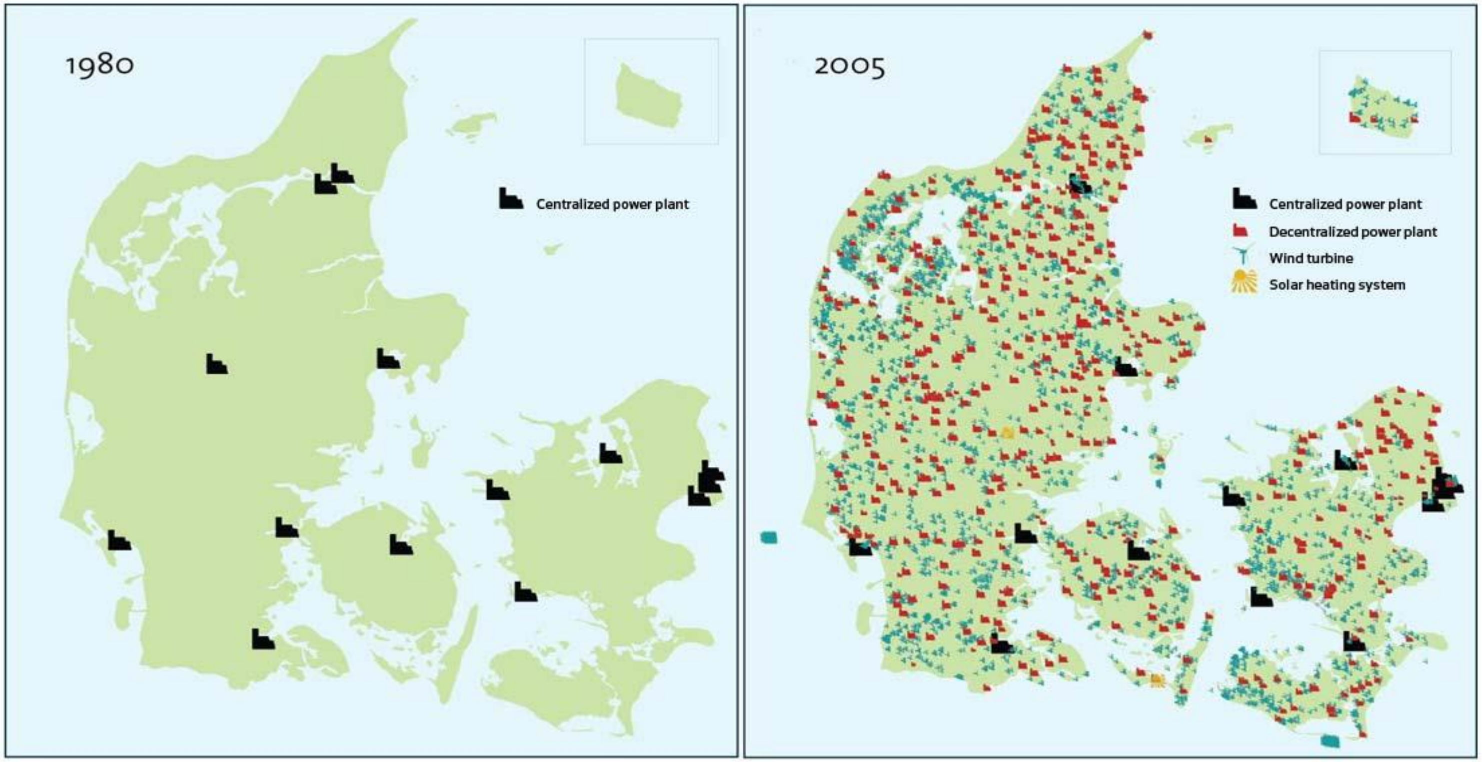

Denmark

Key aspects uncertainty

- Capital cost
  - A project can lose value because an asset might cost more to create than the cost on which the decision was predicated.
  - Construction delays add hugely to cost.
- Operating
  - Reliability
  - Running costs (mostly operating, fuel and maintenance) could be higher than anticipated; or its
- Benefits (mostly revenue) could be less than anticipated.
  - E.g. New competing technologies could emmerge that offer cheaper power.
  - Demand could be far greater or far less than forecast (e.g. IEP 2010 forecasts)
  - Over a period of between 15 – 50 years or longer.

Planning strategies in the face of uncertainty

- Incrementalism: “The science of muddling through” Lindblom (1959 and 1979)
  - Eschews attempts at large-scale rational comprehensive planning;
  - In favour of modest approaches that recognise the realities of bounded rationality and uncertainty;
  - Poses a challenge to the *mastery-via-understanding* tradition of Western civilization;
  - Effective response to complexity and uncertainty in the context of bounded rationality

Planning strategies in the face of uncertainty (2)

- Flexibility (of an investment or technology)
  - Lower complexity
  - Shorter lead times (shorter technology cycles)
  - Smaller unit sizes
  - Lower capital intensity per unit of output
  - Less dependence on dedicated infrastructure
  - Higher substitutability of inputs
- Allows for trial and error learning (Collingridge, 1992)
- Enables adaptation to changing circumstances and therefore reduces the potential costs of errors (Collingridge and James, 1991).

  With inflexible technologies *“ordinary mistakes lead to extra-ordinary consequences”.*

Planning strategies in the face of uncertainty (3)

- Diversity (of a system)
  - promotes beneficial forms of innovation and growth
  - hedges against exposure to uncertainty and ignorance
  - mitigates the adverse effects of institutional ‘momentum’ and ‘lock-in’ in technological trajectories
  - accommodates disparate interests associated with social choice in modern pluralistic societies. Stirling (1998: 37)
- These strategies imply that: <u>Options have value</u>
  - Inflexible strategies destroy options

Lessons to learn from the SA planning case

- Plan for disruption.
  - We need to quantify and include the relative “option value” (hedge against uncertainty) embedded in different technology options.
- South Africa is a disproportionate contributor to climate change.
  - The IRP base case should now explicitly include its carbon costs (risk to SA economy).
- Need to make sure that IRP planning does not just become a cloak of legitimacy to hang over a process that is actually primarily about protecting vested interests.
- In the past the SA the government has simply “policy adjusted” the optimised least cost IRP plan to get the outcomes that they wanted.
  – This effectively discards the entire rational planning process
- All policy objectives (not outcomes) should be <u>finalised upfront</u> and specified in quantifiable terms as part of the objective function or constraints of the model.