An Extended Evaluation Framework for Nuclear Power Plants – A Dynamic DCF and Real Options Approach

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Presentation agenda

- Quick introduction to Dynamic DCF and Real Options
- DCF discounting and cash flow risk profiles
- A preliminary analysis a project financing proposal for a nuclear power plant
  - Project background
  - Financing
  - Equity, creditor, and government cash flow streams
  - Evaluation of participant cash flows
- Concluding comments

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Dynamic DCF and Real Options –
What it is / What it is not

- Dynamic Discounted Cash Flow ("Dynamic DCF") and Real Option ("RO") are NPV calculations that are increasingly being used for investment decisions.
  - However, understanding the application of these methods to mining investment analysis is not widespread which leads to some confusion and misplaced concerns.
- Dynamic DCF and RO methods <u>are</u>:
  - An integral part of a company-wide valuation and risk management framework.
  - An excellent means of communicating project uncertainty characteristics and their impact on project value and corporate risk exposure.
  - Gaining acceptance through multiple channels such as financial reporting and investment decision-making.
  - An extension to the Static Discounted Cash Flow methods you are using now.
- Dynamic DCF and RO methods <u>are not</u>:
  - A substitute for knowledgeable professional experience in the industry.
  - The locator of "hidden" project value.

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Dynamic DCF and Real Options –
Why question the use of static DCF models?

- There are three reasons for extending the economic and risk analysis of a static DCF model through the introduction of Dynamic DCF / RO.

  Reason 1: A static DCF model may provide a cash flow and value estimate that has unacceptable errors due to flexibility or finance / taxation cash flow non-linearities.

  Reason 2: A standard DCF discounting formula may incorporate a risk adjustment profile that is inconsistent with how risk varies over the investment horizon.

  Reason 3: Standard sensitivity or scenario analysis does not fully communicate project risk characteristics so that more sophisticated tools are required.

- Moving beyond a static DCF model will be motivated by important these concerns are for your investment analysis.
  - Note that a Static DCF model is always your starting point in an investment analysis.

Dynamic DCF and Real Options –
The difference between Dynamic DCF and RO NPV

- Dynamic DCF and RO are both methods of calculating NPV. They are structurally very similar and they have the same theoretical foundation.
- The primary difference between the two NPV calculations is in the application of a risk adjustment. Note that flexibility is not the differentiator here.

DCF present value calculation

Price · Power amount =	Revenue
–	OpCost
	Operating profit
–	CAPEX
	Net cash flow
∗	Time & risk adj.
	Present Value of net cash flow

RO present value calculation

Price · $RDF_{Electricity}$ =	RA Price
∗	Power amount
	RA revenue
–	OpCost
	RA operating profit
–	CAPEX
	RA net cash flow
∗	Time & residual risk adj.
	Present Value of net cash flow

Abbreviations

RDF_{Metal}: Risk discount factor for a specific metal.
RA: Risk-adjusted
adj: Adjustment

Re-thinking DCF risk discounting –
Matching risk adjustments with risk profile

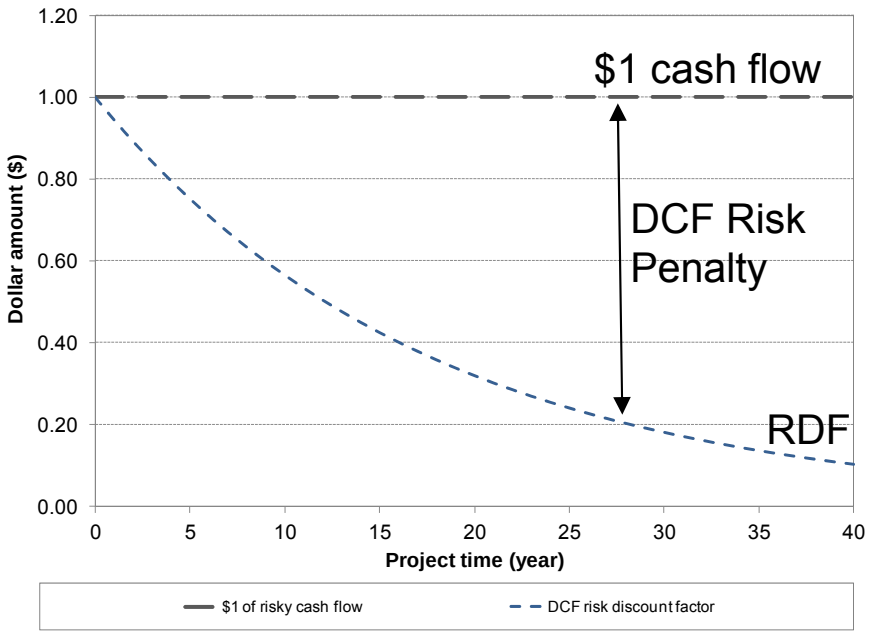
- Standard method of adjusting cash flow for uncertainty and risk is through discounting with the formula:

$$\text{Time and risk discount factor} = \frac{1}{(1+R_f+RP)^t} \qquad \text{Risk discount factor (RDF)} = \frac{1}{(1+RP)^t}$$

where:

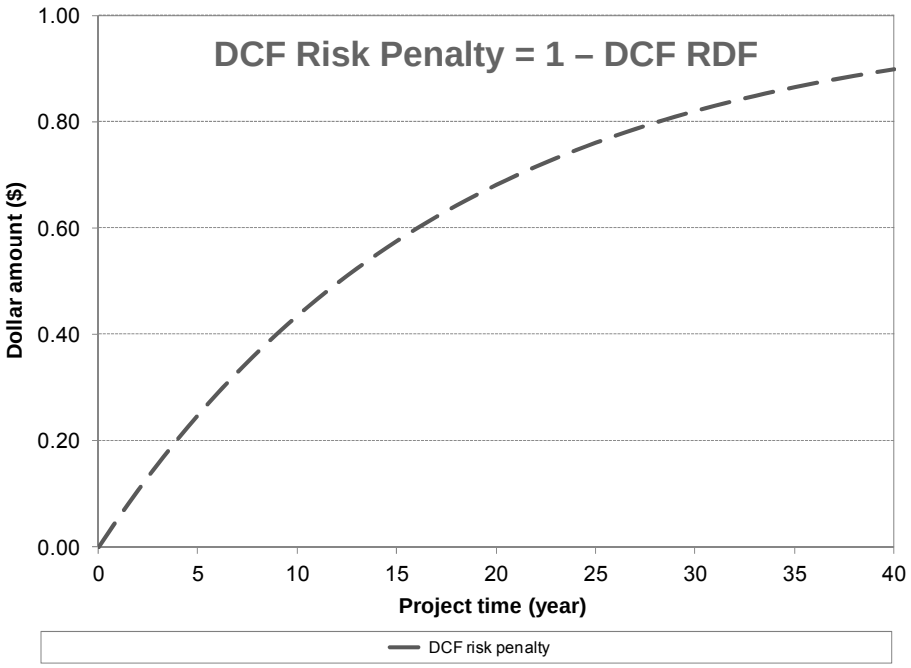
R_f = risk-free interest rate (%); RP = risk premium (%); t = time (years)

- A **RDF** represents the amount an investor will pay now on a risk-adjusted but not time-adjusted basis for a $1 of risky cash flow received some time in the future.
- A **Risk Penalty** is the difference between $1 and the RDF. It represents the compensation an investor requires for bearing risk.



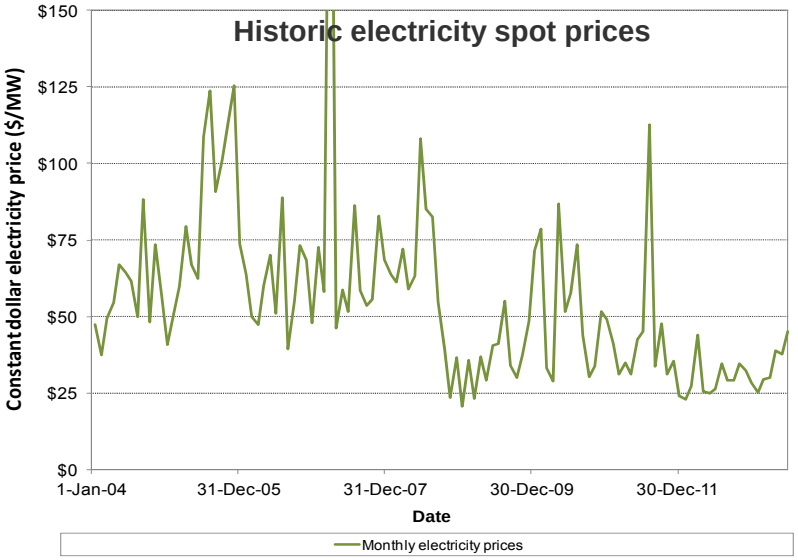
Re-thinking DCF risk discounting –
Matching risk adjustments with cash flow risk level

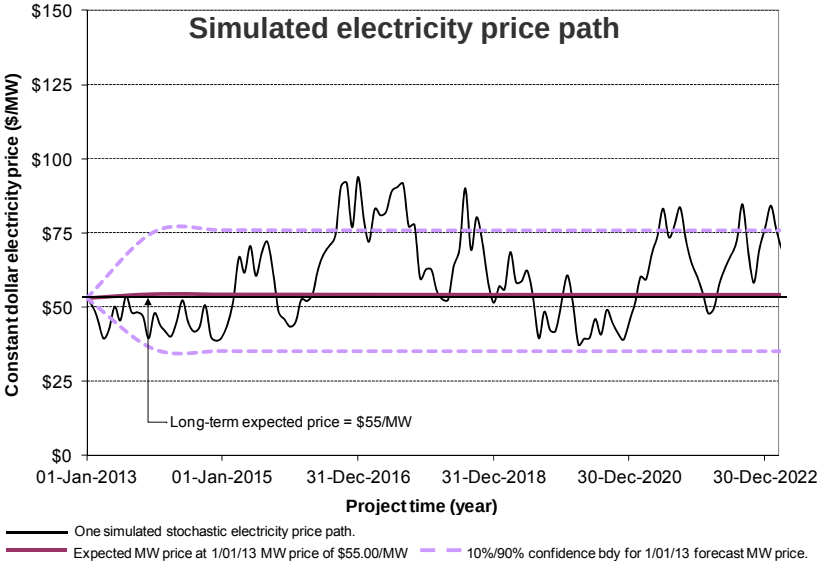
- Investor risk aversion requires that the Risk Penalty change with variations in project cash flow uncertainty.
  - Increases in uncertainty should be marked by an increase in Risk Penalty and vice versa.
- **Question**: How often have you compared the pattern of Risk Penalties to the project risk profile to determine if risk adjustments are appropriate?
- **Question:** What should we conclude about the DCF risk discounting formula if the DCF Risk Penalty grows through time in a well-behaved manner but cash flow uncertainty appears to stabilize?



Re-thinking DCF risk discounting –
Power projects and electricity price risk characteristics

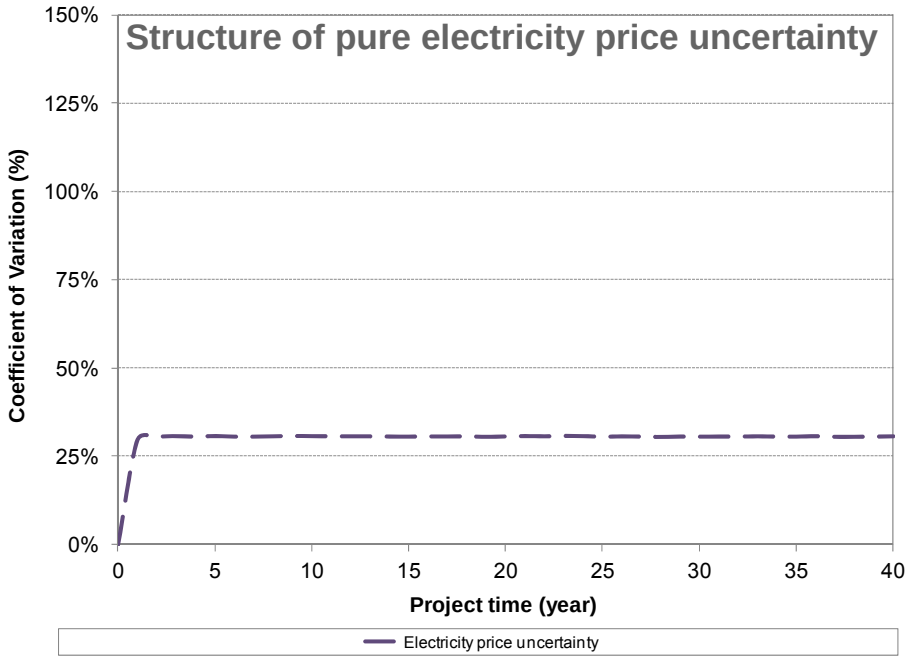
- Long-life nuclear projects are one class of power investment where questioning the standard discounting approach is appropriate because of the behaviour of electricity prices in financial markets.
- Historic electricity spot (**Upper Graph**) provide visual support for reversion.
- A reverting electricity process is displayed in the **Lower Graph** where key characteristics are:
  - Price uncertainty initially grows and then saturates as confidence boundaries become parallel due to reversion.
  - Impact of price shock declines with term as price forecast reverts to long-term equilibrium level.

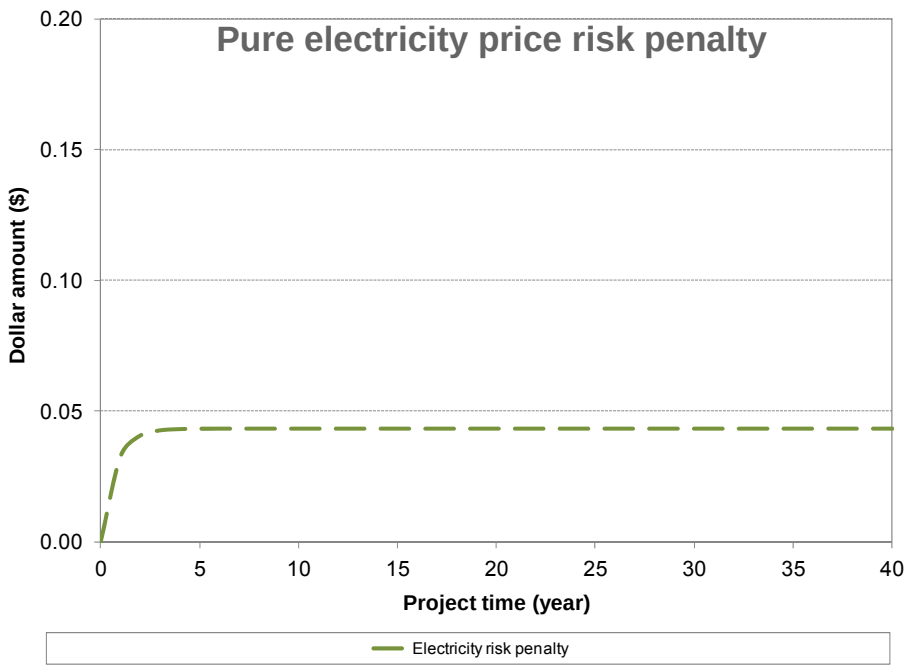




Re-thinking DCF risk discounting –
Electricity risk characteristics and risk adjustment

- A model of electricity price uncertainty and associated risk adjustments can be constructed based on the Capital Asset Pricing Model such that the model also recognizes the impact of reversion on risk adjustments.

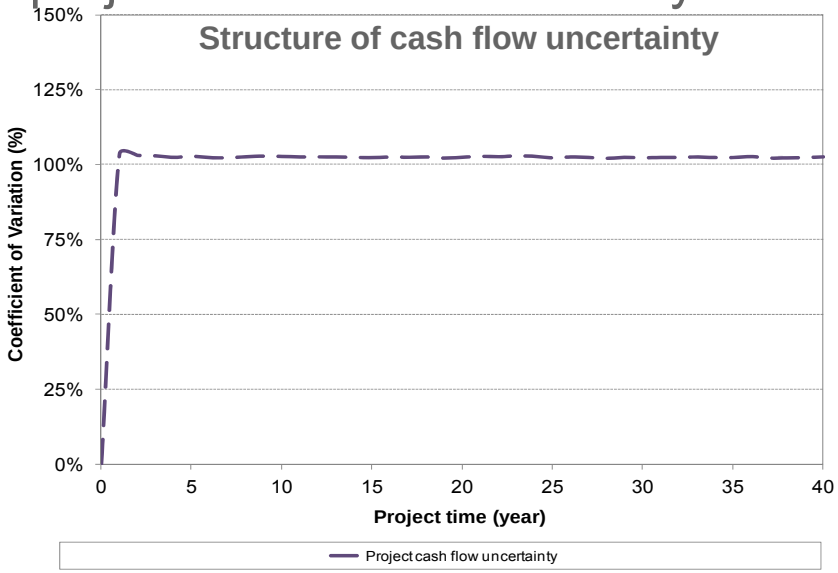


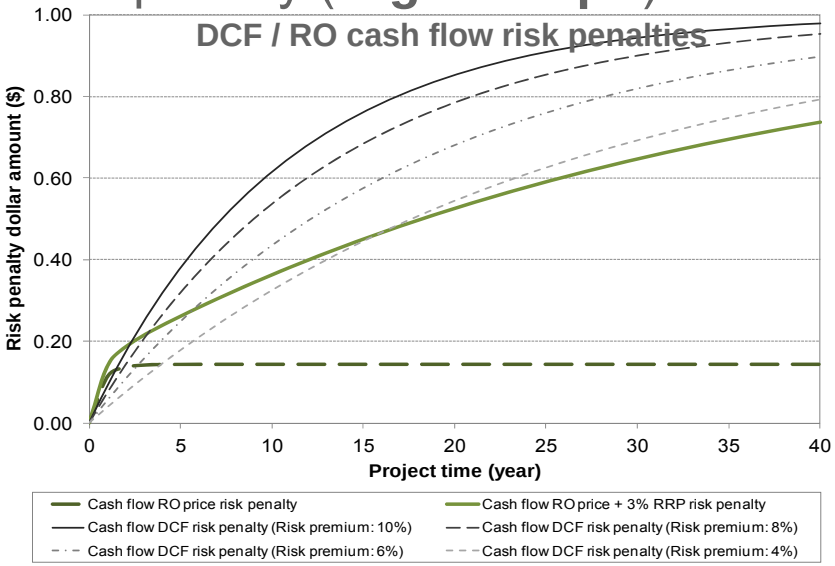


Re-thinking DCF risk discounting —

Copper project risk characteristics and risk adjustment

- The previous electricity price uncertainty model can be built into a project cash flow analysis using the RO NPV method.
  - Remember both RO and DCF calculate project NPV. They have the same theoretical foundation but are differentiated by risk adjustment approach.
- A long-life power project with a 30% profit margin may have the following structure of cash flow uncertainty (**Left Graph**) due to electricity reversion.
- The RO method produces a cash flow Risk Penalty that is a better match with project cash flow uncertainty than the DCF risk penalty (**Right Graph**).





Project background –
A merchant nuclear power plant

- A 2200 MW merchant nuclear power plant is being planned with a construction period of 8 years and an operating horizon of 50 years.
  - Estimated development capital costs are $7.7 billion in constant dollar terms with a further $2.3 billion of sustaining capital costs incurred over the life of the plant.
  - Direct operating and maintenance costs including fuel and upgrading are estimated to be approximately $17/MWhr.
  - Project flexibility is ignored in this example.
- Equity sponsors for the power plant are a consortium of utilities and energy companies.

Project financing proposal –
Debt financing with a possible loan guarantee

- A loan consortium of banks, infrastructure funds, and pension plans are considering whether to provide debt financing.
  - The proposed debt / equity split is 60/40.
- Debt has a principal amount of $5.0 billion (real: $4.6 billion) plus $710 million in capitalized interest and pays a 8% coupon.
  - The debt coupon is a 6% spread over government long-term rates.
  - Annual debt service (interest + principal) is $580 million.
- The loan consortium is considering whether to cover any debt service shortfalls through either default recovery provisions in the loan agreement or with a government loan guarantee.
  - Both loan default recovery provisions or government loan guarantee require debt service shortfalls to be carried forward at a penalty interest rate of 10% until the shortfall is recovered from future project profits.
  - Main difference between the two default management structures is who covers the debt service shortfall.

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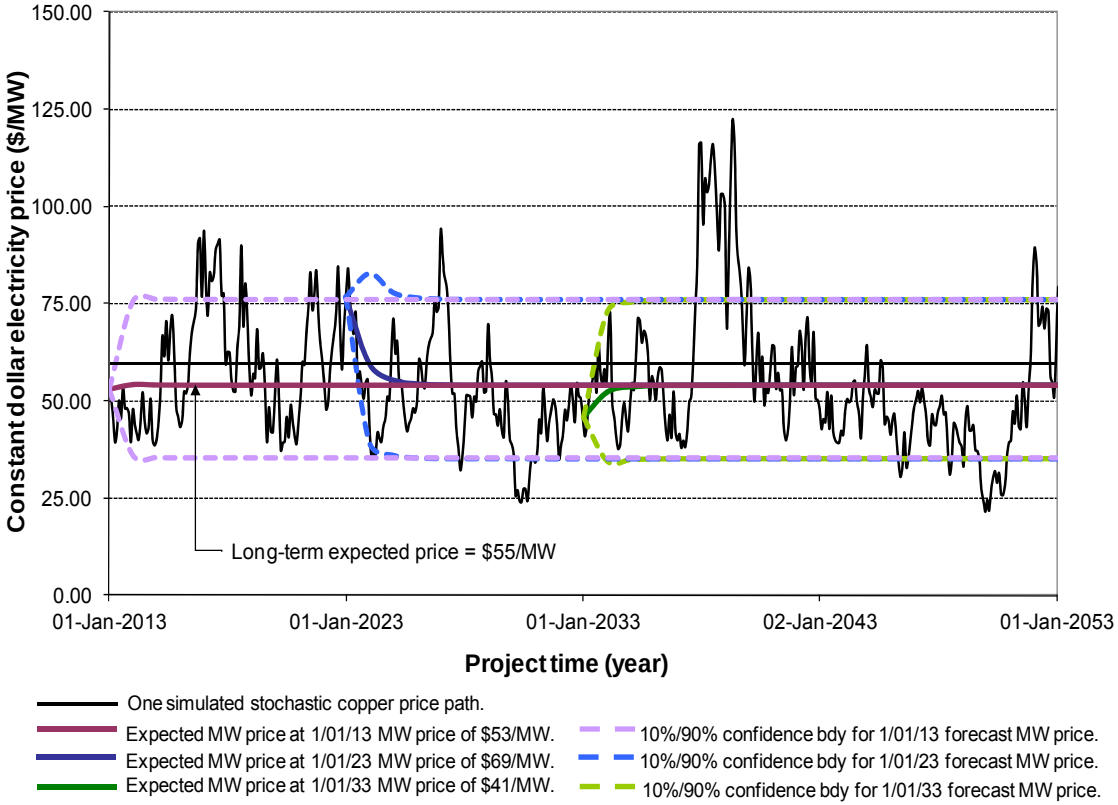
Economic environment –
Discount rates and electricity price uncertainty

- Long-term nominal risk-free interest rate is 4%.
- Inflation and OpCost/CAPEX escalation rates are 2%.
- Electricity price is the primary uncertainty source. This is modeled as a time-correlated (stochastic) statistical process with a real long-term expectation of $55/MWh.
  - Electricity prices also revert to a long-term equilibrium level of $55/MWh as high electricity prices force conservation and low prices induce consumption.
- Uranium price is also uncertain but has minor impact on economics.

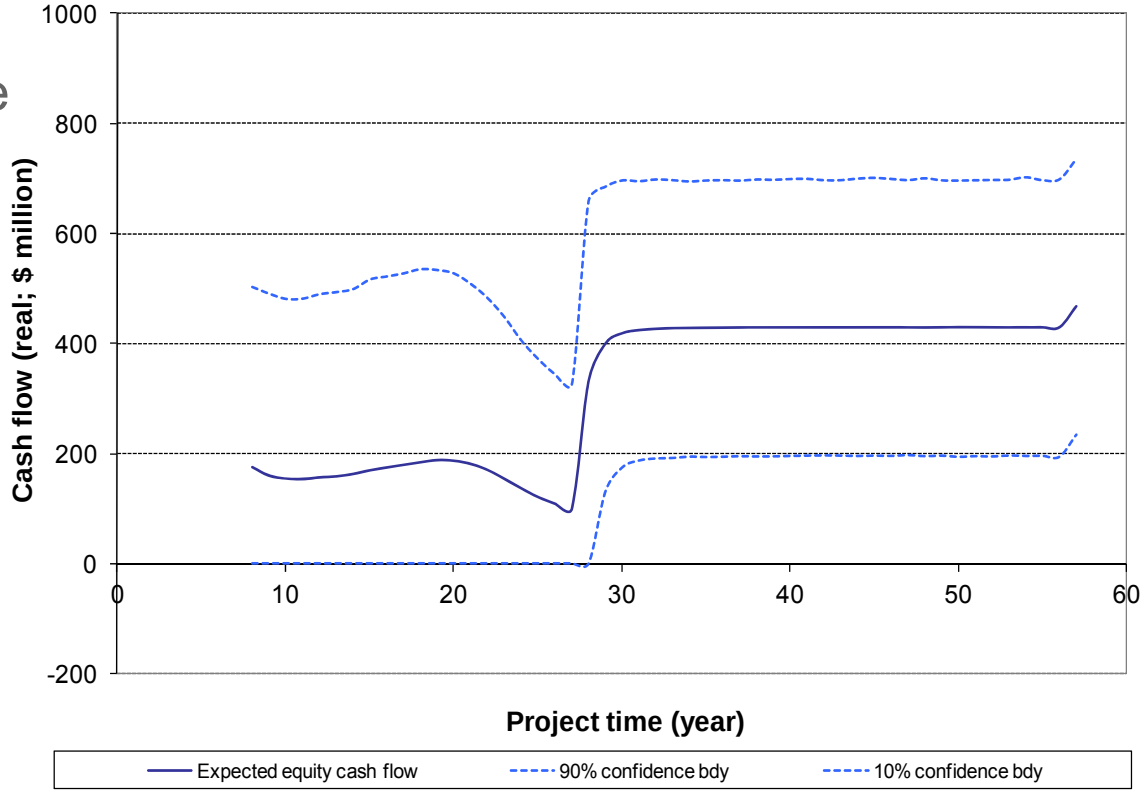
A simulated electricity price path with forecast updating



Cash flow streams –

Equity cash flow stream in real (inflation-adjusted) terms

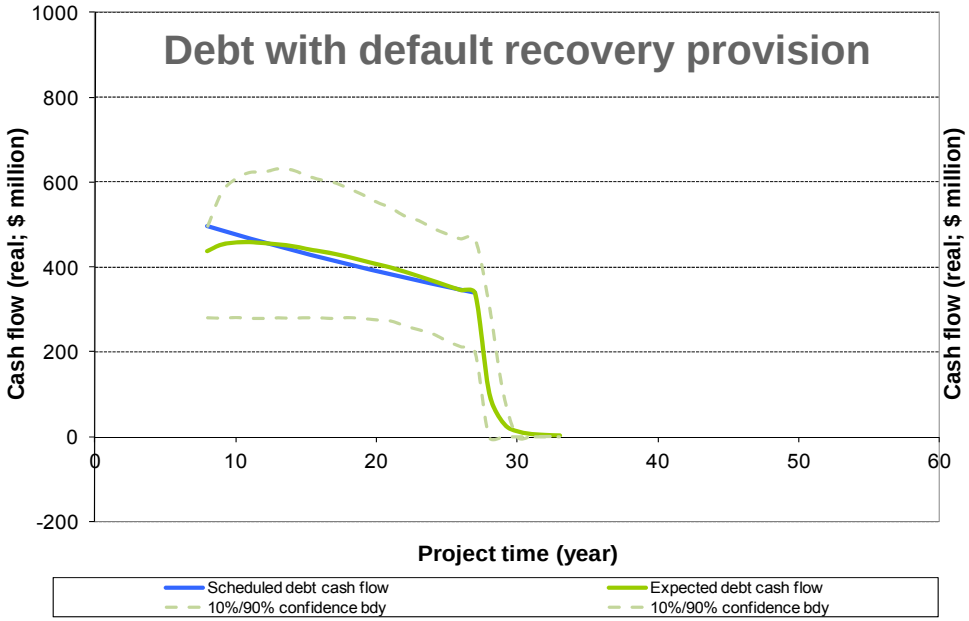
- Equity cash flow ("CF") averages $159 million for the first 20 years of operation and then increases to $430 million for the final 25 years (solid BLUE line) after debt is repaid.
  - Upper 90% and lower 10% confidence boundaries (dashed light BLUE lines) highlight level of uncertainty in equity CF.
  - 80% of simulated CFs in a given year are between the two confidence boundaries.

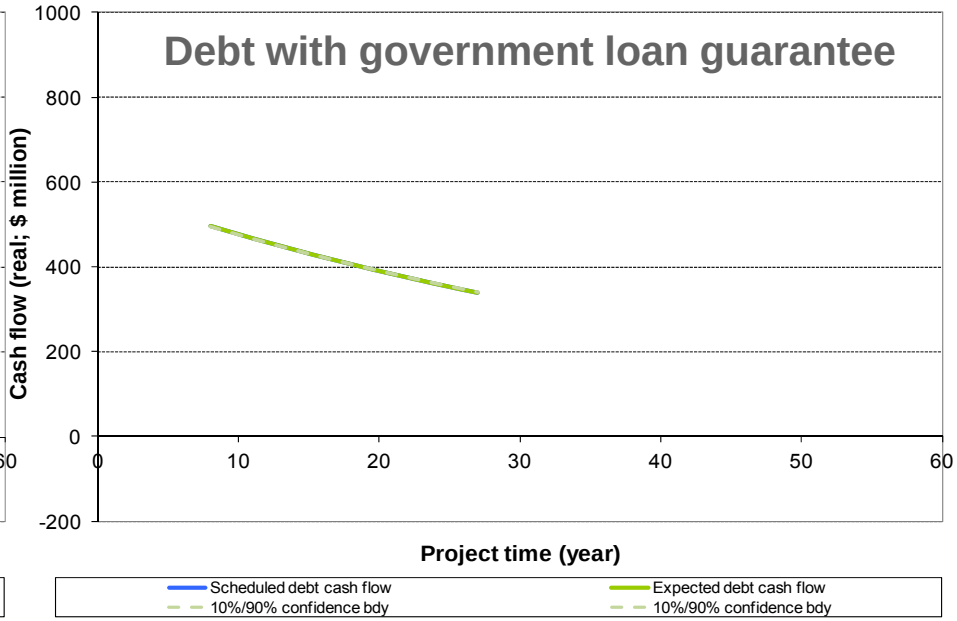


- Equity CF confidence boundaries are roughly parallel (*i.e.* CF uncertainty is not increasing) because of electricity price reversion.

Cash flow streams –
Creditor cash flow stream in real terms

- Annual scheduled debt service is $582 million in nominal terms.
  - The BLUE line in the graphs are scheduled debt service while the solid GREEN line is expected debt service. Dashed lines are 10%/90% confidence boundaries.
  - Creditor cash flows vary in the LEFT graph depending on whether there is a debt service shortfall or extra cash to repay an outstanding shortfall.
  - There is no uncertainty in the creditor cash flow in the RIGHT graph because the government loan guarantee makes up any shortfall.

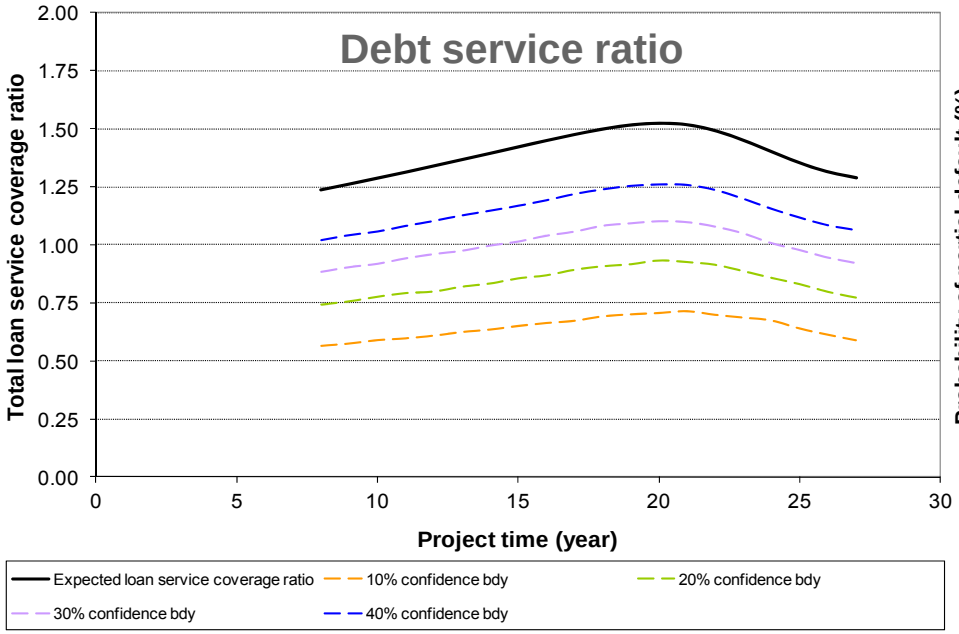


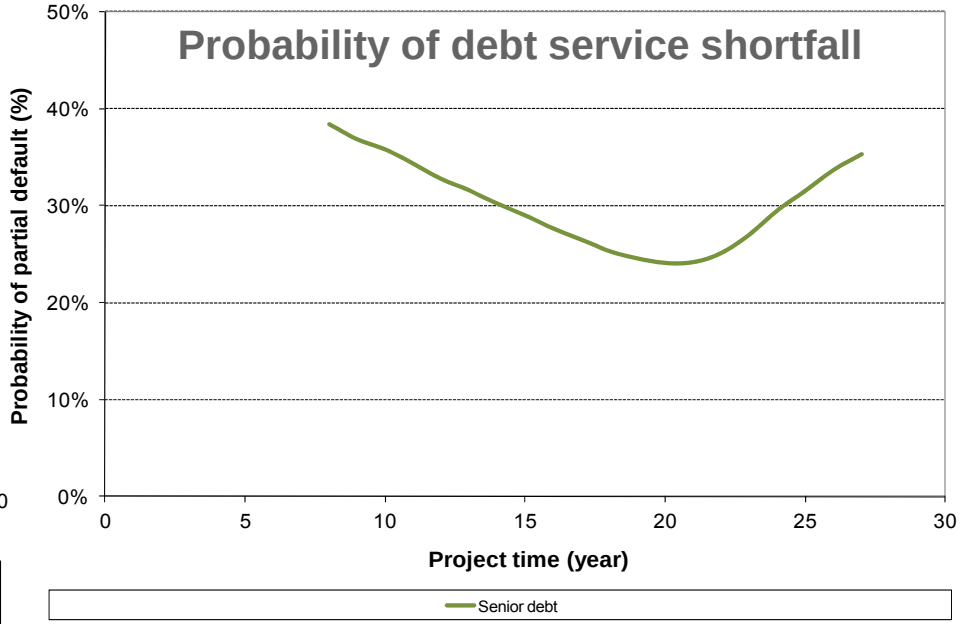


Cash flow streams –

Debt coverage ratios with / without a loan guarantee

- The LEFT graph displays the effect of electricity price uncertainty on the Debt Service Ratio ("DSR"; cash flow available to cover principal and interest).
  - The expected DSR is approximately 1.5 over the life of the loan.
  - However, simulation suggests that there is a 30% probability that the DSR may decline below 1 in any given year.
- The RIGHT graph displays the annual probability of a debt service shortfall.

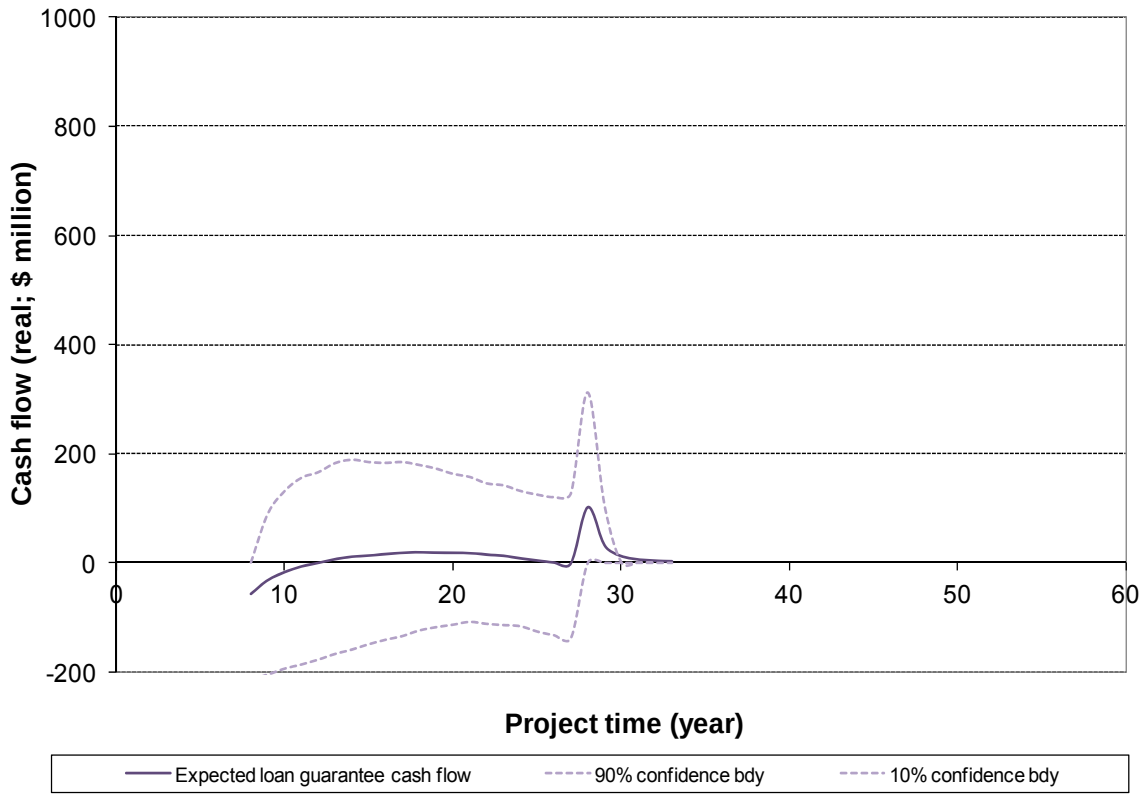




Cash flow streams –

Loan guarantee cash flow stream in real terms

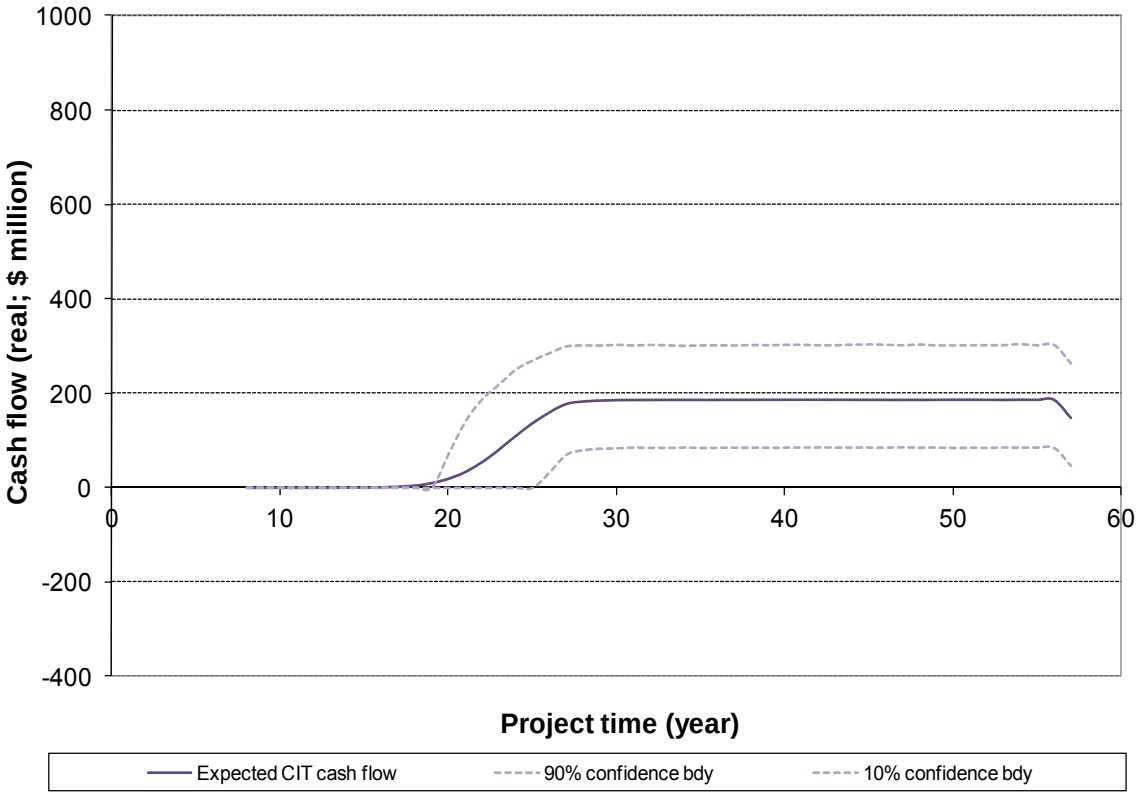
- Loan guarantee has a low expected payout for much of the loan life.
  - The average payout for Years 8 to 26 is approximately ZERO.
  - The positive expected payouts in later years is repayment of outstanding guarantee balances after the loan is paid back.
- Positive/negative confidence boundaries show that there is a significant possibility that the loan guarantee facility is used over the life of the loan.
  - In most cases, any outstanding guarantee balance is repaid.
  - Additional stress testing can be performed to test the robustness of the guarantee.



Cash flow streams –

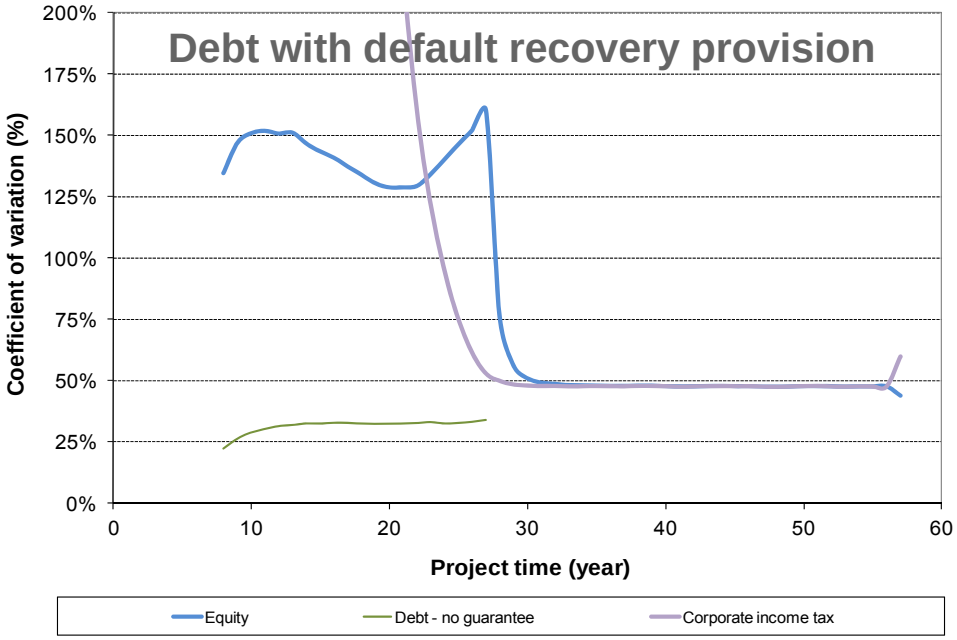
Corporate income tax cash flow stream in real terms

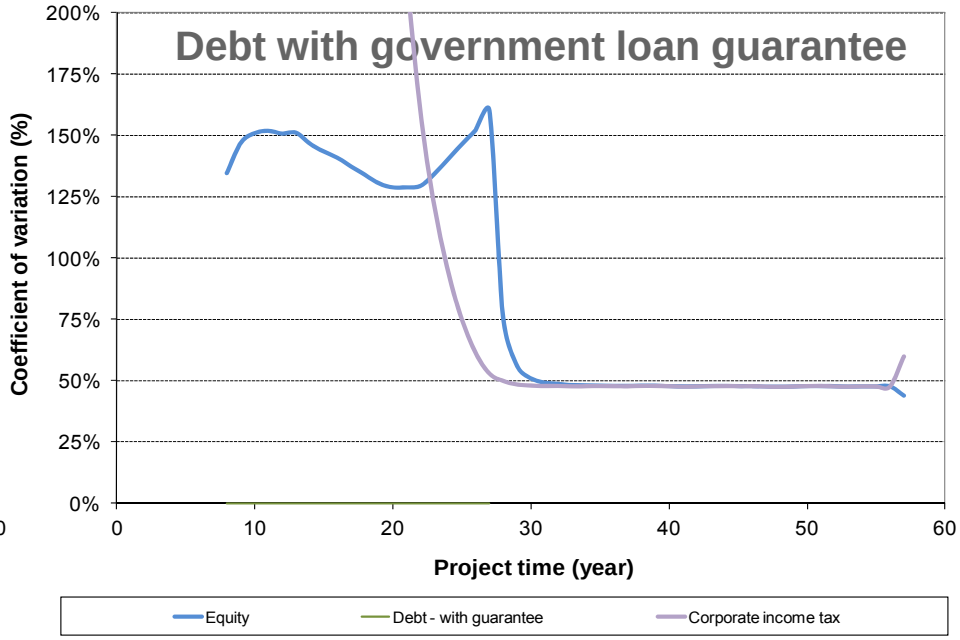
- The average annual corporate income tax paid over the life of the project is $126 million in real terms.
  - Corporate income tax averages $176 million per year once the depreciation and interest service tax shields are exhausted.
  - Price reversion causes the parallel structure of cash flow confidence boundaries.
  - Corporate income tax cash flow is not affected by presence of either a default recovery provision or government guarantee in this model.



Cash flow streams –
Comparing cash flow stream uncertainty

- Coefficient of Variation ("CoV") is an indication of uncertainty where a larger CoV indicates a higher level of uncertainty.
  - Defined as a standard deviation of a variable divided by its expected value.
  - Equity CoV averages 142% until the debt is repaid and then declines to 59%.
  - Average debt CoV is 32% with a default recovery provision.
  - Large CIT CoV caused by the uncertainty linked to when tax shields will be exhausted.





Evaluation results –
Dynamic DCF and Real Option net present value

Stakeholder	DCF(8%) NPV ($ million)	RO NPV (with 3.0% residual risk premium) ($ million)		
	Guarantee	No default facility	Default provision	Guarantee
Reference project	**496**	**1379**	**1379**	**1379**
Equity	-95	677	239	239
Debt	-96	-150	288	246
Loan guarantee	15	N/A	N/A	41
Corporate income tax	671	852	852	852

- RO results are higher than DCF because the effect of reversion is recognized in the RO risk adjustment – long-term cash flows have more value with RO.
- Government has the most valuable interest through corporate income tax.
- Loan guarantee has positive value because of repayment terms.
  - Debt declines in value because the repayment facility covering technical default is transferred to the loan guarantee. Explicit models of types of default are important.

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Concluding comments

- Outlined an evaluation framework for large infrastructure projects that highlights a detailed description of project uncertainty and structure and an extended valuation and risk assessment “toolkit”.
- A preliminary review of a merchant nuclear power project within the evaluation framework provides the following thoughts:
  - Reversion affects uncertainty in long-term cash flows. Real option NPV incorporates the saturation of uncertainty in the value calculation. DCF does not.
  - Debt service shortfall provisions such as a loan guarantee may have a positive NPV depending on the terms and the underlying causes of the shortfall.
  - Government has a valuable interest in power plant through tax cash flow stream.
- Some overall benefits of using the extended evaluation framework:
  - Increased descriptive detail of business / project environment in economic model.
  - Business and project risk characteristics recognized in the RO NPV.
  - Allows richer communication when discussing risks and benefits of a nuclear power plant with equity, creditor, and government participants.

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Concluding comments

- Some costs associated with the extended evaluation framework:
  - The model is an approximation of reality. Model results need a critical review and should be compared with insights from other analytical methods.
  - Requires additional numerical skills to implement which may not be available in an organization.
  - Analysis may not be accepted due to the lack of familiarity with the evaluation process and how to interpret results.
- Areas of further work include:
  - Multi-factor electricity price models with uncertain long-term equilibrium levels, seasonality, and price spikes.
  - Construction uncertainty linked to cost overruns and delays.
  - Construction guarantees with upper exposure limits. Subordinated debt financing.
  - Benefits of incremental generation capacity expansion.
  - Increased default detail – catastrophic default vs short-term cash flow shortfalls.