# INVESTMENTS IN GENERATING CAPACITY: THE ROLE OF RISK AND LONG-TERM CONTRACTS


*John Parsons, MIT Sloan School of Management and MIT Center for Energy and Environmental Policy Research*

*relying on work by*

*Fernando de Sisternes, MIT Engineering Systems Division*

*Charlotte Bonnin, MIT Sloan School of Management*



*CEEPR / EPRG / Iberdrola European Electricity Workshop, Madrid, July 2-3, 2014*

# Outline

- Motivation
- Research Results
- Lessons

# Motivation

# Hinkley Point C

- Proposed 2 EPR reactors totaling 3,260 MW capacity.
- Southwest England (Somerset) at the site of Hinkley A (closed) and B (operating).
- Lead contractor, EDF. Equity partners with AREVA and Chinese nuclear corps.
- Total installed cost estimated at £16 billion, including £2 billion already invested in site preparation and other start-up costs.
- 13 TWh/year equal to approx. 7% of the UK's electricity.
- If built, it will be the first new UK reactor in over 20 years.

# Supporting New Investments with Long-Term Contracts

- The UK's Electricity Market Reform employs a specialized contract design – the Contract-for-Differences – as an essential tool for lowering the cost of capital intensive generation projects.
  - *"Each of the low-carbon technologies the Government is considering differs materially from this standard investment choice. In particular, low-carbon generation typically has high construction (capital) costs and low operating costs, and as a result low-carbon plants are wholesale price takers. It is therefore difficult to make an investment case for them in a market where wholesale electricity prices are predominantly set by the short-run marginal costs of unabated gas and coal plant, even if the carbon price was high enough for their levelised costs to be similar."*
  - *"These long-term contracts, Feed-in Tariffs with Contracts for Difference (FiT CfDs), which stabilise revenues, should increase the rate of investment and lower the cost of capital, thereby reducing costs to consumers. In our central scenario, the FiT CfD reduces the cost of decarbonisation to 2030 by £2.5 billion compared to using the Premium Feed-in Tariff (PFiT) to deliver the same investment."*

# The October 2013 Agreement

- The price: £92.50/MWh guaranteed for 35 years;
  - if Sizewell C does not go ahead; £89.50/MWh if it does;
  - inflation-adjusted.
- A Contract-for-Differences (CfD) arrangement;
  - power is sold into the market. If the market price is below the strike price, the generator receives a top-up payment;
  - objective is to assure a 10% IRR to EDF.
- Construction risk falls to EDF and partners, although savings in construction costs are shared with the public through a lower strike price.
- In addition, there is a separate UK government guarantee of debt financing 65% of the costs.

# Conflicting views on the role long-term contracts

- A tool for lowering the cost of financing and thereby lowering the cost of electricity.

- An expensive giveaway. A lifeline for costly technologies.

# The same issue arises in other contexts

- Long-term contracts are widely used in the US to spur deployment of renewables.
  - An exception to the usual prohibition on long-term contracts. Massachusetts' Green Communities Act. Cape Wind offshore wind farm.

- The six states of New England are exploring financing natural gas pipeline expansion with a charge to electricity ratepayers.

- What should be the term for capacity mandates, capacity markets?
- What products should be included?
  - New California mandates for ramping capacity and for storage.

# Research Results

# Current Approaches to Risk Valuation

- A widely used approach leans on the now widespread availability of computing to generate large Monte Carlo distributions of payoffs to different assets or for the same asset financed with different contract.
  - Usually the different distributions are compared on the basis of means and variances. For example, fixing the mean, a distribution with a higher variance is considered worse than a distribution with a lower variance.
- One shortcoming of this approach is its failure to connect with the standard tools of modern valuation and asset pricing.
  - #1 This approach ignores the key insight from portfolio theory that expected return is not a function of total variance, but rather of the component of variance that is correlated to macroeconomic variables.
  - #2 It also ignores the key insight from derivative pricing that variance in the final payoff is a poor tool for ranking risk.
    - The non-linearity of many payoffs makes the problem more difficult than is acknowledged in a simple mean-variance framework.
- This disconnect undermines the reliability of many conclusions drawn from these Monte Carlo simulations, and it undermines the confidence we might have in the specific values calculated using the simulations.

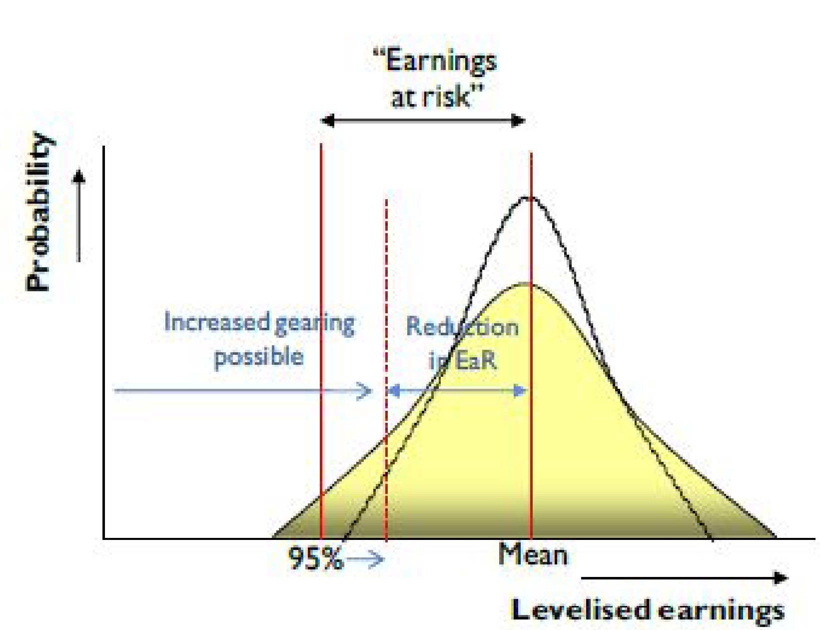
# The Poster Child: the UK EMR & CfDs

- The UK EMR fancies that CfDs reduce the cost of capital, without shifting an equivalent cost onto taxpayers.

Figure 7: Comparison of the impact of possible decarbonisation mechanisms on cost of capital

| Technology | Reduction in cost of capital due to PFiT (%) | Reduction due to FiT CfD (%) | How reduction in cost of capital under FiT CfDs compares to that under PFiTs |
|---|---|---|---|
| Onshore Wind | 0% | 0% to 0.3% | 0% to 0.3% lower under FiT CfD |
| Offshore Wind (emerging) | 0% | 0.5% to 0.8% | 0.5% to 0.8% lower under FiT CfD |
| Offshore wind (established) | 0% | 0.5% to 0.8% | 0.5% to 0.8% lower under FiT CfD |
| CCGT with CCS | 0.1% | 0.1% | 0% (reduction is the same under each) |
| Coal with CCS | 0.4% | 0.4% | 0% (reduction is the same under each) |
| Nuclear | 0.9% | 1.5% | 0.6% lower under FiT CfD |
| Biomass (power only) | 0% | 0.5% | 0.5% lower under FiT CfD |

Figure 79 Simulated earnings risk




- This result is produced using a Monte Carlo simulation of project level earnings. It employs a completely arbitrary discount for TOTAL risk.

# Our Contribution

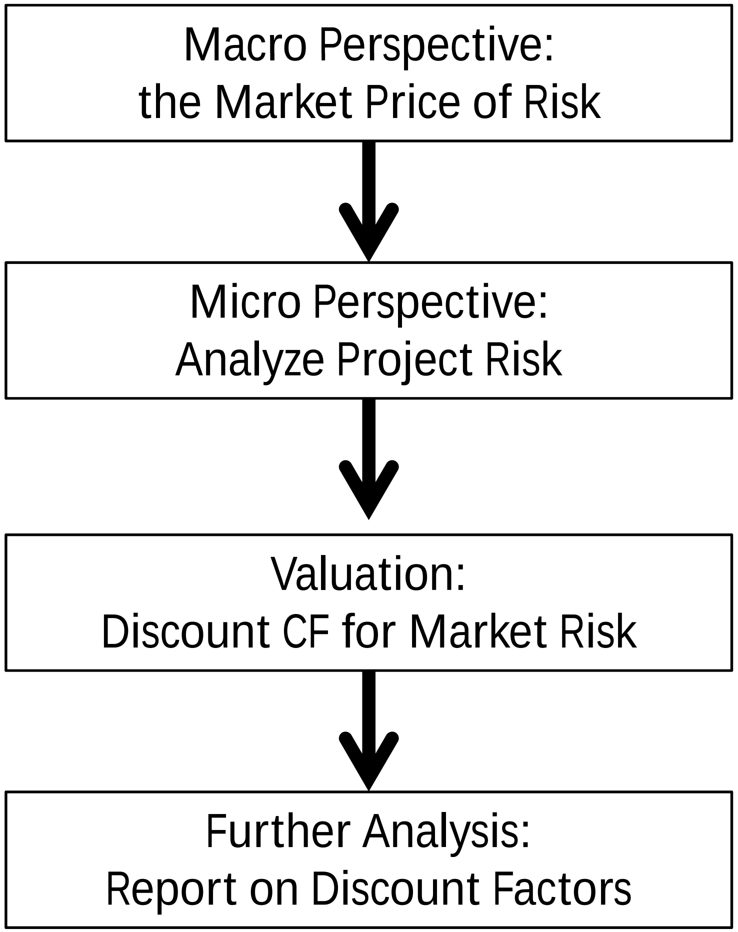
- We show how to incorporate standard risk pricing principles into the popular Monte Carlo simulation analysis.

- Our methodology has many conservative advantages.
  - The foundation is identical with core principles of valuation and asset pricing.
  - The structure is a transparent generalization of traditional DCF.
  - The structure is consistent with widely applied Monte Carlo approaches.

- Our methodology has one key radical advantage.
  - It makes explicit demands on the modeler to be precise about the critical elements of risk and the price of risk.
    - "Whereof one cannot speak, thereof one must be silent."

– Ludwig Wittgenstein, *Tractatus Logico-Philosophicus*

# The General Algorithm



# Step #1: The Market Price of Risk

- We employ a model that is consistent with the two most familiar asset pricing models:
  - the CAPM – Beta
  - the Black-Scholes-Merton derivative pricing model
- Cumulative stock market returns evolve as a random walk – arithmetic Brownian motion.
- We derive the stochastic discount factors pertinent to discounting cash flows for risk.
  - This is unfamiliar territory for many analysts, but entirely old news for finance.
- This is the simplest model. One could get fancy and use a different model of the underlying market risk factor or complicate it with multiple factors.

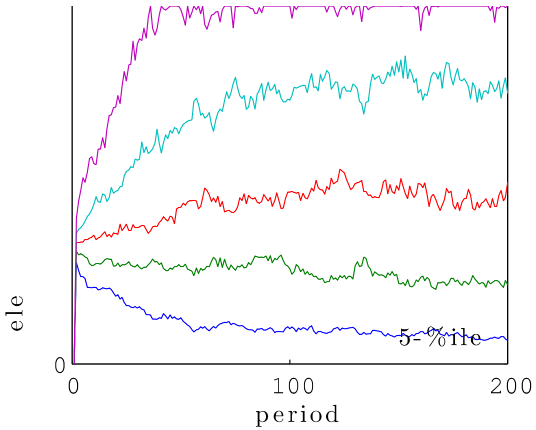
## Step #2: Overlay a Model of Electricity Price Risk

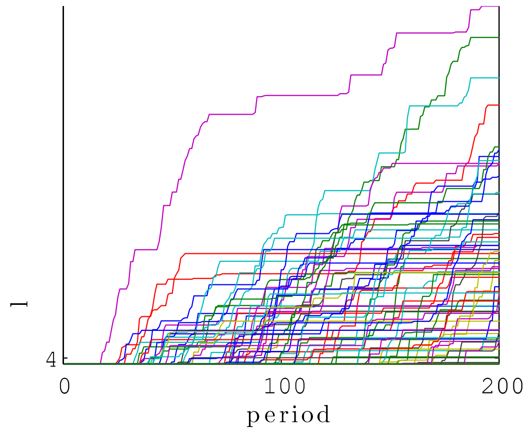
- Assume that electricity demand growth is stochastic, but correlated with returns on the stock market.

- Yields a stochastic electricity price as follows…
  - given installed capacity, demand growth increases the electricity price, but,
  - at a high enough price, capacity additions become profitable, and this caps the price;
  - given installed capacity, demand drops decreases the electricity price and halts any new capacity additions.

- The result is a ‘regulated Brownian motion’ tied to the stochastic demand and to the stochastic stock market returns.

# Step #2: Overlay a Model of Electricity Price Risk



# Step #3: Value a Project

- Model the project cash flows;
  - specify how the electricity price enters the cash flow;
  - both price risk, but also dispatch risk;
  - other risks.
- Valuation
  - enumerate the states;
  - calculate the probability;
  - calculate the cash flow;
  - calculate the state-contingent discount factor;
  - sum across states;
  - present value using the risk-free rate.

# Applied to Sample Electricity Assets

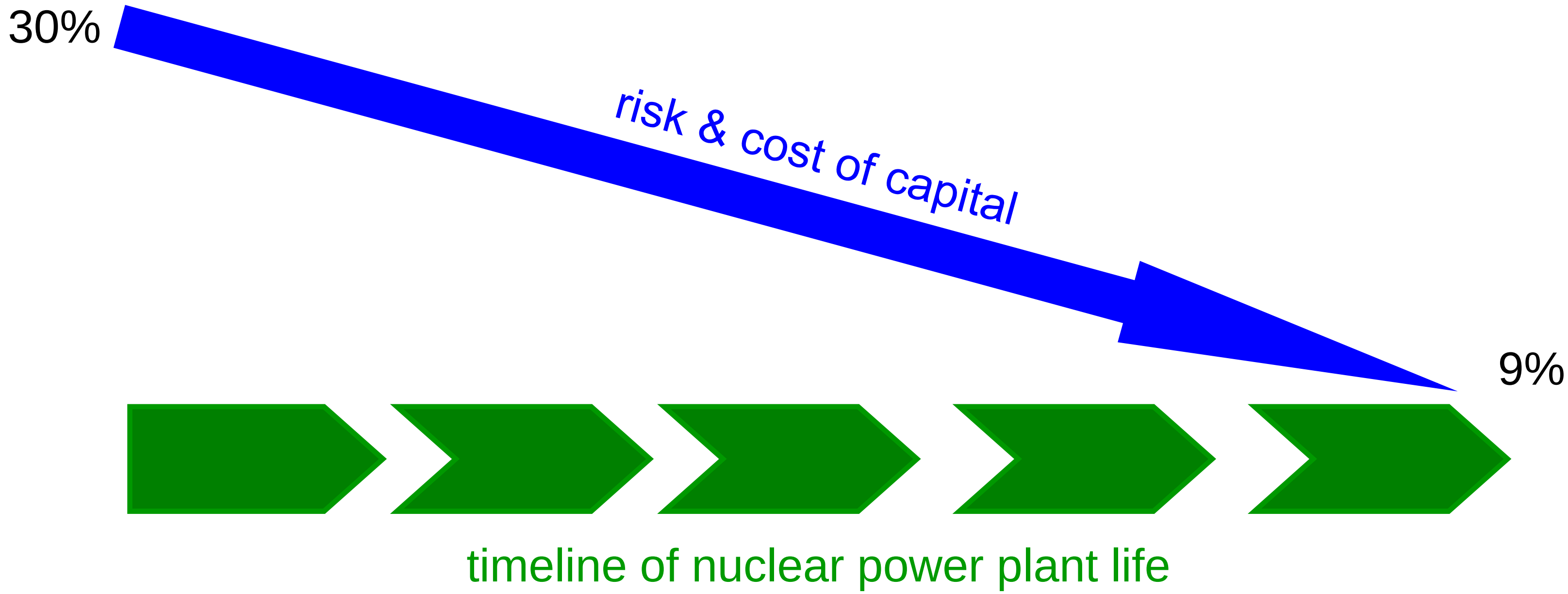
- #1 An electricity price swap.
- #2 A baseload generation plant.
- #3 A peaker generation plant.

# The Risk Premium on 3 Different Electricity Assets

initial electricity price in $/MWh

# The Risk-Return Staircase for Nuclear New Build

- Work backwards…
- Later project operation contains modest amounts of "priced" market risk.
- But early project development is an option on this completed project. It contains MUCH more "priced" market risk. Returns are "levered".



# Caveats

- This is more of a demonstration than a reliable set of values. The logic is correct, and the relationships shown are solid, but the specific values can only be consumed with the help of a heap of salt.

- The stochastic discount factor methodology puts great demands on risk modeling.
  - The underlying priced risk factor, and
  - The specific project representation … how the priced risk enters.

- The precision of the tools in principle far exceeds our ability to accurately calibrate them. So what is the point?

# Lessons

# One Positive & One Negative

- We can get part way in resolving a puzzle surrounding the cost of capital for nuclear new build:
  - Traditional methodologies for calculating a discount rate, such as the CAPM model, give figures that are too low.
  - This is due to a failure to recognize the leverage involved with development.

- We cannot justify long-term contracts, such as CfDs, as a tool for lowering the cost of capital.
  - The claim that capital intensive projects have a higher cost of capital is wrong. It is inconsistent with all standard models of pricing risk.
  - It overlooks quantity risk, that is the risk of dispatch.

# The Contract-for-Difference is a Stalking Horse

- The price guarantee matters. But the issue has nothing to do with the volatile natural gas price. Look at the fine print of the Hinkley Point C Agreement.
- *Arrangements whereby the Strike Price could be adjusted, upwards or downwards, in relation to operational and certain other costs (including balancing and transmission charges and business rates) at certain fixed points, and in relation to certain future changes in law (including in respect of specific nuclear taxes, and uranium and generation taxes).*
- *Arrangements whereby Hinkley Point C would be protected from being curtailed without appropriate compensation, with reviews expected to occur at 7.5 years, 15 years and 25 years after the commercial operations date of the first reactor as well at the end of the contract term.*
- *Protection would be provided for any increases in nuclear insurance costs as a result of withdrawal of HMG cover or in certain circumstances where market cover in the nuclear insurance market is no longer available, with compensation limited to the cost of additional capital required to self-insure.*
- *Compensation to the Hinkley Point C investors for their expected equity return would be payable in the event of a Government directed shut down of Hinkley Point C other than for reasons of health, safety, security, environmental, transport or safeguards concerns. The arrangements include the right to transfer to Government, and for Government to call for the transfer to it of, the project company which owns Hinkley Point C in the event of a shutdown covered by these provisions. The compensation arrangements would be supported by an agreement between the Secretary of State for DECC and the investors.*

# Commitment by the State is the Key

- Long-term fixed investments often exposes one party to exploitation by another party – ex post opportunism.
- Long-term contracts are a longstanding tool for trying to minimize ex post opportunism.
- This is at odds with the tactics used to restructure and open up these markets. Long-term contracts were viewed as a tool of monopoly incumbents and were proscribed.
- Can we reintroduce long-term contracts while preserving the liberalized market?