**645 – Computational Economics**

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**October 22, 2025**

**HW1 – Part B**

**Question 1**

Indices

* s ∈ S: scenarios for permitting and construction outcomes (delay, overrun, abandonment), with probabilities πs​ and ∑𝑠𝜋𝑠 = 1
* t ∈ {1,…,T}: operating years after Cost of Delay (COD).

The index s ∈ S represents the different possible scenarios the project could face during permitting and construction. Each scenario combines a unique set of outcomes for delay, cost overrun, and the chance of abandonment, and each has an assigned probability (πₛ). The probabilities across all scenarios sum to one, ensuring the model calculates an expected outcome that reflects uncertainty in project performance.

The index t ∈ {1,…,T} represents the operating years after the project reaches commercial operation (COD). This allows the model to track yearly revenues and costs over the plant’s lifetime when computing discounted cash flows or levelized costs.

Parameters

* Cbase [$]: baseline EPC capital (include soft costs unless noted separately).
* ϕs [decimal]: cost overrun multiplier in scenario s (e.g., 0.25 means +25%).
* Δts [years]: time from FID to COD in scenario s.
* r [%]: risk-adjusted discount rate (WACC plus risk premium).
* pt [$/MWh]: expected real price in year t.
* Qt [MWh]: expected energy in year t (e.g., 8760 × Cap × CF, adjusted for outages if desired).
* T [years]: financial lifetime for operating cash flows.

The model parameters define the main economic and technical factors affecting project outcomes. Cbase represents the baseline construction cost before any overruns, while ϕₛ captures scenario-specific cost increases. Δtₛ measures the years from investment to completion, reflecting potential delays that raise financing costs. The risk-adjusted discount rate (r) converts future cash flows into present value, accounting for uncertainty. pₜ and Qₜ represent the expected electricity price and output in each operating year, determining annual revenues, and T defines the project’s total operating lifetime used for discounted cash flow calculations.

Variables

* x ∈ {0,1}: binary build decision variable
* z: objective (result) variable

The variable x represents the project’s build decision and can take only two values. When x = 1, the project is built and begins operation; when x = 0, it is not built. This variable allows the model to determine whether construction is economically worthwhile based on expected costs, revenues, and risks. The model chooses x = 1 when the expected levelized cost of electricity (LCOE) is low enough to make the project competitive under the assumed scenarios. The variable Z stores the value of the minimized function, representing the expected LCOE that the model seeks to minimize.

Objective Function

The model minimizes the expected levelized cost of electricity (LCOE), represented by Z. The numerator captures the total capitalized construction cost, which increases with higher baseline costs, cost overruns, financing rates, and delays. The denominator reflects the present value of expected electricity revenues over the plant’s operating life, discounted at the same rate. The model computes the expected LCOE as a probability-weighted average across all scenarios. Permitting reform improves these outcomes by shortening and stabilizing construction timelines, reducing cost overruns, and lowering financing risk, which together decrease the expected LCOE and increase the project’s overall economic value. The build decision is determined by a benchmark rule: the model sets x = 1 (build) when the expected LCOE Z is less than or equal to a benchmark price L\* (set at 60 $/MWh), and x = 0 (do not build) otherwise.

Constraints

* *Scenario probabilities*

Each scenario s represents a possible realization of delay (Δts) and cost overrun (ϕs) outcomes. The probabilities πs weight each scenario in the expected value of the objective function.

* *Delay and cost overrun bounds*

Δtmin ​≤ Δts​ ≤ Δtmax​, ϕmin ​≤ ϕs ​≤ ϕmax​

These constraints ensure delays and overruns remain within realistic limits (e.g., truncating extreme values). Under reform, both the mean and variance of these parameters decrease.

* *Policy shift relationships*

Rreform ​< rbaseline​, E[Δts​]reform ​< E[Δts​]baseline​, E[ϕs​]reform ​< E[ϕs​]baseline​

These comparative conditions represent the effect of permitting reform, which shortens timelines, reduces uncertainty, and lowers financing risk. They are not strict optimization constraints but define how parameter inputs differ between policy cases.

* *Feasibility condition for construction and operation*

Both the capitalized cost (numerator) and the discounted revenue term (denominator) must be positive to ensure a valid LCOE value. These implicit constraints keep the model well-defined without binary build or completion variables.

* *Decision Linkage*

Z ≤ L\* + M(1 − x)

This constraint enforces the benchmark rule linking the build decision to economic viability. If x = 1, the constraint requires the expected LCOE (Z) to be less than or equal to the benchmark price (L\*), meaning the project is built only when it is competitive. If x = 0, the right-hand side becomes large due to the big-M term, effectively relaxing the constraint and allowing non-construction when the LCOE exceeds the benchmark.

Sample Code

*Refer to text file in repository*

**Question 2**

Data Sources

* *Portugal-Pereira et al. (2018), Energy Policy 120, pp. 162–164, Section 3.1 and Figures 4–9 (author’s calculations based on IAEA PRIS data).*

This paper compiles global data on cost overruns and construction delays for 180 nuclear reactor projects. Drawing from decade-by-decade averages in Section 3.1, the authors find that typical construction times increased from about 5 years in the 1960s to over 10 years in the 2000s, yielding an overall mean of roughly 7 years. During the same period, overnight construction costs (OCC) rose from about 1,700 to 2,600 US $2010/kW; an increase of roughly 40–50 percent that corresponds to about a 15–20 percent cost escalation for each additional year of delay. These empirical relationships are used to calibrate the baseline delay (Δtₛ) and cost-overrun (ϕₛ) distributions in the stochastic model, forming the basis for estimating how permitting reform could shorten timelines and reduce uncertainty. Below figures below are from the paper.

A graph with orange and black lines

AI-generated content may be incorrect.

A graph with orange squares and black lines

AI-generated content may be incorrect.

These two figures clearly illustrate the decade-by-decade rise in both construction duration and cost; from roughly 5 years in the 1960s to more than 10 years in the 2000s, and from about 1,700 to 2,600 US $ 2010/kW. They visually support my analysis by showing how longer construction periods are associated with higher costs, providing the empirical foundation for the estimated seven-year average delay and roughly 20 percent cost increase per additional year used in my model calibration.

* *Guaita, Spangler & Hansen (2025), “Parametric and Nonparametric Models of U.S. Cost Overruns for Nuclear Power Plants,” Idaho National Laboratory*

This forthcoming INL study provides updated U.S. parameters for cost growth, financing burden, and schedule risk after 2000. I will use its reported probability density functions for cost overruns to validate the Monte Carlo sampling and to benchmark U.S. project performance against international experience. The data help distinguish “status-quo” versus “reform” variance in project outcomes.

* *Jacobs, Jantarasami & Fishman (2024), Licensing and Permitting Reforms to Accelerate Nuclear Energy Deployment, Bipartisan Policy Center*

This policy report provides estimated reductions in permitting duration (25 to 40 percent) and administrative costs (10 to 15 percent) under proposed NRC process reforms. I will apply these values to define the “moderate” and “comprehensive reform” scenarios that shift the delay and soft-cost parameters in the model.

**Assumptions**

* *Construction Financing*: Interest during construction (IDC) compounds annually at the project WACC, consistent with IEA/NEA (2020) methods for levelized cost modeling.
* *Risk Premium Reduction*: Permitting reform lowers the project risk premium by 150 basis points, following the midpoint of estimates in Jacobs et al. (2024).
* *Abandonment Probability*: Projects with combined delay > 14 years or cost overrun > 80 percent are treated as abandoned, consistent with the historical tails reported in Portugal-Pereira et al. (2018).
* *Operating Life*: A 60-year lifetime is assumed for private projects and up to 80 years for public ownership scenarios, consistent with IEA (2023) Projected Costs of Generating Electricity.
* *Price and O&M Path*: Constant real wholesale price of $60 per MWh and O&M cost of $12 per MWh are used, reflecting median U.S. reactor data.
* *Elasticity Example (illustrative)*: For sensitivity testing of market response, I will assume an electricity demand elasticity of –0.5, consistent with Brown et al. (2024). This ensures that small price reductions from reform do not imply unrealistic demand growth.

These data and assumptions turn broad policy ideas into measurable inputs for the model. Portugal-Pereira et al. (2018) and Guaita et al. (2025) supply the numbers on how long projects take and how costs change, while Jacobs et al. (2024) provides realistic estimates for the effects of permitting reform. Together, these sources and assumptions keep the model clear, realistic, and manageable for a classroom project.