In NPRE 412, a large part of your grade is earned with a project proposal and a final project. This project is intended to tie together the lessons of the course with an independent analysis of a relevant topic in the context of nuclear power economics and fuel management (or, the nuclear fuel cycle). The project will be assessed as independent research work, much like a journal article undergoes peer review. I will be looking for :

- Relevance
- Novelty
- Technical Detail
- Analytic Rigor
- Verifiability
- Clarity
- A Conclusion

This work will consist of two deliverables, a proposal and a final report.

1. **Proposal: Due 2025.03.13**

   To help determine of reasonable scope, the first step of the project will be a proposal. Once you submit this proposal, I will respond with feedback. Much like a conference abstract, the proposal should meet the following guidelines:

   - Minimum 500 words.
   - Maximum 1000 words.
   - Two columns.
   - Reasonable margins.
   - 10 pt font or larger.
   - State the question you plan to answer.
   - Summarize the current state of the art in the literature.
   - Motivate the problem, explaining its relevance.
   - Describe the approach and methods you will take to answer the question.
   - Propose an outline of the analysis, software, data, and/or conclusions that will be delivered.

   Feel free to run ideas past me as needed via email. I would be happy to provide specific feedback on a draft of your proposal (once) before it is due. For your guidance, a list of example topics appears at the end of this document. Feel free to choose one of these. However, choosing a creative topic of your choice is also encouraged.

2. **Final Report: Due 2025.05.13**

   Prepare a final document in the style of a journal article or conference proceedings. It should meet the following guidelines:

   - Minimum 3000 words.
   - Maximum 10000 words.
   - Two columns.
   - Reasonable margins.

- 10 pt font or larger.
- State the question you answered.
- Comprehensively report and cite the current state of the art in the literature.
- Motivate the problem, explaining its relevance.
- Describe the approach, methods, and other elements of your solution.
- Describe in detail: the analysis, software, data, conclusions produced in this work.
- Include publication quality graphs and figures.
- Cite and provide data and code generated for this work sufficient to reproduce the conclusions.
- Compare this result to previous results in the literature, reinforce the relevance of the work.
- Suggest future work.

Topic Examples

For your guidance, a list of example topics appears here. Feel free to choose one of these. However, choosing a creative topic of your choice is encouraged. This section may be expanded if I have new ideas as the semester progresses.

Evaluate Price Impacts of the Inflation Reduction Act Consider the nuclear energy tax credits in the Inflation Reduction Act. Analyze the impacts of these tax credits on the ultimate price of electricity from both new and existing nuclear power plants if they were to leverage these tax credits.

Calculate the Potential Impacts of Federal Pyroprocessing Calculate the cost of a federal pyroprocessing facility capable of recycling the nation's spent nuclear fuel by 2075, considering only the fuel that has been generated so far. Calculate the cost of that facility and its operations through 2075. Consider the value of the recycled fuel in this calculation as well as any resulting reductions in the cost of an ultimate spent fuel repository.

Predict the need for HALEU The US is increasing its domestic enrichment capabilities (via Centrus) to support naval reactors, advanced commercial reactors, military-focused micro-reactors, and space reactors. Make a calculation-informed prediction, or many, regarding the likely need for HALEU in the coming 100 years of US nuclear fuel cycle needs.

Economic and Carbon Impacts of Potential Illinois Nuclear Plant Closures 11 carbon free nuclear power reactors at 6 sites produce the majority of electricity in Illinois and critically underpin its clean energy future. *Quantitatively* demonstrate the role nuclear energy could play in maximizing job creation, minimizing cost, and meeting Illinois' carbon goals through 2050. Review the policy recommendations in the Clean Energy Jobs Act and consider the timeline of possible Illinois Nuclear Plant closures currently in the news. Conduct a 50-year techno-economic optimization of the Illinois energy system and to analyze scenarios with and without the current at-risk plants to compare and contrast the economic and carbon implications of these energy futures. You should expect to reveal regionally relevant findings consistent with the February 2021 National Academy of Sciences, Engineering, and Medicine report, "Accelerating Decarbonization of the U.S. Energy System", which determined unequivocally that US decarbonization will require keeping existing nuclear plants open. Consider tools like Temoa, which may be helpful in this endeavor.

Quantifying the Costs of Weatherizing the Texas Grid Using any references you can find along with the 2011 report on weatherization needs for the ERCOT grid and data from EIA regarding the Texas blackouts in 2021, quantitatively establish the following as accurately as is feasible:

- The cost (to the TX ratepayers) of weatherization actions taken by TX generators between 2011 and 2021.

- The total weatherization costs (to the TX ratepayers) that would have been incurred had all of the 2021 recommendations been employed.
- The total cost (to the TX ratepayers) of the blackouts. Include housing damage estimates, the cost of loss of life, loss of work, etc.
- Consider the time value of money and compare these scenarios. Assume that taking all weatherization actions 10 years ago would have avoided all February 2021 damages. Would paying for this preparation (10 years ago) have cost the ratepayer more or less than the ultimate damages ultimately cost?

Impact of a Zero Emissions Tax Credit New York state recently (summer 2016) implemented a zero emissions tax credit. It was enough to save the Fitzpatrick nuclear generating station. Were the parameters of that state-level to be implemented accross the US, either federally or individually in each state, the risk of owning and building nuclear plants would decrease. Quantify the change in risk. Predict the impacts to the nuclear industry. Would it be enough to save at-risk plants? Would we likely see an increase in new builds? What other impacts might we see?

The Likelihood and Implications of the Duck Curve The California Independent System Operators published the "duck chart." This curve, describing the predicted mid-day overgeneration of grid-bound electricity, caused by installations of solar, primarily, makes load-following generation sources or storage methods necessary. A few questions that would make interesting projects on this topic include:

- What is the level of alarm appropriate in reaction to this chart and why?
- Can you suggest a novel strategy that would allow nuclear generation to be adapted to load follow?
- What would the impact to nuclear power be if this situation is allowed to proceed and there is no curtailment of variable generation sources?
- How could current storage technologies smooth this curve?

Liquid vs. Solid Fuelled Molten Salt Reactor Source Term and Release Pathways Reactor designs involving molten salts can have either solid fuel or fluidized fuel. In the fluid fuel case, proponents are often heard to say they can't melt down because they operate safely at a melted state. Compare the source term and release pathways of a containment breach in a solid fuelled salt reactor vs. a fluid fuelled one.

Economics of Uranium Extraction of Seawater A great deal of research is being undertaken to lower the costs of uranium extraction from seawater. Can you replicate the results of a previous calculation of those costs? To what extent are those results sensitive to uncertain assumptions (assumptions of a political, technical, or economic nature, it matters not.)

Metrics for Proliferation in the Nuclear Fuel Cycle Suggest a metric that captures proliferation concern in a nuclear fuel cycle scenario.

Assessment of Dose To Workers in Reprocessing Schemes Propose a model for calculating the dose impact on workers within an arbitrary fuel cycle. Include dose due to all steps of the fuel cycle, including reprocessing and disposal. Compare and contrast fuel cycle strategies with and without reprocessing.

Fuel Cycle Transition Scenario Choose one of the Evaluation Groups identified by the Fuel Cycle Options Evaluation and Screening. Use a simulator (e.g. Cyclus, CLASS, or Orion) or your own model to assess the time-to-transition from our current reactor fleet to 100% deployment of the new technology (e.g. SFRs, MSRs, etc.)

Repository Cost Estimation Suggest a high level waste repository site. Suggest appropriate waste forms, waste packages, and other disposal system design features for this geology. Estimate construction rates, loading rates, transportation costs, and a closing timeline. With these estimates, defended by analysis, conduct a life cycle cost estimation of your proposed site.

Energy Return on Investment Choose a nuclear reactor and a compatible fuel cycle. Calculate the energy return on investment of that fuel cycle. Include all facilities in the fuel cycle from the mine to the final repository as well as any reprocessing.

Waste Comparison Choose a nuclear reactor and a compatible fuel cycle. Categorize and quantify the waste products of this fuel cycle. Include all facilities in the fuel cycle from the mine to the final repository as well as any reprocessing. How does this compare the waste products generated by solar panels, wind turbines, etc?

Assessment of Competitiveness In the paper refernced below [1], the factors impacting competitiveness of fast reactors are assessed. Conduct a similar assessment for your favorite, different, reactor type (e.g. HTGR, MSR, FHR, etc).

[1] A. Baschwitz, G. Mathonnière, S. Gabriel, J.-G. Devezeaux de Lavergne, and Y. Pinc, "When would fast reactors become competitive with light water reactors? Methodology and key parameters," Progress in Nuclear Energy, vol. 100, pp. 103–113, Sep. 2017.