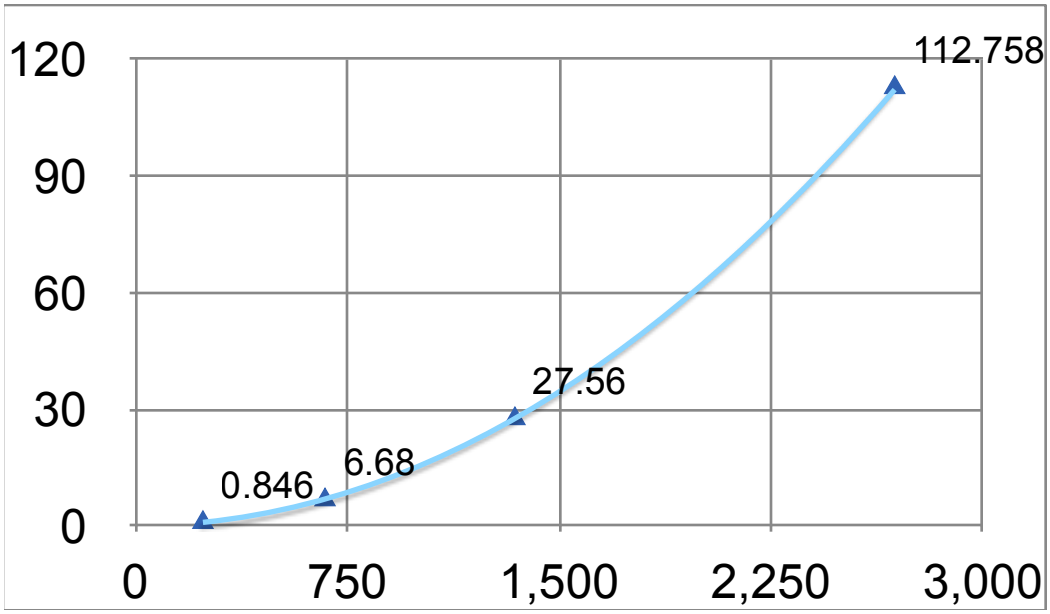
Answers for Homework 5

Question 1

A. 0.8455 seconds
B. The solution time increases exponentially with increase in time steps, so we can say that the computational performance has an increasing exponential relationship with the number of time steps in the model.



C. There are a few noticeable differences when the model is computed with different time steps. The total costs results fluctuate but remain around the same value for all time steps. But the real difference is on what type of generators the model decided to build. All the scenarios retire the same amount of generators, but the use of the existing renewable generators and building new renewable generators vary by scenarios. The model shows an increase in renewable generation capacity share as the time steps increase. This could be because, with increasing time steps the generation variability for solar and wind increase, adding more granularity for the model to assess the solar and wind profile and generation , increasing the share of renewable generation share.
D. The total average cost for all scenarios increase by almost 1.5 times and the values remain around the average for all scenarios. With the added carbon tax, the model tries to reduce the amount of generators that include the carbon tax and increase more renewable generators. This was expected as introducing carbon tax would increase the cost of carbon based generators, forcing the model to choose more carbon-neutral options.

Overall, the time sampling method work if the objective is to find the total costs of the system as all the scenarios with different time sampling do give out roughly the same value. However, if the objective is to study individual generators to understand questions like renewable energy penetration, a higher duration of sample periods might be helpful as increasing granularity of variability for solar and wind helps the model to make better decisions for renewable generators.

Question 2

B. With unit commitment constraints, the total costs for the system almost doubles compared to the one without unit commitment constraints. And the model decides to build more unit commitment (thermal) generators and reduce the percent share of energy from renewable generators. This might be because, as we introduce unit commitment constraints like ramp up/down constraints and minimum run time for generators, it might be more feasible for the model to build and maintain thermal generators compared to building and/or maintaining renewable generators. The non-served energy results increase for the model with unit commitment constraints because with increasing thermal generators, there are excess energy that is produced. The model also introduces storage options, which might be to store the excess energy produced by these thermal generators. I don't think unit commitment constraints should be ignored if the entire behaviour of the model is to be studied, but if the study or the research question is more about renewable energy penetration and not about how thermal generators affect the system, it might be safe to ignore unit commitment constraints and just implement economic dispatch constraints.

C. This implementation is almost 1.5 times faster than the integer unit commitment constraints. But the model increases its dependence on renewable energy generators alone compared to thermal generators when the unit commitment constraints are relaxed. This approach might be useful to study high renewable energy penetration grids.

Question 3

I studied the CES policy constraint in this homework, where the CES requirement was increased from 0 to 100 percent with 20 percent increments. The cost of the system increased almost 8 times when the CES requirement was set from 20% to 80%, and increased almost 9 times when the CES requirement was set to 100%. The solution time was reduced from 27 seconds to an average of 3 seconds when the CES requirement was introduced. This could be because with stricter policy constraints, the model just ignores the non-CES generators for most part and builds new renewable generators to adhere the CES policy constraints which explains the higher cost of the system.