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How to value an option to add a generator under uncertainties

Background

Building a small-scale power plant such as wind or solar farm for a community is a significant decision for generation and transmission planners. Such a decision has a significant consequence on labor and capital requirements, and it is faced with volatile demand.



Wind turbines in rural Iowa

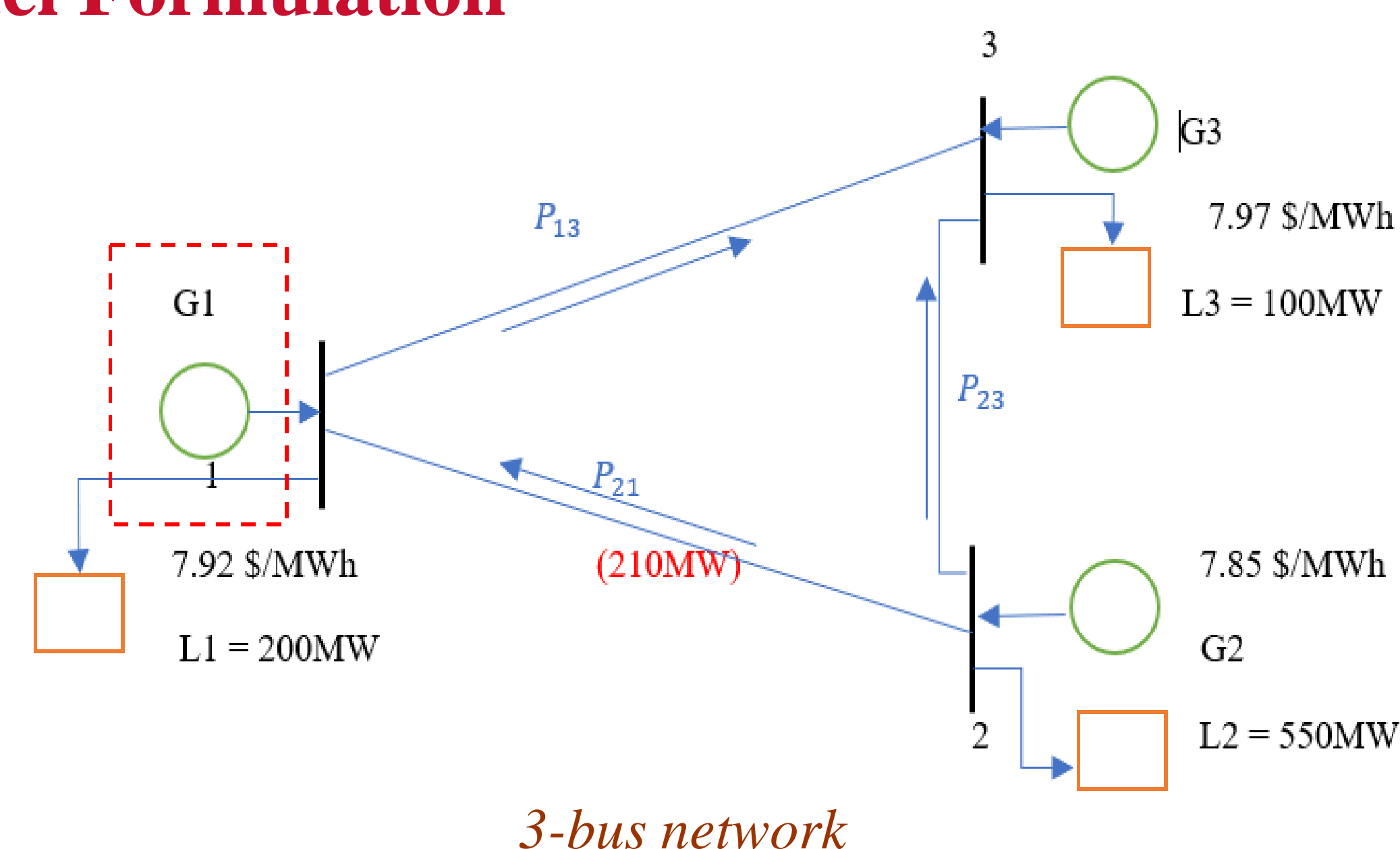
Research Question

- What is the option value of adding a generator considering the demand uncertainty?
- What is the optimal timing of the generator addition?

Where,

- Adding a generator to a network alters power flow and locational marginal price
- Demand uncertainty is modelled as a geometric Brownian motion

Model Formulation

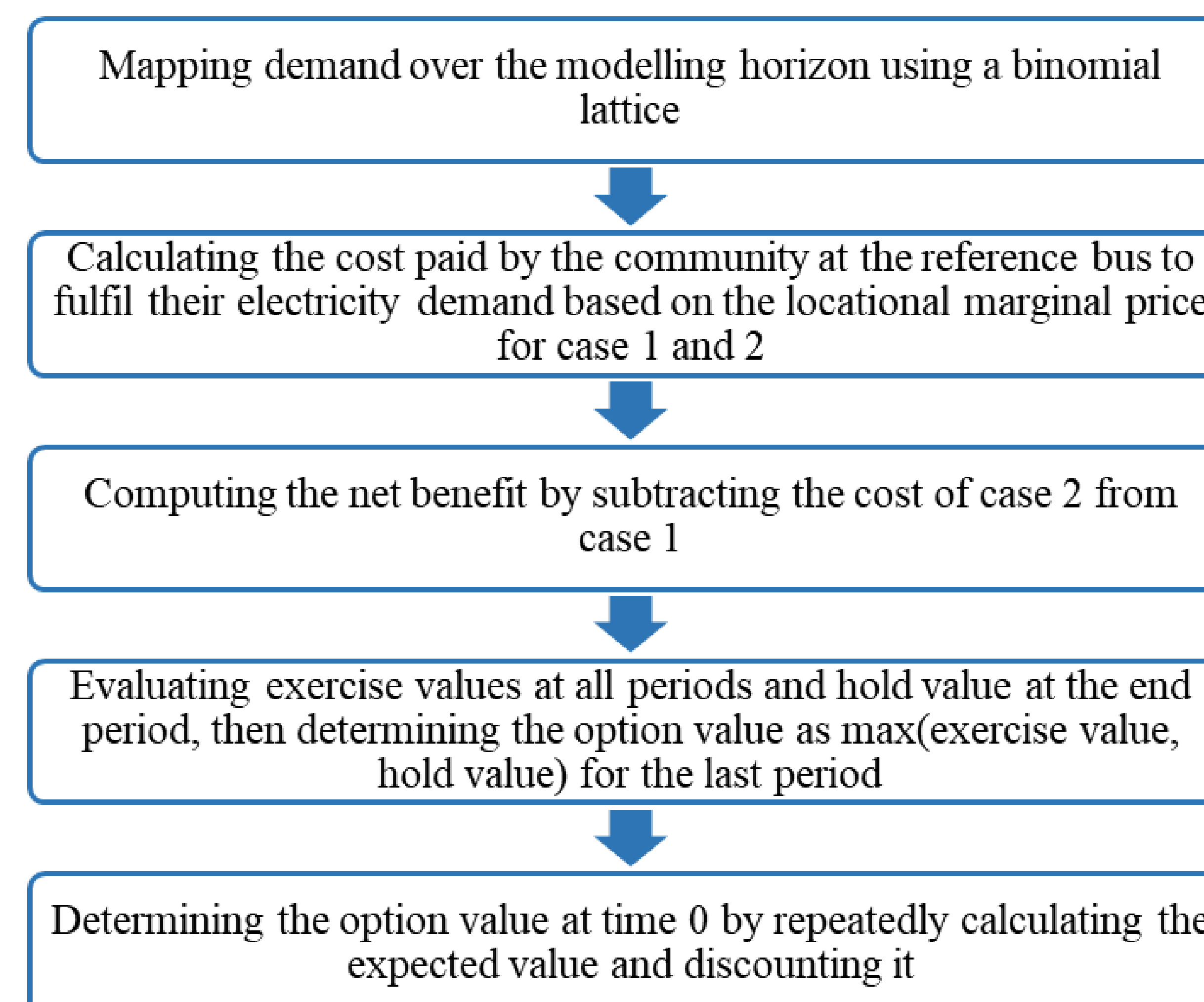


Cases used for the study

Case 1: Bus 1 has no generator

Case 2: Bus 1 has a generator

Option valuation framework



Derived from: Demand evolution at bus 1 (Binomial lattice)

time	0	1	2	3	4
					664
				492	
		270	364	270	364
	200		200		200
		148		148	
			110		110
				81	
					60

Up factor (u) = $e^{\sigma\sqrt{\Delta t}} = 1.35$

Down factor (d) = $1/u = 0.741$

Up demand, $S(t,i) = u \times S(t-1,i-1)$

Down demand, $S(t,i-1) = d \times S(t-1,i-1)$

Demand lattice (in MW)

Locational Marginal Price (LMP)

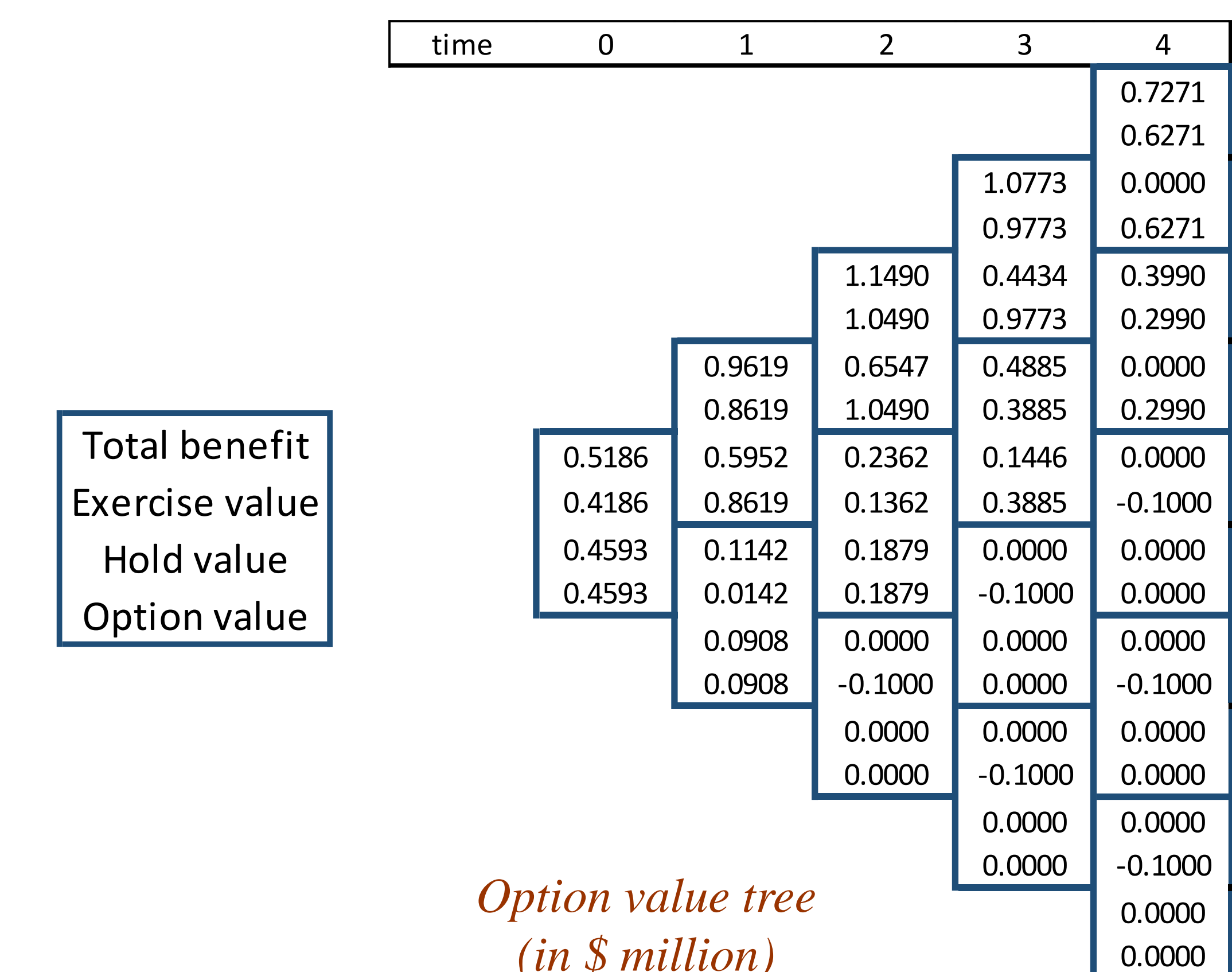
Demand 200 MW at bus 1 → LMP (case 1) = \$7.85/MWh

→ LMP (case 2) = \$7.85/MWh

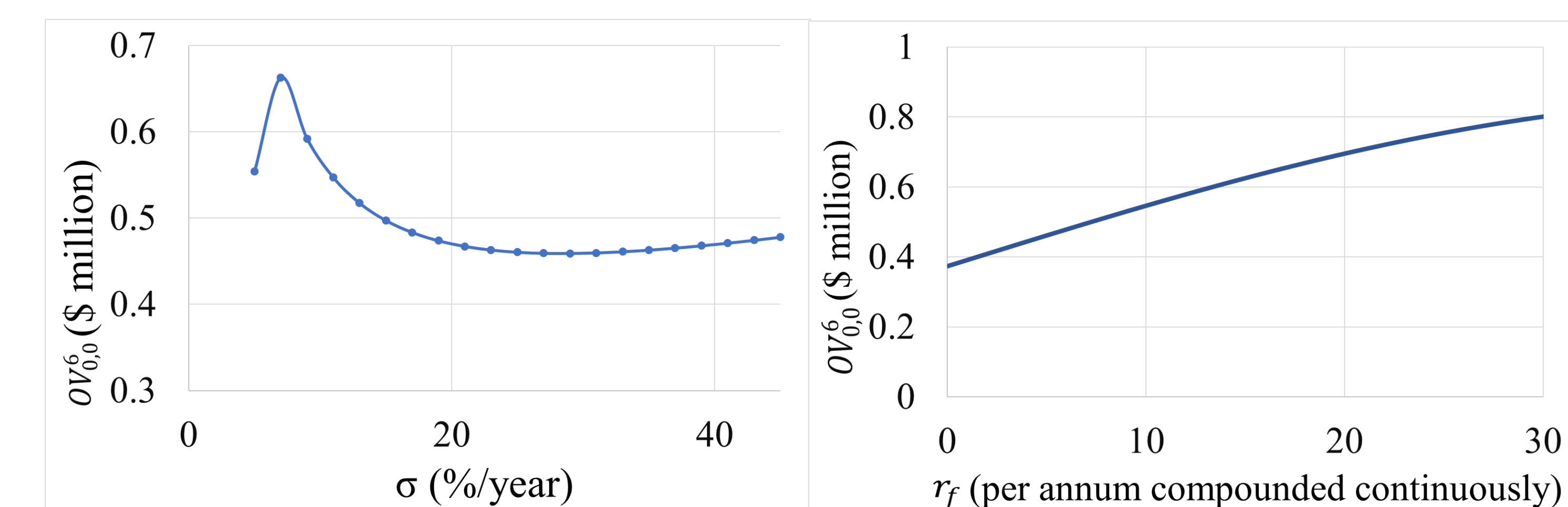
Demand 270 MW at bus 1 → LMP (case 1) = \$8.045/MWh

→ LMP (case 2) = \$7.92/MWh

Result and Sensitivity



- The option value of adding a generator for 4 time periods (years) is \$459,000
- Option value is sensitive to volatility and risk-free discount rate
- Option value is monotonically non-decreasing with increasing modelling horizon



Option value vs. Volatility

Option value vs. Discount rate

Ongoing and Future Research

- We evaluated the option value of adding a generator in a risk averse condition considering the fact that all risks cannot be hedged
- We calculated the option value of adding a transmission line

For more information, visit Solar and Wind Energy using Engineering Economics Theory (SWEET) project website <https://www.imse.iastate.edu/sweet/>