Using Multi-stage Stochastic Programming to investigate a 100% renewable New Zealand Electricity Sector

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Overview

In order to reduce greenhouse gas emissions countries around the world are implementing markets and regulations for the GHG emissions. In New Zealand, the government has announced policies for 100% of New Zealand's electricity to be produced by renewables in a normal hydrological year. In this work, we investigate an optimal investment policies for new generation in New Zealand, which adapts to observed electricification of various industries, and overall population growth. These policies are simulated over both the long- and medium-term to assess how much shortage or use of non-renewable generation in dry years.

Methods

We build a long-term investment planning model for New Zealand using a package called JuDGE, written in the programming language Julia. This enables us to describe a scenario tree of future demand and technology cost scenarios, and solve for the least-expected-cost investment policy, using Dantzig-Wolfe decomposition.

Given this investment policy, we can then simulate the medium-term hydro-management, for each of the nodes of the scenario tree using JADE, which is applies stochastic dual dynamic programming (using SDDP.jl) to determine optimal water values for the New Zealand electricity market.

Results

We find that reaching 100% renewables in the electricity market is prohibitively expensive, and depending on how "dry year" is defined, trying to avoid using thermal plants early in the year, may lead to the use of less efficient thermal plants, or even shortage during winter, when inflows into reservoirs are limited.

Conclusions

We find that an objective which minimises the cost of dispatch, with an appropriate price on carbon emissions is the best way to minimize emissions in the long-run. In fact, the price of emissions can be uncertain in the investment planning model.