Introducing Jade

An open source SDDP model of New Zealand electricity supply

2021 EPOC Winter Workshop

10 September 2021

Overview

- Doasa at the Electricity Authority
- The case for Jade
- Activity to date
- What's next
- Some illustrative outputs

- Shout out to Tuong Nguyen

Doasa

At a glance

- Dynamic Outer Approximation Sampling Algorithm (Doasa) is an optimization technique for hydro-thermal scheduling and water valuation
- Based on the Stochastic Dual Dynamic Programming (SDDP) algorithm
- Created (and used extensively) by Professor Andy Philpott and Dr Geoffrey Pritchard at Auckland University – and various colleagues over past ~15 years
- Written in C++ and compiled into a Windows-based executable
- Authority uses the Gurobi solver, Philpott et al use Cplex
- Purpose of model is to create a policy for releasing water from reservoirs to generate electricity in addition to that generated by thermal (and other) plant to meet expected demand at least cost – in the face of uncertain inflows into reservoirs
- Model operates in weekly time steps or stages
- Thermal fuel prices are a key determinant of water values in this setting

Authority use of Doasa

- Started working with Andy on first Authority version of Doasa in 2012
- Fair to say our use of the model has been sporadic and intermittent
- Added new features/functionality in 2017-18 in the context of using the model to review the winter energy and capacity standards (M Keir presentation at 2018 EPOC workshop). For example:
  - Treatment of contingent storage via a penalty for usage
  - Transmission outages by week and transmission losses included
  - Integrity checks, e.g. non-physical network loops and transmission losses, post-solve check for circulating branch flows
  - Realistic restrictions on spill
  - Breakout input costs to facilitate easier experiment design
  - Resolved numerical stability issues under certain conditions
  - Several additions to output reporting

Some drawbacks

- Doasa awkward to modify without the source code
- Solver (Gurobi) license and version hard-wired in executable
- Almost impossible to distribute
- Ill-suited to cloud-based solving – i.e. containers
- Transparency somewhat compromised

Further motivations for a new approach

- 100% renewables and decarbonisation
  - requires richer treatment of demand-side participation, including involuntary load shedding, in a model that values water in absence of thermal fuel prices
  - i.e. costs of DSP/VoLL need to be better understood and modelled
- Market design issues in presence of low or zero short run marginal cost plant
- Batteries – grid-scale electrochemical, pumped hydro
- Monitoring of new trading conduct rule – first cab of the rank
- Rapid prototyping
- Open source

Which brings us to Jade…

- Jade – Just Another Doasa Executable
- Written using the open-source Julia language
- Relies on the JuMP, the mathematical programming language embedded in Julia
- At the heart of Jade is the SDDP.jl package – Oscar Dowson
- Flexible to modify – access to source code
  - Quickly and easily develop bespoke applications to support Authority work
- Containerise production instances
  - Scheduled ADF job calls an Azure function which invokes a container instance, pulls code for specified Jade version from GitHub repository
  - Floating token Gurobi license
    - Outputs (weekly water values) delivered to end user

Work to date and next steps

- Evaluation of Jade v Doasa – completed. Both models produce same results when supplied with identical inputs
- Expand features – infinite horizon (steady state mode), risk aversion - WIP
- Still working on an up to date, base input data set
- Process/tools to create/update model inputs on regular basis – largely built but yet to be tested and deployed
- Schedule Jade to run automatically on a weekly basis to estimate water values for trading conduct monitoring – ready to go but waiting on finalisation of input data
- Make Jade source code available via Github
  - Mozilla Public License (MPL) v2.0
  - Before year end?
- Publish Jade data sets on regular basis – the vSPD/GDX model
  - Enable user community to work from a common, accepted data set and focus efforts on applications and experimental design

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Some illustrative outputs

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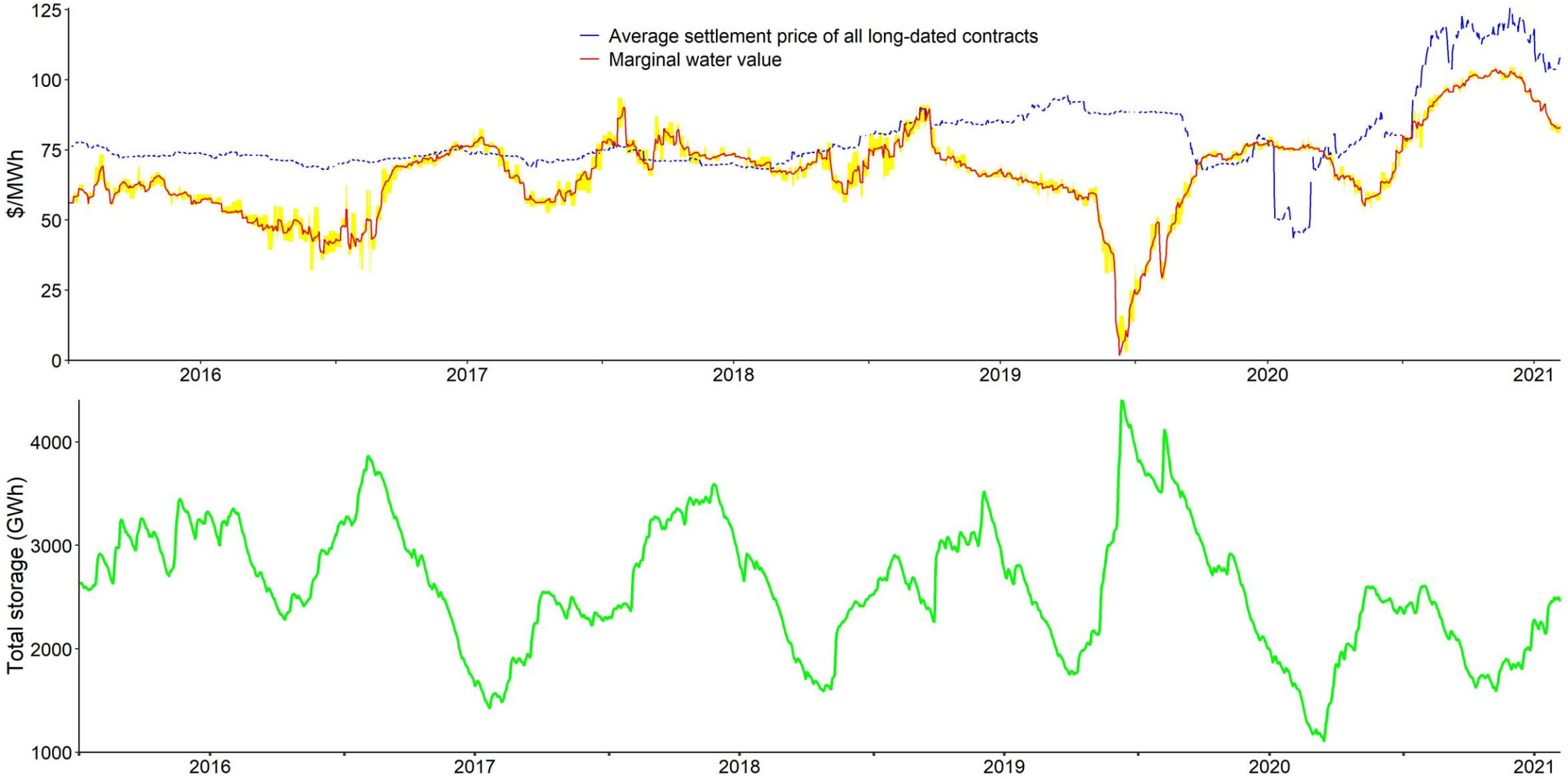
Daily marginal water value versus total national storage

(Illustrative only and not to be attributed to the Electricity Authority)

Daily marginal water value versus long-dated forward price (Benmore)

(Illustrative only and not to be attributed to the Electricity Authority)



Daily marginal water value versus 7-day simple average spot price (Benmore)

(Illustrative only and not to be attributed to the Electricity Authority)

Daily marginal water value: national versus individual reservoirs

(Illustrative only and not to be attributed to the Electricity Authority)