

# SDDP Optimal Generation and Transmission Planning Model

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## Stochastic Dual Dynamic Programming

- What is SDDP
- Other users
- Why was SDDP selected
- Main Features
- Typical outputs
- Possible Electricity Commission application

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## What is SDDP?

- Medium and long term planning model
- Horizon several years, weekly/monthly steps
- Global optimum, as would be determined by a central dispatcher
- **Objective: Minimize fuel costs**
- **No gaming effects**
- Stochastic and multi-reservoir
- General purpose dispatch model - no special code for New Zealand model

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## Other Users of SDDP

- First used to analyse the six Central American countries - World Bank study
- Consultants, generation companies, grid operators, regulators, government planners
- **Licensed in:** Argentina, Austria, Bolivia, Brasil\*, Chile, China, Colombia\*, Costa Rica, Dominican Republic\*, Ecuador, El Salvador\*, Guatemala\*, Honduras, Nicaragua, Panama\*, Scanadania\*, Spain, US Pacific Northwest\*, Venezuela, several United States based companies with international portfolios

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## Why SDDP was Selected

- Tested by ECNZ in 1995
- Known ability to model NZ system
- Stochastic
- Detailed model for generation & transmission
- Extensive use elsewhere - on-going support
- All model details available
  - algorithm published in Mathematical Programming
  - manuals describe the maths in detail
  - vendors answer every question
- Usually only a functional specification available - no implementation details

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## Stochastic Model

- Deterministic models - easy to build & solve
  - anticipate the future, better use of resources
- SDDP stochastic model uses statistical information about inflows only
  - use only the information known to a real decision maker
- Other models compromise on
  - stochastic aspects
  - multi reservoir representation
  - level of detail

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## Solution Methodology

- Rigorous mathematical basis
  - No heuristic rules
- Mathematics aids understanding
- Solve a large number of one week optimal dispatch problems using a linear program
- LP gives
  - sensitivity information
  - consistent results

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## SDDP Capabilities (1)

- Time horizon several years
- Weekly or monthly time step
  - weekly for NZ study
- Load duration curve, up to 5 blocks
- Each hydro reservoir modeled
  - no aggregation of reservoirs
- Each hydro station included, actual flow paths

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## SDDP Capabilities (2)

- Each thermal plant modeled
  - constraints on fuels shared by several stations
- Multiple fuels possible at each station
- Unit commitment
- Huntly coal stockpile modeled as a hydro reservoir with specified inflows

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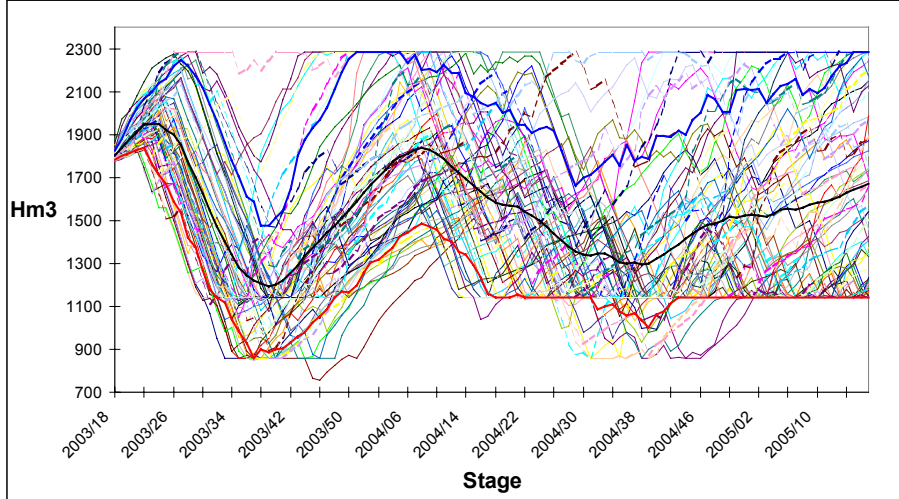
## SDDP Capabilities (3)

- Transmission system model similar to SPD
- AC system represented by DC power flow
  - nodal prices available
- 300 lines, 120 busses in simplified system for the trial study
  - most of 220 & 110 kv systems
- Contingency constraints

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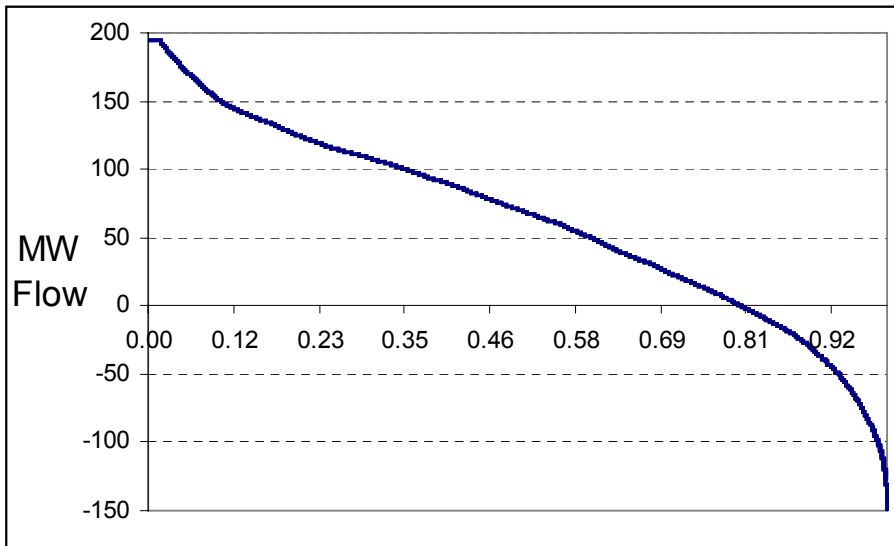
# L Hawea Storage

(Hm<sup>3</sup> = 1 million cubic metres)

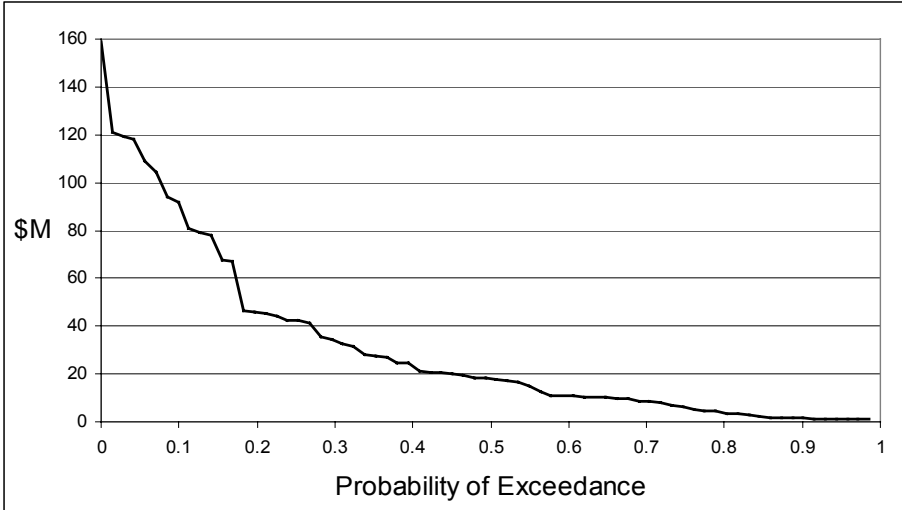


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# Line flow TKU\_WKM1.1

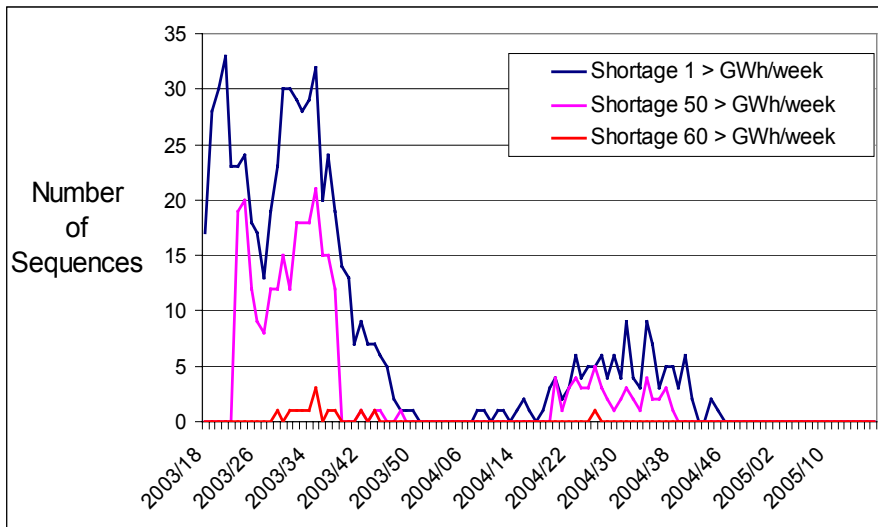


## New CT Annual Revenue minus Fuel Cost 2004/05



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## Number of Inflow Sequences with Shortage



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## Electricity Commission Use?

- Monitoring of 1 in 60 standard
- Selection of a portfolio of contracts
- Management of contracts
  - it is too late when a very dry year is observable
- Possible strategy: Offer plant to approximate an optimal dispatch outcome
  - offer plant to an optimal dispatch schedule
- Transpower may use SDDP for transmission planning studies
  - lease for the remainder of this year

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