Research Journal

Logan Wu

# Weekly Summaries

## Week starting March 8th

### meeting:

* Familiarise with spreadsheet
* Find examples of forecasting, optimisation and stochastic simulation in oil & gas industry
* Choose part of project

### Documents used:

* Fifty years of geothermal power generation at Wairakei
* AEE - 104706 Take Variation Appn 2017\_final.pdf
* contact\_email\_instructions.pdf
* Liquid wells (version 1).xlsx
* Wairakei Tauhara Draft SMP May 2016.pdf
* WK TH 2016 Annual Report FINAL.pdf

### Notes:

* Excel spreadsheet is missing links to SteamTab.xla
* Some things will take a long time to understand without knowing the original formula. See ‘WK26A’!K12 – maybe if I wrote it out replacing all the cell references with column names I could work it out, but there’s also all the constants. Not sure if it’s a good use of time to understand the physics.
* Also, there are slight inconsistencies I don’t understand. For example, see ‘WK26A’!O12 and ‘WK26A Trend’!I10. I expected these to be the same data point.
* Propose doing proof of concept in something else to better facilitate visualisation, optimisation and simulation. Suggest R or Python (no personal preference). Could use SQL but probably overcomplicating. Should be easy to move to Excel afterwards.
* I do not mind which part I do. Here are the pros and cons of me doing each part:

|  |  |  |  |
| --- | --- | --- | --- |
| **Optimisation** | | **Simulation** | |
| **Pros** | **Cons** | **Pros** | **Cons** |
| * ENGSCI 355 linear programming * Have programmed heuristics (ENGSCI 255 & 760) | * Don’t understand the spreadsheet * Haven’t yet found examples | * STATS 731 Bayesian Inference * Have programmed simulations in C++/Python | * Don’t yet understand the energy extraction process |

## Week Starting March 16th

### Meeting:

* Model wk255: inputs and outputs. Create Python script to extract data and replicate plots. Then generalize to other sheets
  + Plots: mf = f(whp) and mf = f(time | whp)
* Mass flow = f(WHP): Inputs: WHP, outputs: linearly declining res P to predict mass flow in future
* Look at using regression uncertainty to create a distribution of future mass flows
* Make reasonable assumptions
* Missing data points are not important
* Maybe use Jupyter notebook?

### Notes:

* Done linear regression on data

## Week starting March 23rd

### Meeting

* Need to fit elliptic curve
* Make sure it generalises to all wells
* Input function for making predictions. mf = f(well, whp, date)
* Road trip!! To see all there is to see in Wairakei. Second week of break, sometime April 12th-15th?

### Meeting with Julian March 28th

**Operations**

* Decline rate done by operator (Christine). Can indicate if something happened in the well (e.g. scaling) to cause observed long-term changes in the decline rate
* A workover (de-scaling) increases mass flow and pressure
* Separation pressure determines the fraction of steam and fluid in the mass flow, where mf = f(sep\_p). Christine may explain why all the inconsistent equations.
* Begin by looking at one or two flash vessels and calculating enthalpy.
* (Out-of-scope) considerations could also include variability in power prices (affects objective) and air temperature (affects efficiency).
* One goal (objective function) is to get less brine as a proportion of mass flow.

**Data**

* Well numbers indicate age (lower numbers are older) – wells from similar periods will act similarly
* ‘PI’ sheet: gives whp. ‘Equation’ sheet: gives decline rates
* Try to extract data into Python for a more readable form? [Note: crashed my laptop trying to do this and haven’t tried again yet – Logan]

**Mathematical modelling**

* Try to predict what decisions would be made
* Predict causes of pressure decline (e.g. decision tree / tree classifier) e.g. local scaling, global pressure drawdown
* Make a new spreadsheet (General Projection [note: can’t remember what this was])
* Enthalpy: Maybe just do a user-controlled constant (as indicated by no trend in the enthalpy graphs). Also make mass flow / enthalpy decline rate manual from regression. It can change periodically.
* Create a well operating schedule and predict steam flow.
* WHP → mass flow → steam flow → enthalpy → power. Predict for one year and optimise steam flow s.t. total mass constraints. Discretise over large time periods (e.g. 3 months to begin)

### Notes

* Modify regression and plots to operate on multiple wells simultaneously
* Remove formulae from Generation Projection spreadsheet to make it run faster

## Week starting April 12th

### Meeting with Contact in Taupo

**Current State**

* GE (General Electric) is currently working on a similar project which includes trading – out of scope for us. **CSV-formatted data has been made available to them and has been requested for us.**
* Well test data comes from two sources: bore tests and tracer flow tests (TFTs). Bore tests are denoted by three simultaneous data points and are expensive. TFTs are identified by a single test on a day, and are *run under normal operating conditions*.
* Liquid wells regression is satisfactory in its current state. Modifying to fit w269 is unnecessary right now.

**Modelling**

* Validation (regression): check that mass flow predictions match TFTs. **N/A, we use the TFTs in the regression training set.**
* Validation (model): check that flow meters downstream from FPs matches FP input flows.
* Variables (well head pressure): *whp* is not a decision variable. It is usually taken from the most recent TFT, representing full load.
* Variables (enthalpy): *h* is often independent of *whp* in watery wells, but confirm for all wells in use before going forward with a constant. *h* also has variability, so confirm with the FP in case there are any short-term fluctuations.
* Constraints (consent): bioreactor (did I hear this correctly?) limits, mass limits, temperature (heat energy) limits, temporal limits
* Constraints (physical): FP min/max *h*, network connectivity, LP/IP FP capacity
* Scope: For actual optimisation, the entire system (e.g. including Te Mihi) has to be considered because it is all interconnected.

**Decisions**

* Workover: whether to do a workover (out of scope or later on)
* Flipping: which plant to send a well to. High *h* wells are usually sent to Te Mihi, ranked in order of *h*. Flips only happen when turning a well on (not one that is already running).
* Well on/off: in general, almost all wells are used.

**Objectives**

* Maximise power
* Minimise wasted mass from disk blowout events (difficult to quantify because there are random system trips)

## Week starting April 26th

Make one-day plan

Lit review: Don’t expect 10 pages/30refs

WHP: More realistic one might take varying whps.

#### Notes:

* What about a greedy heuristic / complete enumeration? Would make it easier to do the stochastic simulation if every component is represented by an object
* Resource consent?
* Get all the data
* Split tasks
* What constraints exist? Chemical/mass/physical(fractions)
* Data for each well on chemicals
* Parasitic power needs
* Confints/prior dists

## Week starting July 19th

Well MFs are calculated. Only FP mass flows are measured

## Week starting August 9th

Verify Bayesian with analytic calculations

## Week starting August 16th

discussion of recommendation and model

discussion of internal and external considerations/factors