Tank Bulk Temperature (*dTt/dt*) Model

- Heat In: *Ke*
  - *Ke* represents exothermic heat (*Ke* > 0)
  - Temperature as proxy for (specific) heat
  - Units of deg/h
  - 0.138-0.175ºC/h estimate based on slope of temperature rise on trend plot when *CV*=0 (no cooling); temperature as proxy for
- Heat Out: *f(CV)*
  - Chilled glycol jacket
  - Three-parameter model:
    - *CVe – CV* at which *f(CV) = Ke* i.e. heat balance with exotherm
    - *CVe0 – CV* below which *f(CV) = 0*
    - *CVexp – exponent of linear relation (CV-CVe0)/(CVe-CVe0)*
- Final result: In – Out = *Ke - f(CV)*

$$\frac{dTt}{dt} = \begin{cases} Ke - Ke \times \left(\frac{CV - CVe0}{CVe - CVe0}\right)^{CVexp} = Ke \times \left(1 - \left(\frac{Cv - CVe0}{CVe - CVe0}\right)^{CVexp}\right), CV > CVe0 \\ Ke, CV \leqslant CVe0 \end{cases}$$

- Implemented as: $Tt_{t+\Delta t} = Tt_t + \frac{dTt}{dt} \times \Delta t$ i.e. Explicit Euler integration
- Caveats
  - Excludes heat loss to environment (Province of Alberta, CA - *brrrrr*)
  - Temperature is linear proxy for heat i.e. *Ke* units are ºC/h, not W
  - Ignore any dependence of [Heat In] (*Ke*) and [Heat Out] on *Tt*

Temperature sensor (dPV/dt) model

- Heat in: *Ke*
  - Same as Tt above
- Heat out: *f(PV,Tt)*
  - Fluid around sensor at *PV* in thermowell is thermally isolated from cooling jacket, but will be cooled by bulk tank media at *Tt*
  - *PV* will always be greater than, and decay towards, *Tt*
  - First-order diff. equation: $\frac{dPV}{dt} = \frac{Tt - PV}{\tau}$
    - One-parameter model: $kPV = e^{\frac{-1}{\tau}}$
      - *kPV* is reduction of *PV* as it decays toward *Tt* in 1s
- Implemented (nearly) as: $PV_{t+\Delta t} = Tt_t + (PV_t - Tt) \times kPV^{\Delta t} + K_e$