What might an NZ TVZ Supercritical Well Produce

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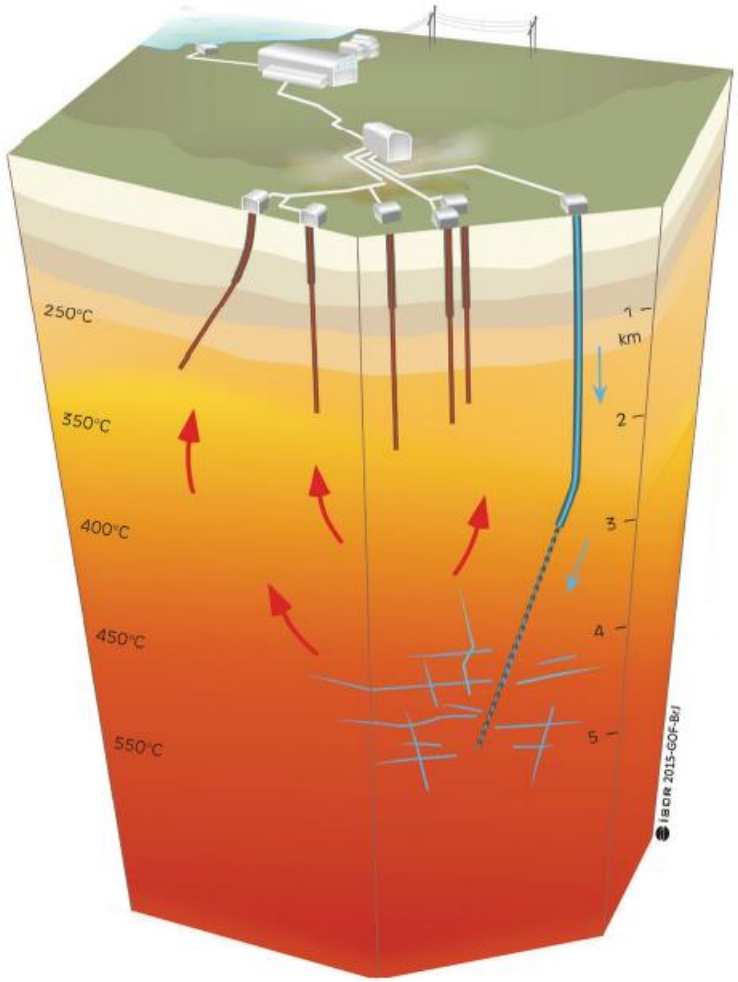
Background: Well IDDP-1 on Test

Julius Rivera – Geothermal Reservoir Engineer

- 8 years as Reservoir Engineer in the Philippines
- Specialist Wellbore Modelling, Reservoir Evaluation, and Resource Management
- Geothermal Engineering and Production Analysis
- Lead the Well Integrity and Risk Management of Geothermal Fields

Supercritical Fluid Production for NZ - Taupo Volcanic Zone



Iceland Conceptual Model (from Fridleifsson and Elders, 2017)

- **Conventional Wells**
  - 2-3 km deep
  - ~280ºC temperature
    - NZ hottest well 337 ºC
  - Liquid / steam reservoirs

- **Supercritical Wells**
  - More than 5 km deep
  - Temperature of more than 400ºC
  - Reservoir pressure of more than 221 bar
  - Supercritical fluid in the reservoir

Exergy and Thermal Power

- **Exergetic Power (MW_{ex}) – open geothermal system (DiPippo, 2016)**

$$\widehat{W} = \dot{m} \times [h - h_o - T_o \, x \, (s - s_o)]$$

  - Maximum available work output independent of any power cycle
  - Use to identify wellhead conditions for optimum theoretical work output

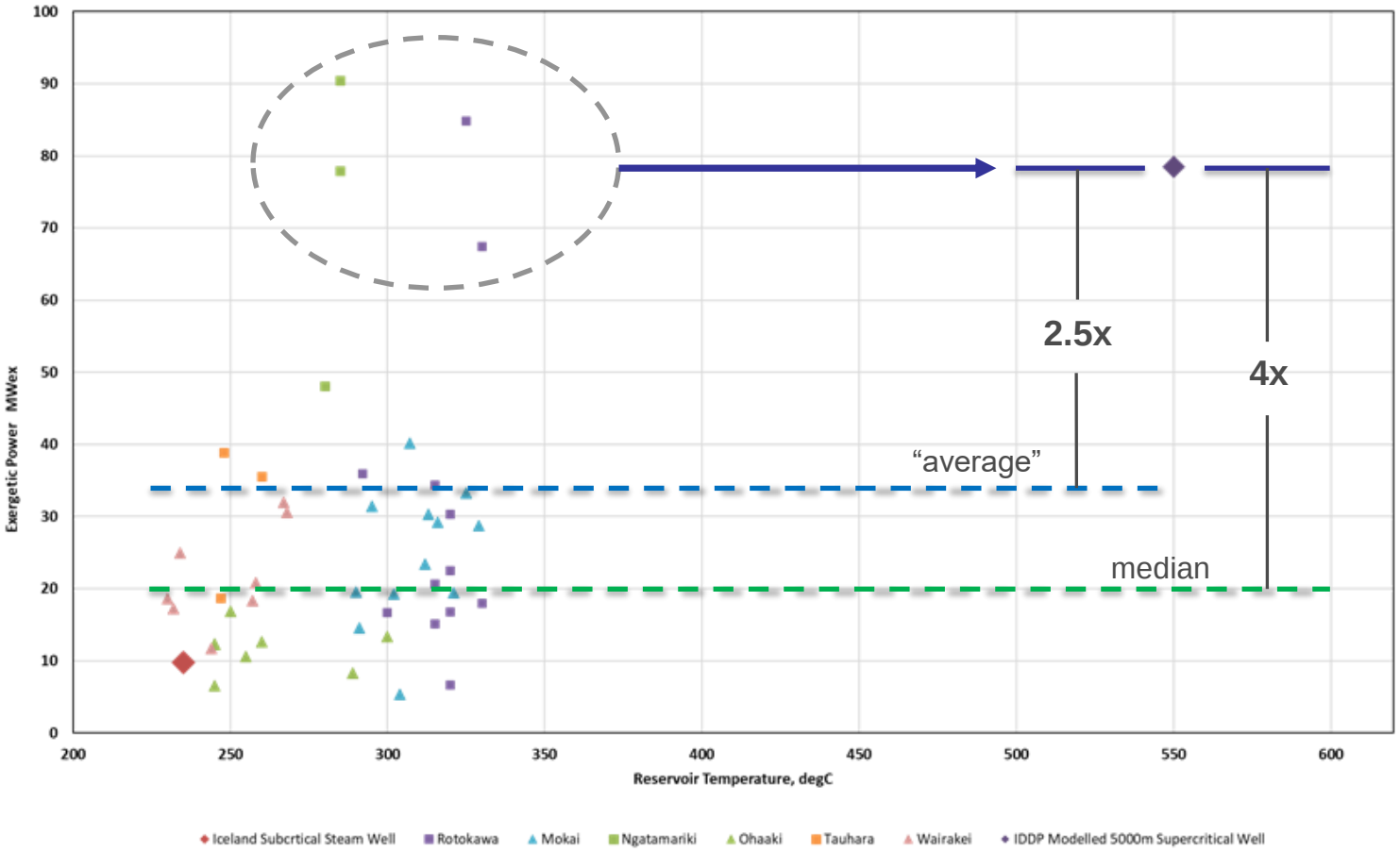
- **Thermal power (MW_{th}) – mass flow * specific enthalpy**

$$q = \dot{m} \times h$$

Icelandic Supercritical Outputs - 2003

- **2003 Icelandic Modelling**
  - Conventional steam well: **5 MWe**
    - Exergetic Power of 10 MW_{ex}
  - Well producing from supercritical conditions: **48 MWe**
    - Exergetic Power of 80 MW_{ex}
- **This captured interest that SC well is**
  - producing 10 times output of a conventional geothermal well
  - providing 8 times exergetic power
- **But what is relevant here in the TVZ**

Icelandic Well Model and NZ Sub-Critical Well Comparison

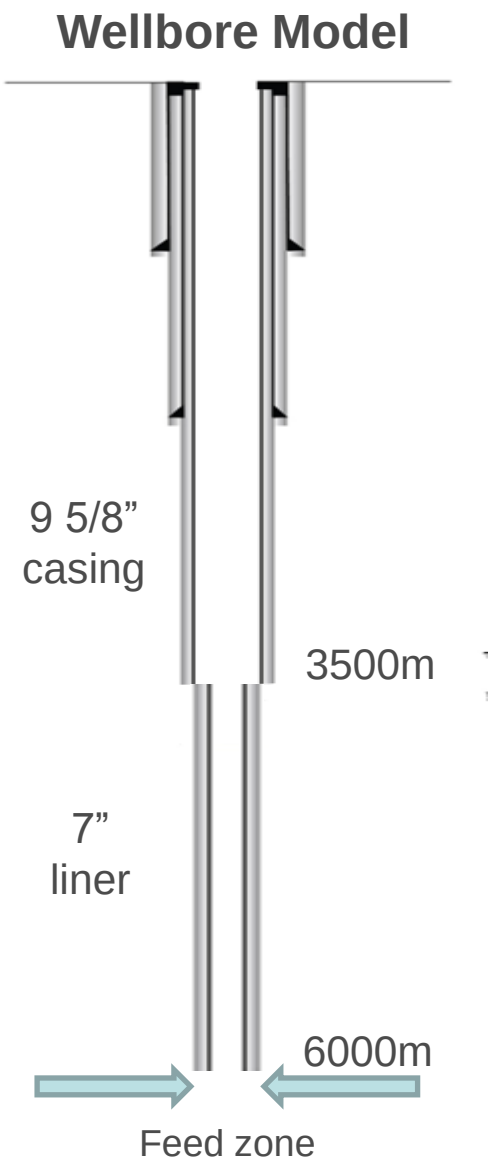


Icelandic modelled SC well equivalent potential to a larger NZ conventional well or about 2.5x the "average" or 4x the median.

TVZ Wellbore Modelling

- **Wellbore Modelling is done to**
  - Estimate potential output
  - Characterise Fluid Flow

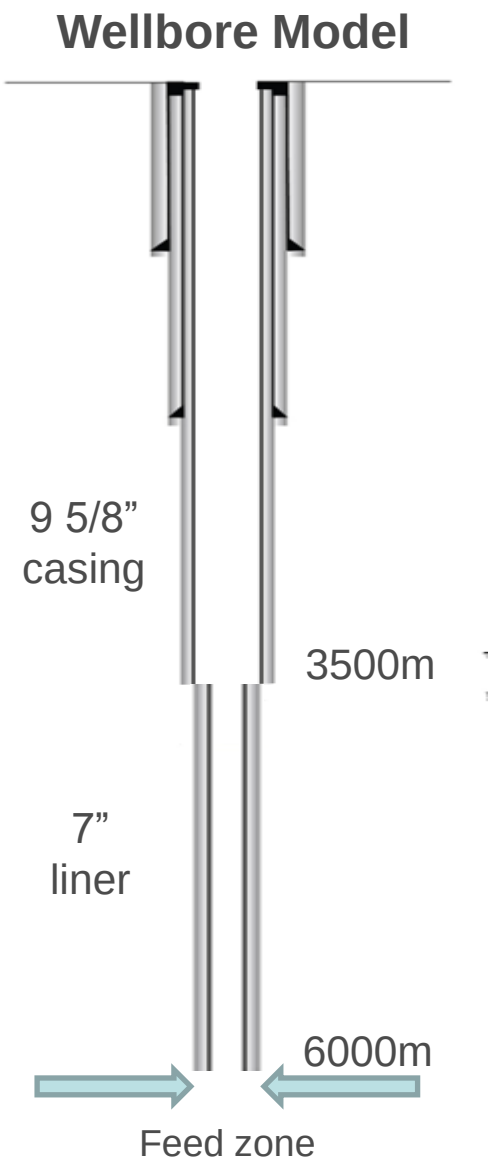
- **Wellbore Simulation Details**
  - TVZ Bulk Formation Properties
  - Heat Transfer to Formation at t = $1x10^7$ s
  - Casing roughness value = 0.5mm
  - Simulator is Gflow
    - Assumed as pure water



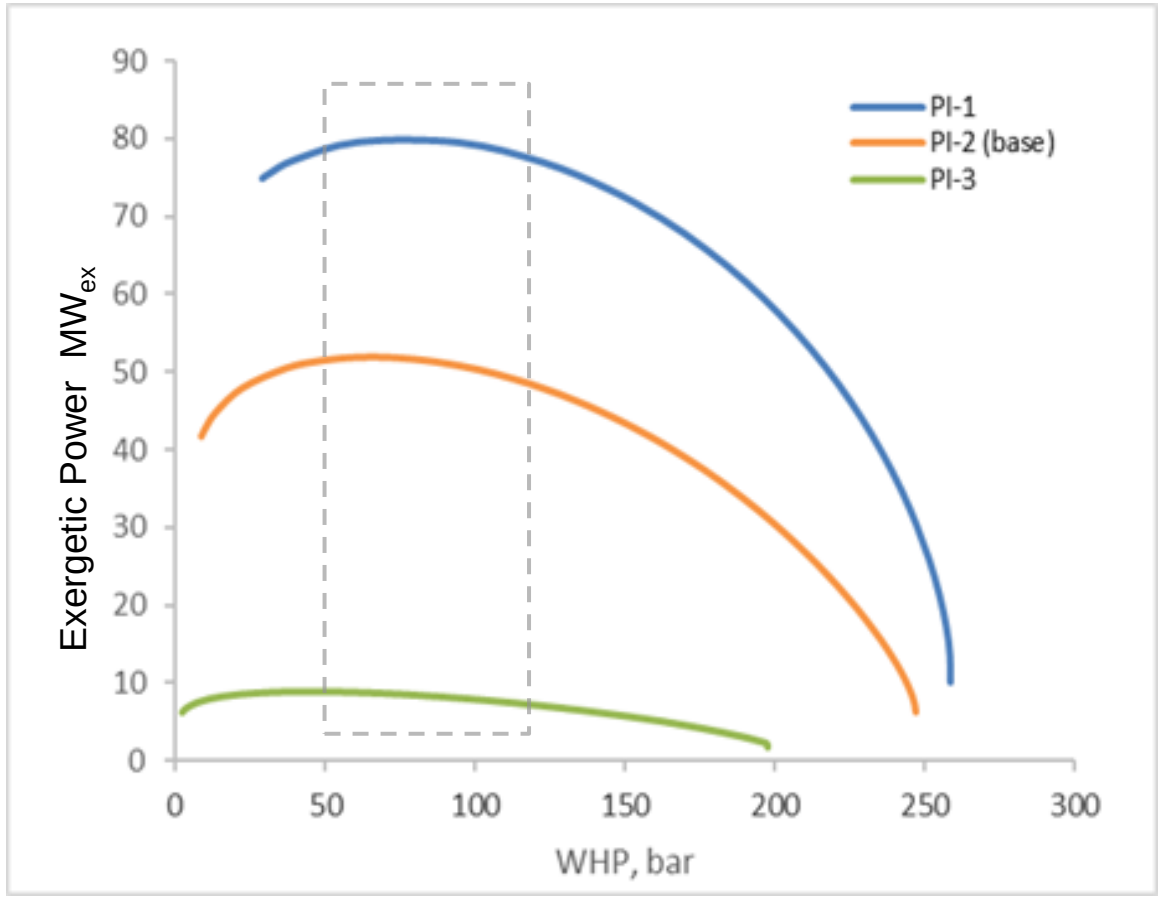
TVZ Wellbore Modelling

- **Feed Parameters**
  - Hydrostatic pressure at the feed zone
  - Temperature (^oC): 450, 500, 600
  - Depth (m): 4500, 5000, 6000
  - Productivity (m^3): $1x10^{-11}$, $1x10^{-12}$, $1x10^{-13}$

- **Well Model – Results and Discussion**
  - Temperature = 500^oC
  - Depth = 6000m
  - Productivity at different order of magnitude
    - PI-1 = $1x10^{-11}$; PI-2 = $1x10^{-12}$; PI-3 =$1x10^{-13}$



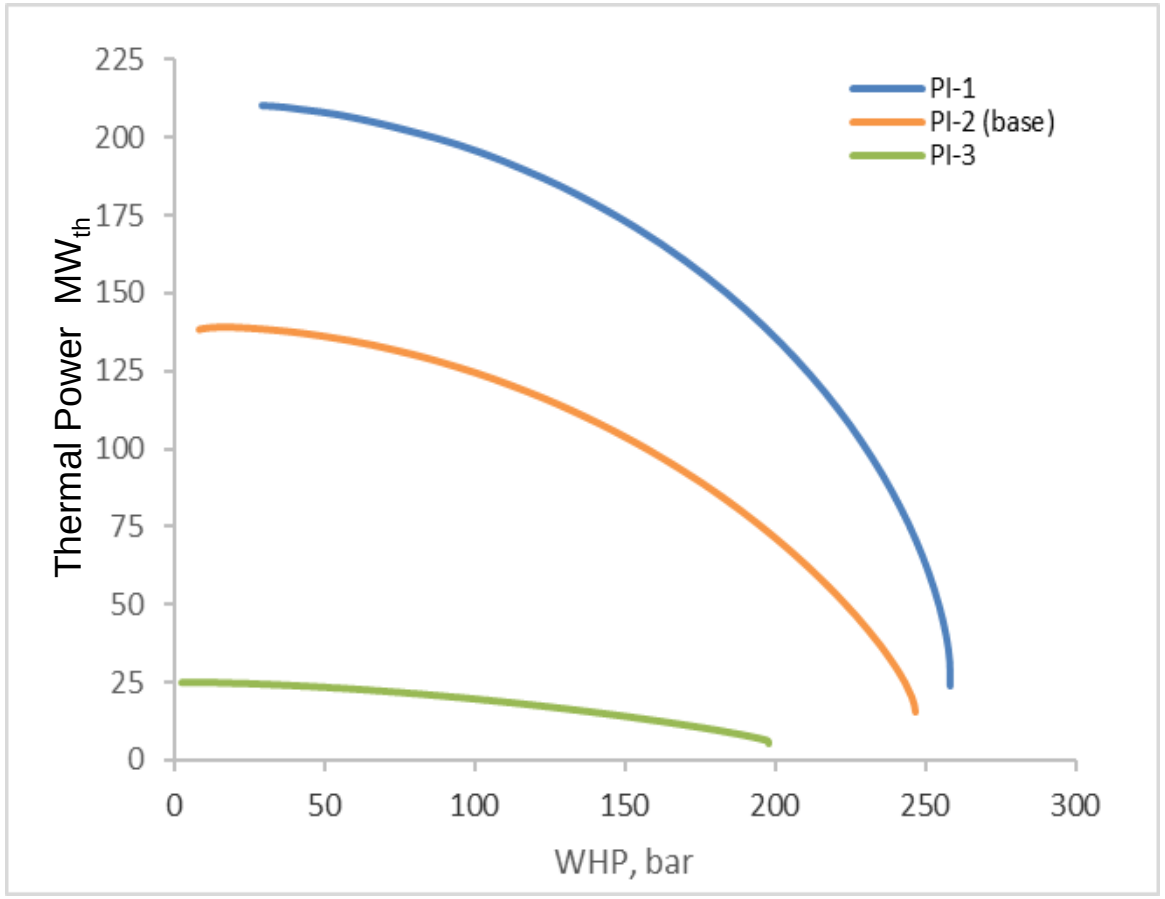
Optimum Operating Wellhead Pressure from Exergetic Power



- **Wellhead Pressure**
  - Optimum: 50-120 bar
  - Maximum: ~200-260 bar

Well output for 500ºC reservoir temperature at 6000m depth

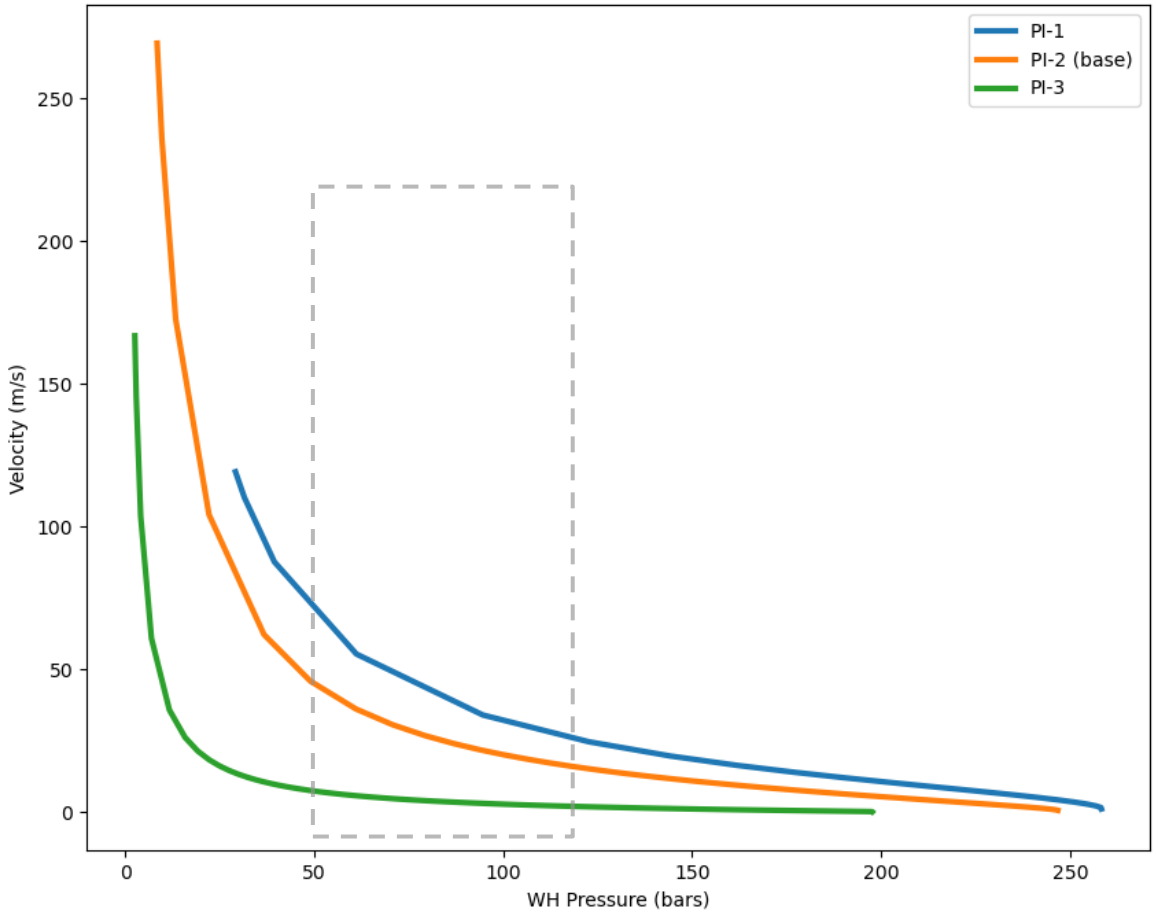
Optimum Operating Wellhead Pressure from Thermal Power



Well output for 500ºC reservoir temperature at 6000m depth

- **Wellhead Pressure**
  - Optimum at low WHP
  - Maximum: ~ 200-260 bar

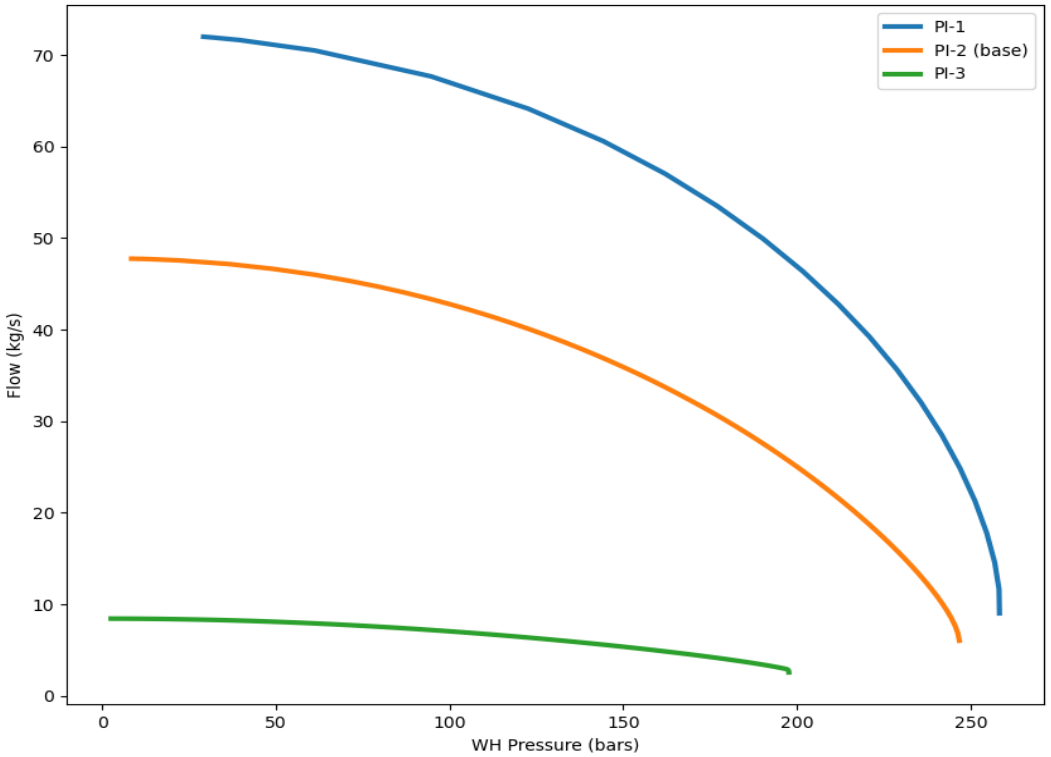
Wellbore Fluid Velocity Concerns

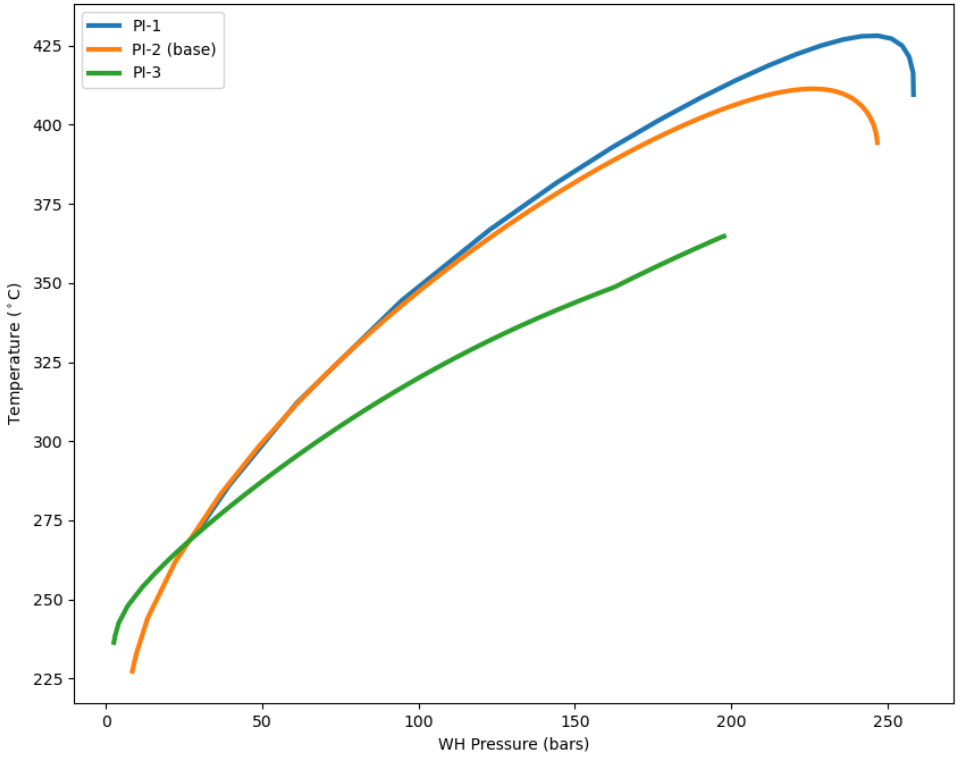


Well output for 500ºC reservoir temperature at 6000m depth

- **Fluid Velocity**
  - Exponential increase at low wellhead pressures
  - Issue on material erosion and uncontrolled vibration
  - Likely to be an operational constraint

Mass flows and temperatures at the surface





- **Mass Flows**
  - 10-70 kg/s at optimum WHP
- **Temperature**
  - 275-375ºC at optimum WHP

In summary, what do we get from a 500ºC well at 6000m?

- **The optimum well operating conditions are**
  - Pressures 50 to 120 bar
  - Temperatures 275 to 375 ºC
- **Supercritical fluid unlikely to produce at the surface**
  - Would require very high wellhead pressures
  - Off the optimum exergetic or thermal power
  - Steep part of the well curve – unstable operation
- **Transition from supercritical to superheated occurs in the well.**
- **Likely TVZ will be producing ultra-hot geothermal at the surface.**

And to round it out…

- **Report in Preparation**
  - Comparative Geothermal Well Performance – Supercritical and Sub-Critical
  - Published early 2023 – GNS Science Report 2023/01

Thank you

Questions for now