WINDY COVE ENERGY

Blackstone

A Renewed Look at Dimensionless Curves

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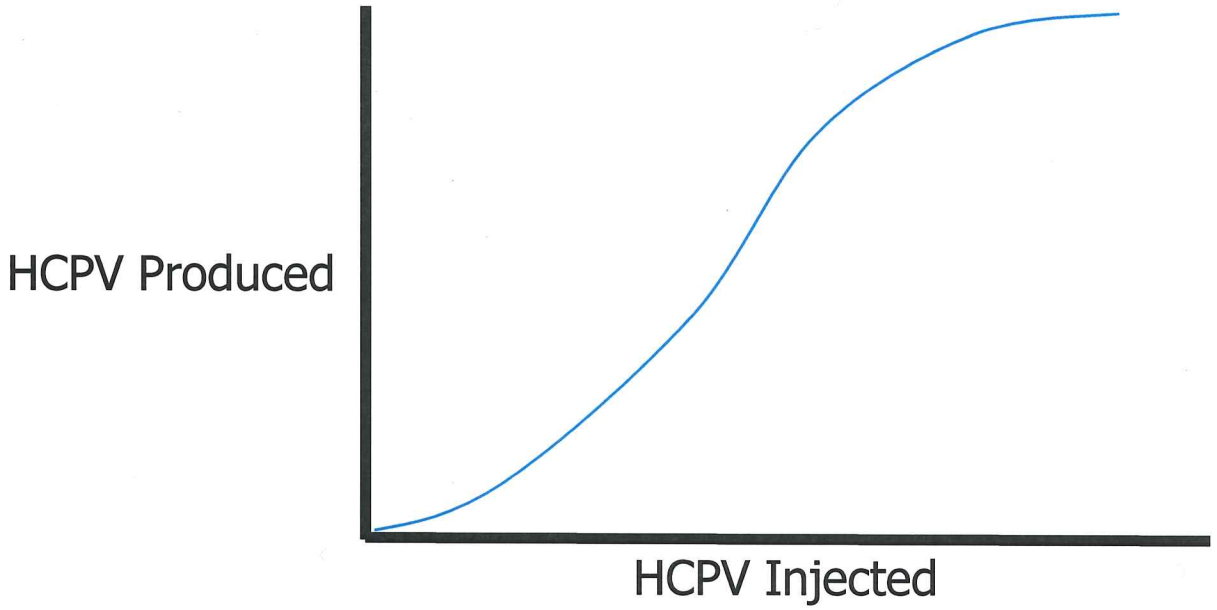
Outline

- What is a dimensionless curve?
- The secret equation
- Curve fitting
- Weakness of the dimensionless curve
- The super secret equation
- Uses of the super secret equation

What is a Dimensionless Curve?

- **A plot where everything is normalized by dividing by Hydrocarbon Pore Volume (HCPV)**



Why Oh Why?

- **Enables you to compare different projects on a somewhat equal basis**
  - Small field to large field
  - Individual pattern to full field
  - Slow pattern to fast pattern
  - Different start times
  - Different field implementation speeds
- **Issues (whining)**
  - Small changes in the curve make large changes in plans
  - Difficult to interpret what the curve means

Equations are Helpful but Dangerous

- + If you express the dimensionless curves as an equation you can merrily spread your predictions throughout your project.
- + Excel is very good at fitting polynomials to data sets.
- - If you go outside the bounds of the data fit with your prediction who knows where it is going. (It could blow up.)
- That you may need many decimal places for each parameter to keep the fit is merely annoying.

The Secret Equation

$$f(x) = A - A * \exp[-(K * x)^d]$$

In Excel speak (Excel doesn't like unary minus signs)

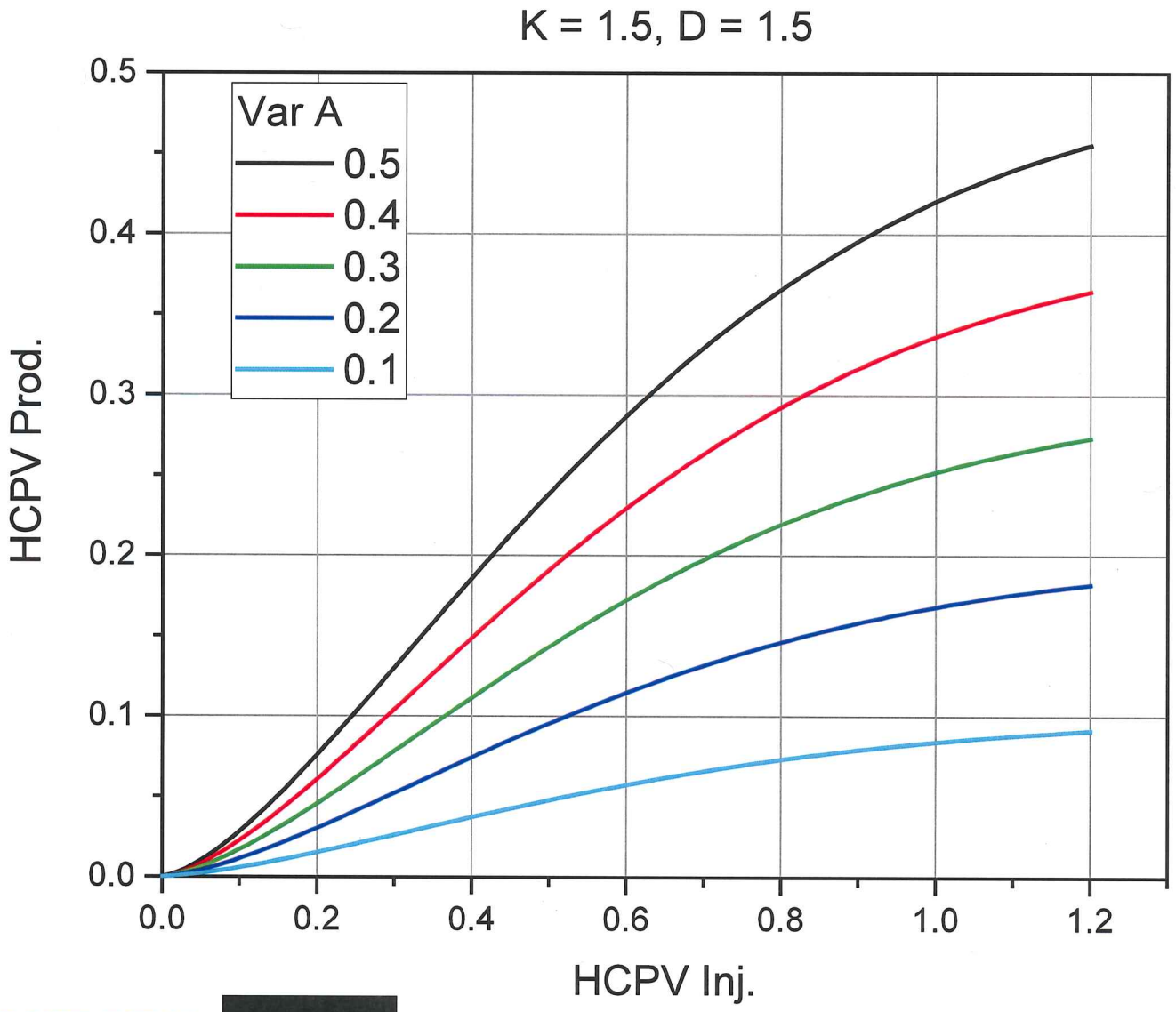
$$=(A - A*EXP(-((K*X)^d)))$$

A, K, d are static cell references and X is the cumulative HCPV injected.

Why Oh Why this Weird Equation?

- **Already has the correct shape for dimensionless curves**
- **Asymptotes at zero and upper limit A**
  - This means it can't blow up
- **Can be fit manually**
- **Usually requires only 1 or 2 decimal places on each parameter for the fit**

A, the Asymptote



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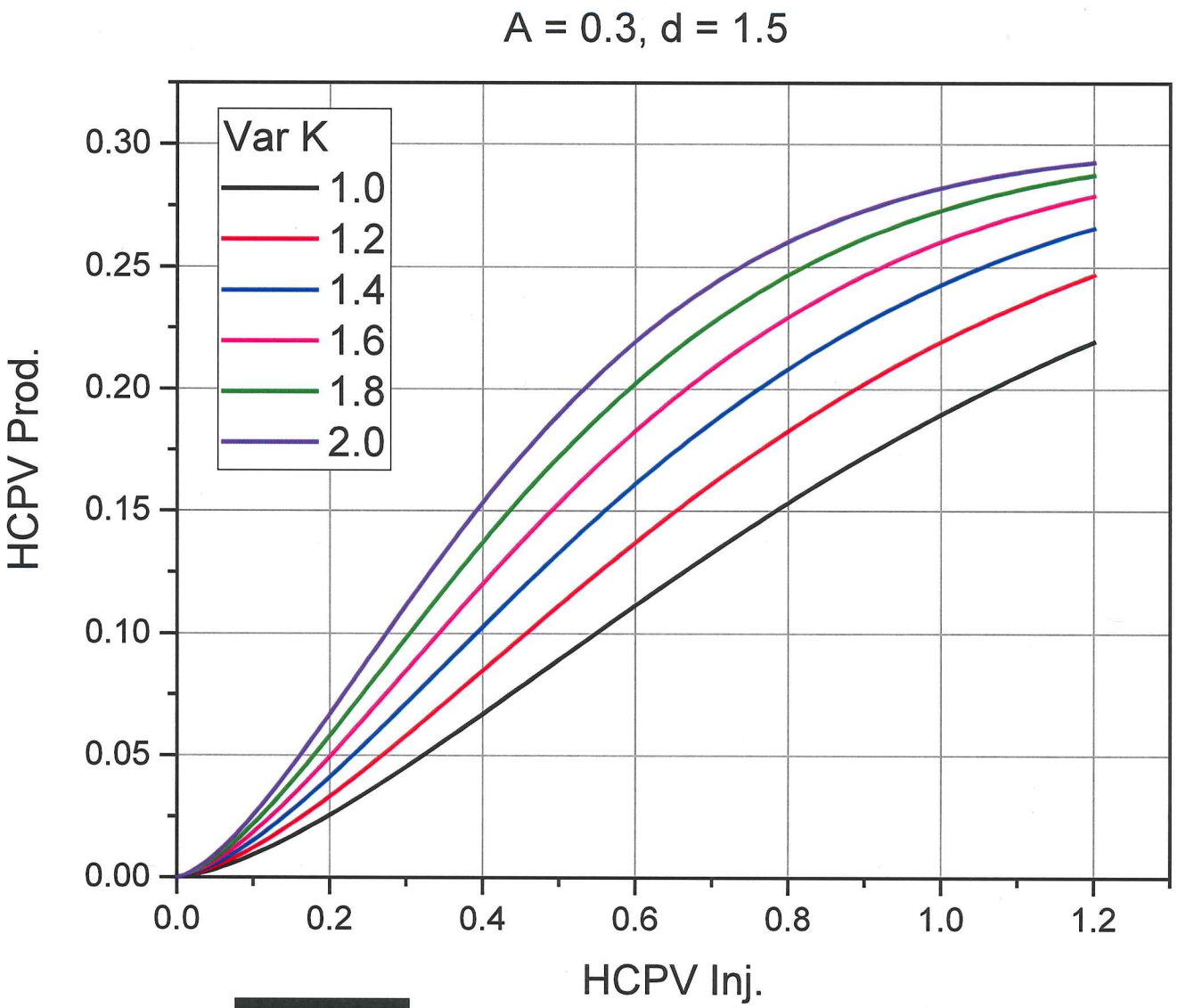
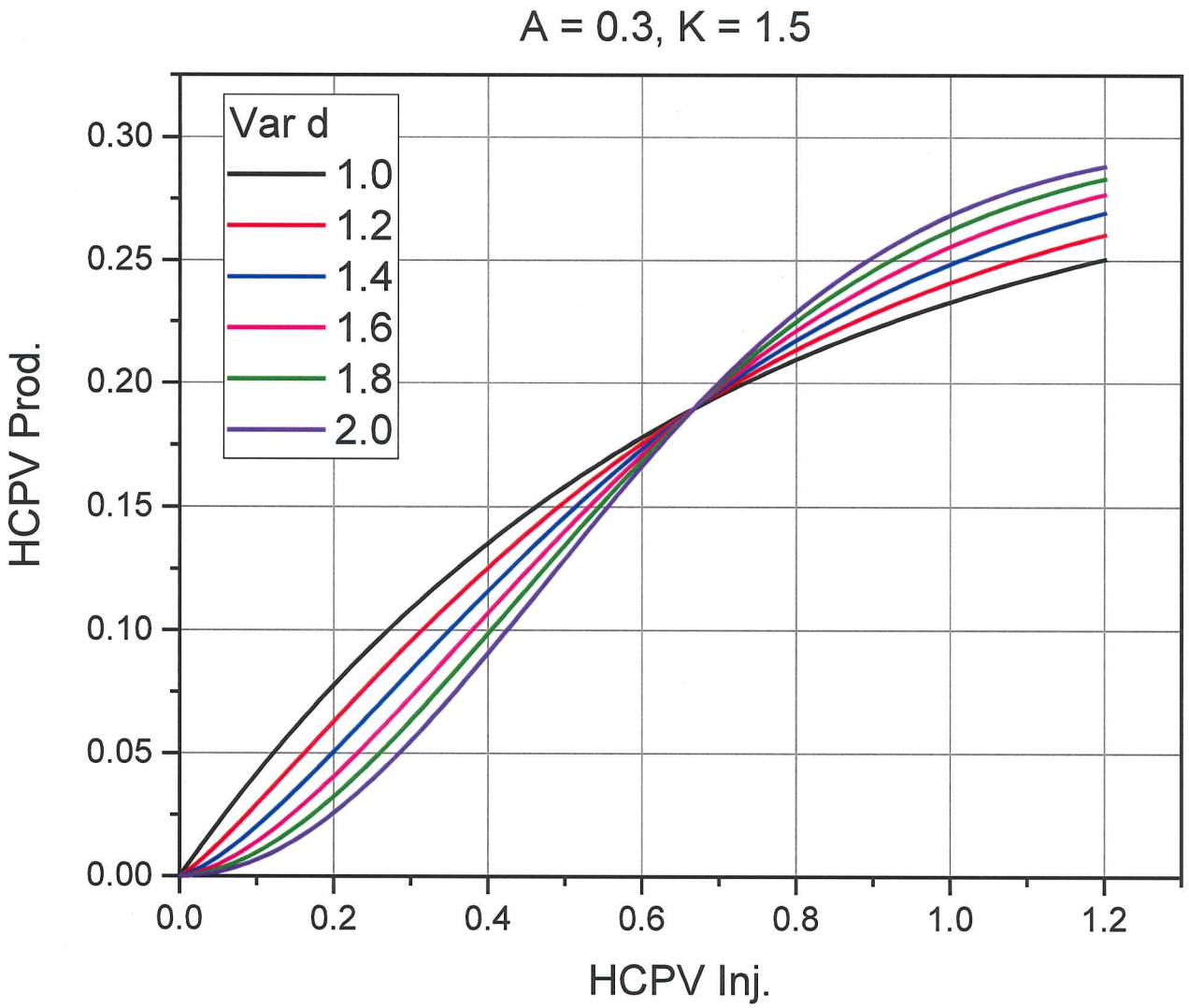
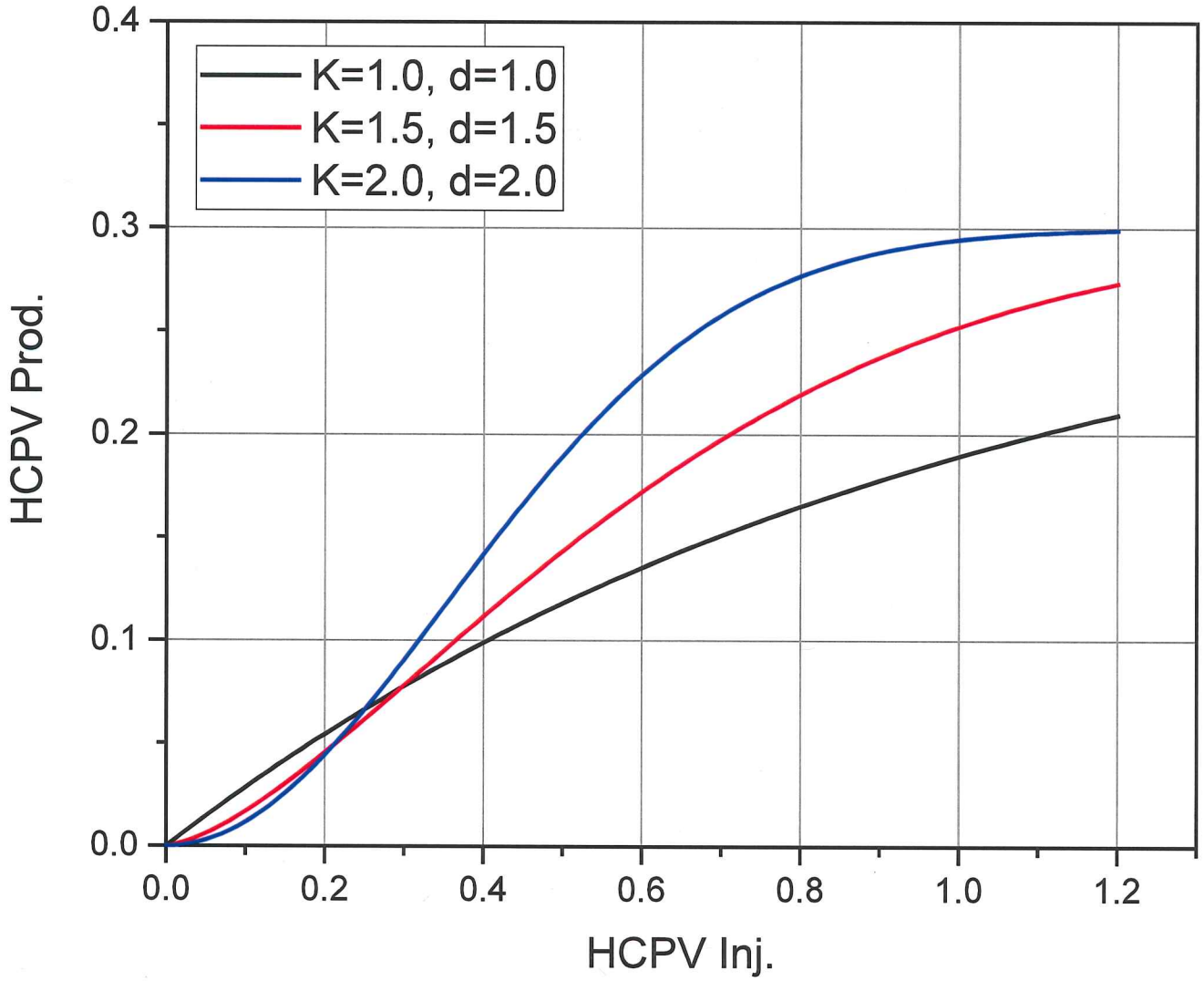
K, How Quick to the Top



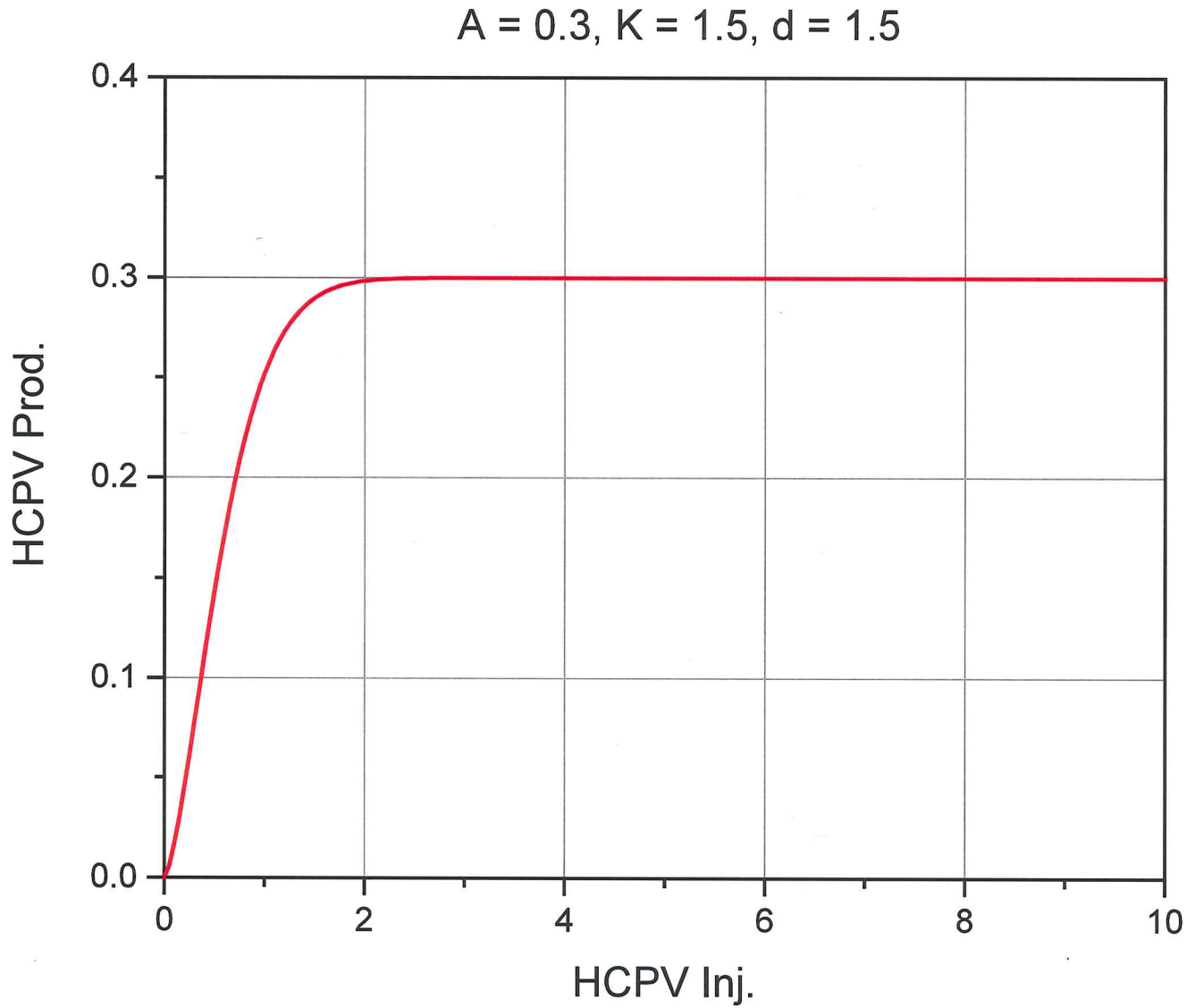
d, How Long to Get Going



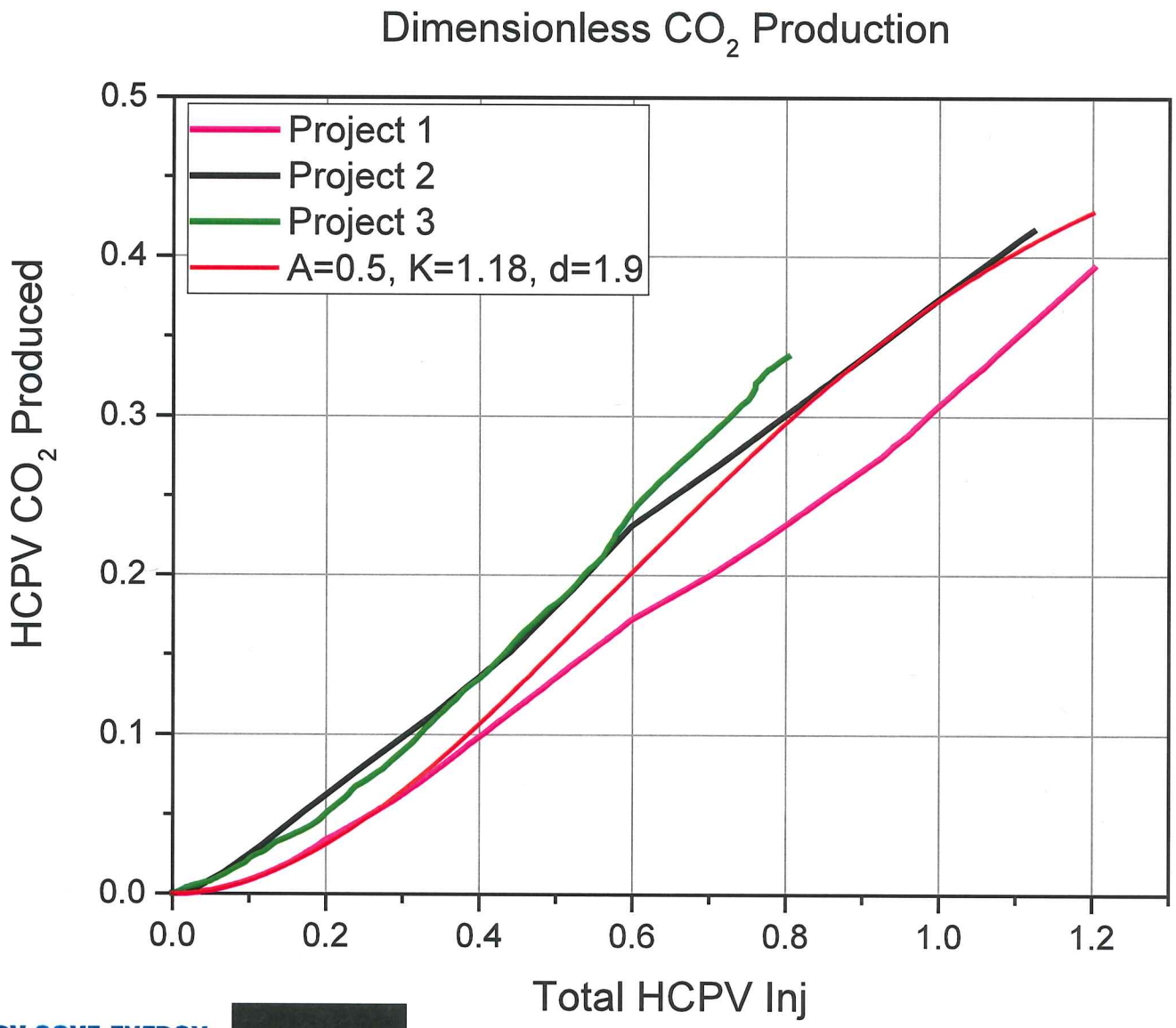
K and d Oppose Each Other



Will it Blow Up?



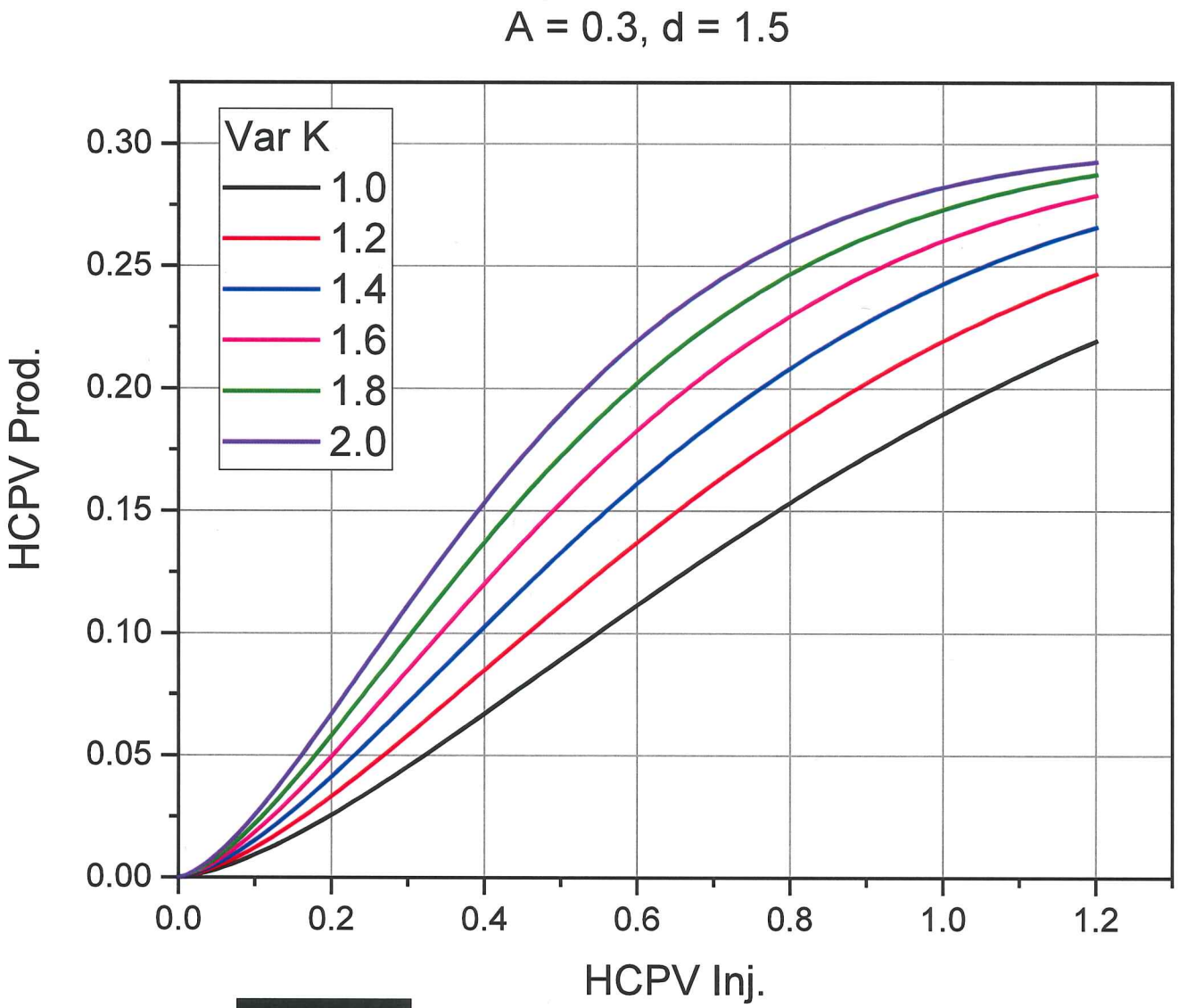
A Real Example



Everything is Wonderful

- **So why am I whining?**
- **The real world is revealed in the slope**
  - Same as speedometer as compared to an odometer
- **Slopes are difficult for people to interpret**
- **Very small changes in slope make huge changes in the real world**
- **What you really want is BOPD not HCPV/HCPV.**

When is the Next Compressor?



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The Super Secret Equation

$$f'(x) = \frac{A * d * \exp[-(K * x)^d] * (K * x)^d}{x}$$

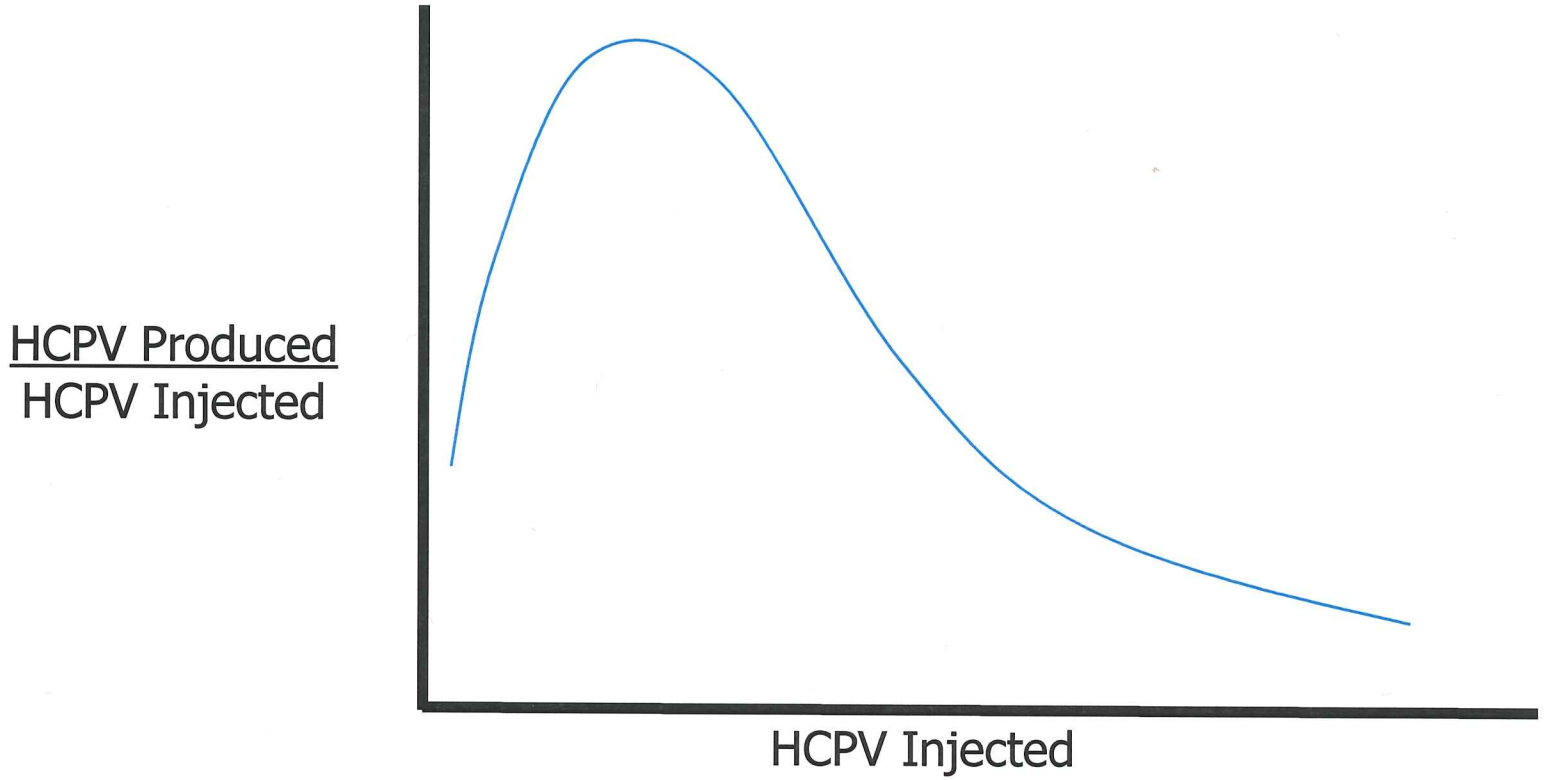
In Excel speak again

=(A*d*EXP(-((K*X)^d))*(K*X)^d)/X

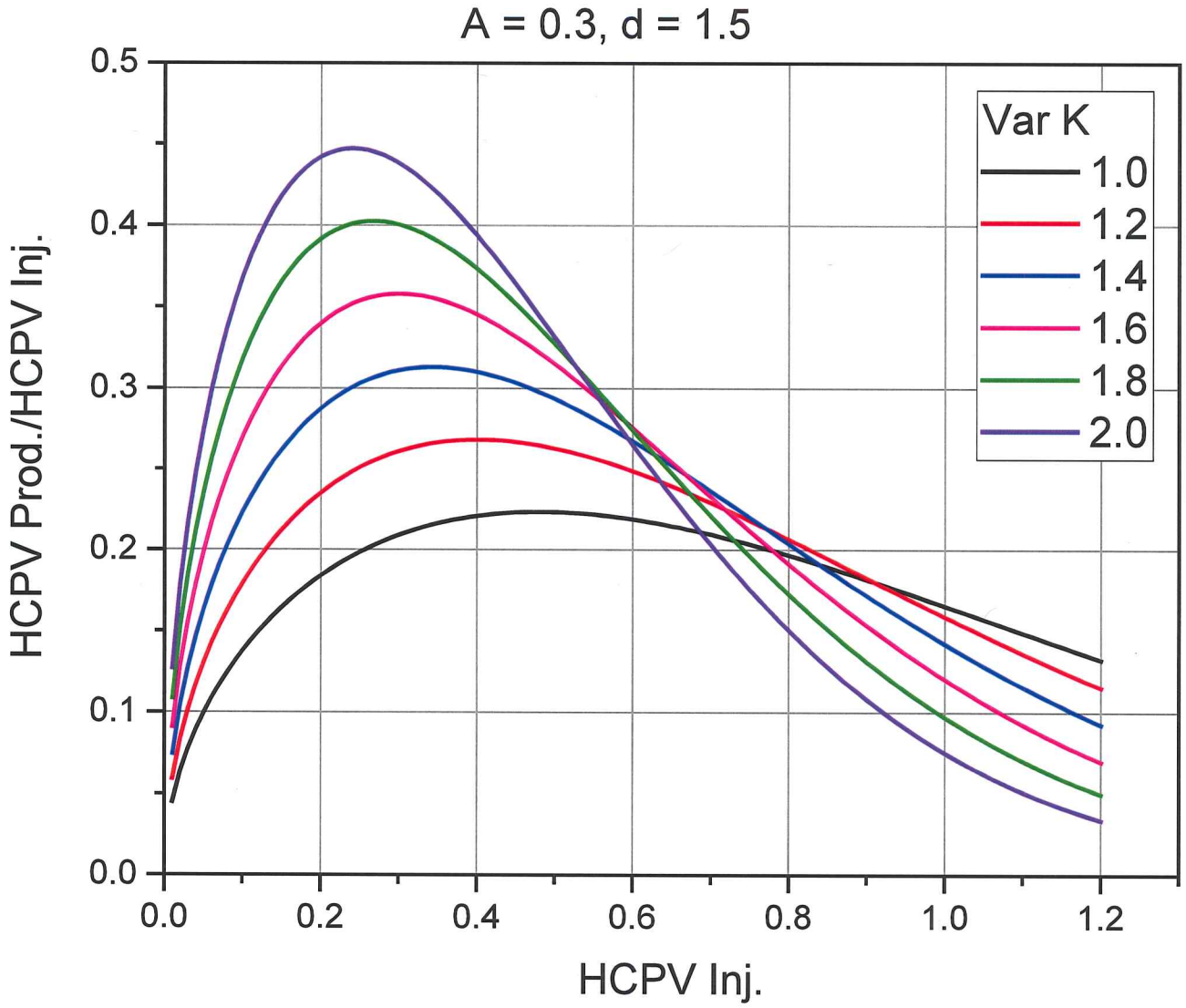
A, K, d are static cell references and X is the cumulative HCPV injected.

OMG! Is this for real?

- **Changes the dimensionless curve to dimensionless rate vs. HCPV Injected**

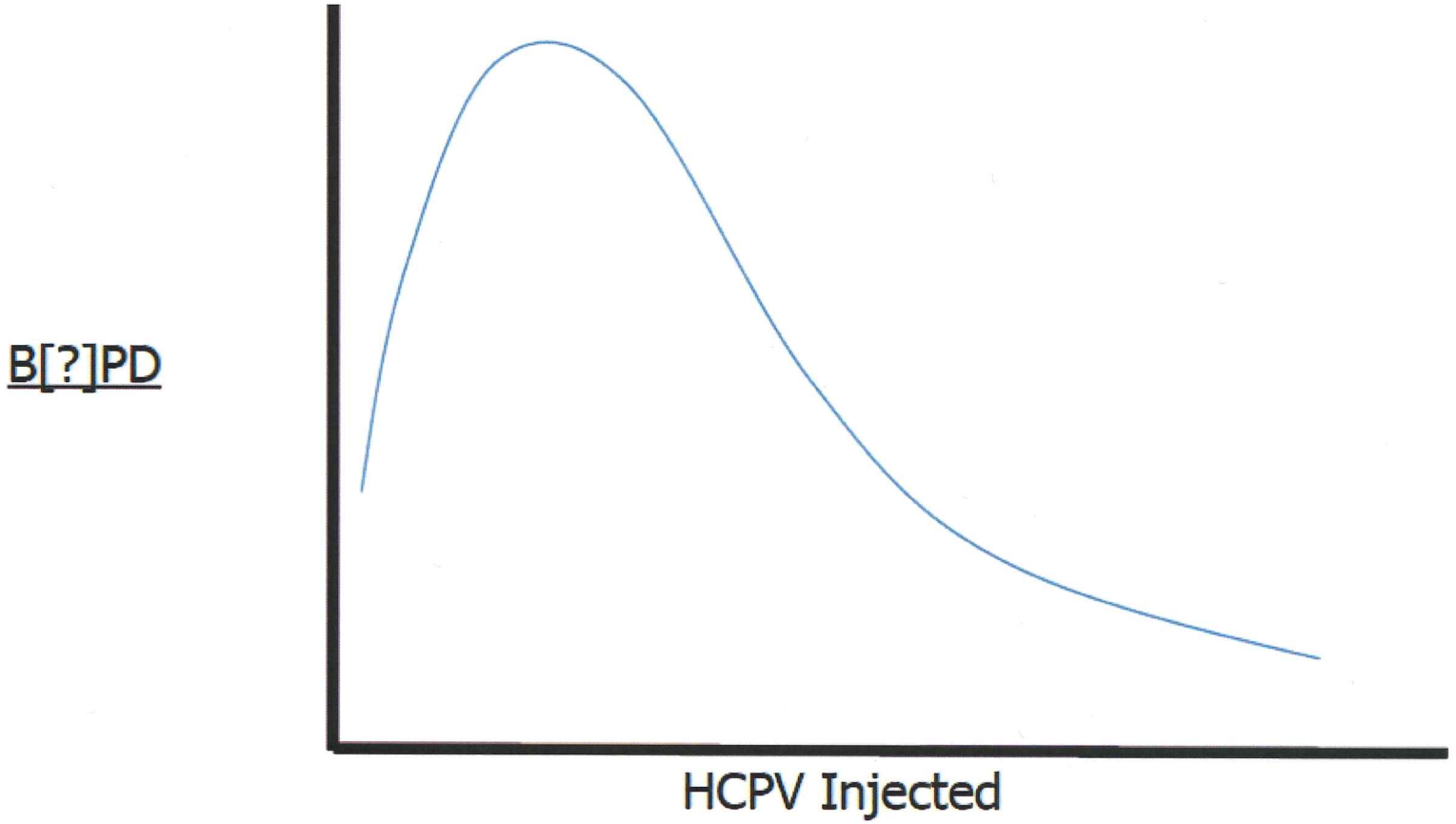


Clues at the Dimensionless Level



We Don't Live in a Dimensionless World

- **Multiplying dimensionless rate by bbls/HCPV and then by injection rate in HCPV/day results in actual rates of bbls/day**



Real World Units of Imaginary Field

$$OOIP = 50 \frac{MMBO}{HCPV}$$

$$Inj.Rate = 0.1 \frac{HCPV}{year}$$

Lets Get an Oil Rate

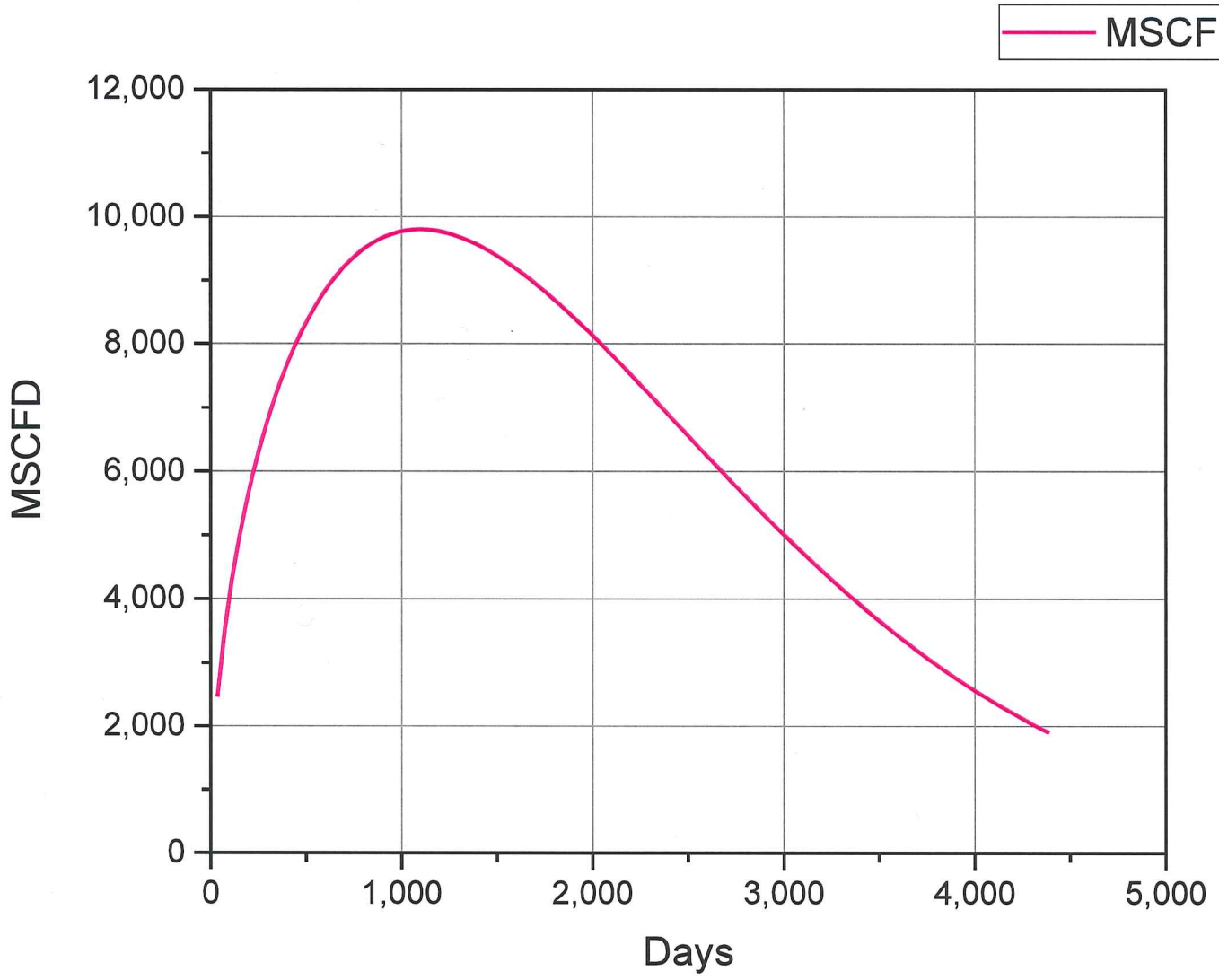
$$Oil\ Rate = 0.4\frac{HCPV}{HCPV} * 0.1\frac{HCPV}{year} * 50\frac{MMBO}{HCPV} = 2\frac{\text{MMBO}}{\text{year}}$$

$$Oil\ Rate = 2\frac{MMB}{year} * \frac{Year}{365\ days} = 5{,}479\frac{\text{bbls}}{\text{day}}$$

Or If a CO_2 Curve

$$CO_2\ Rate = 5{,}479\frac{bbls}{day} * 2\frac{mscf}{bbl} = 10{,}959\frac{mscf}{day}$$

Something You Can Deal With



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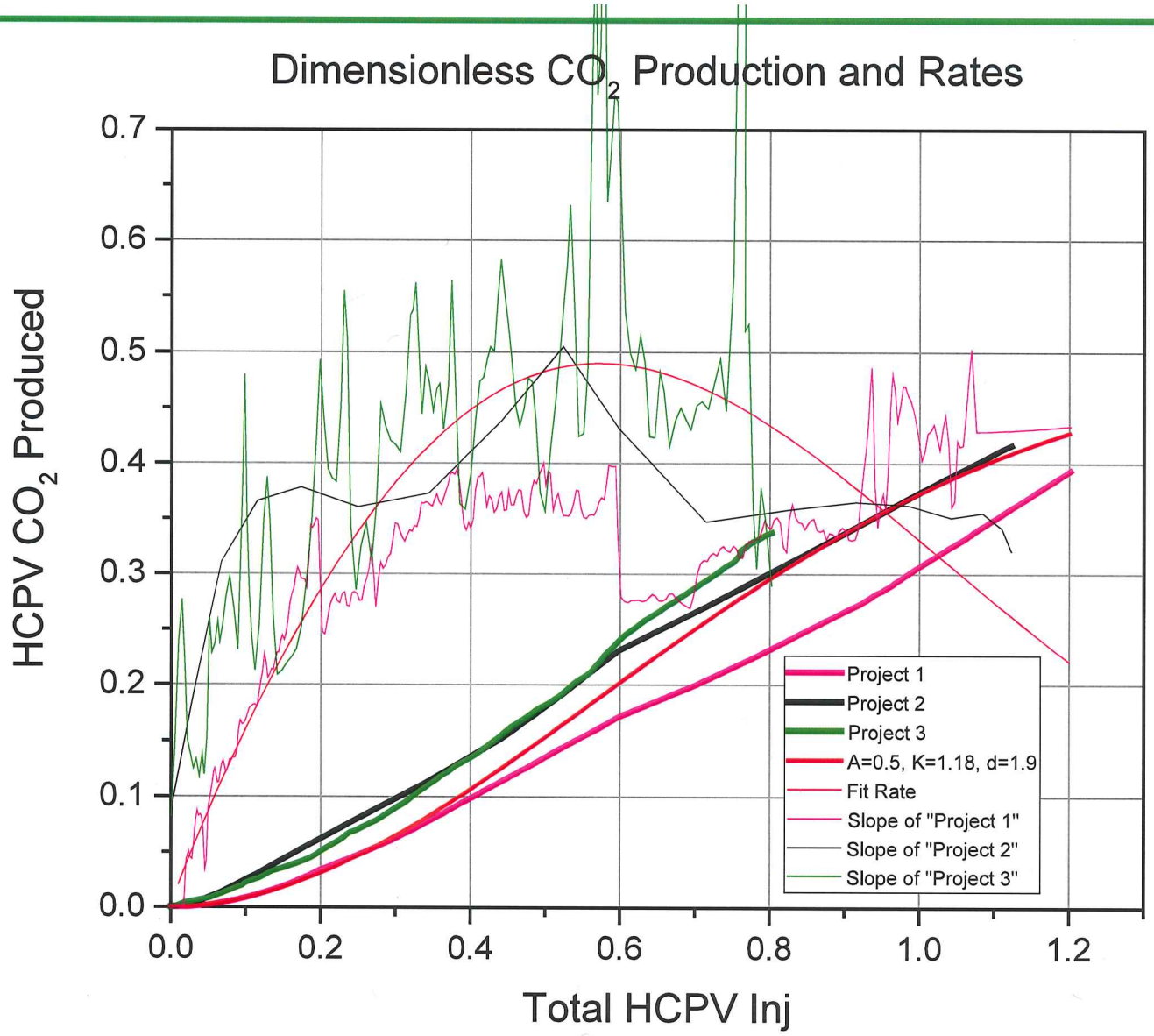
How Good is the Fit?

- Judging the fitted equation can be difficult
- Once more, we don't do well with slope judging
- Well test methodologies went to derivative curves long ago
- So…

How Good is the Fit?



Thank You for Your Attention

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