PPSDM Jakarta, 31 October, 2016

Company decision-making for geothermal projects

(GEOCAP course 1.07)

Topic: Drilling risk, well success learning curves

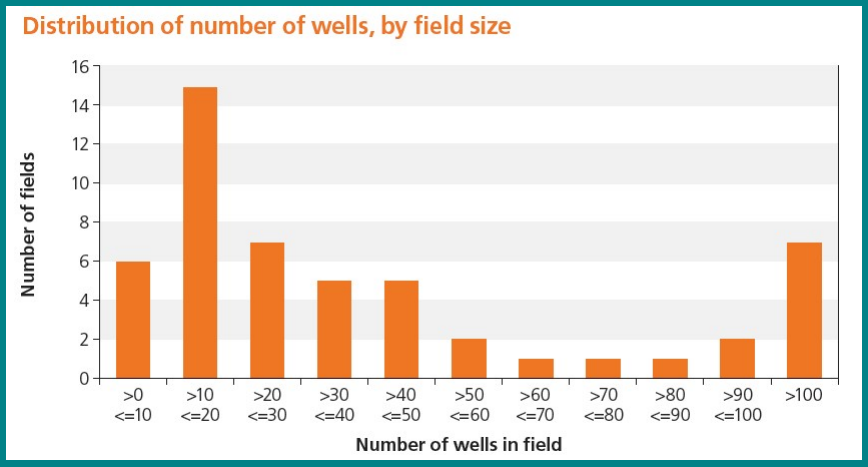
Lecturer - Ir. Christian Bos

Public document (GEOCAP-2016-REP-TNO-1.07-1)

Some remarks on drilling risk

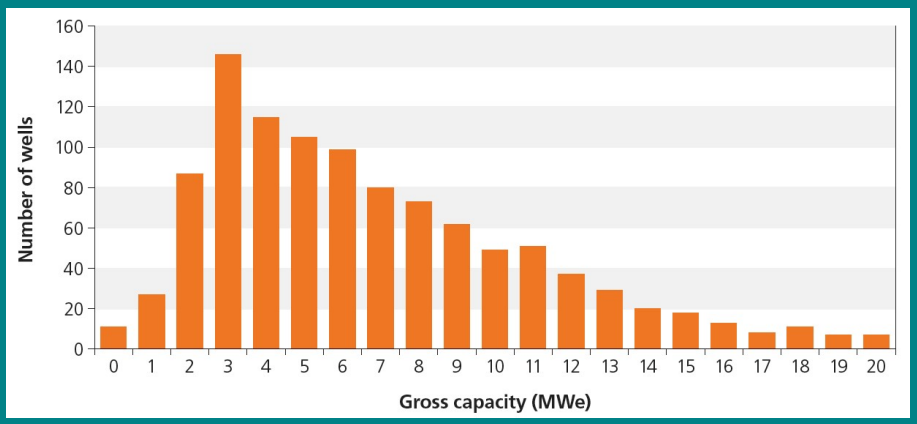
- Risk = probability x undesired outcome
- Drilling risk = e.g. 50% x $7M = loss of $3.5M
  - Note: drilling always gives information that may be used successfully subsequently. Therefore, the VoI should be subtracted from the risk.
- GT 'dry hole' is a rarity. 'Failure' normally defined as well capacity < some threshold (typically 3MWe or higher).
- Drilling costs comprise some 35–40% of total capex of a GT project, most of which will be incurred in determining the size, location, and power capacity of the GT resource. This investment will, of course, be lost if no 'reserves'.

GT fields & well count



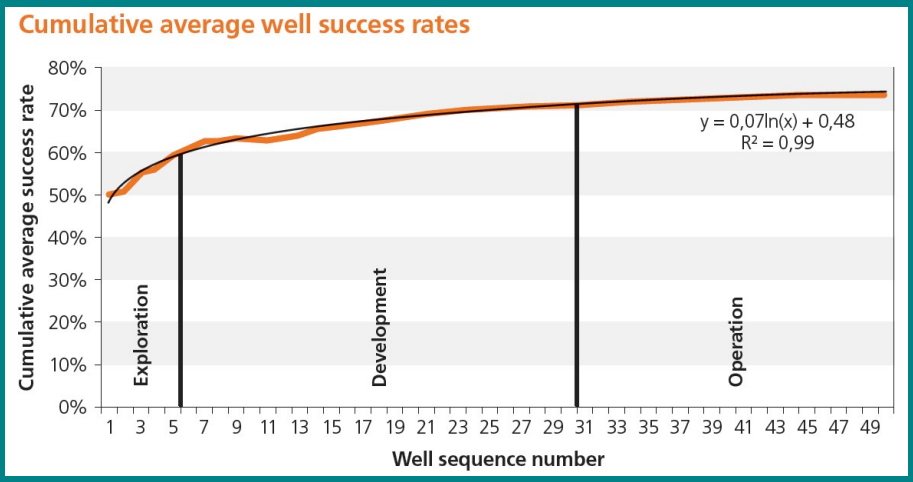
- Ref: *Success of Geothermal Wells: A global study*; International Finance Corporation (WB), June 2014

Distribution of well capacities



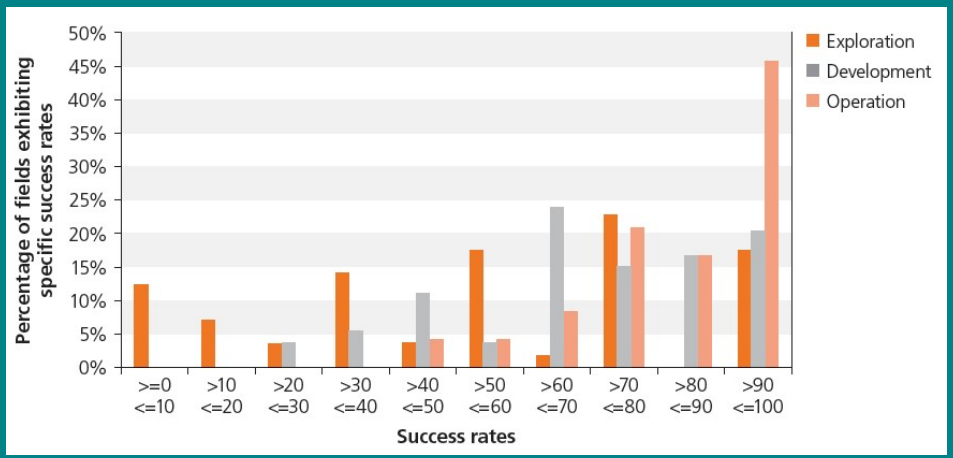
- Incremental individual well capacity subject to large uncertainty

Learning curve – well success rates



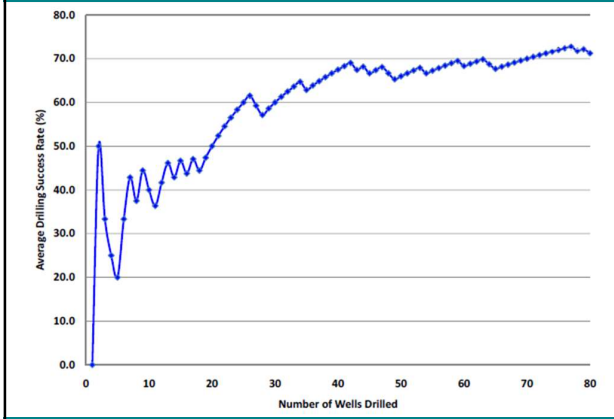
- *Average* success rate!
- Individual fields may deviate.
- See next slide.

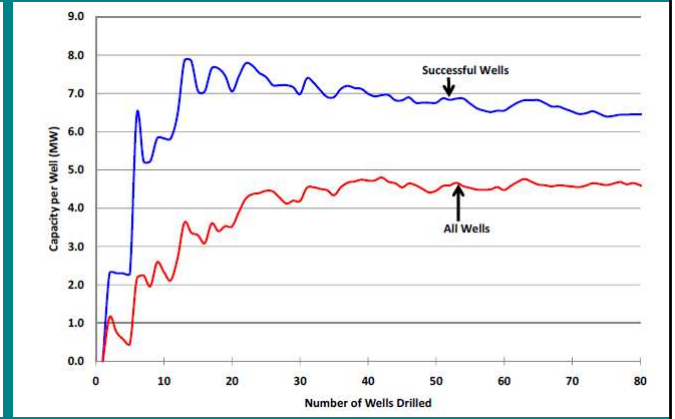
Variation in success rate per phase



- Significant standard deviation per individual field
- This implies a large investment risk
- Not many companies would accept this for the expected RoI
- Govt may assume this risk

Kamojang field (Indonesia)



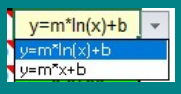


- Learning effect
- Running average MWe/well

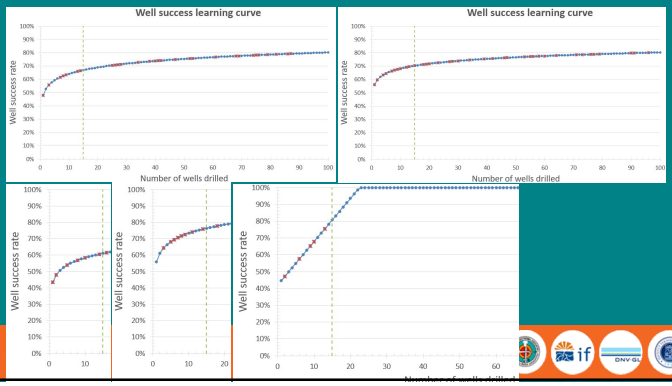
26/10/2017 7

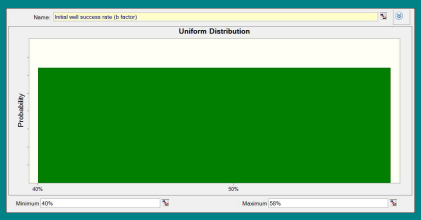
Implementation in XL tool

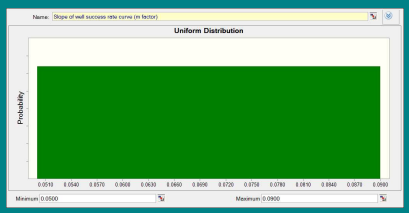
Well success rate	Read comment
Select eqn. for well success learning curve	y=m*ln(x)+b
Initial well success rate (b factor)	48%
Slope of well success rate curve (m factor)	0.0700
Select realization of the random number generator	Variable



- Some Monte Carlo realizations of learning curve:







8