# STATUS AND ACHIEVEMENTS
# EGS RESERVOIR CREATION

# WHAT DID WE LEARN FROM THE PAST?

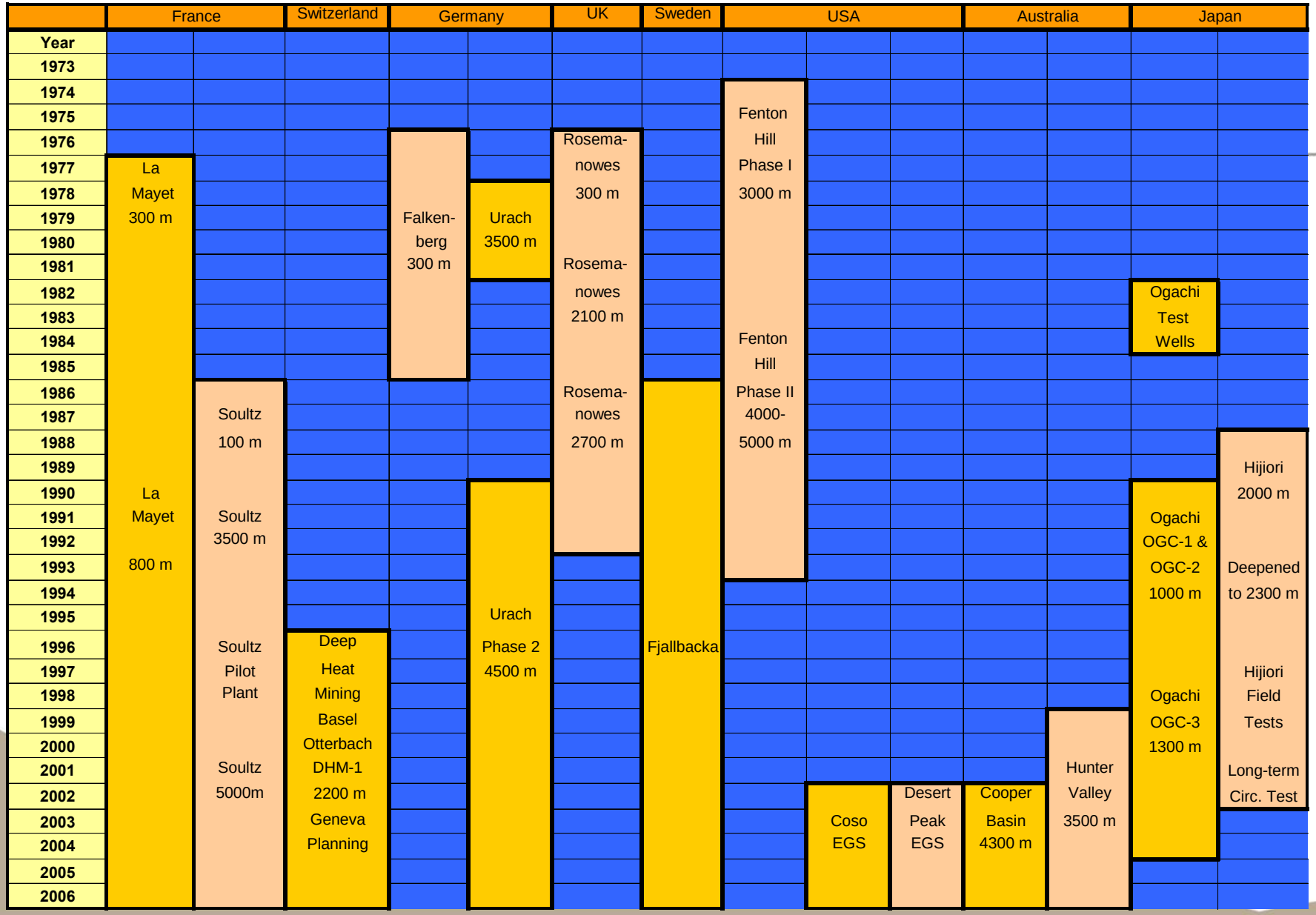
## PAST PROJECTS

- FENTON HILL
- ROSEMANOWES
- HIJIORI
- OGACHI
- SOULTZ

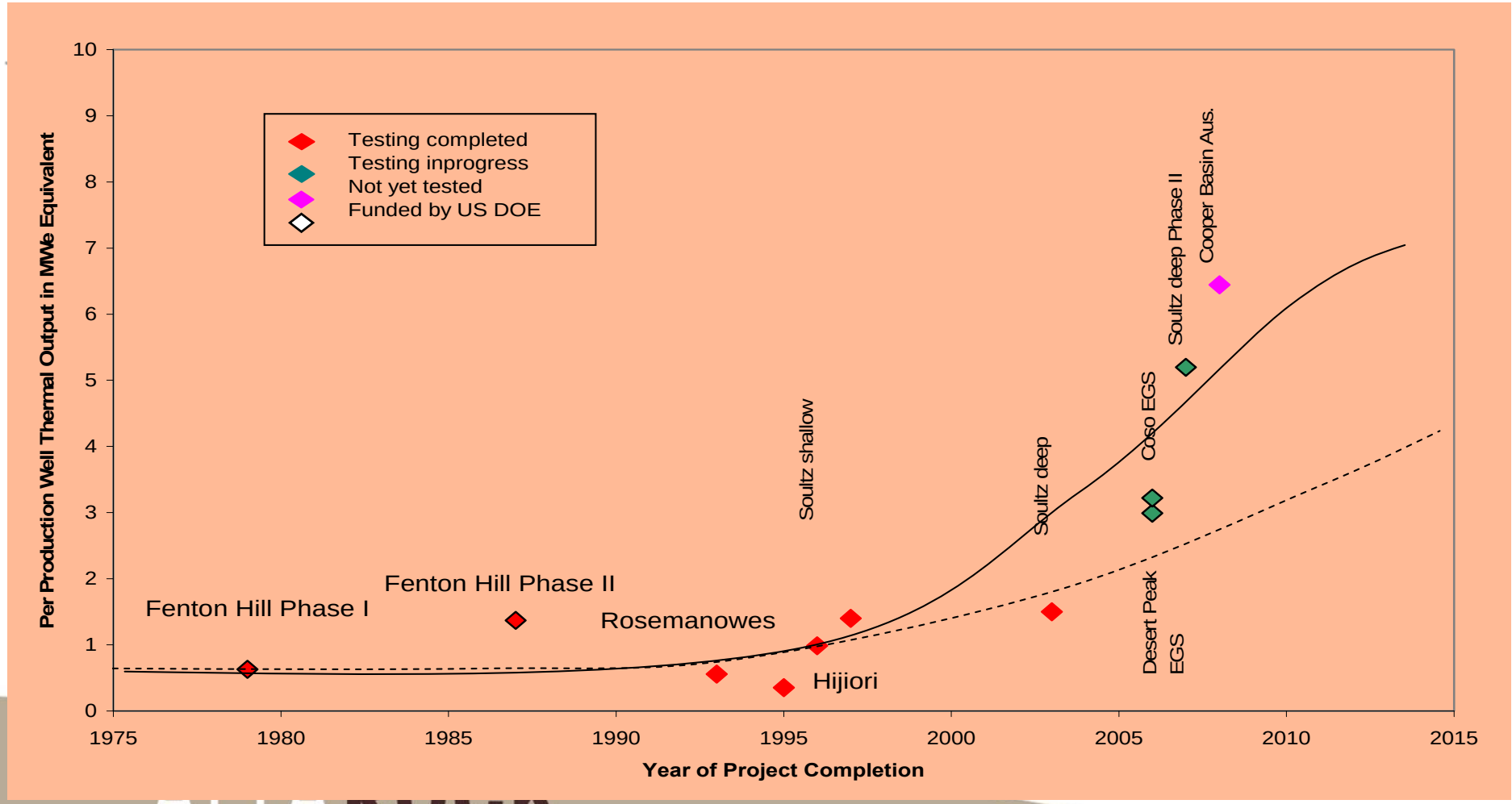
## LESSONS LEARNED

- **WE CAN:**
  - DRILL WELLS IN HARD, HOT ABRASIVE ROCK
  - UNDERSTAND FRACTURE DIRECTION/ORIENTATION WITH BOREHOLE IMAGING
  - FRACTURE BY INJECTING COLD WATER
  - FRACTURE LARGE VOLUMES OF ROCK – OVER 2.5 $KM^3$
  - MAP THE CREATED FRACTURES USING MICROSEISMIC MONITORING
  - DIRECTIONALLY DRILL TO INTERSECT THE CREATED FRACTURES
  - CIRCULATE AT FLOW RATES OF BETWEEN 25-35 KG/S WITHOUT INDICATIONS OF PREMATURE COOLING
  - GENERATE POWER AT COMMERCIAL RATES FOR THE BEST AREAS

ALTA ROCK ENERGY INC


France
Switzerland
Germany
UK
Sweden
USA
Australia
Japan
Year
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
La Mayet 300 m
La Mayet 800 m
Soultz 100 m
Soultz 3500 m
Soultz Pilot Plant
Soultz 5000m
Deep Heat Mining Basel Otterbach DHM-1 2200 m Geneva Planning
Falken-berg 300 m
Urach 3500 m
Urach Phase 2 4500 m
Rosema-nowes 300 m
Rosema-nowes 2100 m
Rosema-nowes 2700 m
Fjallbacka
Fenton Hill Phase I 3000 m
Fenton Hill Phase II 4000-5000 m
Coso EGS
Desert Peak EGS
Cooper Basin 4300 m
Hunter Valley 3500 m
Ogachi Test Wells
Ogachi OGC-1 & OGC-2 1000 m
Ogachi OGC-3 1300 m
Hijiori 2000 m
Deepened to 2300 m
Hijiori Field Tests
Long-term Circ. Test

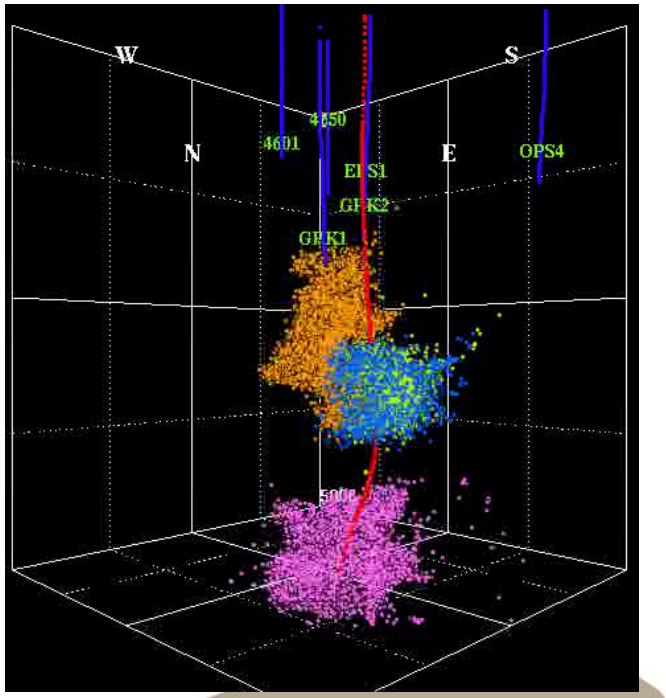
# Energy Output of Past and Current Projects




EGS Assessment

The Future of Geothermal Energy

# MOVING FROM EXPERIMENTAL TO COMMERCIAL




ALTA ROCK
ENERGY INC

# CURRENT STATUS OF TECHNOLGY

- How do we go about developing an EGS reservoir?
  - Install a microseismic monitoring system
  - Drill a well into high temperature rock >200°C
  - Evaluate the natural fracture system and stress state
  - Stimulate a large volume of rock by pumping cold water at just above the critical pressure for the local stress regime
  - Map the created fracture system using MEQ monitoring
  - Drill wells into created fractures
  - Re stimulate to improve connectivity
  - Circulate fluid by pumping production wells

ALTA ROCK
ENERGY INC

## COMPARISON OF MAIN HDR RESERVOIRS IN THE WORLD

| PROJECTS | PERIOD | MAX. ROCK TEMP. Deg C | RESERVOIR DEPTH meters | WELL SEPARATION meters | OUTLET FLOW l/s | WATER LOSSES % | IMPEDANCE MPa/l/s | THERMAL OUTPUT MWth | BREAKTHROUGH VOLUME Cubic meters |
|---|---|---|---|---|---|---|---|---|---|
| **Los Alamos** (USA) | 1973-1979 | 232 | 3500 | ~ 150-300 | ~7 | <10 | 2.5 | ~5 | ~ 80-100 |
| **Rosemanowes** (UK) | 1980-1993 | 80 | 2000 | ~ 180-270 | ~15 | ~25 | 0.4 | ~ 4 | ~ 200-300 |
| **Hijiori** (Japan) | 1985-> | **270** | **2200** | ~ 130 | ~12 | ~25 | 0.3 | ~7 | ~ 50-150 |
| **Soultz** (France) | 1989-1997 | 168 | 3500 | **~ 450** | **~ 26** | **0** | **0.23** | **~ 11** | **~ 7000** |
| Anticipated 2000 + | 1997-> | 202 | 5000 | ~ 600-700 | ~ 100 | 0 | 0.12 | ~ 50 | ~ 20,000 |
| Actual in 2004 | 2004 | 202 | 5000 | **~ 650 -730** | 22 l/s | 0 | 0.29 (2 wells) | ~10 | BTT 4.5 days |

**lower values = Advantageous; low running cost**

**Higher value = Advantageous; bigger resource & longer life**

**Lower value = Advantageous; lower capital investment.**

**Best value achieved to date.**

RB/coparison1xls

ALTA ROCK ENERGY INC

# ADVANCES IN RESERVOIR CREATION

## 1978 FENTON HILL

- MECHANICAL TOOLS AND ONE OFF HT ELECTRONICS FOR PRESSURE TEMPERATURE LOGGING. OTHER LOGGING TOOLS IN DEVELOPMENT
- MICROSEISMIC MONITORING TO MAP FRACTURES – LOCATION METHODS GAVE “CLOUD” OF FRACTURES
- ACCOUSTIC BOREHOLE FRACTURE IMAGING LIMITED AND POOR QUALITY.
- ASSUMED TENSILE FRACTURING SIMILAR TO OIL AND GAS
- HIGH PRESSURE SHORT TERM FRACTURING
- DRILLED TWO WELLS AND ATTEMPTED FRACTURING TO CONNECT THEM
- HIGH PRESSURE INJECTION TO INCREASE FLOW MEANS LARGE WATER LOSSES

## 2008 CURRENT TECHNOLOGY

- HT PRODUCTION LOGGING (PTSγ) UP TO LIMIT OF LOGGING CABLE (340ºc) FOR SURFACE READ-OUT HIGHER FOR SLICK LINE
- HT ULTRASONIC TELEVIEWER TO 250ºc, ADVANCED ANALYSIS METHODS
- MEQ MONITORING WITH ADVANCED LOCATION AND FAULT PLANE SOLUTION
- ASSUME SHEAR FAILURE OF EXISTING MICROFRACTURES
- DRILL AND FRACTURE, MAP FRACTURES AND DRILL INTO THEM INCREASES CONNECTIVITY
- PUMPED PRODUCTION WITH LOW PRESSURE INJECTION INCREASES FLOW RATES WITH VERY LOW WATER LOSS

ALTA ROCK
ENERGY INC

# REALITY CHECK EGS

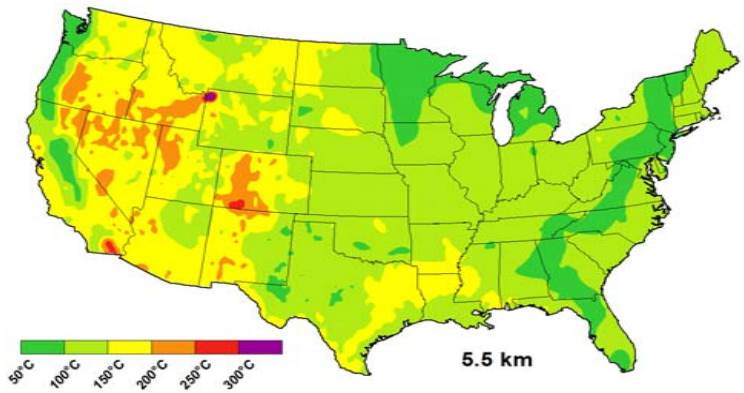
## What would need to happen to make EGS a reality?

- Reduce the cost of power through technology improvement and learning by doing
  - Increase flow rate per producer by improving stimulation methods
  - Reduce drilling cost by reducing number of casing intervals, improving rate of penetration and reducing risk
  - Improve conversion efficiency
- Demonstrate the technology at a number of sites with different geology
- Develop a large scale, ie >250 MW, commercial project with industry

ALTA ROCK ENERGY INC

# REACHING THE GOAL

- To get 1000 MW of EGS power on line we need:
  - 1 well  every months, average 5 MW per well
  - 16 rigs drilling for three years
  - 4 sites with 250 MW potential
  - Start with EGS on edges of hydrothermal systems
  - Move to large areas of uniform hot rock at reasonable depth




ALTA ROCK
ENERGY INC