WILLCOX GREENHOUSE

INTEGRATE GEOTHERMAL TO AUGMENT EXISTING GREENHOUSE HEATING

- Resource Assessment
- Preliminary Engineering
- Economic Analysis

USDOE Funded
Technical Assistance
Contractor
MILLENNIUM ENERGY

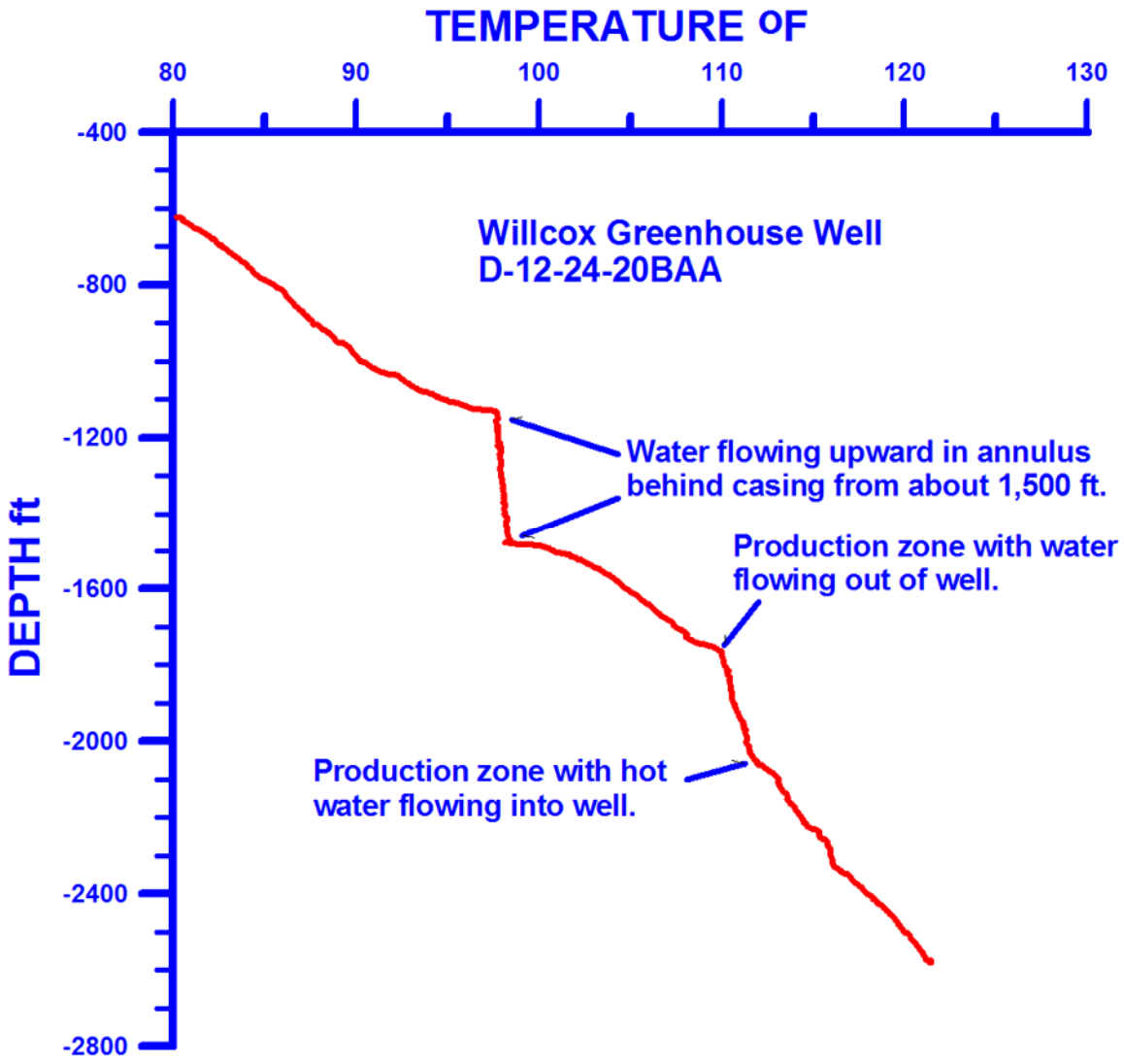
Joe Bourg
Kevin Rafferty
Jack Whittier
Jim Witcher

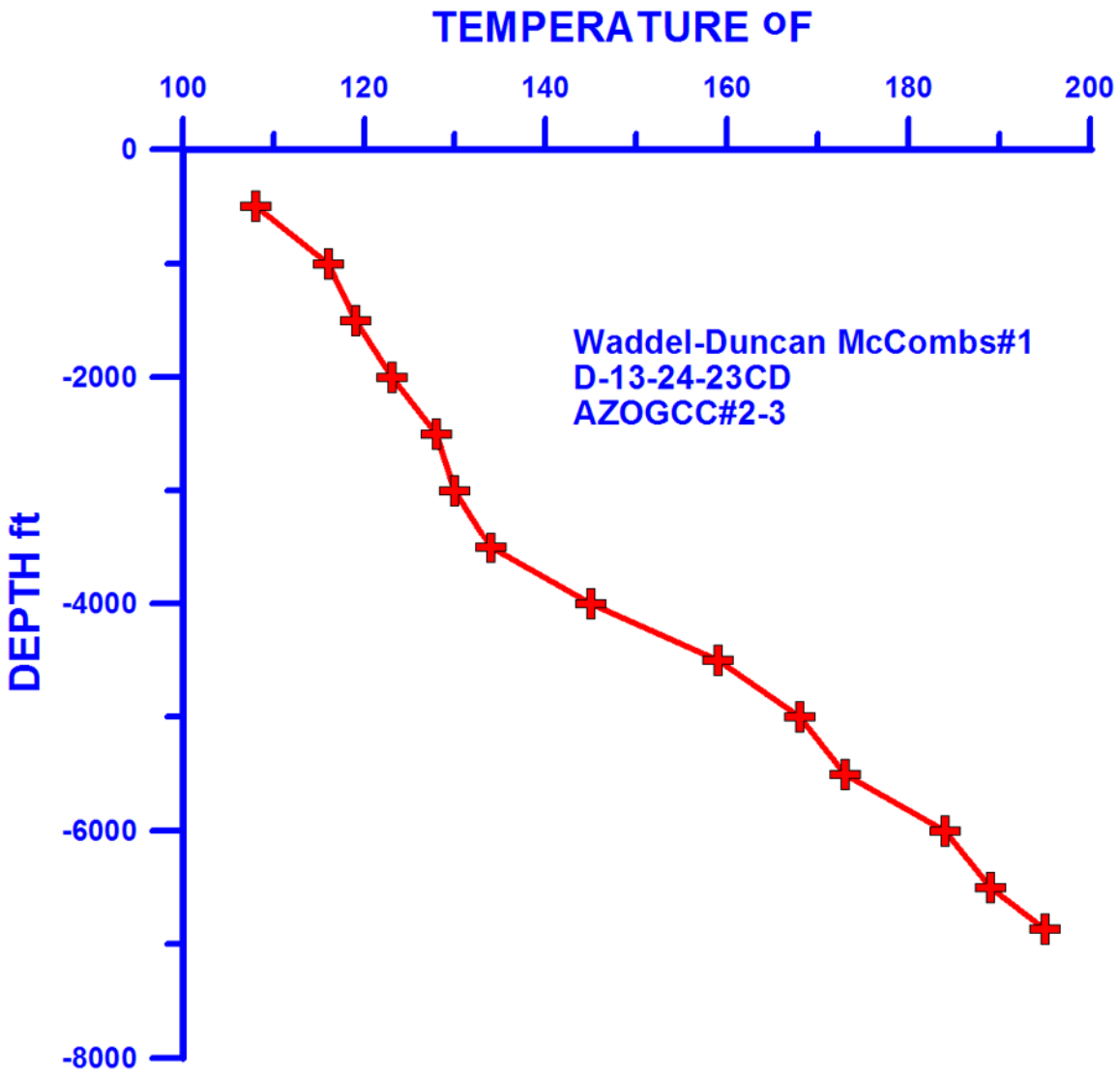
Witcher

WILLCOX GREENHOUSE WELL AND USE OPTIONS

- Depth 2,730 ft
- 257 mg/L TDS
- 1,500 to 1,925 gpm
- 110 to 112 ^{o}F

- Use Existing Well 110 ^{o}F
- Deepen Existing Well to 4,000 ft produce 135 ^{o}F
- Drill New Well to 4,000 ft produce 135 ^{o}F


TEMPERATURE °F
80
90
100
110
120
130
-400
-800
-1200
-1600
-2000
-2400
-2800
DEPTH ft
Willcox Greenhouse Well
D-12-24-20BAA
Water flowing upward in annulus behind casing from about 1,500 ft.
Production zone with water flowing out of well.
Production zone with hot water flowing into well.


TEMPERATURE °F
100
120
140
160
180
200
0
-2000
-4000
-6000
-8000
DEPTH ft
Waddel-Duncan McCombs#1
D-13-24-23CD
AZOGCC#2-3

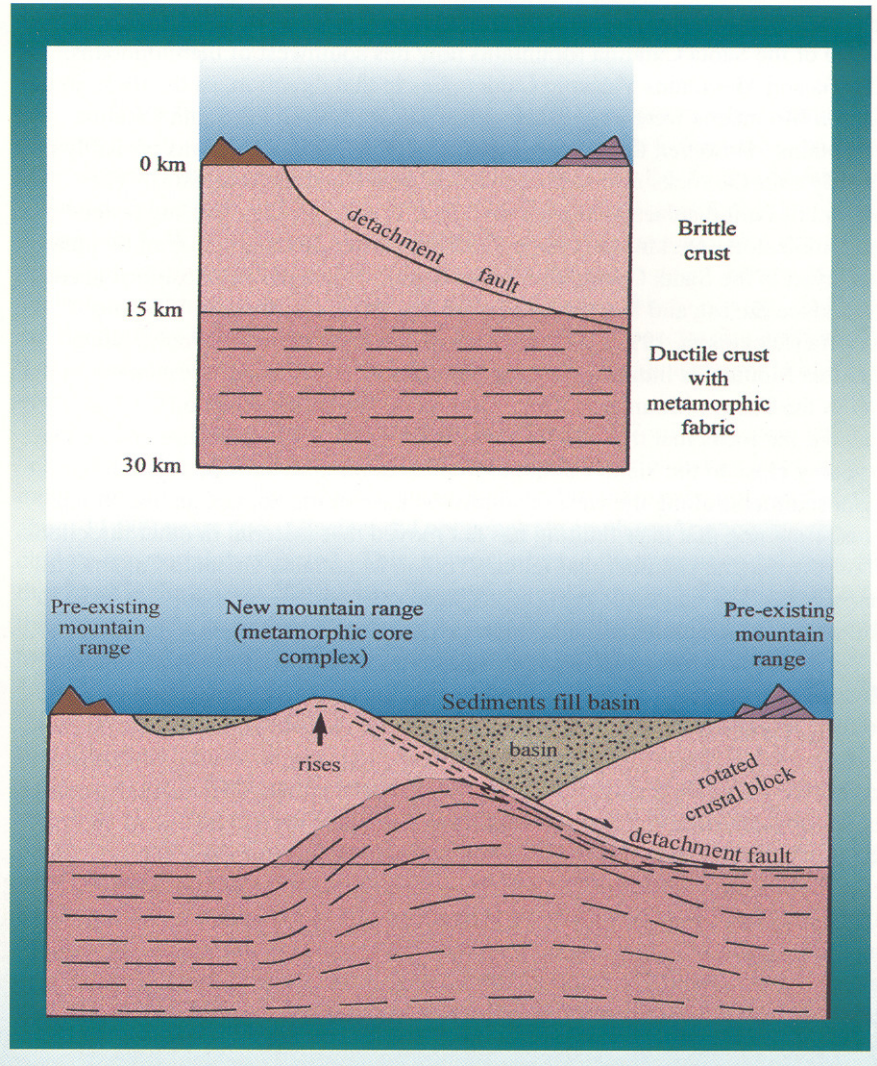
WELL CHEMISTRY AND GEOTHERMOMETRY

Well	Date	Temp	pH	Na	K	Ca	Mg	HCO3	SO4	Cl	F	SiO2	Li	B	TDS
D-12-24-20BAA	8/1/81	44	9.3	97	0.66	2	0.38	88	22	24	3.2	73.8	0.032	0.15	267
D-12-24-20CAA	8/1/81	37	9.1	79	0.68	109	0.4	68.3	30	27	3.1	70.8	0.042	0.14	318

LOCATION	20BAA	20CAA	
GEOTEMPERATURE	°C	°C	REFERENCE
Measured at surface	44	37	Witcher (1982)
Na/K	55.8	64.4	Arnorsson (1988)
Na/K/Ca (4/3)	60.7	60.6	Fournier and Truesdell (1973)
K/Mg	46.4	46.6	Fournier (1991)
Li/Mg	52.7	57.9	Kharaka and Mariner (1989)
Chalcedony	92.6	90.4	Arnorsson and others (1983)
Qrtz	120.9	118.8	Fournier and Rowe (1966)
Calcedony (corrected)	65.7	72	Witcher and Stone (1983)
Qrtz (corrected)	94.3	100.7	Witcher and Stone (1983)

REGIONAL GEOLOGIC SETTING

Pinaleno Metamorphic Core Complex



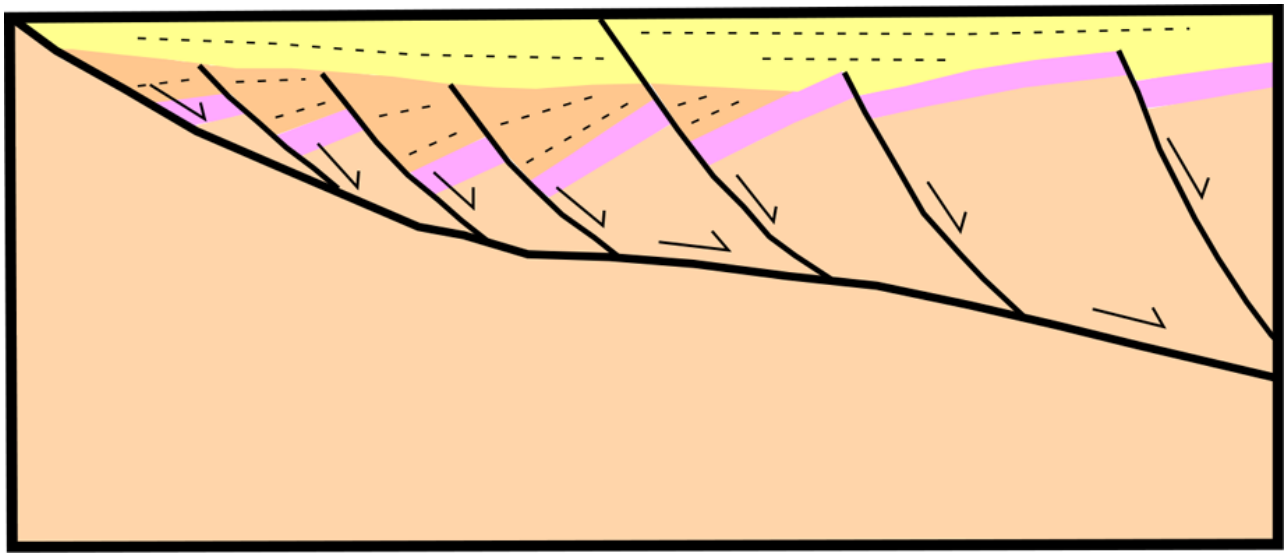
Kring (2002) modified after Kruger and Johnson (1994) and Spencer and Reynolds (1989)

DRILLERS LOG OF WILLCOX GREENHOUSE WELL

DEPTH ft	DESCRIPTION
0-10	top soil
10-400	clay
400-600	streaks sand and clay
600-900	clay
900-1000	sandy clay
1000-1100	clay
1100-1300	boulders
1300-1500	clay
1500-2730	water in rock

SCHEMATIC CROSS SECTION OF NORTHERN WILLCOX BASIN SUBSURFACE SHOWING RESERVOIR TARGETS

Fracture Permeability in Rotated Fault Blocks Above Detachment Fault



SPECIFIC CAPACITY AND TRANSMISSIVITY ESTIMATES

Pumping Drawdown Data/Deep Well Willcox Greenhouse							Razack and Huntley (1991)		Huntley and Steffey (1992		Driscoll (1986)
Bills Pump Service, Willcox				Static water level = 200 ft (5/9/2000)							
date	time	RPM	gpm	PWL ft	Temp °C	spcapity (gpm/ft)	est T (ft^2/d)	est T (gpd/ft)	est T (ft^2/d)	est T (gpd/ft)	est T (gpd/ft)
5/9/2000	10:30 AM	1150	600	251	30	11.8	5,946	44,473	679	5,078	23,529
		1150	600	246	40	13.0	6,371	47,656	765	5,724	26,087
		1150	600	246	41	13.0	6,371	47,656	765	5,724	26,087
		1260	800	270	42	11.4	5,831	43,618	656	4,910	22,857
		1260	800	270	41	11.4	5,831	43,618	656	4,910	22,857
		1260	800	270	41	11.4	5,831	43,618	656	4,910	22,857
		1260	800	270	41	11.4	5,831	43,618	656	4,910	22,857
		1260	800	273	41	11.0	5,670	42,408	625	4,677	21,918
		1260	800	273	41	11.0	5,670	42,408	625	4,677	21,918
		1460	1,000	310	41	9.1	5,002	37,417	503	3,766	18,182
		1460	1,000	310	41	9.1	5,002	37,417	503	3,766	18,182
		1460	1,000	310	41	9.1	5,002	37,417	503	3,766	18,182
		1250	750	260	41	12.5	6,192	46,317	728	5,448	25,000
		1250	750	266	41	11.4	5,809	43,451	652	4,878	22,727
		1250	750	266	41	11.4	5,809	43,451	652	4,878	22,727
		1250	750	266	41	11.4	5,809	43,451	652	4,878	22,727
		1250	750	266	41	11.4	5,809	43,451	652	4,878	22,727
		1250	750	266	41	11.4	5,809	43,451	652	4,878	22,727
5/11/2000	10:30 AM	1250	750	266	41	11.4	5,809	43,451	652	4,878	22,727

APPROACH AND COST TO DEEPEN EXISTING WELL

	DEEPEN EXISTING WELL					
	TASKS AND MATERIALS	*SIZE*	*AMNT*	*UNIT*	*UNIT COST*	*TOTALS*
A.	**MOBILIZATION/DEMOBILIZATION**					
1	MOBILIZATION	n/a	1	job	$30,000.00	$30,000.00
2	DEMOBILIZATION	n/a	1	job	$25,000.00	$25,000.00
B.	**RIG TIME AND DRILLING**					
1	RIG TIME (standby)	n/a	40	hour	$300.00	$12,000.00
2	RIG TIME (WOC)	n/a	48	hour	$300.00	$14,400.00
3	DRILL PRODUCTION HOLE (6/1/4 inch dual tube RC)	6 1/4	1300	feet	$40.00	$52,000.00
C.	**CASING AND TUBING**					
1	PRODUCTION CASING HANGER	5	1	item	$2,125.00	$2,125.00
2	PRODUCTION CASING CENTRALIZERS	7	16	items	$125.00	$2,000.00
3	PERMANENT CASING PACKERS	5	2	items	$5,000.00	$10,000.00
4	PRODUCTION BLANK CASING (5 inch)	5	600	feet	$30.00	$18,000.00
5	PRODUCTION SCREEN (5 inch)	5	700	feet	$40.00	$28,000.00
D.	**WELL SITE EQUIPMENT**					
1	DIVERTER/ROTATING HEAD RENTAL	16	14	days	$2,000.00	$28,000.00
D.	**SUPPLIES AND DRILLING MUD**					
1	REIMBURSEMENT OF AUTHORIZED PURCHASES	n/a	n/a	n/a	n/a	$20,000.00
2	GEOPHYSICAL LOGGING	n/a	n/a	n/a	n/a	$10,000.00
3	GEOLOGIC AND ENGINEERING SERVICES	n/a	n/a	n/a	n/a	$10,000.00
					TOTAL	$261,525.00

MODEL COMPARISONS		**1,300**	**DEPTH (ft)**	**Drilling**
	YR			**Price Index**
INEL polynomial (NM oil and gas)	2003	$192,798	Slim-hole equivalent	145
	2006	$259,281	Price Index Corrected	340
SNL exponential (US geothermal)	2000	$606,945	Large high capacity	120
	2006	$1,112,732	Price Index Corrected	340

WELL DESIGN AND COST FOR A NEW PRODUCTION OR INJECTION WELL

	DEEP PRODUCTION HOLE (high capacity)					
	TASKS AND MATERIALS	*SIZE*	*AMNT*	*UNIT*	*UNIT COST*	*TOTALS*
A.	**MOBILIZATION/DEMOBILIZATION**					
1	MOBILIZATION	n/a	1	job	$150,000.00	$150,000.00
2	DEMOBILIZATION	n/a	1	job	$100,000.00	$100,000.00
B.	**RIG TIME AND DRILLING**					
1	RIG TIME (standby)	n/a	100	hour	$800.00	$80,000.00
2	DRILL CONDUCTOR HOLE (26 inch rotary)	26	20	feet	$250.00	$5,000.00
3	DRILL SURFACE CASING HOLE (17 1/2 inch rotary)	17 1/2	450	feet	$150.00	$67,500.00
4	DRILL INTERMEDATE CASING HOLE (12 1/4 inch rotary	12 1/4	3000	feet	$110.00	$330,000.00
5	DRILL PRODUCTION HOLE (8/1/2 inch rotary)	8 1/2	700	feet	$90.00	$63,000.00
C.	**CASING AND TUBING**					
1	CONDUCTOR CASING (20 inch)	20	20	feet	$80.00	$1,600.00
2	SURFACE CASING (13 3/8 inch)	13 3/8	450	feet	$60.00	$27,000.00
3	SURFACE CASING CENTRALIZERS	13 3/8	6	items	$125.00	$750.00
4	SURFACE CASING FLOAT COLLAR	13 3/8	1	item	$2,000.00	$2,000.00
5	SURFACE CASING FLOAT SHOE	13 3/8	1	item	$700.00	$700.00
6	INTERMEDIATE CASING (9 5/8 inch)	9 5/8	2850	feet	$50.00	$142,500.00
7	PRODUCTION CASING HANGER	9 5/8	1	item	$2,125.00	$2,125.00
8	INTERMEDIATE CASING CENTRALIZERS	9 5/8	36	items	$125.00	$4,500.00
9	INTERMEDIATE CASING FLOAT COLLAR	9 5/8	1	item	$1,250.00	$1,250.00
10	INTERMEDIATE CASING FLOAT SHOE	9 5/8	1	item	$625.00	$625.00
11	PRODUCTION CASING CENTRALIZERS	7	9	items	$125.00	$1,125.00
12	PRODUCTION CASING HANGER	7	1	item	$2,125.00	$2,125.00
13	PRODUCTION BLANK CASING (7 inch)	7	100	feet	$45.00	$4,500.00
14	PRODUCTION SCREEN (7 inch)	7	600	feet	$70.00	$42,000.00
D.	**WELL SITE EQUIPMENT**					
1	DIVERTER/ROTATING HEAD RENTAL	13 3/8	45	days	$2,000.00	$90,000.00
E.	**CEMENT CASING**					
1	CEMENT CONDUCTOR CASING	n/a	1	job	$5,000.00	$5,000.00
2	CEMENT SURFACE CASING	n/a	1	job	$70,000.00	$70,000.00
3	CEMENT INTERMEDIATE CASING	n/a	1	job	$70,000.00	$70,000.00
F.	**SUPPLIES AND DRILLING MUD**					
1	REIMBURSEMENT OF AUTHORIZED PURCHASES	n/a	n/a	n/a	n/a	$40,000.00
2	GEOPHYSICAL LOGGING	n/a	n/a	n/a	n/a	$10,000.00
3	GEOLOGIC AND ENGINEERING SERVICES	n/a	n/a	n/a	n/a	$10,000.00
					TOTAL	$1,323,300.00

MODEL COMPARISONS		**4,000**	**DEPTH (ft)**	**Drilling**
	YR			**Price Index**
INEL polynomial (NM oil and gas)	2003	$414,453	Slim-hole equivalent	145
	2006	$557,368	Price Index Corrected	340
SNL exponential (US geothermal)	2000	$907,785	Large high capacity	120
	2006	$1,664,273	Price Index Corrected	340