OUTLOOK FOR LARGE SCALE CONCENTRATING SOLAR POWER

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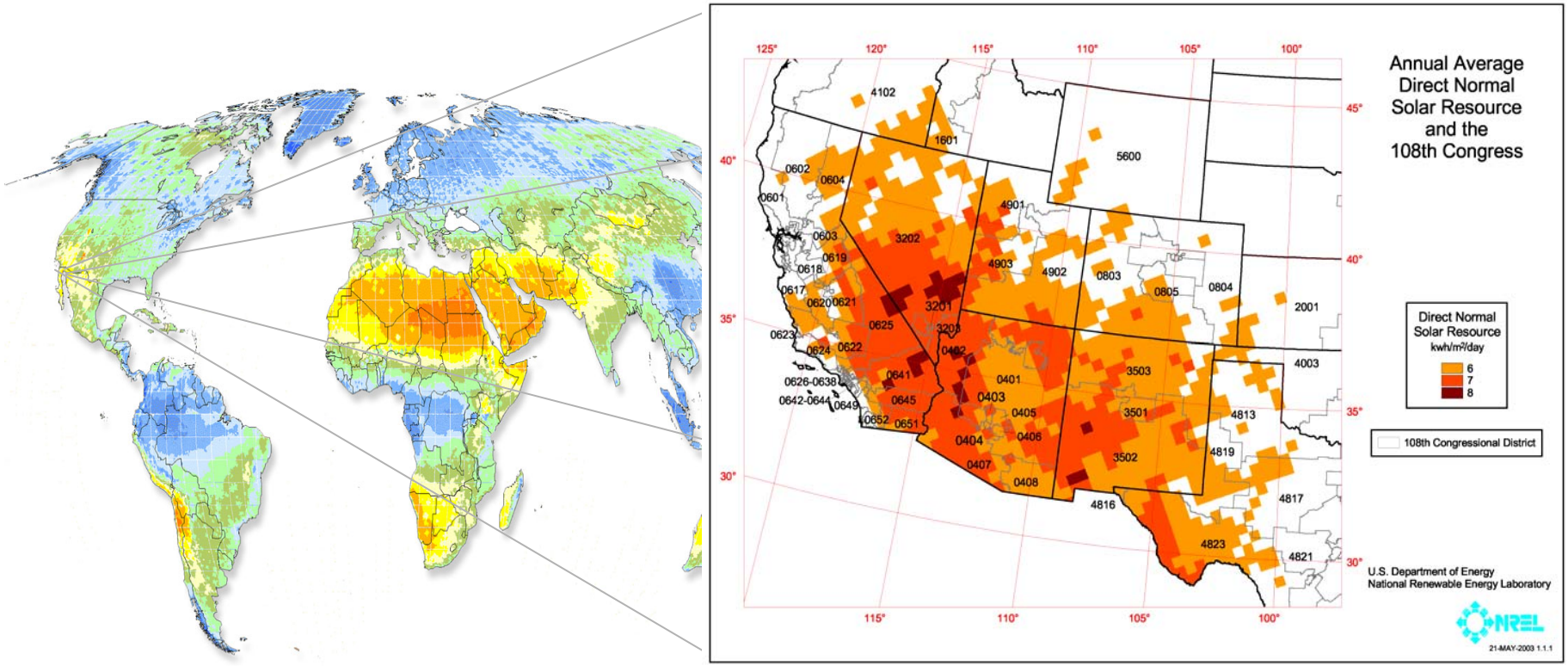
Acknowledgement

The information contained in this presentation was taken from various sources, including NREL, Sandia, DOE and a recent study performed by Black & Veatch for the state of New Mexico.

Southwest Solar Resource

Solar energy resources in the Southwest U.S. are among the finest in the world



How do we develop this resource?

- Concentrating Solar Technologies can be used to “mine” this resource.
- Some of these technologies use curved mirrors to focus the sun’s rays and to make steam, others directly produce electricity.
- This steam is used to produce electricity via conventional power equipment.
- In multi-Megawatt plants, CSP provides the lowest cost solar electricity.
- Can provide bulk and/or distributed generation.

CSP Options for Large-Scale Power

CSP Characteristics

Distributed Power

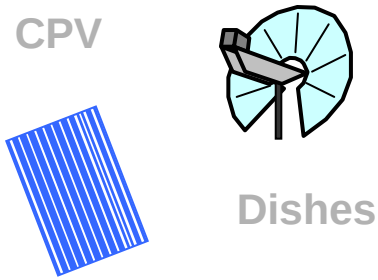
(kW's to MW's)

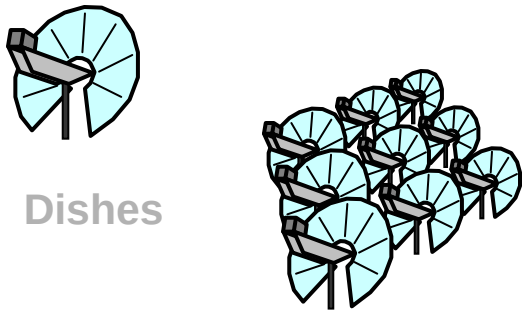
- on-grid (e.g., line support)
- stand-alone, off-grid

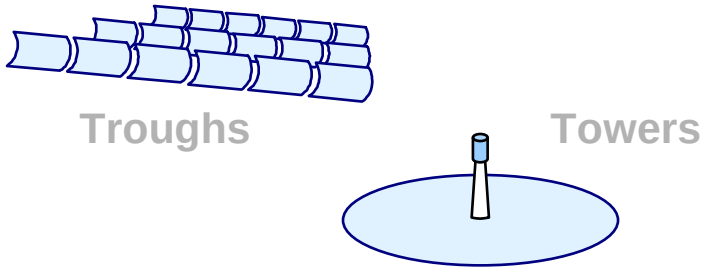
Dispatchable Power

(50s to 100s of MW's)

- Utility-scale intermediate power
- "Peaking" power where appropriate







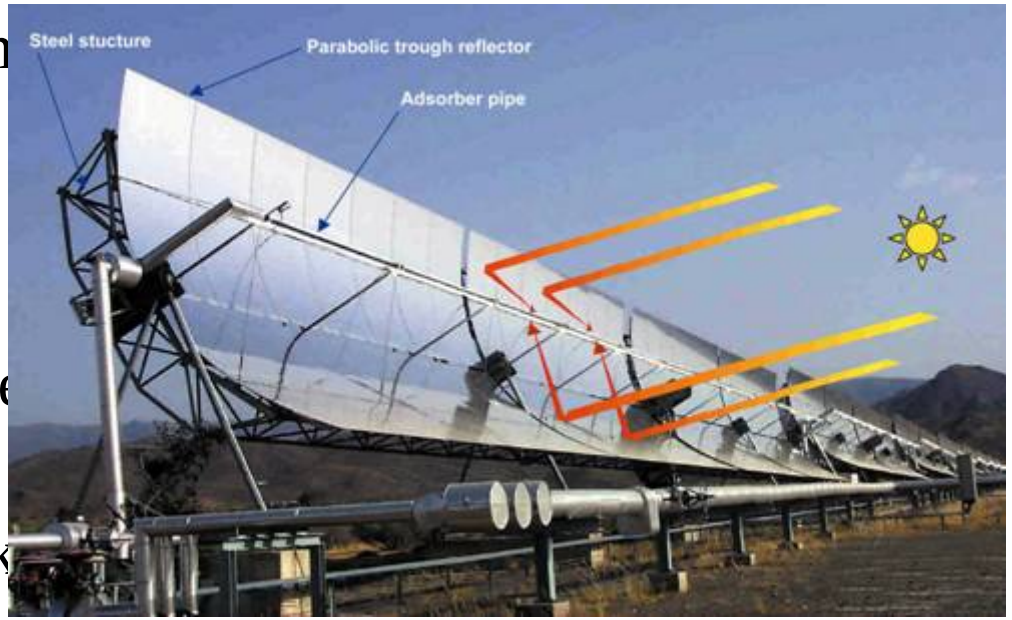
Dispatchability of Electricity : **Through storage or hybridization**

Conventional technology : **Generally, made of glass, steel, gears, turbines, etc. allows rapid manufacturing scale-up, low risk**

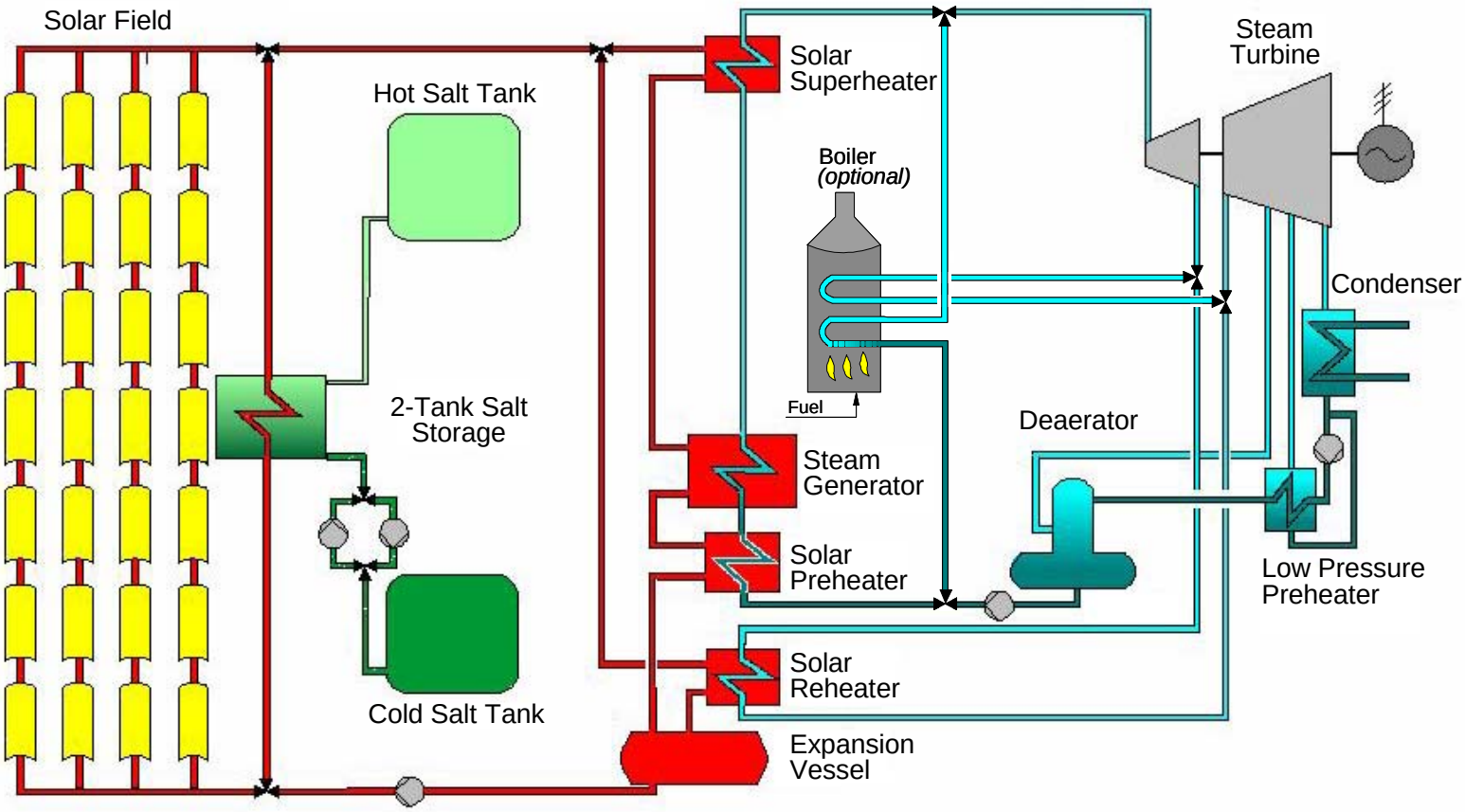
Unique solar components **: Will be identified during the presentation**

Trough Technology

- Trough Collectors (single axis tracking)
- Heat-Collection Elements
- Heat-transfer oil (Therminol VP1)
- Oil-to-water Steam Generator
- Oil-to-salt Thermal Storage
- Conventional steam-Rankine cycle power block



Schematic of Typical Trough Plant



Trough Components

Drive

Controller

Trough Collector

Receiver

Molten Salt Storage Tanks

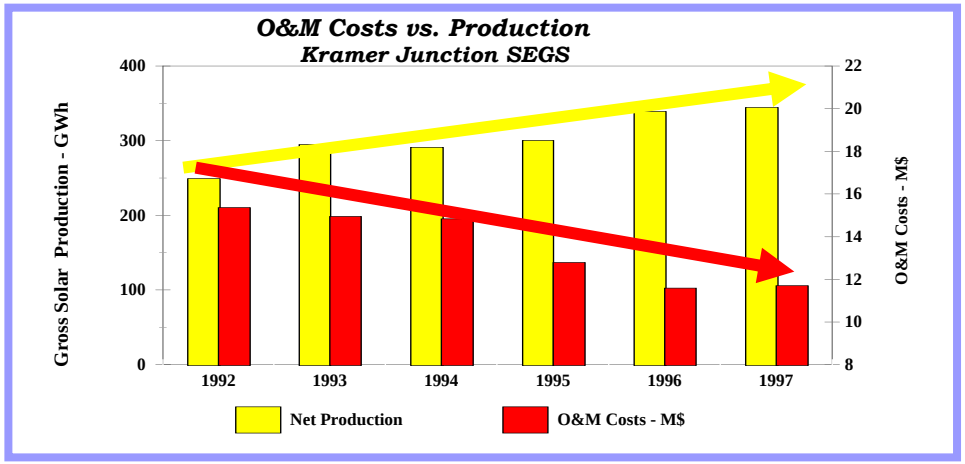
Picture from PT Solar Two

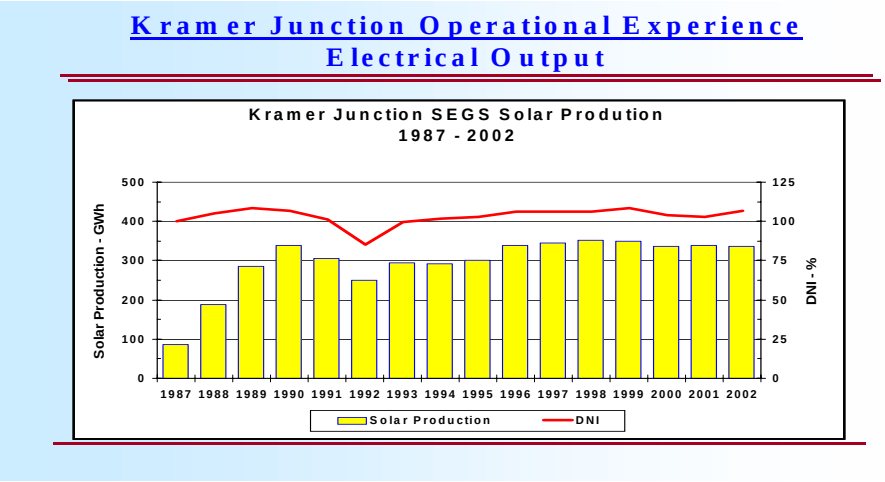
Status of Trough SEGS Plants

- **354+ MW operating in Mojave Desert since 1985**
- **Total reflective area > 2.3 10^6 m^2**
- **More than 117,000 receivers**
- **30 – 80 MW turbine rating**
- **Generation > 650 GWh annually**

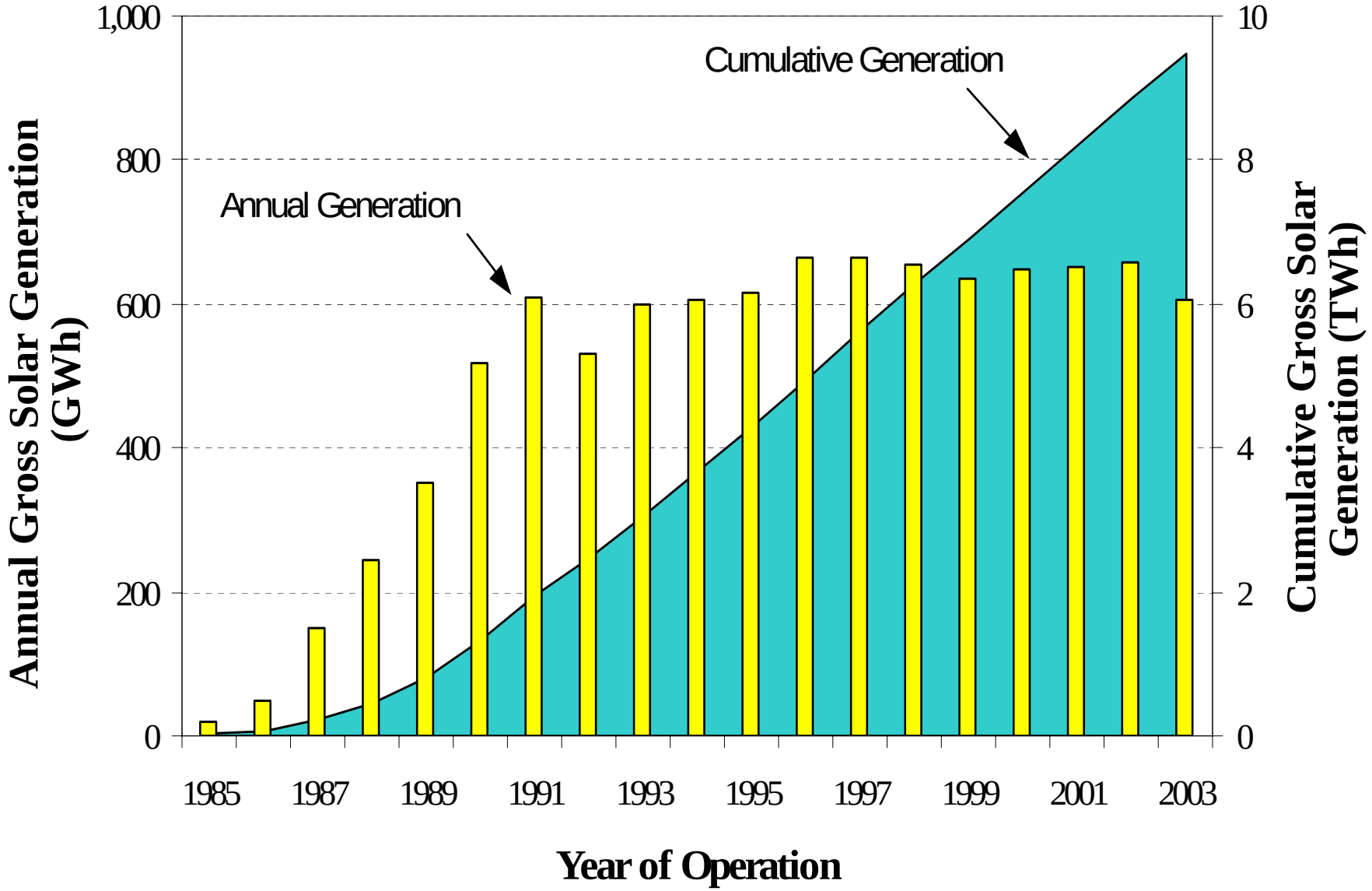
Near Edwards AF Base in Mojave Desert, California

SEGS Plant Experience (KJ)

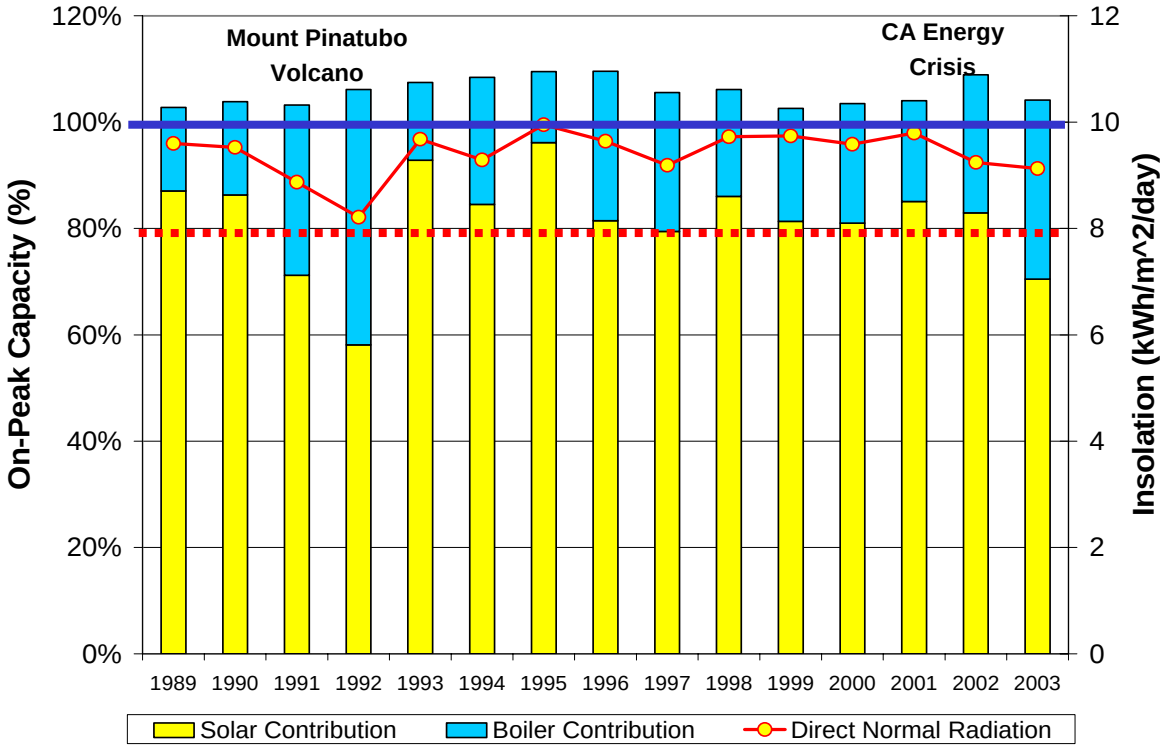




- O&M costs have dropped sharply over time, coincident with performance gains.
- Component reliability has been good, but not excellent. Field experience has improved lifetimes of mirrors and receivers. New models of receivers from both suppliers perform better with evidence of significantly reduced failure rates.
- These plants, placed in operation from 1987 through 1989, set many performance records over the last 5 years.
- Using 25% energy input from natural gas via a supplemental boiler, capacity factors during SCE on-peak operation have exceeded 100% for over a decade (with >85% from solar operation).


Annual Gross Solar Generation (GWh)
Cumulative Gross Solar Generation (TWh)
Year of Operation
Annual Generation
Cumulative Generation
1,000
800
600
400
200
0
10
8
6
4
2
0
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003

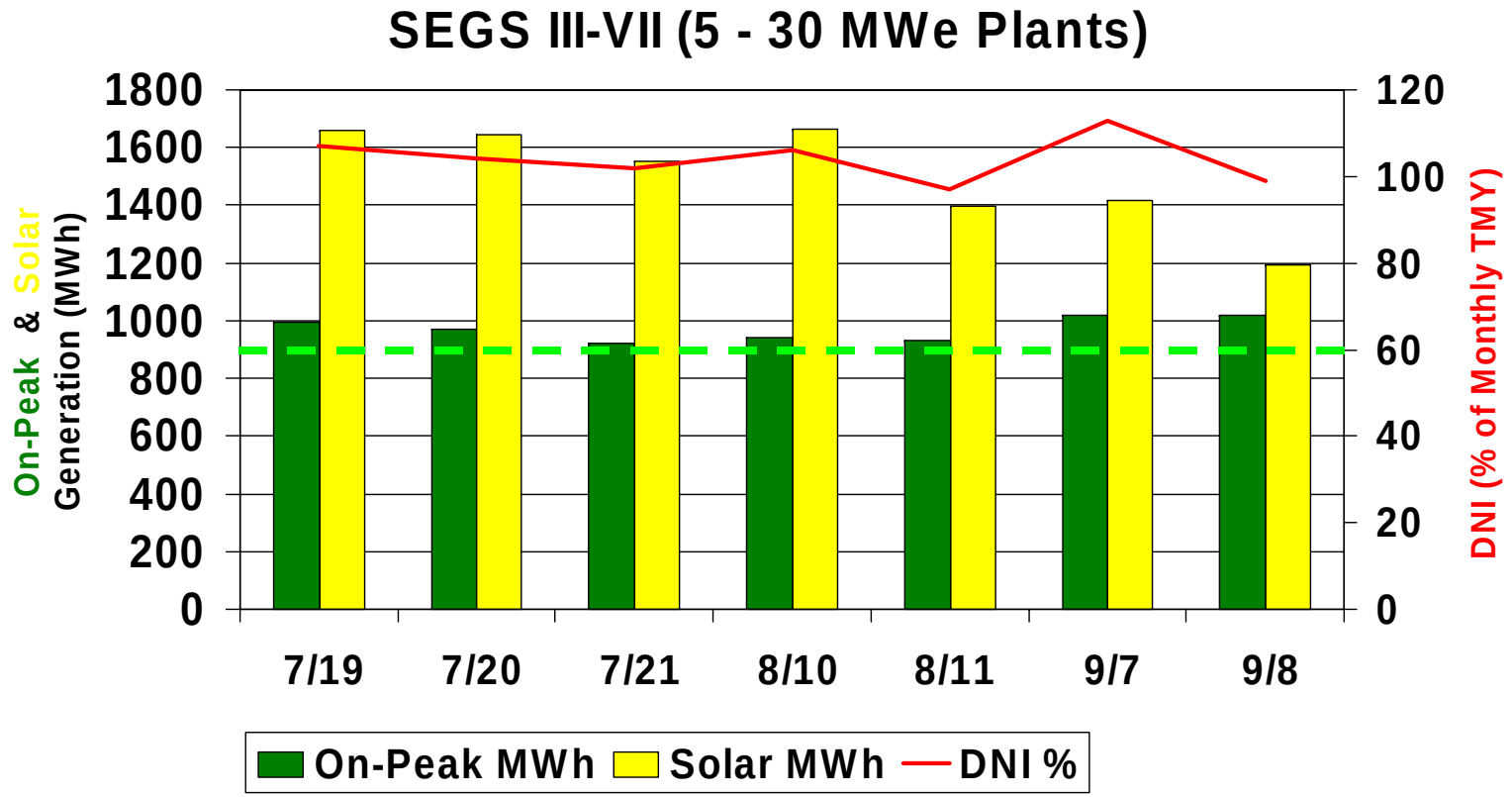
CSP Has Worked for California



- **Averaged 80% on-peak capacity factor from solar**
- **Over 100% with fossil backup**
- **Could approach 100% from solar with the addition of thermal energy storage.**

SCE Summer On-Peak
Weekdays: Jun - Sep
12 noon - 6 pm

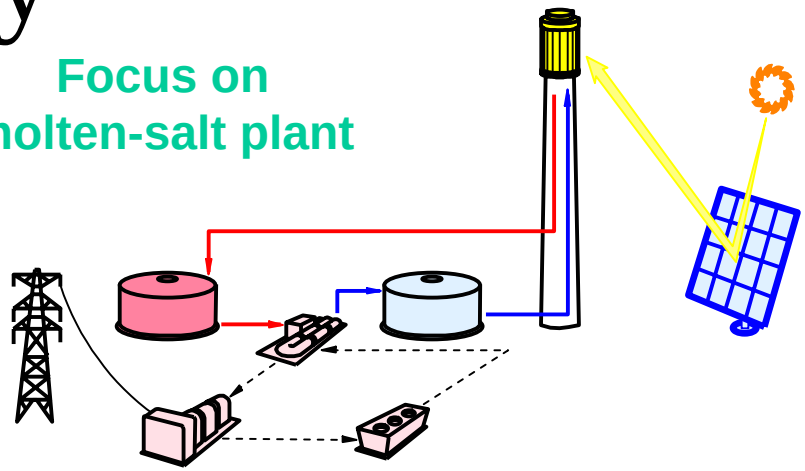
California 2004 New Peak System Loads

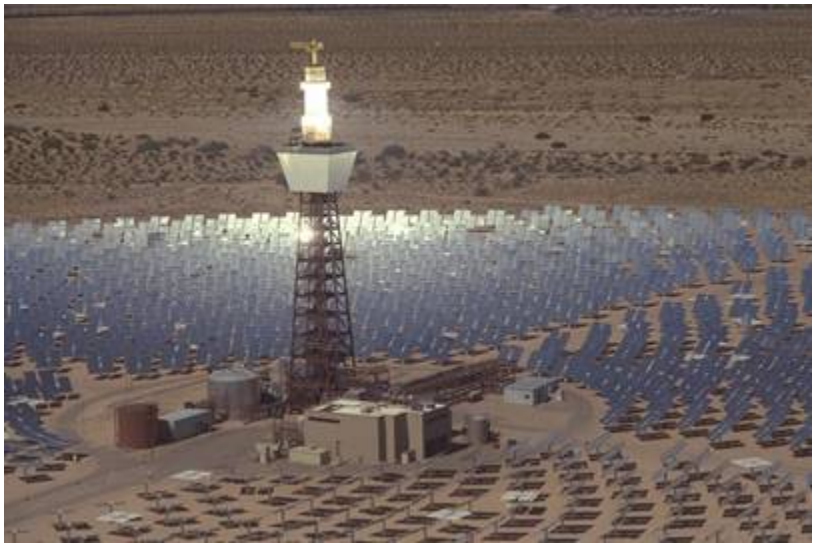


Power Tower Technology

- Heliostats (two-axis tracking)
- Air or Molten-Salt Receiver
- Air or Molten-Salt Working Fluid
- Thermal Storage
- Conventional steam- Rankine cycle power block, or Combustion Turbine

Focus on molten-salt plant





Dish Stirling Technology

- Dish (two-axis tracking)
- 10 and 25 kW Stirling Engines
- Thermal receivers
- Distributed generation or bulk power
- 8 different system configurations built and tested over the last 20 years

Concentrating PV Technology

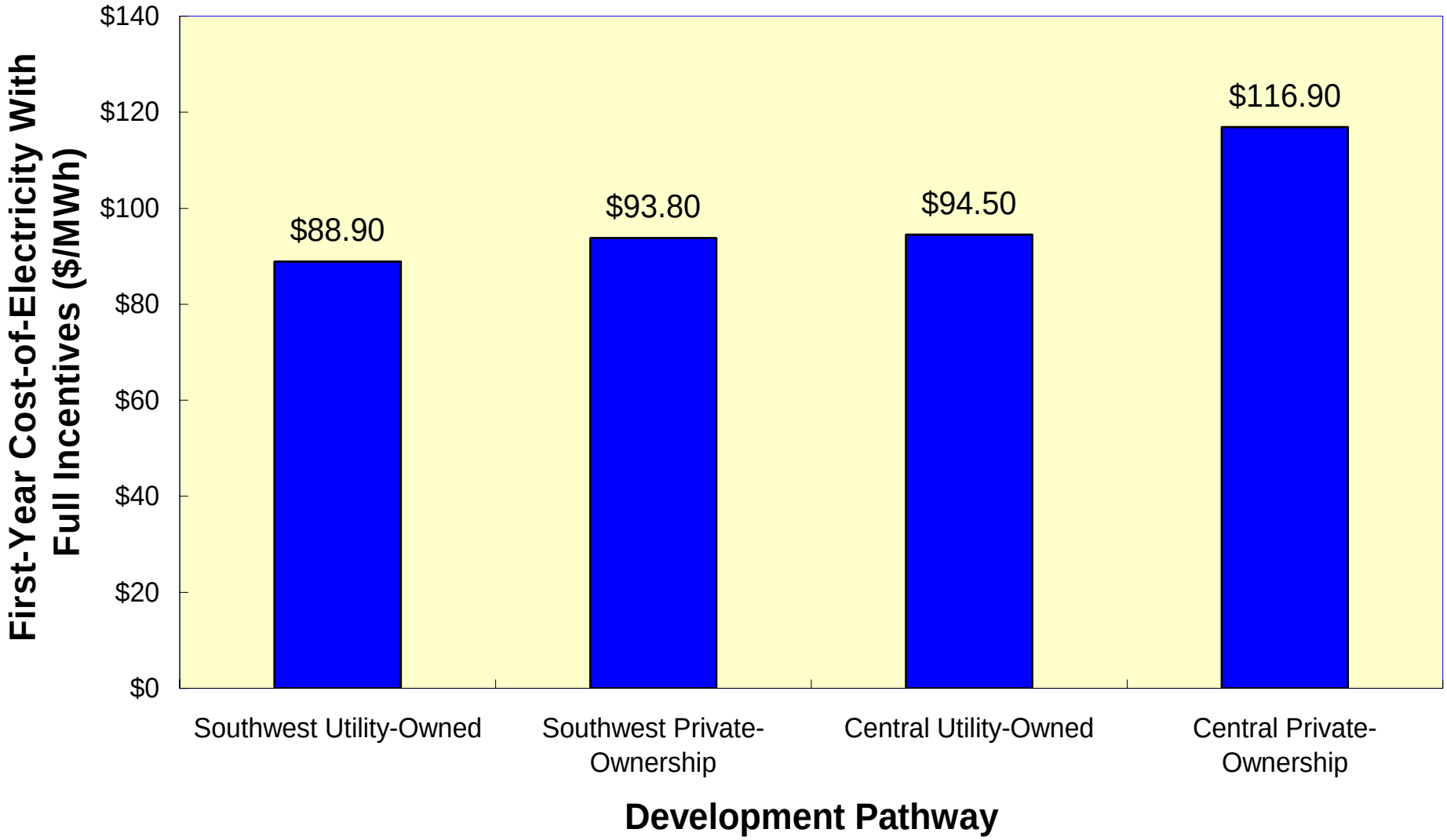
- 25- 35 kW CPV Systems
- Two axis tracking structure
- 350 m^2 concentrator
- 3M Acrylic lens concentrator at 250X or parabolic dish with PV at focal point
- Silicon solar cells

Cost of Electricity

The four most promising scenarios and the cost of electricity based on the full set of subsidies are:

1. Utility owned CSP plant in SW NM –8.9 cents/kWh
2. Private owned CSP plant in SW NM – 9.4 cents/kWh
3. Utility owned in Central NM – 9.5 cents/kWh
4. Private owned in Central NM – 11.7 cents/kWh

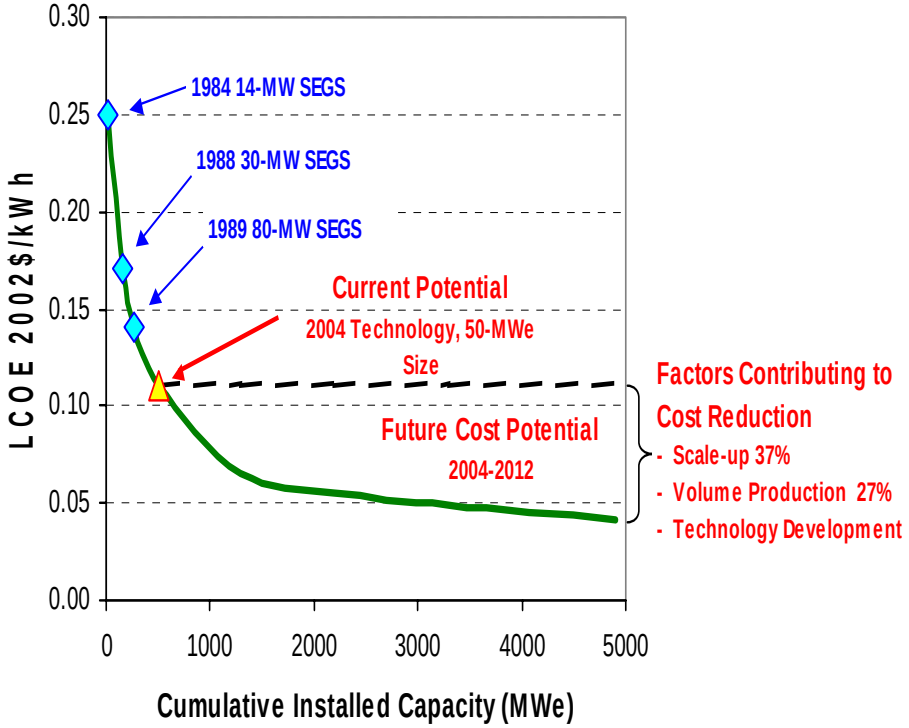
Fig. 3 CSP Development Pathways
Cost-of-Electricity Estimates ($/MWh)



Sargent &Lundy Due Diligence

- The cost of solar power comes down over time.

- Cost Reduction comes from
  - **Plant Scale Up**
  - **Technology Development**
  - **Volume Production**



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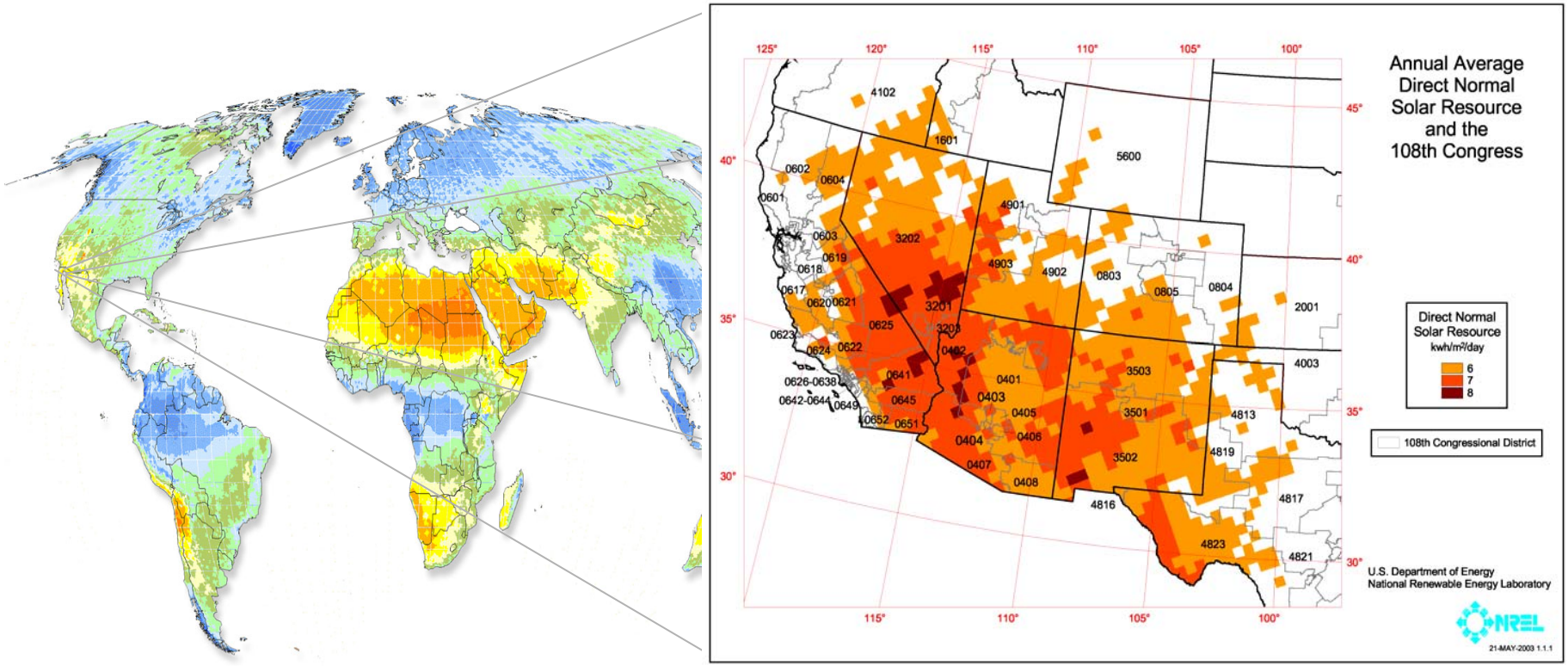


Task 2 Results

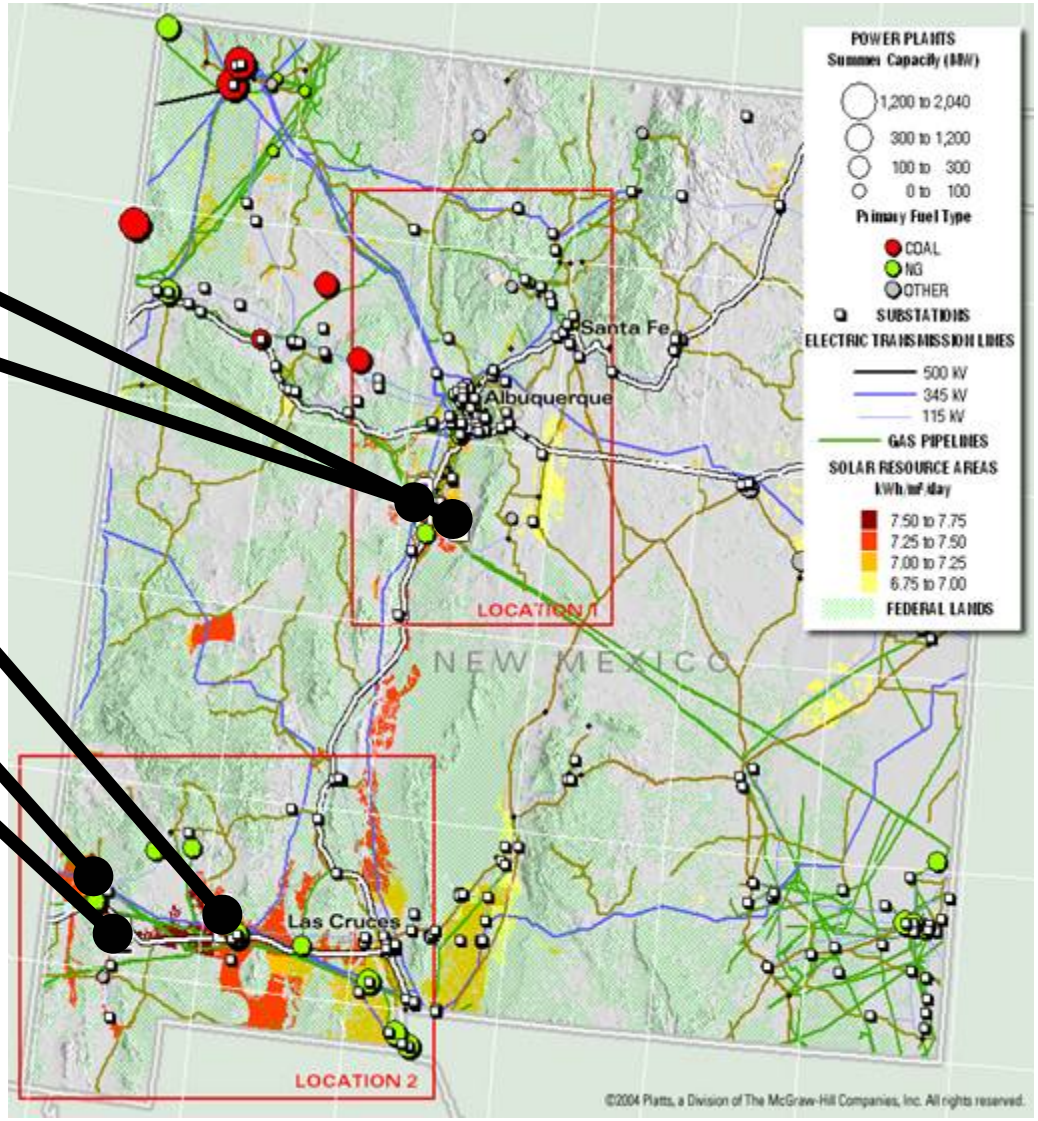
Site Options

Location 1: Central

7. 10 Miles SE of Belen
5. 2 Miles West of Belen

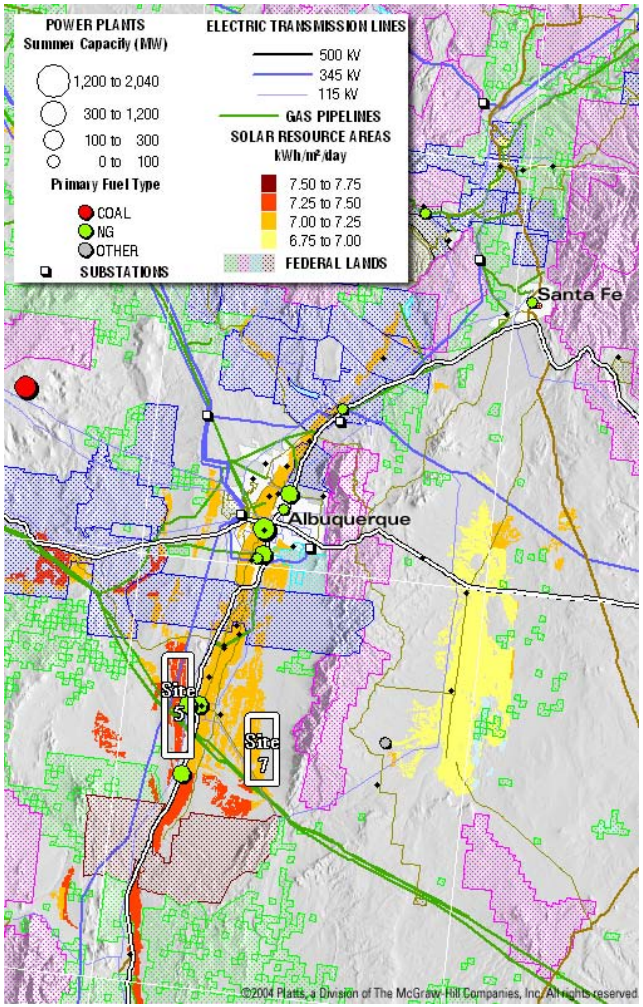
Location 2: Southwest

1. Immediately NW of Deming
3. Immediately NE of Lordsburg
2. 12 Miles SE of Lordsburg

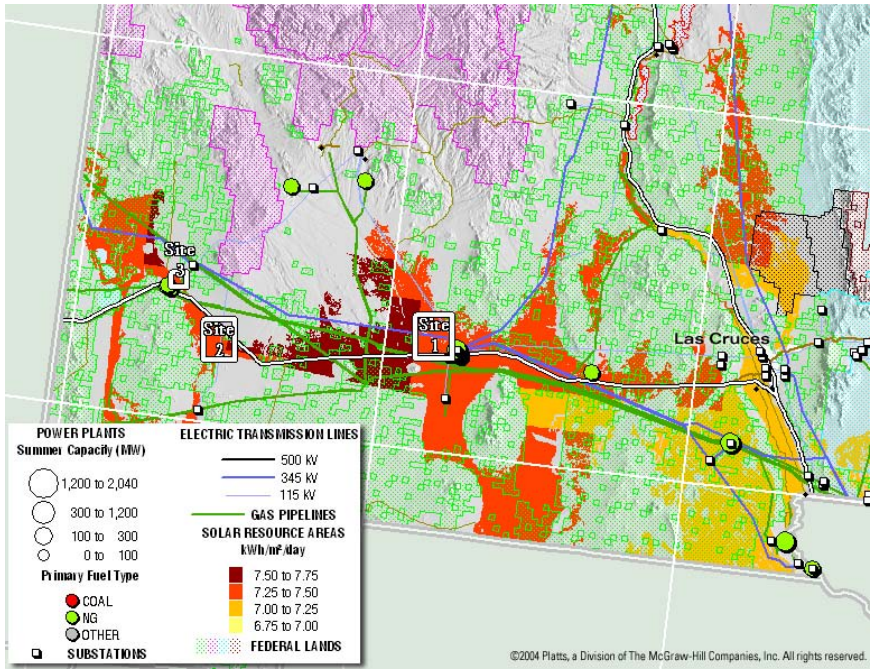


Initial Map Refinement

Location 1

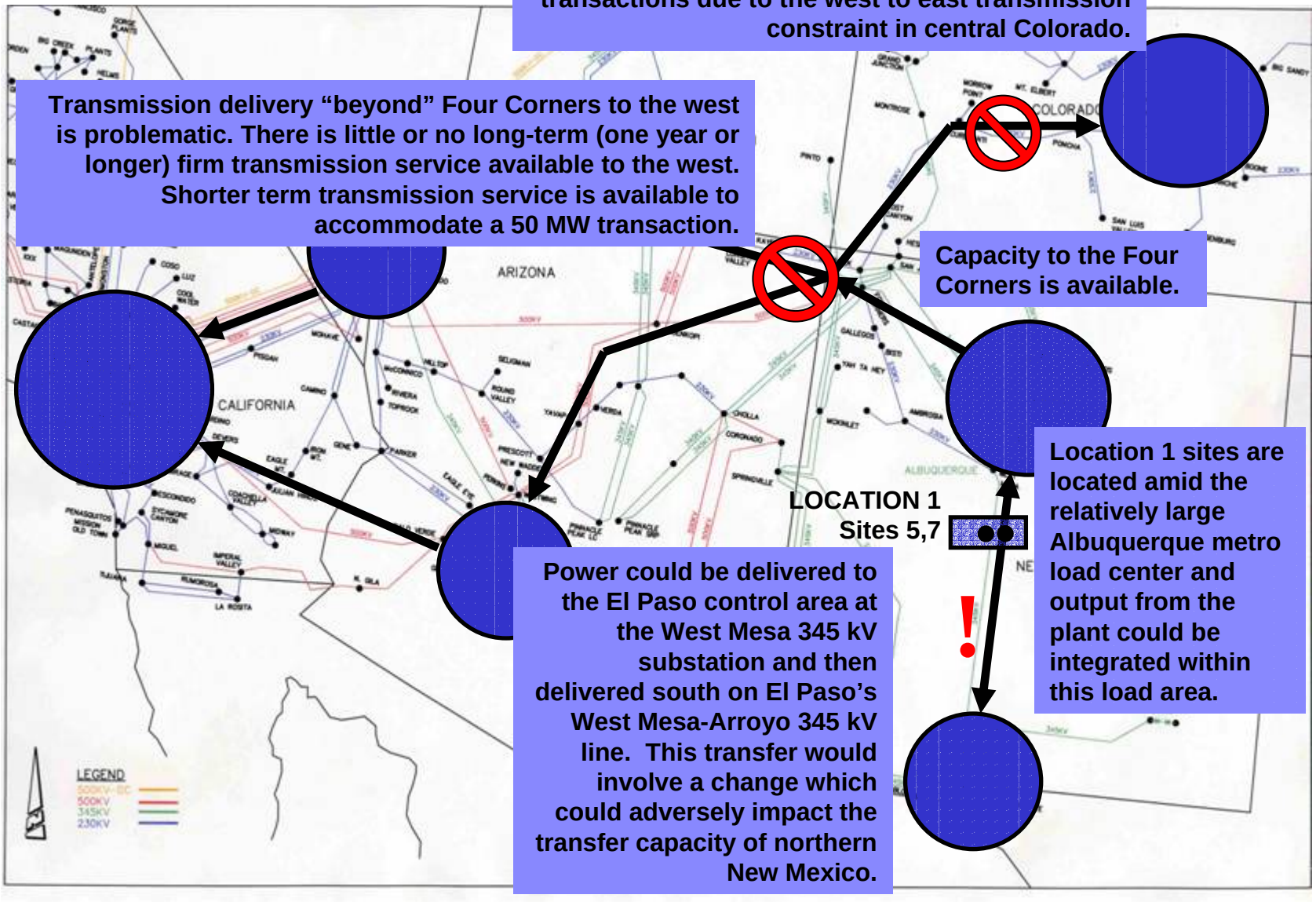


Location 2



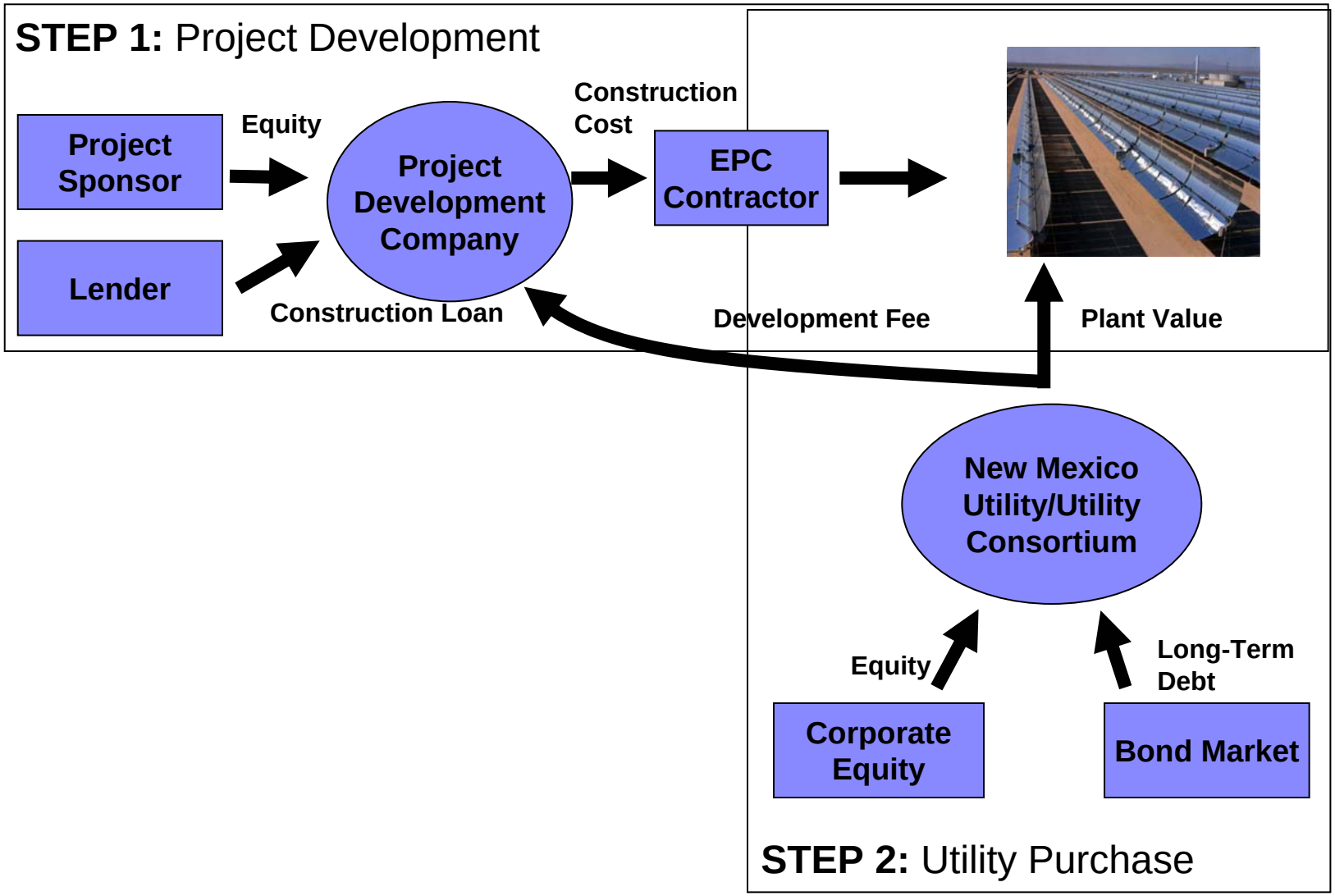
Task 4 Results

Market Access

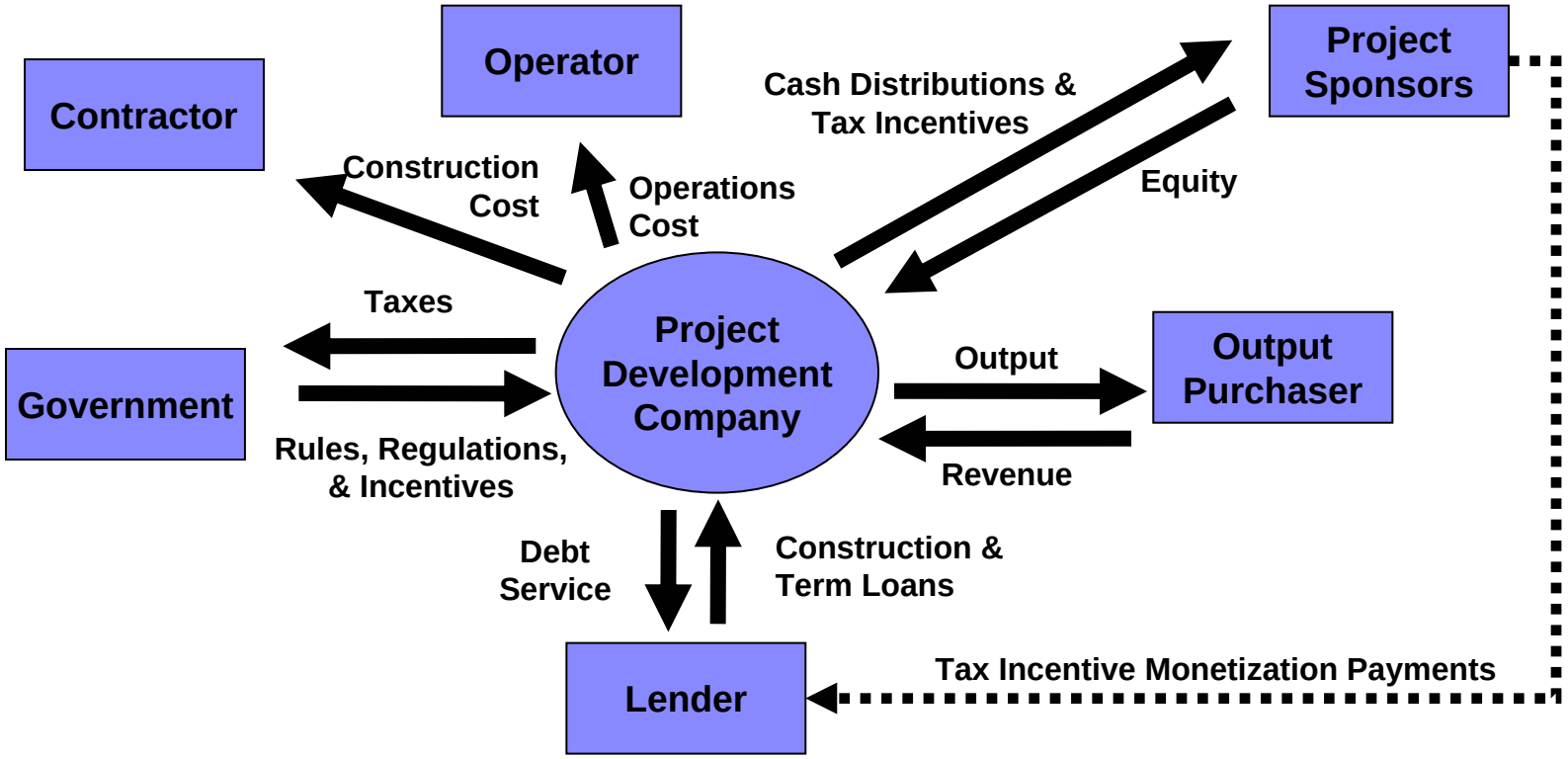


Task 5 Results

Development Options: Utility Purchase

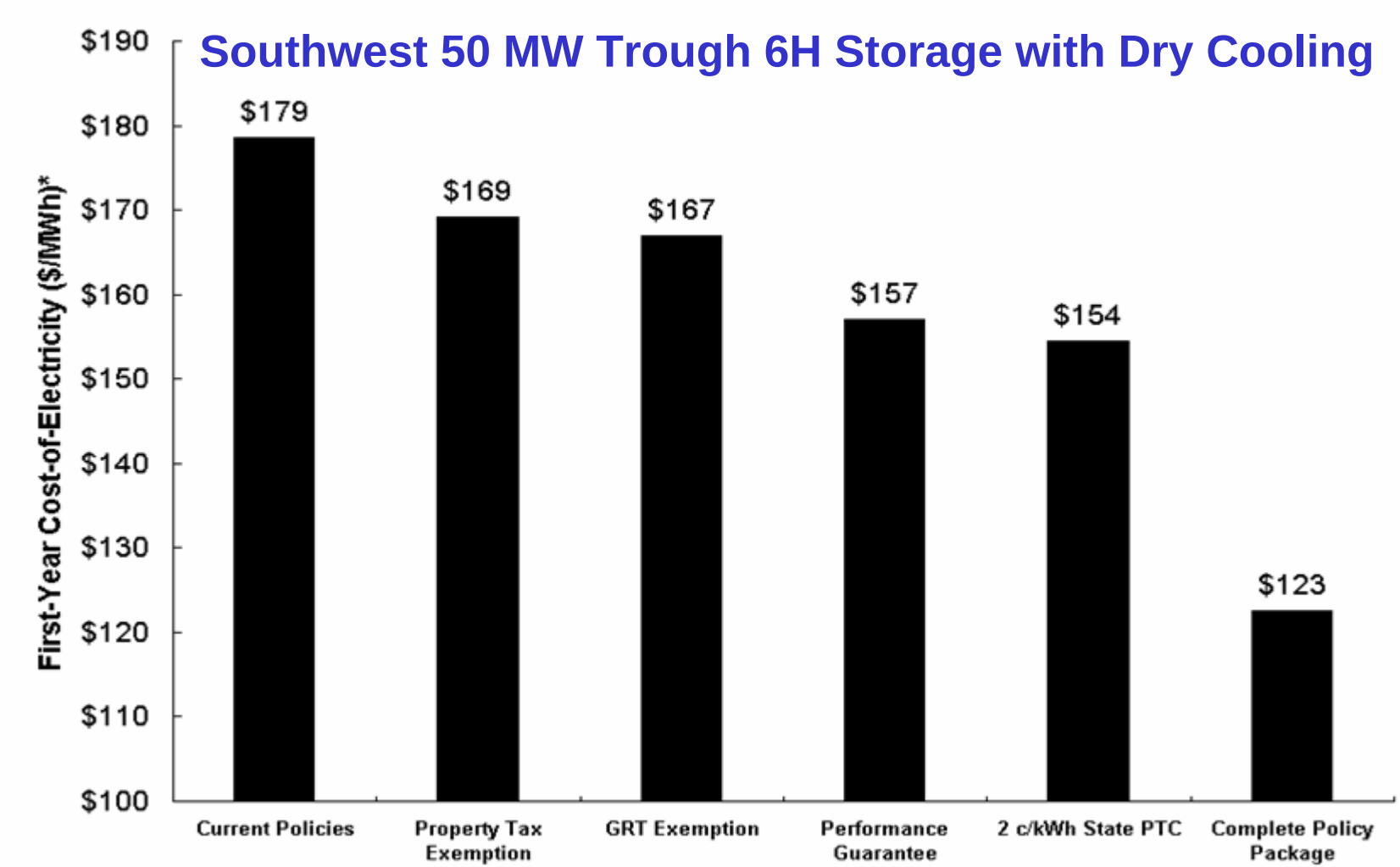


Task 5 Results
Development Options: Private Ownership



Task 3 Results

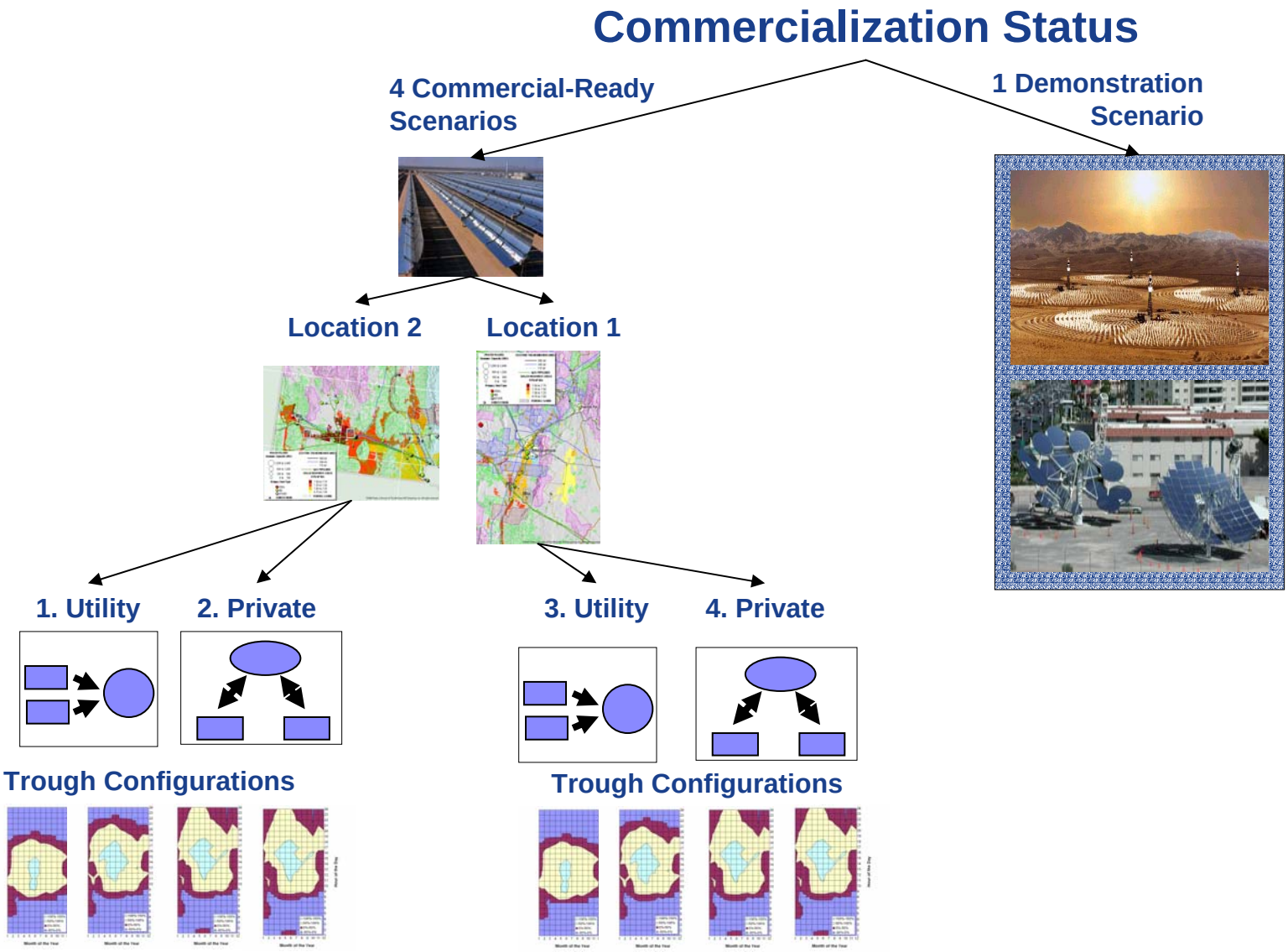
Incentive Options



*Cost-of-Electricity (COE) is assumed to escalate annually at 2 percent. These figures assume a 50:50 debt-to-equity capital structure, commercial bank 14-year debt at 6.2% and an equity hurdle rate of 15%.

Task 7

Development Scenario Approach



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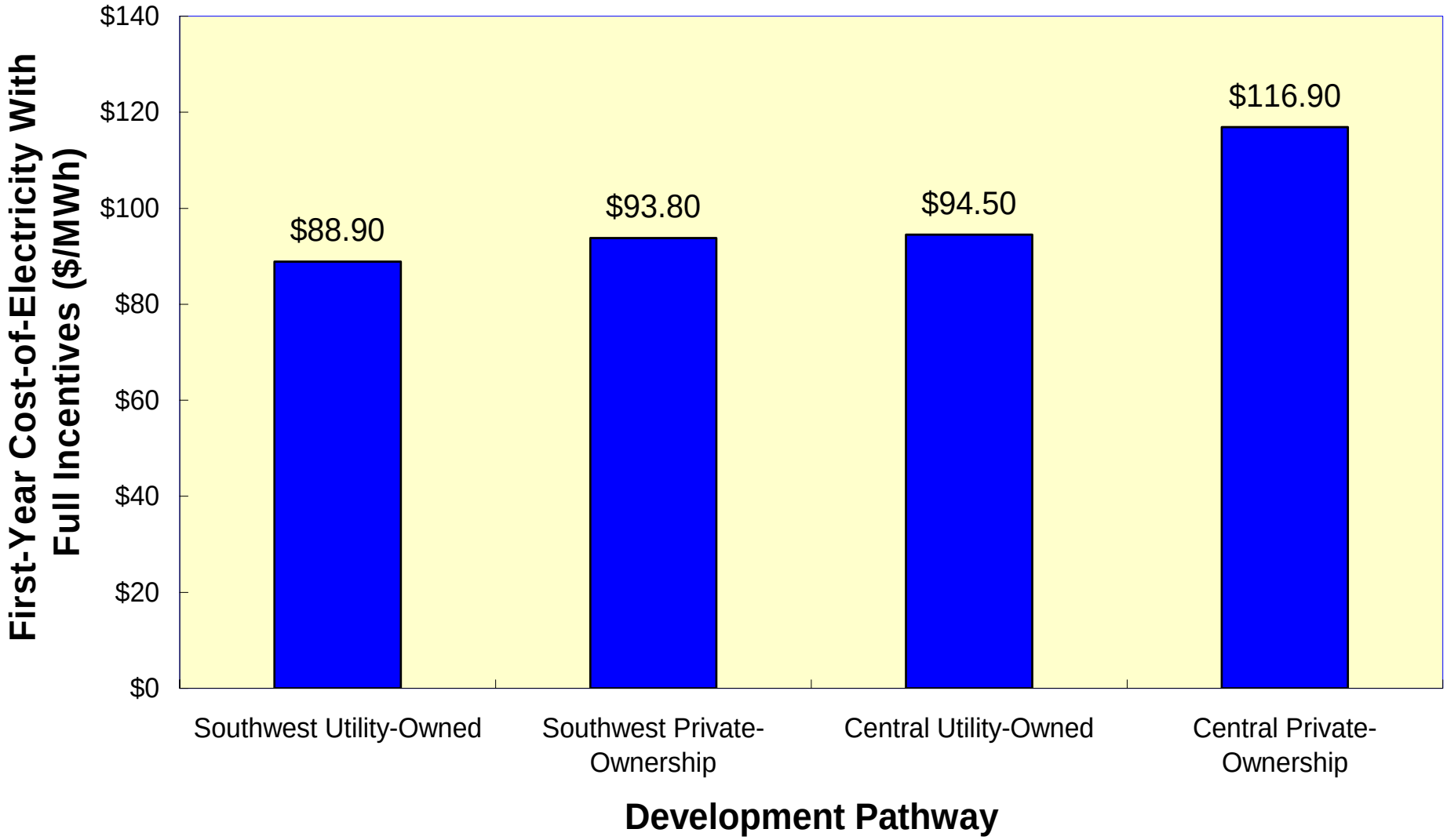

Economic Benefits

- **The Bureau of Business and Economic Research (BBER) of the University of New Mexico studied the economic impact on the state of building a single 50 MW CSP plant, a single 100 MW CSP plant, or five 100 MW CSP plants in 10 years.**
- **If a 50 MW CSP plant were to be built in New Mexico, the state's net tax revenue would increase by $104 million over the 30 year life of the plant.**
- **In addition, the state's economy would gain almost $500 million and about 1,000 temporary construction jobs and 74 permanent jobs would be created.**
- **If the state were to provide the full set of state incentives, the cost to the state's treasury would be about $33 million, leaving a net $70 million.**

Planned Trough Deployments

- Contracted **Deployments**
  - 50 MW Rankine cycle, Solargenix, Nevada
  - 1 MW ORC , Solargenix, Arizona
  - 2 x 50 MW, 6 hrs storage, Solar Millennium, Spain
- Proposed/planned **Deployments**
  - Spain - 8 x 50 MW, 6 hrs storage
  - India; Egypt; Morocco; Mexico GEF Projects – ISCCS
  - Algeria – 140 MW ISCCS
  - Israel - 500 MW
- California RPS Activity
  - At least two trough system developers actively submitting proposals on selective basis – generally at 100 MW capacity

Western Governor's Association

1000 MW CSP Initiative

- Included in the 30 GW Clean Energy Initiative
- Utility consortium under review
- Regulatory issues to be resolved – cost recovery and qualifying out-of-state generation under the RPS