



U.S. Department of Energy
Energy Efficiency and Renewable Energy

Parabolic Trough 2007 Workshop

Welcome to NREL

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U.S. Department of Energy
Energy Efficiency and Renewable Energy

Meeting Objectives

- Provide a forum for information exchange on parabolic trough technology, markets, and related topics of interest.
- Provide an opportunity for the R&D laboratories to get feedback from industry on R&D activities.
 - DOE looking to understand how to better support current and future CSP developments



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Housekeeping

- Introduction of support team
- Please sign-in
- Location of restrooms
- Phone/Internet access
- Meals & breaks
- Presentations/TroughNet
- Foreign National Data Cards
- Laboratory Tours
- You're at altitude, drink lots of water!



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Agenda Review

- Markets
- Resource Assessment
- Current Technology Overview
 - Parabolic Trough
 - Thermal Energy Storage
 - Power Cycle
- Advanced Technologies
 - Molten-Salt
 - Direct Steam Generation
- Laboratory capabilities and R&D



Introductions

- Introduce self, description of products/services
- By business type & organization
- Order
 - Laboratory/DOE
 - Universities
 - Utilities
 - SEGS O&M Companies
 - Trough Technology Providers
 - Engineering
 - Developers
 - Financial
 - Other



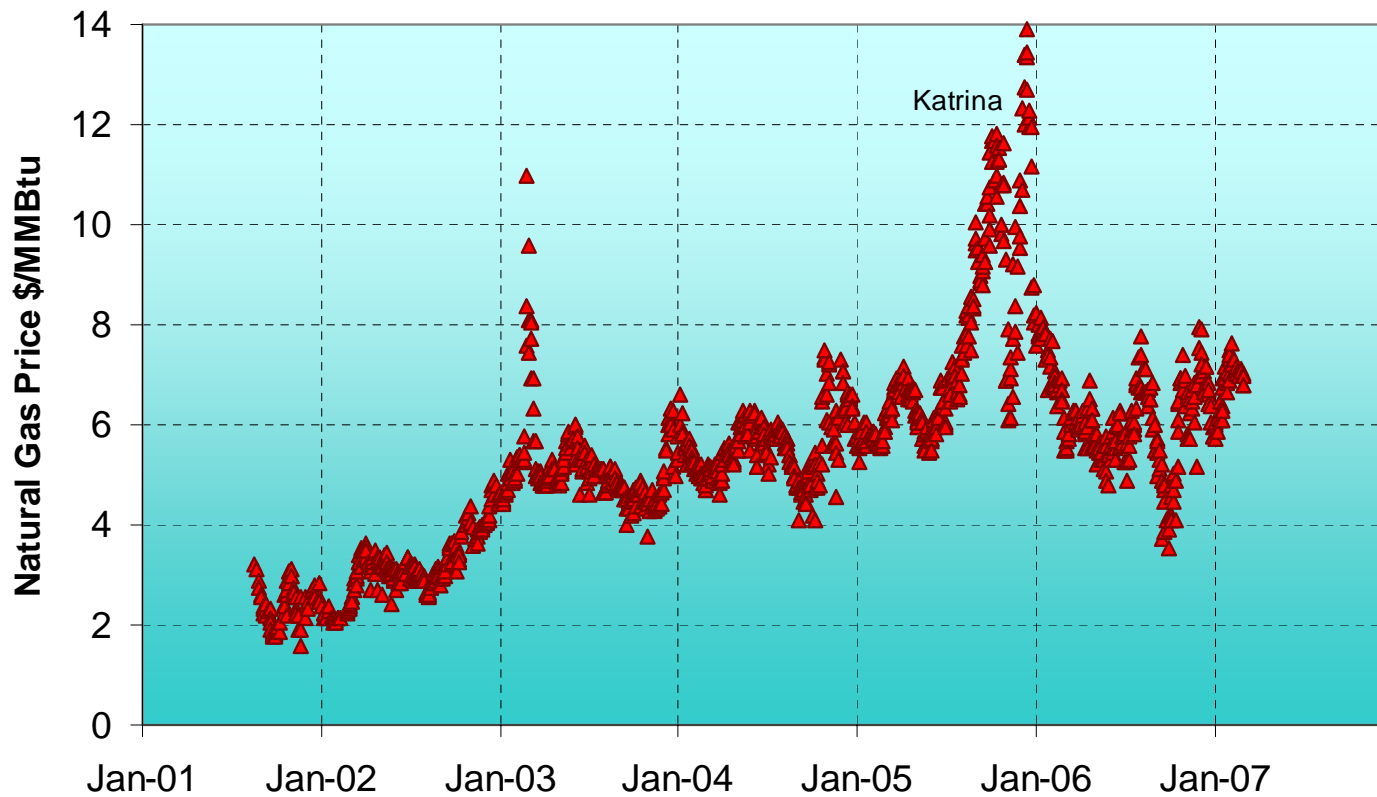
Setting the Stage

COLLECTORS, HARPER LAKE, CALIFORNIA



Natural Gas Prices

Historical data for SoCal Border
from 01/01/2001 to 03/03/2007



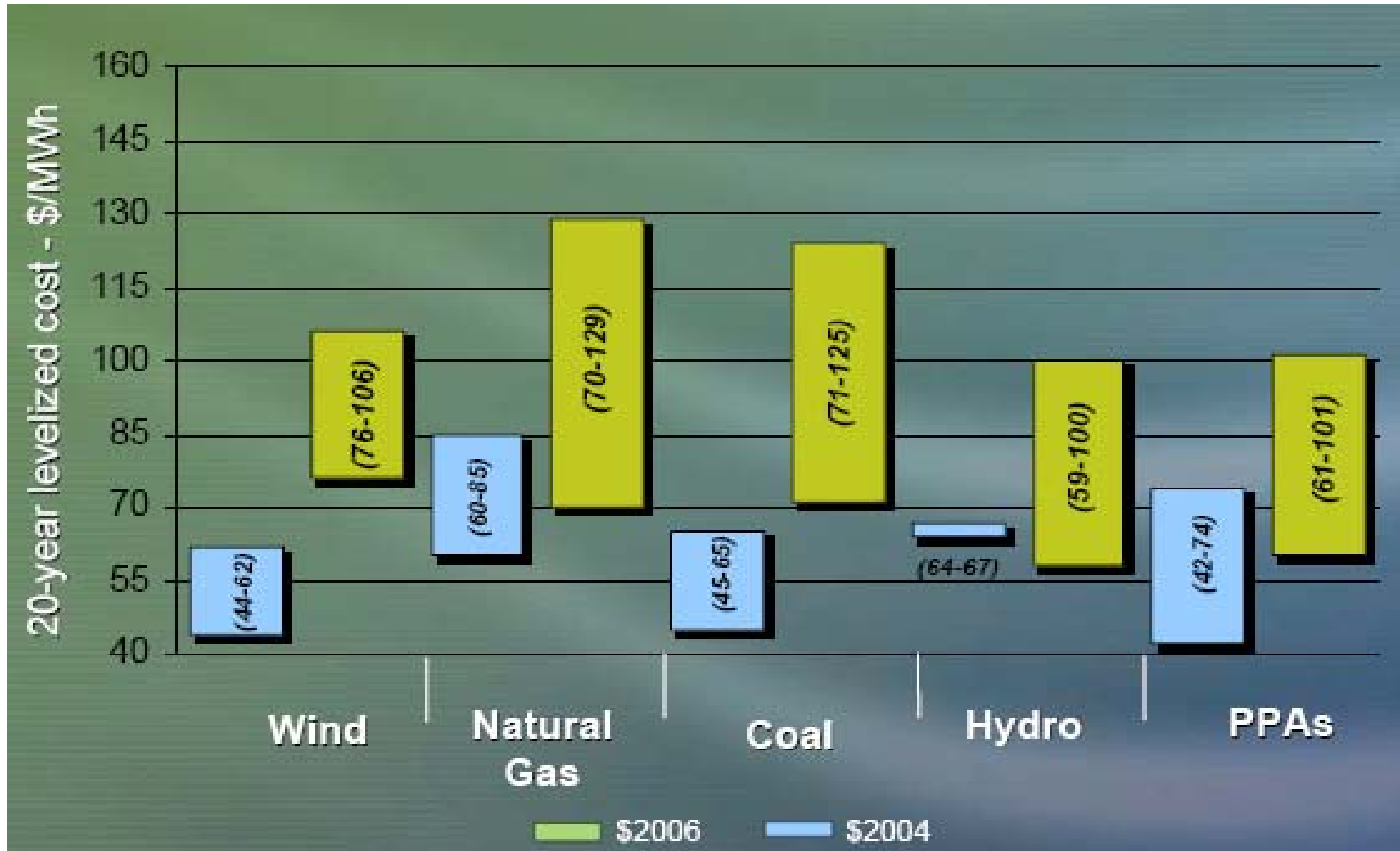
Source: ONLINE DATABASES - <http://www.energycentral.com>



Union of
Concerned
Scientists

Costs have increased for all technologies

Prices from Puget Sound Energy RFPs



Source: Puget Sound Energy IRPAG, powerpoint presentation, June 22, 2006.

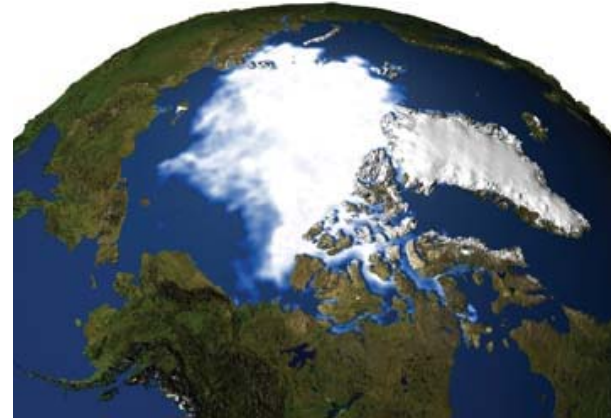


Union of
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Climate Change Highlighting the science



Arctic sea ice in 1979



Arctic sea ice in 2003

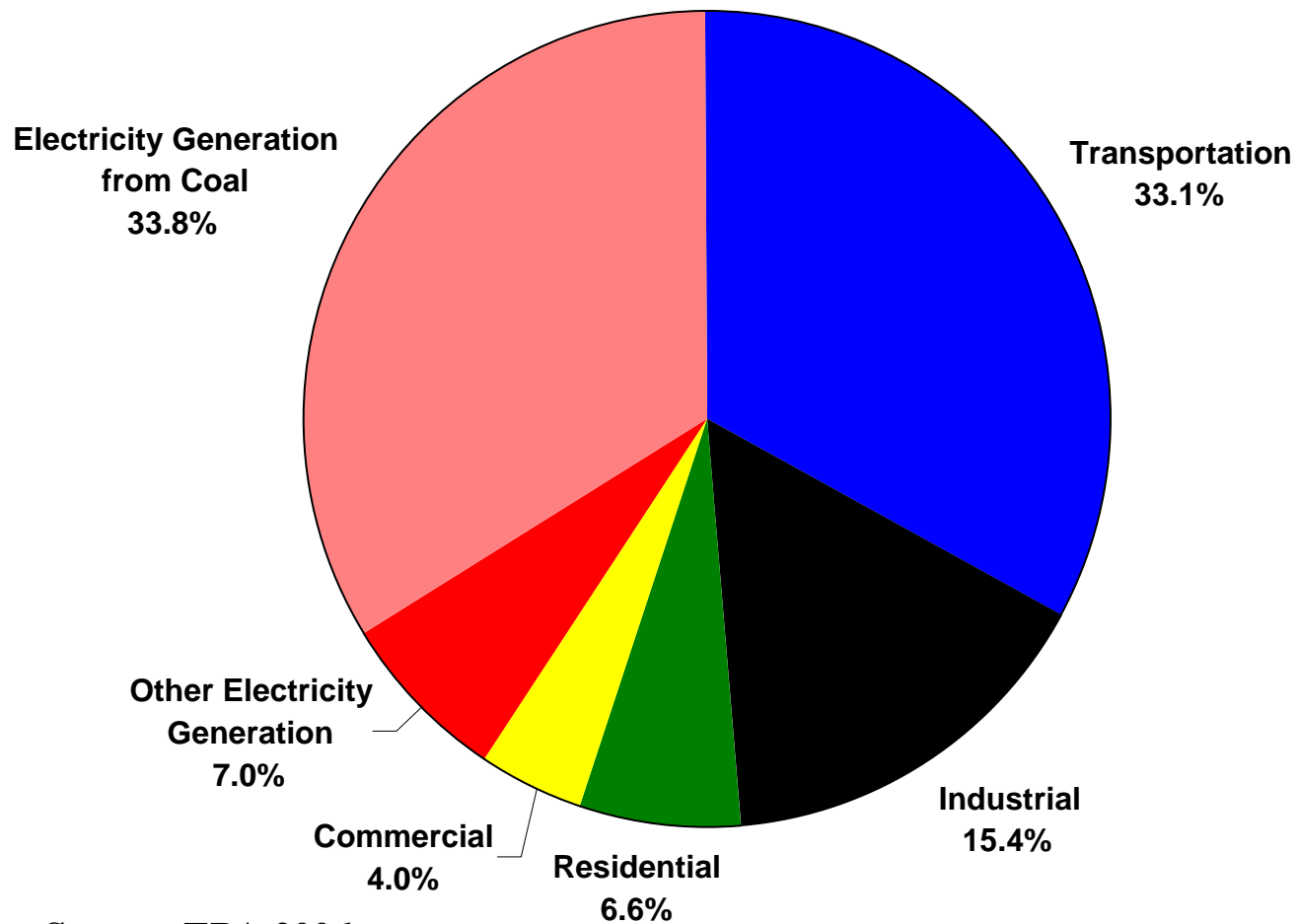
- **Powerful scientific consensus on global warming**
- **Damage already occurring**
- **Much worse lies ahead, including risk of abrupt changes**
- **Major reductions (60-80% by 2050) needed to avoid dangerous warming: CA, NM, EU, UK, New England Governors and Eastern Canadian Premiers**



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Coal plants a large part of the problem

Sources of U.S. Energy Related CO₂ Emissions: 2004



Source: EPA 2006



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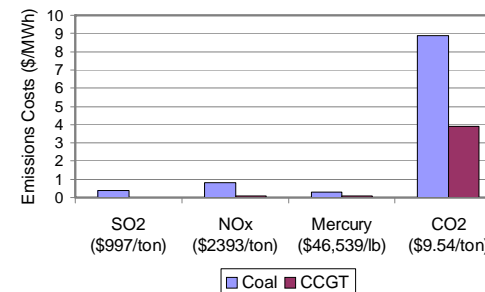
Currently a Major Resurgence in Coal

Coal's Resurgence

- High natural gas prices driving new coal rush and higher carbon emissions
- 159 new plants proposed
- No plans to capture and store CO₂
- Locks us in for decades to highest-carbon energy, with huge environmental AND financial risk
- IOUs believe they can pass costs on to ratepayers

Push Back on Coal

- Growing public support for GHG reductions
- Pressure from investors
- Ratepayers shouldn't bear the risk of these imprudently incurred costs
- Grandfathering of new coal plants is not likely.
- Many utilities are starting to include an assumed CO₂ cost





Carbon Sequestration

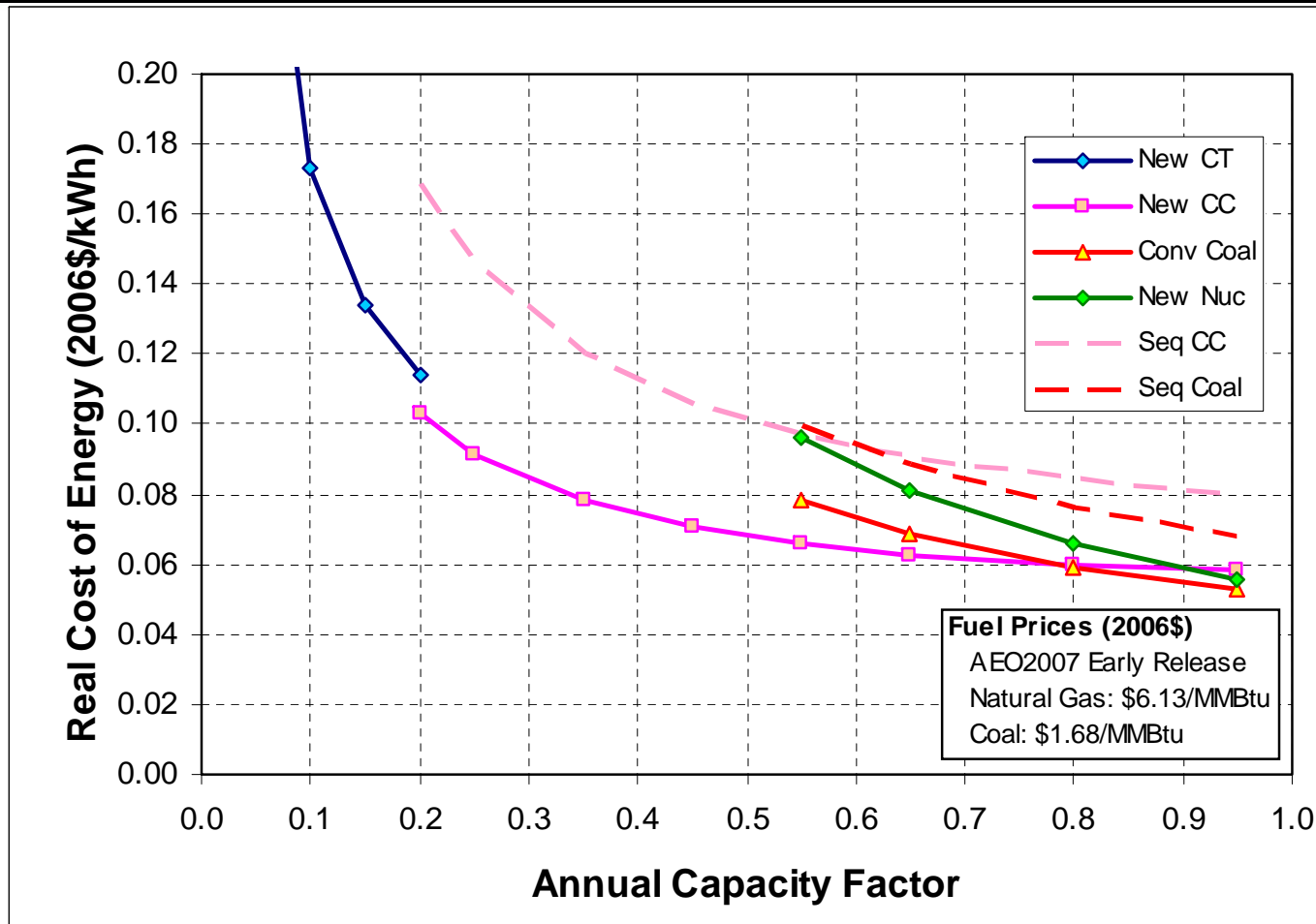
IPCC Special Report 2002

| US\$2002 | Pulverized Coal | Natural Gas CC | Integrated Coal Gasification CC |
|--|--------------------|--------------------|---------------------------------|
| Cost of Electricity w/o CCS (\$/kWh) | 0.043–0.052 | 0.031–0.050 | 0.041–0.061 |
| Carbon Capture & Sequestration | | | |
| - Increased fuel requirements | 24-40% | 11-22% | 14-25% |
| - CO2 Avoided | 81-88% | 83-88% | 81-91% |
| - Cost of Carbon Capture (\$/kWh) | 0.019–0.047 | 0.012–0.029 | 0.010–0.032 |
| - Mitigation Cost (\$/tCO2 avoided) | 30–71 | 38–91 | 14–53 |
| Cost of Electricity w/ CCS (\$/kWh) | 0.063–0.099 | 0.043–0.077 | 0.055–0.091 |
| Potential value of EOR (\$/kWh) | 0.014–0.018 | 0.006–0.007 | 0.013-0.015 |

Natural Gas Price: 2.8-4.4 US\$/GJ (LHV)
Coal Price: 1.0-1.5 US\$/GJ



Conventional Energy Prices (Black & Veatch)





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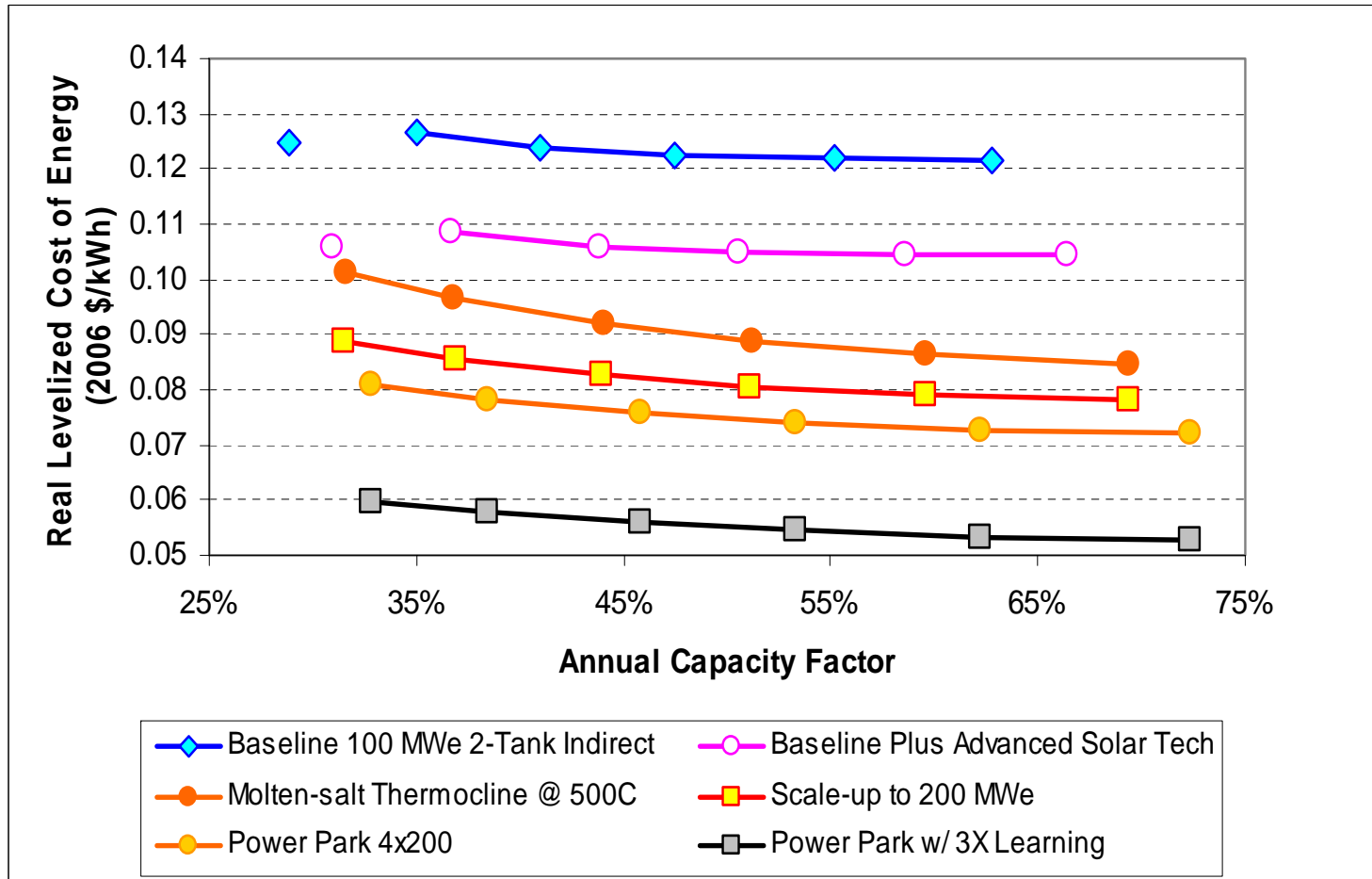
Parabolic Trough Technology

- 354MWe SEGS plants continue in daily operation
- First new projects in 15 years are coming on line
- Growth in industrial players
- New trough technology is improved



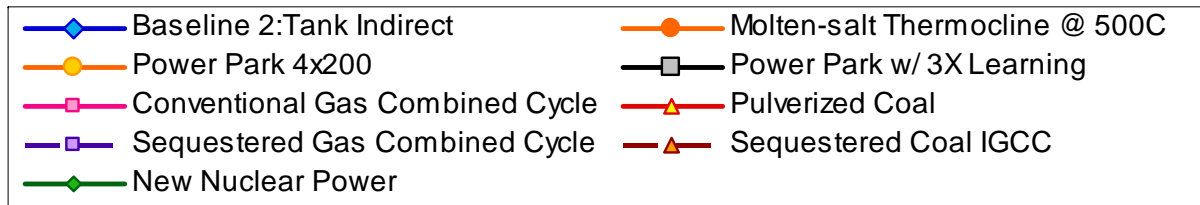
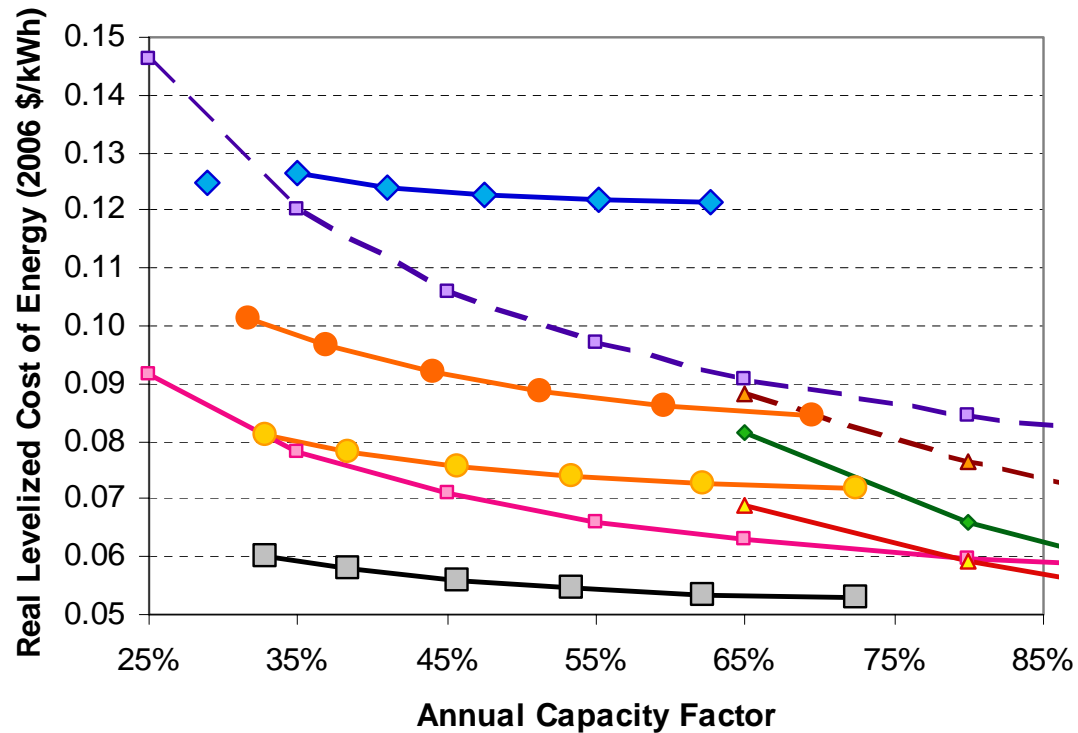


Parabolic Trough Potential Cost Reductions





How Does CSP Stack Up?





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Next up...

- **Markets**
 - **Value of CSP Power for U.S. Utilities**
 - **Tackling Climate Change in the U.S. with Renewables**
 - **CSP Project Developments**