<table>
<thead>
<tr>
<th>Margot Gerritsen</th>
<th>Energy Seminar</th>
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Making Large Scale Solar Work

and

Why We Want to
Why?

SOLAR ENERGY MOST ABUNDANT

Each day, the sun supplies thousands of times more energy than what we need.
An excellent large scale solar resource is rated at approximately 2500 kWh/m²/year or higher (light yellow areas in map)
Where?

SOUTH-WEST A SOLAR MECCA

Direct Normal Solar Radiation
(Two-Axis Tracking Concentrator)

Model estimates of monthly average daily total radiation using inputs derived from satellite and/or surface observations of cloud cover, aerosol optical depth, precipitable water vapor, albedo, atmospheric pressure, and ozone resampled to a 40km resolution. See http://www.nrel.gov/grisl_csp.html for documentation for more details.

Annual

KWh/m2/day

> 9.0
6.5 - 9.0
6.0 - 6.5
5.5 - 6.0
5.0 - 5.5
4.5 - 5.0
4.0 - 4.5
3.5 - 4.0
3.0 - 3.5
2.5 - 3.0
2.0 - 2.5
< 2.0

top rate

Produced by the Electric & Hydrogen
Technologies & Systems Center - May 2004
CAN WE POWER THE US?

Filter resource Western US by
- > 6.75 DNI
- <1% slope
- not protected, not urban
- not overly fragmented

<table>
<thead>
<tr>
<th>Total gross resource</th>
<th>6.5 million MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total US consumption</td>
<td>3 million MW</td>
</tr>
<tr>
<td>Total land required US</td>
<td>100x100 miles</td>
</tr>
</tbody>
</table>

CA, NV, AZ, NM have 400,000 MW 7.5 DNI and higher
6.75 DNI corresponds to approximately 275 W/m²
With 40% efficiency of large scale solar 110 W/m²
TROUGHS: THE OLD WORKHORSES

Focuses rays onto single surface

Performance trough (dish)
- Concentration 10-50 (30-1000)
- max. temp 400 °C (1200 °C)
- max. efficiency 55% (75%)

Linear Fresnel to reduce costs
CSP

BASE LOAD WITH STORAGE

http://www.solarmillennium.de/upload/Animationen/andasol_blue_engl.swf
Focuses rays onto boiler

Performance central tower
- max. temp 2000 °C
- max. efficiency 85%
CREATIVE STIRLING DISHES
LSS IS NOT A NEW CONCEPT

SEGS VIII-IX, NextEra, CA
Nevada Solar One, Acciona, NV
Andasol I, Solar Millenium, Spain
SEGS I-VII, NextEra, CA
PS20, Abengoa, Spain
162m, 1255 heliostats
PS10, Abengoa, Spain
Solar I, CA
Solar II, CA
Kimberlina, Ausra, CA
HAVE WE BEEN SLEEPING?

It’s not that we have not been building energy systems!

What caused the stagnation since the mid ‘80s?
Costs, politics, vested interests, (very) low investment levels

US past (& predicted) consumption

Huh?
2008, Energy Improvement and Extension Act
2009, American Recovery and Reinvestment Act

- 30% federal grant new commercial projects, no cap
  Must break ground in 2010, operation by 2016

- 30% Investment tax credit
  Extended till 2016

- Modified Accelerated Cost Recovery System (MACRS)
  Recover investments more quickly through accelerated depreciation
  Break ground 2009

- Clean Renewable Energy Bonds (CREBS)
  low-cost financing for public entities (public power, gov. entities, co-ops)
  800M$ 2008, 1.6B$ 2009

- Loan Guarantee programs
Presently

<table>
<thead>
<tr>
<th>Company</th>
<th>Location</th>
<th>MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>NextEra</td>
<td>Sonoran, AZ</td>
<td>375MW</td>
</tr>
<tr>
<td></td>
<td>Beacon, CA</td>
<td>250MW</td>
</tr>
<tr>
<td></td>
<td>Genesis, CA</td>
<td>250MW</td>
</tr>
<tr>
<td>Solar Millenium</td>
<td>Blythe, CA</td>
<td>1000MW</td>
</tr>
<tr>
<td>Abengoa</td>
<td>Mojave, CA</td>
<td>250MW</td>
</tr>
<tr>
<td></td>
<td>Solana, AZ</td>
<td>280MW</td>
</tr>
<tr>
<td></td>
<td>Solucar, Spain</td>
<td>300MW</td>
</tr>
<tr>
<td>FirstSolar</td>
<td>Desert Sunlight, CA</td>
<td>550MW</td>
</tr>
<tr>
<td></td>
<td>Inner Mongolia</td>
<td>2000MW</td>
</tr>
<tr>
<td>Stirling Energy Systems</td>
<td>Imperial Valley, CA</td>
<td>750MW</td>
</tr>
<tr>
<td></td>
<td>Calico Solar, CA</td>
<td>850MW</td>
</tr>
<tr>
<td>BrightSource</td>
<td>Ivanpah, CA</td>
<td>400MW</td>
</tr>
</tbody>
</table>
Suss it out

STAKEHOLDERS IN ONE ROOM

Woods/Precourt Large Scale Solar Technology & Policy Forum
April 7-9, 2010

What are the main challenges facing Large Scale Solar?
Which of these are most critical?
What can we do to move forward?
What can each of the stakeholders bring to the table

Bring together
- Non-Governmental Organizations (policy, environmental)
- Industry (developers, utilities)
- Agencies and policy makers
- Foundations
- Scientist

http://woods.stanford.edu/ideas/solar-forum.html
• Regulatory framework for projects and transmission not good
  Who builds, who uses, who pays and who earns?
  Under current system utilities obliged to build transmission interconnections
  No current state or federal framework to decide who lines are for

• Today’s transmission not fully utilized
  California dispatches every 5 minutes, others hourly
  Full deployment demand-response will be a game-changer

• Site selection process must be accelerated and integrated
  Need consistent politics across authority levels

• Weather is a contingency
  Intermittency currently requires ramping capability
  Meet electricity needs through most efficient mechanisms
Obstacles

AN INDUSTRY PERSPECTIVE

**Congress**
- Investment Tax Credit / Grant
- Loan Guarantees
- Transmission
- RPS
- Climate Change
- Land Use Issues

**FERC**
- Interconnection Rules
- Transmission Funding
- Transmission rates & allocation
- Reliability
- Backstop siting
- Transmission planning

**DOE**
- Loan Guarantees
- Backstop siting
- Transmission corridors
- Solar development policy
- R&D Assistance

**BLM**
- 299 Applications
- Solar Energy Zones
- Land use planning
- Environmental / project permit (NEPA)
- Rent
- PEIS for Southwest
- Transmission Corridors

**Investors**
- PPA’s
- Project & Company Financing
- On time/budget Construction, O&M
- Access to transmission / market

**SOLAR DEVELOPER**
- PPA’s
- Project & Company Financing
- On time/budget Construction, O&M
- Access to transmission / market

**Lenders**
- PPA
- Transmission Construction
- Interconnection Agreements
- Procurement and cost recovery

**ISO**
- LGIP
- Expansion/upgrades planning
- Funding transmission and Gen. ties
- Interconnection Agreements

**Utility**
- PPA
- Transmission Construction
- Interconnection Agreements
- Procurement and cost recovery

**State Legislatures**
- RPS
- Climate
- Generation Permitting & Siting
- Transmission Permitting & Siting
- Property Tax
- Sales Tax

**State Agencies**
- Approval of PPA or Purchase/Sale
- Siting and permitting of Project
- Siting and permitting of Transmission
- RPS Compliance
- Standards for Pricing (TOD/MPR)
- Standards for Gas Use
- Resource adequacy

**Stakeholders**
- Communities
- Consumers
- Environmentalists

**WECC**

**PMAs**

**WREZ**

**RETI**

**California**

**Arizona**

**Nevada**

**New Mexico**

**Utah**

**Colorado**
A NGO PERSPECTIVE

- No wonder we are facing problems
  Large scale, fast track, conflicting interests
  Decision making institutions designed for completely different purpose
  Currently, no driver to lead the coordinated process

- Pace of change is key
  We need to move quickly, but also need to develop public will

- Looking for the least environmentally sensitive sites
  Work closely with all stakeholders

- Look at true costs
  Level playing field

- Integrated resource approach is important.
Obstacles

**SHORT TERM (PIPELINE)**

Fast-track projects must complete before end 2010
- Environmental impact studies
- Permitting
- Financing

**Main problem areas**
- **Siting and Mitigation**
  Environmental impacts, conflicting land use preferences
- **Costs and financing**
  Equity availability and affordability, loan guarantees

General discomfort amongst NGOs
General frustration amongst industrial developers
General exhaustion at agencies like CEC
Obstacles

NEAR AND MEDIUM TERM

(Not in any specific order)

• Transmission
  Planning, timing, cost allocation

• Lack of predictable policy & regulatory frameworks wrt siting (environmental impacts) and financing
  No market certainty
  Insufficient coordination federal/regional/state authorities
  No one-stop shop

• Education
  Insufficient understanding of solar technologies

• No level playing field
  Comparing apples to oranges
  Lack of effective mechanisms to drive progress
Obstacles

LONG TERM

- Technology shortcomings/challenges
  Size of installations, scalability
  Costs

- Intermittency and storage
  Secure base load, avoid additional fossil back-up

- Integration
  Optimization
Compromises
Dry cooling technology
Reduce plant size by 23%
Reduce land use by 12%
Avoid highest rare plant density
Translocate 15% fewer tortoises
Number towers from 7 to 3
Heliostats reduced by 45,000
Avoid grading, large rock removal
Power reduced from 440 to 392 MW
IS WATER REALLY AN ISSUE?

The graph shows the amount of water (in Gallons/MWh) used by different energy sources. The x-axis represents various energy sources, including Conventional Fossil Fuels, Nuclear, Natural Gas CC, Coal, Mining, Coal, Slurry, Coal, IGCC, Coal, Supercritical, Coal, Subcritical, Coal, IGCC w/CCS, Coal, Subcritical w/CCS, Geothermal, Solar Thermal, Trough, Solar Thermal, Dry Cooling, and Solar Photovoltaic. The y-axis represents the water usage in Gallons/MWh, ranging from 0 to 1800.

- Conventional Fossil Fuels use the least water among the listed sources.
- Nuclear and Natural Gas CC use a moderate amount of water.
- Coal, Slurry, and Coal, IGCC have similar water usage, with slightly more than Coal, Mining.
- Coal, Supercritical and Coal, Subcritical have higher water usage.
- Coal, IGCC w/CCS and Coal, Subcritical w/CCS have the highest water usage, with values close to 1800 gallons/MWh.
- Geothermal, Solar Thermal, Trough, Solar Thermal, Dry Cooling, and Solar Photovoltaic have low water usage.

The bars for each energy source are marked with error bars, indicating variability in the data.
Hot seat

SPECIFIC FOR SOUTH-WEST

Average domestic                          74,000 gallons/year/person
Water from energy consumption    4,300 gallons/year/person
All RPS with CSP and wet cooling    4,800 gallons/year/person
(Toilet flushing 8000, clothes washing 6500)

Golf course
4.5M gal/hole/yr
Distributed Generation (DG)
Ground or rooftop solar
Many smaller systems
In or near load centers
Generally lower quality insolation

vs

Large Scale Solar (LSS)
Fewer larger systems
Remote locations
High quality insolation

DG availability
DG integration threshold
RPS allocations
Competition for equity
Cost effectiveness
“Help pipeline projects succeed”
“We want to get to a place where we just don’t get sued”

- Clear policy/regulatory frameworks
- Market mechanisms that can provide eco-incentive for industry to succeed
- Smart integration
- Storage development
- Partnerships with environmental stakeholders and agencies
  Recognized forums of exchange
- Concerted effort to collect and share key information
- Concerted effort to educate & advocate
PRIORITIES & IDEAS NGOs

“We need to make sure we do not create harmful precedents”

- Clear policy/regulatory frameworks
  screening criteria, go/no-go, modeling & survey protocols

- Monitoring (!)

- Financial and human resources

- Regional perspective

- Partnerships with environmental stakeholders and agencies
  Recognized forums of exchange

- Concerted effort to collect and share key information
  Mapping (!), economic & biological in particular

- Concerted effort to educate & advocate
WHAT CAN STANFORD DO?

“We can do LOTS of really great stuff!!”

• High quality key data collection
• Develop site selection, site design and Go/No-Go guidelines
• Monitor current and fast track projects, best practices

• Think about clear inter-state policy/regulatory frameworks
  Lessons learned from other industries?
• Market mechanisms that can provide eco-incentive for industry to succeed
  Ecosystem services focused, ecosystem credits

• Multi-attribute optimization of LSS projects
• Optimization existing transmission, and future transmission
• LSS and DG assessments
  Needs, costs, resource, integration, trade-offs, co-benefits

• Storage development over different timescales

• Provide continued forums for exchange
• Educate, dissemination of knowledge to stakeholders & general public
WHAT YOU CAN DO

Courses on Large Scale Solar
- Energy 108/208, winter 2011
- Continuing Studies, winter 2011
woods.stanford.edu/ideas/solar-forum.html

Summer internships

Check back in summer for research positions

Support responsible LSS development

Support SULLS - we take donations