Renewable Energy Development in California: Some Insights for Community Development in Southeast Asia

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Special Seminar
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TheSEARCA Agriculture & Development Seminar Series (ADSS)
Outline

• Introduction
• SMUD – Community-Owned Utility in CA
• Key Policy Drivers
• Status of Renewable Energy in CA
• Challenges/Barriers
• Implications in South East Asia
• Final Remarks
Introduction

• Acknowledgements
• Davis & Los Banos = Sister Cities
• Energy propels society, community, country – and globally!
SMUD – Community Owned Utility

• Not for Profit, Publicly Owned Utility
• Sacramento County (small part of Placer County)
• Almost 600,000 Customers; 1.4 Million Population
• 6th Largest utility in the U.S. (5th in CA)
• 7 Member Board of Directors
  • Elected by Ratepayers
• Not a Part of City or County
• Low Rates, Innovative & Green!
  • 1st in customer satisfaction survey in the nation for the last 11 consecutive years (J.D. Power & Associates Survey)
Why Renewable Energy?

- The concept of renewable energy – energy from resources that replenish naturally like sunlight, wind, hydro/tides, biomass and the earth’s heat (geothermal) – being converted to power, steam, fuels, and other value-added products.

- Governments, businesses, communities, and environmental groups worldwide now increasingly promote the use of renewable energy to address myriad goals including resource diversification and security, reliability and safety, economic growth and competitiveness, and climate change mitigation.

- In California, renewable energy and energy efficiency are the cornerstones of the state’s energy policy.
Renewable Energy Sources

- Biomass
- Solar PV
- Geothermal
- Wind
- Solar Thermal
- Hydro
Key California Renewable Energy Policy Goals

California has aggressive policy goals that position the State to be a leader with respect to the use of renewable energy.

Key Renewable Energy Policy Impacting California

- **Renewable Portfolio Standard** (Senate Bills 1078, X1-2)
- **California Solar Initiative Go Solar**
- **State Bioenergy Goals**
- **GHG Reduction Targets** (AB 32 - Global Warming Solutions Act)

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td><strong>Renewables</strong> 20% of Generation (~54,000 GWh)</td>
</tr>
<tr>
<td>2017</td>
<td><strong>New Roof-top Solar PV 3,000 MW</strong> (~5,000 GWh)</td>
</tr>
<tr>
<td>2020</td>
<td><strong>Renewables</strong> 33% of Generation (12,000 MW DG &amp; 8000 MW utility scale)</td>
</tr>
<tr>
<td></td>
<td><strong>New Biopower 1,500 MW</strong> (~12,000 GWh)</td>
</tr>
<tr>
<td></td>
<td><strong>Biofuel 2 Billion Gallons Per Year with 40% produced in California</strong></td>
</tr>
<tr>
<td></td>
<td><strong>California’s goals to reduce GHG emissions to 1990 levels by 2020 and 80 percent by 2050</strong></td>
</tr>
</tbody>
</table>
State Portfolio Standards Create Opportunities for Renewable Project Development

Renewables Portfolio Standards

CA 33% by 2020

Source: DSIRE: www.dsireusa.org
Assembly Bill 32

- Requires the California Air Resources Board to Adopt Regs to reduce state GhG’s back to 1990 levels by 2020
- Includes emissions from imported electricity
- Mandatory Reporting for all sources over 1 MW or 25,000 tonnes in 2009
- Regs to take effect in 2012
Benefits of Renewables

• Create local jobs – RE is a central element of rebuilding California’s economy.
• Provide economic benefits in the form of increased property and sales taxes
• Improves California’s energy independence by using local energy resources
• Reduce fossil-fuel generation
• Reduce environmental impacts (e.g., air & water)
• Reduce greenhouse gas emissions and reduce climate change impacts
### STATUS
California In-State Renewable Capacity and Generation (2010)  (16% of statewide retail sales)

<table>
<thead>
<tr>
<th>Renewable Resource</th>
<th>Utility-scale Capacity (MW)</th>
<th>Wholesale Distributed Generation Capacity (MW)</th>
<th>Distributed Generation Capacity (MW)</th>
<th>Total Capacity (MW)</th>
<th>Total Generation (GWh)</th>
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</thead>
<tbody>
<tr>
<td>Biomass</td>
<td>598</td>
<td>454</td>
<td>25</td>
<td>1,077</td>
<td>5,745</td>
</tr>
<tr>
<td>Geothermal</td>
<td>2,470</td>
<td>130</td>
<td>0</td>
<td>2,600</td>
<td>12,740</td>
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<tr>
<td>Small Hydro</td>
<td>308</td>
<td>1,072</td>
<td>0</td>
<td>1,380</td>
<td>4,441</td>
</tr>
<tr>
<td>Solar</td>
<td>387</td>
<td>16</td>
<td>953</td>
<td>1,356</td>
<td>908</td>
</tr>
<tr>
<td>Wind&lt;sup&gt;C&lt;/sup&gt;</td>
<td>2,191</td>
<td>620</td>
<td>8</td>
<td>2,819</td>
<td>6,172</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5,954</strong></td>
<td><strong>2,292</strong></td>
<td><strong>986</strong></td>
<td><strong>9,232</strong></td>
<td><strong>30,005</strong></td>
</tr>
</tbody>
</table>

Source: California Energy Commission
California Renewable Energy Generation by Type of Renewable Resource, 1983-2010

Source: California Energy Commission
California Existing Renewable Facilities

Source: California Energy Commission
Status of California -- RPS

IOU = Investment Owned Utility
# California’s Renewable Energy Potential

<table>
<thead>
<tr>
<th>Technology</th>
<th>Technical Potential (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass</td>
<td>3,820</td>
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<tr>
<td>Geothermal</td>
<td>4,825</td>
</tr>
<tr>
<td>Small Hydro</td>
<td>2,158</td>
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<tr>
<td>Solar</td>
<td></td>
</tr>
<tr>
<td>Concentrating Solar Power</td>
<td>1,061,362</td>
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<tr>
<td>PV</td>
<td>17,000,000</td>
</tr>
<tr>
<td>Wave and Tidal</td>
<td>32,763</td>
</tr>
<tr>
<td>Wind</td>
<td></td>
</tr>
<tr>
<td>On-shore</td>
<td>34,000</td>
</tr>
<tr>
<td>Off-shore</td>
<td>75,400</td>
</tr>
<tr>
<td><strong>TOTAL TECHNICAL POTENTIAL</strong></td>
<td><strong>18,214,328</strong></td>
</tr>
</tbody>
</table>

Source: California Energy Commission.
• Sustainable Power Supply reduces SMUD’s long-term greenhouse gas emissions from generation of electricity to 10% of its 1990 carbon dioxide emission levels by 2050 (<350,000 metric tonnes/year) while assuring reliability of the system; minimizing environmental impacts on land, habitat, water quality, and air quality; and maintaining a competitive position relative to other California electricity providers.
TECHNOLOGY DEVELOPMENT CONTINUUM
PLANNING: From Innovation to Market

RD&D
New Energy Idea
Proof of Concept
Technology Development
Demonstrations
Valley of Death (Need for Market Subsidy)
Self Sustaining Market
Market Development
Renewable Energy Pathways from the Resource to the End-User

Renewable Resources
- Wind
- Solar
- Biomass
- Geothermal
- Hydroelectric
- Ocean

Efficient Energy Use
- Buildings
- Industry
- Transportation

Energy Delivery and Storage
- Electricity Transmission & Distribution
- Alternative Fuels
- Hydrogen Delivery and Storage

Foundational Science

Applied Science
Issues/Challenges Affecting Future Development of Renewables in CA

• Permitting
• **Transmission Issues** (lack of coordinated land use & transmission system planning)
• Integration Issues
• Investment & Financing Issues
• Cost Issues
• R&D Issues
• Environmental Issues
• Local Government Coordination Issues
• Workforce Issues
• Lack of Public Awareness
# Investment & Financing Issues

<table>
<thead>
<tr>
<th>Stage 1</th>
<th>Stage 2</th>
<th>Stage 3</th>
<th>Stage 4</th>
<th>Stage 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research &amp; Development</td>
<td>Proof of Concept</td>
<td>Deployment / Pilot Facility</td>
<td>Early Commercial</td>
<td>Commercial Maturity</td>
</tr>
<tr>
<td>Generate idea, technology, intellectual property</td>
<td>Design and test technology — prototype, build company, improve intellectual property</td>
<td>Prove technical validity in the field, market technology, product development</td>
<td>Prove manufacturing process can be scaled</td>
<td>Proven technology is sold and distributed</td>
</tr>
</tbody>
</table>

**Financing Gap 1**

**Financing Gap 2**

## Government

- Venture Capital
- Private Equity

## Other Sources of Finance

- Public Equity
- Mergers and Acquisitions
- Credit (Debt)
- Carbon Finance

*Source: The Pew Charitable Trusts, Bloomberg New Energy Finance*
Cost Issues

Past Investments Have Yielded Impressive Cost Reductions

Source: NREL 2010
10-Yr Average Installed Cost of Solar PV

California IOU Public Purpose Program PV Systems – Trends

Source: Itron Inc.
Programs include the Emerging Renewables Program (ERP), the Self-Generation Incentive Program (SGIP), the CSI General Market (CSI-GM), Single-family Affordable Solar Homes Program (SASH), Multi-family Affordable Solar Housing (MASH), and the New Solar Homes Partnership (NSHP)
California Wind Turbine Prices in the US—Trends


$2.3 billion
CARBON CAPTURE AND STORAGE

$12.2 billion
TRADITIONAL RENEWABLES

$53.9
Direct spending
(inner circle)

$16.3
Tax breaks
(outer ring)

$70.2 billion
TRADITIONAL FOSSIL FUELS

$16.8 billion
CORN ETHANOL

$11.8
Climate protecting

$5.0
Damaging

Source: Energy Subsidies Black, Not Green.
R&D to Support CA Renewable Generation Goals

Significant levels of research, development, invention, and innovation” will be necessary to develop the technologies needed to achieve the state’s 2050 GHG emission reduction target.

Energy Commission’s Public Interest Energy Research (PIER) Program ($86.5 million annually). From 1997 to 2010 the PIER program have invested total of $179 million.

In addition, in 2010, the PIER Program successfully leveraged more than $500 million in federal stimulus funding under the American Recovery and Reinvestment Act (ARRA) of 2009 and $900 million in private investment funds using only $20 million of PIER Program funding.
R&D to Support CA Renewable Generation Goals

Source: California Energy Commission
R&D to Support Alternative Fuels and Vehicles

Energy Commission’s Alternative Fuels and Vehicle RD&D & Deployment Program (AB 118)

- with over $100 Million dollars to support advanced transportation fuels and vehicles
- Reduce environmental impacts, reduce GHG emissions
- Help meet low carbon fuels standard
Advanced Vehicles and Fuels Options

Conventional Vehicles

Hybrid Electric Vehicles

Plug-in Hybrid Vehicles

Hydrogen Vehicles—ICE or Fuel Cell

- Hydrogen from Natural Gas
- Renewable Hydrogen

- Electricity from Grid
- Distributed Renewable Electricity

- Corn Ethanol, Cellulosic Ethanol
- Biodiesel, Fischer-Tropsch Diesel
- Natural Gas other Petrochemicals

Source: NREL
Jobs Creation

Investment in renewable development creates new jobs.

According to a 2011 report by Next 10, from 1995 to 2009 the energy generation sector created the most jobs in California’s green economy, adding nearly 20,000 jobs, 3,000 of which were added from January 2008 to 2009.

Nationally, in 2008 the American Wind Energy Association reported that the wind industry employed 85,000 workers, exceeding the 81,000 workers employed by the U.S. coal mining industry.

In addition, a 2011 Brookings Institution report concludes that, nationally, the clean economy employs more people than the fossil fuels and biotech industries, with four of the five fastest growing clean tech segments between 2003 and 2010 in renewable energy, which added about 50,000 jobs in the solar thermal, solar PV, wind power, biofuels, fuel cell production, and smart grid industries.
US & CA Renewable Power Solutions

- Accelerating high penetration of wind and solar power by addressing the key integration and inter-connection challenges of intermittency and variability.*

- Fostering greater dispatchability and response for solar and wind by developing and evaluating energy storage solutions.**

- Enabling wind power to produce up to 20% of the Nation’s electricity by improving the performance of turbines, blades, and related components.

- Continuing Solar America Initiative to lower cost of photovoltaics to reach unsubsidized grid parity by 2015 and CA Solar Initiative by 2017.

- Establishing demonstration sites for Enhanced Geothermal Systems and evaluating reservoir creation techniques.

- Benchmark testing of leading ocean, wave, and tidal technologies.

*(Cooperative programming with Office of Electricity Delivery and Energy Reliability (OE))

**(Joint program with OE and Office of Science)
Key SMUD EE & Renewables Goals

- SMUD’s Board of Directors adopted aggressive energy efficiency goals – 15% over ten years. The most aggressive utility energy efficiency goals in the state

- Aggressive renewable energy goals

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<tbody>
<tr>
<td>RPS</td>
<td>18.8%</td>
<td>20%</td>
<td>20.4%</td>
<td>33%</td>
</tr>
<tr>
<td>Greenergy</td>
<td>3.5%</td>
<td>3.8%</td>
<td>3.8%</td>
<td>4%</td>
</tr>
<tr>
<td>Total</td>
<td>22.3%</td>
<td>23.8%</td>
<td>24.2%</td>
<td>37%</td>
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</table>
SMUD's Renewable Energy Growth 2003-2010

July 19, 2011

Renewable Energy (GWh)

Year

Total Committed Greenergy
Total Committed - Operational RPS
Combined RPS and Greenergy Goals

Total % of Retail Sales (RPS + Greenergy)

2003 2004 2005 2006 2007 2008 2009 2010

561 810 969 1430 1718 1804 2008 2158

6.4% 10.5% 11.1% 13.3% 16.5% 19.5% 22.3% 24.2%
SMUD's RENEWABLE ENERGY MIX 2010

2010 Total GWh ~ 11,000 for all sources

Wind, 719 GWh, 27%
Biomass, 1356 GWh, 52%
PV, 4 GWh, 0%
Small Hydro, 301 GWh, 12%
Geothermal, 0 GWh, 0%

Biomethane*, 247 GWh, 9%
(Pipeline gas to CPP)
SMUD Renewables Strategy

• Pursue Multiple Paths
  – Own & Operate Renewables where Risk is low and Opportunity is high
  – Competitively Purchase from Market – RFOs + Open
    • Least Cost, Best Fit

• Eligibility: 1. RPS = CEC Eligibility Guidebook; 2. Greenergy = Green-E Certification Eligibility

• Investigate New Transmission, but Expand Local Renewables
Abundant RE Resources!

• RETI Assessments of Technical Potential: for AZ, Baja, BC, CA, NV, OR, WA.
  • Biomass: 68,200 GWh
  • Small Hydro: 2,600 GWh
  • Wind: 240,400 GWh
  • Geothermal: 35,300 GWh
  • Solar PV: 41,000,000 GWh (CA only) - if Distributed, Little Need for Transmission
  • Solar Thermal: 2,200,000 GWh
  • Wave & Marine Current: 92,500 GWh
  • TRANSMISSION?

Source: RETI Phase 1A Report, CEC, 2008
SMUD Local Renewables

- Limited to Biomass and Solar
  - Solano Wind (233 MW) outside territory
  - Biomass = 81 MW; Solar = 3600 MW (only portion of unshaded rooftops + 13 disturbed land sites)
- All other Renewables need Transmission!

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<tbody>
<tr>
<td>Thermochemical</td>
<td>200</td>
<td>61</td>
<td>259</td>
<td>69</td>
</tr>
<tr>
<td>Biochemical</td>
<td>26</td>
<td>11</td>
<td>28</td>
<td>12</td>
</tr>
<tr>
<td>Total MW</td>
<td>226</td>
<td>72</td>
<td>287</td>
<td>81</td>
</tr>
</tbody>
</table>
Today... Biomass Is Viewed as a Disposal Problem

- **Reducing Landfill Capacity**
  - About 31 million tons of biomass goes into landfills every year

- **Contributing to Air Pollution and Fire Risk**
  - Open field burning of crop residues emits more than 100,000 tons of air pollutants annually
  - Wildfires contribute over 1.1 million tons per year at a cost of >$900 million/year

- **Local Concerns**
  - California’s 1.8 million dairy cows generate odor and health concerns
California Biomass Resources

Potential Feedstock Energy in Biomass
507 Trillion Btu/year

- Agriculture, 137 TBtu, 24%
- Forestry, 242 TBtu, 41%
- Agriculture, 10 TBtu, 2%
- Urban, 128 TBtu, 22%
- Urban, 61 TBtu, 11%
- Waste-water Treatment, 10 TBtu, 2%

+ 137 BCF/year landfill and digester gas
Biomass Energy Conversion Pathways

**Biomass Resources**
- Agricultural Residues (Livestock Manure, Food Wastes, etc.)
- Forestry Residues
- Municipal Solid Waste
- Wastewater

**Processing & Handling**
- Separation
- Processing
- Handling
- Transportation

**Conversion Processes**
- **Thermochemical** (Combustion, Gasification, Pyrolysis)
- **Biochemical** (Anaerobic Digestion, Fermentation, Direct Hydrogen)
- **Physicochemical** (Oil Extraction, Hydrocarbon Extraction)

**Gas Cleaning & Upgrading**
- Particles
- Tar, organics
- Sulfur, H₂S
- NOx
- CO₂

**Utilization**
- **BioPower:**
  - Electricity
  - Heat
  - CHP & CCHP

- **Pipeline Gas**
- **Biofuels:**
  - Ethanol
  - Biodiesel
  - Methanol
  - Hydrogen
  - SNG
  - Pyrolysis Oil
  - Others

- **Bioproducts & Chemicals**
Influence of Moisture to the Choice of Biomass Conversion Pathway

Siegfried Bajohr & Rainer Reimert
Biofuels

Current Biofuels status
• Biodiesel – 450 million gallons
• Corn ethanol (Dec. 2007)
  – 134 commercial plants
  – 7.2 billion gallon/yr. capacity
  – Rack price highly variable $3.50 – $5.50/gallon of gasoline equivalent (gge)
• Cellulosic ethanol
  – Projected commercial cost ~$3.50/gge

Key DOE Goals
• 2012 goal: cellulosic ethanol ~$1.62/gge
• 2030 goal: 60 billion gal ethanol (30% of 2004 gasoline)

NREL Research Thrusts
• The biorefinery and cellulosic ethanol
• Solutions to under-utilized waste residues
• Energy crops

Sources: 1- National Biodiesel Board, 2 - Renewable Fuels Association, 3 – American Coalition for Ethanol, all other information based on DOE and USDA sources
Ethanol Production

Actual and Projected U.S. Ethanol Production 1999-2012
Billion Gallons of Production

- Renewable Fuels Standard mandates 7.5 billion gallons by 2012
- Total US gasoline market ~140 billion annual gallons
Cellulosic Ethanol Potential and Status

Cellulosic ethanol anticipated cost competitiveness and sustainability attributes are key to biofuels growth potential

Historical and Projected Cellulosic Ethanol Costs

<table>
<thead>
<tr>
<th></th>
<th>2001 (dollars per gallon)</th>
<th>2007 (dollars per gallon)</th>
<th>2012 (dollars per gallon)</th>
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</thead>
<tbody>
<tr>
<td>Enzymes</td>
<td>3.11</td>
<td>0.32</td>
<td>0.10</td>
</tr>
<tr>
<td>Feedstock*</td>
<td>0.82</td>
<td>0.74</td>
<td>0.51</td>
</tr>
<tr>
<td>Conversion</td>
<td>2.02</td>
<td>1.23</td>
<td>0.72</td>
</tr>
<tr>
<td>Total</td>
<td>5.95</td>
<td>2.29</td>
<td>1.31</td>
</tr>
</tbody>
</table>

*Feedstock is assumed to be $53 per dry ton in 2007 and projected at $46 per dry ton in 2012.

N-th plant scenario

All Costs are 2007 $

Federal research has achieved major reductions in the cost of cellulosic ethanol

Source: NREL
Biomass-Derived Methane Gas

- Landfill Gas From Landfills
- Digester Gas From AD of Wastewater Treatment Plants
- Biogas From AD Livestock operations
- Digester Gas From AD of Food Wastes
- Producer Gas or Syngas From Gasification of Biomass?
## Biogas Potentials in the Western US

(Resource Potentials for Pipeline Gas)

<table>
<thead>
<tr>
<th></th>
<th>California</th>
<th>Other 12 Western States</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gross MW*</td>
<td>Gross MW*</td>
<td>Gross MW*</td>
</tr>
<tr>
<td>Wastewater Treatment Plants</td>
<td>210</td>
<td>351</td>
<td>561</td>
</tr>
<tr>
<td>Landfills</td>
<td>1300</td>
<td>990</td>
<td>2,290</td>
</tr>
<tr>
<td>Dairy Manure Digesters</td>
<td>470</td>
<td>566</td>
<td>1,036</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>1,980</strong></td>
<td><strong>1,907</strong></td>
<td><strong>3,887</strong></td>
</tr>
</tbody>
</table>

* All analysis assumes a heat rate of 6900 BTU/kWh for conversion of biogas to power

Source: B&V & SMUD 2010, A case of biogas for pipeline injection (excluding food wastes, FOG, and other organic wastes for co-digestion or stand-alone AD)
Common Carrier of Gas Pipelines in CA
SMUD’s Biopower Today
(1,603 GWh)

- Biopower Provides ~1,600 GWh of Electricity today at SMUD Region through
  - Direct Combustion of solid biomass
  - Landfill Gas to Energy (LFGTE)
  - Wastewater to Digester Gas
  - Dairy Biogas Systems
# Biomass: Barriers/Challenges

*Why isn’t development occurring as expected despite of benefits?*

## Institutional (biggest reason)
- State environmental policies and program are fragmented & sometimes conflicting
- Arduous & complex permitting process
- Limited public awareness of the benefits of biomass
- Jurisdictional concerns – waste ownerships, disposals, no win-win solutions
- Perception of technologies
  - Incineration in disguise?
  - NIMBY

## Technical
- Low NOx and biogas cleanup technologies remain to be fully demonstrated and commercialized
- New biomass developments viewed to have some technical risk
- Lack of commercial success and data for new & emerging technologies
- Utility interconnection/transmission

## Economic
- High costs of biomass conversion systems
- Low price of milk makes farmers difficult to invest and install digesters
- Financing is difficult

## Environmental
- Environmental benefits are not internalized
- Remaining issues with air quality ($NO_x$) and water quality
- Lack of environmental data for new technologies
- Public health – odor, flies
- Catastrophic wildfire threat
Geothermal Energy

Power production from concentrated brines

Heat exchangers and circulation pumps
Projections of installed capacity based on documented projects in various stages of development (GEA, 2006)
Geothermal Resource of the United States

Locations of Identified Hydrothermal Sites and Favorability of Deep Enhanced Geothermal Systems (EGS)

- Map does not include shallow EGS resources located near hydrothermal sites or USGS assessment of undiscovered hydrothermal resources.
- Source data for deep EGS includes temperature at depth from 3 to 10 km provided by Southern Methodist University Geothermal Laboratory (Brewer & Riches, 2009) and analyses for regions with temperatures ≥150°C performed by NREL (2009).
- Source data for identified hydrothermal sites from USGS Assessment of Moderate- and High-Temperature Geothermal Resources of the United States (2008).
- **N/A** regions have temperatures less than 150°C at 10 km depth and were not assessed for deep EGS potential.
- *Temperature at depth data for deep EGS in Alaska and Hawaii not available.*

Favorability of Deep EGS

- Most Favorable
- Least Favorable
- N/A*
- No Data**

*Identified Hydrothermal Site (≥ 90°C)
Solar Energy Growth at SMUD

![Image of solar panels on rooftops and in fields]

**Installed and Forecast Solar Capacity**

- **SB1, Actual & Planned**
- **Non-SB1, Actual & Planned**
- **FIT**

<table>
<thead>
<tr>
<th>Year</th>
<th>Megawatts</th>
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<tbody>
<tr>
<td>2007</td>
<td>0</td>
</tr>
<tr>
<td>2008</td>
<td>0</td>
</tr>
<tr>
<td>2009</td>
<td>20</td>
</tr>
<tr>
<td>2010</td>
<td>40</td>
</tr>
<tr>
<td>2011</td>
<td>60</td>
</tr>
<tr>
<td>2012</td>
<td>80</td>
</tr>
<tr>
<td>2013</td>
<td>100</td>
</tr>
</tbody>
</table>
Solar Energy

PV roofing shingles

210 kW PV system at SMUD's Hedge substation

PV panels

Indo-US Cooperative PV Project

Solargenix 64 MW solar plant near Boulder City, Nevada
PV Issues For SMUD

- PV coupled + high efficiency measures can reduce home peak load by 55%
- Significant shift still between solar peak and system peak
- Variable production resulting from party cloudy conditions

**R&D** Projects: 1. CPUC High Penetration PV Initiative; 2. DOE PV Li-Ion Distributed Storage; 3. DOE Flow Battery Storage
**Wind Issues For SMUD**

- SMUD’s peak load driven by hot summer temperatures
- Wind resource weakest on hottest days
- Comparing daily and hourly system load with Solano Wind Plant production illustrates mismatch
- Must rely on firming resources to address mismatch and ensure system stability
Wind Energy

GE Wind's 1.5 megawatt wind turbine installed in Tehachapi, California

Vestas V-47 Turbines on wind farm in Kansas

Brazilian hybrid power system

Palm Springs, CA, wind farm

Dyess Air Force Base, Texas (near Abilene)
Growth of Wind Energy Capacity Worldwide

Jan 2007 Cumulative MW = 71,476

Rest of World = 11,043
North America = 13,054
  U.S. = 11,603MW
  Canada = 1,451MW
Europe = 47,379

Sources: BTM Consult Aps, March 2005
Windpower Monthly, January 2007
*NREL Estimate for 2007
SMUD’s Solano Wind Project
SMUD-Owned Solano Project
SMUD’s Wind Generation Assets

The Wind Plant Resource:

• 5,500 acres of District-owned land in the Montezuma Hills WRA of Solano County

• Wind speed of more than 20 miles per hour at 80-meter hub height (average for peak months)

• Major transmission corridors nearby

• PG&E interconnection facility constructed

• 250 MW of wind resource potential
Phase 1 Project (1999-2004)

- Vestas V47 (660 kW)
- Single WTG installed in 1999 for evaluation
- 15 WTGs added in 2003 at 50-meter hub height
- 7 WTGs installed in 2004 at 65-meter hub height
- Total Phase 1 capacity: **15 MW**
- 21kV overhead collection system – 3.2 miles
- 230kV interconnection
Phase 2 Project (2005-2007)

- Vestas V90 (3 MW)
- Phase 2A: 8 WTGs installed in May 2006 (24 MW total)
- Phase 2B: 21 WTGs installed in December 2007 (63 MW total)
- Total Phase 2 capacity: 87 MW
Solano Wind Phase 1 & 2
Phase 3 Project

- EIR adopted
- Contracts awarded to Vestas (EPC and O&M)
- 24 V90-3.0MW and 31 V90-1.8MW turbines (55 total = 128 MW)
- Construction completed
688 MW ~ 1700 GWh/yr
SMUD’s Pumped Hydro Project

Key Features of Iowa Hill

• New development added to existing hydro system
• 400-MW Pumped-storage facility
• New 6,400 ac-ft reservoir atop Iowa Hill
• Existing Slab Creek Reservoir as lower reservoir
• Underground water conveyance and powerhouse
• 2.5-mile transmission tie-in connects to existing UARP transmission line

Benefits

• Helps meet load growth
• Enables firming capacity of intermittent, non-dispatchable renewables
• Supports load following, improves system reliability, provides voltage control and spinning reserves
SMUD’S THERMAL GENERATION

Biogas Replacement of Natural Gas
CARSON COGEN PLANT

Sacramento Wastewater Treatment Plant
With Digester – biogas (up to 3 MW+)

57 MW CC
43 MW peaker
GAS PIPELINE
SMART GRID VISION

SMUD received the largest smart grid infrastructure grant of any California utility—$127.5 Million, will serve as a model for the nation’s electrical grid.
SMART GRID ELEMENTS

1. Energy Efficiency
2. Renewables/Distributed Generation
3. Energy Storage
4. Demand Response
5. Advanced Metering Infrastructure
6. Distribution System Improvements
Insights for RE Development in South East Asia

• Based on IEA study Southeast Asian nations (ASEAN): Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam (collectively identified as ASEAN-6) has rapid economic growth, increasing energy demand, rising fossil fuel imports, growing environmental pressures, low rural electrification levels, and heavy reliance on fossil fuels and traditional biomass.

• Has large potentials for renewable energy sources, most still untapped.
Insights for RE Development in South East Asia

• Based on IEA study for Southeast Asian nations in the last two decades (ASEAN: Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam (collectively identified as ASEAN-6) has:
  – rapid economic growth,
  – increasing energy demand, rising fossil fuel imports,
  – growing environmental pressures,
  – low rural electrification levels, and
  – heavy reliance on fossil fuels and traditional biomass.
  – has large potentials for renewable energy sources, most still untapped.
Potentials for RE in ASEAN-6 to year 2030

Source: IEA 2010
### Challenges for Deployment of RE in ASEAN

#### Barriers to the Deployment of Renewable Energy (RE) in ASEAN

- Infrastructure barriers (remoteness)
- Lack of co-ordination between different authorities
- Lack of experience/trust among banks or investors
- Higher costs of connection for small-scale production
- Asymmetrical availability of market information
- Perception of unrealistically high costs of RES-E
- Lack of recognition for side-benefits of distributed generation
- Unclear grid connection rules and/or pricing mechanisms
- Energy, esp. electricity, market structure
- Costs of grid connection
- Grid access is not fully guaranteed
- Invisibility of the full costs of electricity from non-RES
- High number of authorities involved
- Complexity of regulatory/support framework for RES-E
- Complexity obtaining permits & legal appeal procedures

#### Legend:
- **Yellow**: Technical/infrastructure barriers
- **Brown**: Administrative and regulatory barriers
- **Blue**: Market barriers
- **Orange**: Financing barriers
- **Green**: Socio-cultural barriers

**Note**: Barriers are deemed Relevant, Significant or V.S. (very significant) based on survey results.

Source: IEA 2010
Final Remarks

- California has aggressive Renewable Energy Supply goals, e.g. SMUD community as one key model
- Utilization of local renewable resources provide benefits/challenges
- California is committed to sustainable and environmentally beneficial energy solutions
- There is need to design renewable energy policies to complement climate change policies and to derive maximum benefit from climate change financing options in ASEAN countries. This will encourage sufficient investment flows and help meet climate, energy security and environmental objectives.
Final Remarks

• Renewable energy potential is large across all the ASEAN-6 countries. The composition and relative weight of individual renewable energy technologies are similar in all six countries, with hydro, biomass, wind and solar PV contributing significant shares.

• Geothermal electricity and heat are concentrated in Indonesia and the Philippines.
Final Remarks

• Global renewable energy investors in California (US as a whole) and Europe are increasingly looking to Southeast and South Asia – lured by investment incentives rolled out by government support and clean energy outlook to reduce GHG emissions and climate change impacts.

• There is a need to strengthen UC Davis – UP Los Banos Partnership (exchange students, faculty, scholarships, assistantships, etc.)
Thank You

Questions/Comments??

For more information please contact:

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