Assessment of Arizona Renewable Energy Resources

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Agenda

- Introduction
- Arizona Situation
- Project Methodology
- Renewable Resource Assessment
- Next Steps
- Conclusions
Project Objective

- Assess the near-term developable potential of Arizona renewable energy resources
- Account for economic variables of developing those resources
- Study prepared for
  - Arizona Public Service
  - Salt River Project
  - Tucson Electric Power Company
Arizona Renewable Energy Standard (RES)

- Requires 15% by 2025
- Applies to ACC-regulated utilities
  - SRP has adopted similar goals
- Distributed resource set-aside

![Graph showing RES Requirement]
Project Methodology

- Screen technologies
- Characterize resource potential
- Identify potential projects
- Estimate project performance and costs
- Estimate cost to generate electricity
- Develop resource supply curves
- Assess and forecast relative economics
Properly Characterizing Resource Cost

- Renewables costs vary tremendously based on resource quality
- Limited number of very good renewable project sites
- Costs rise as “low-hanging” projects are developed
- Supply curves capture these effects
Supply Curve – Concept Example
Renewable Energy Technologies Reviewed

- Biomass
  - Direct fired
  - Biomass Gasification and IGCC
  - Cofiring
  - Plasma Arc Gasification
  - Anaerobic digestion
  - Landfill gas
- Hydroelectric
  - Conventional Hydro
  - Pumped Storage
- Wind
- Geothermal

- Solar Electric
  - Solar thermal electric
    - Parabolic Trough
    - Parabolic Dish Stirling
    - Power Tower
    - Compact Lens Fresnel Reflector
  - Solar photovoltaic
    - Residential
    - Commercial
    - Utility-scale
- Compressed Air Energy Storage
- Fuel Cells Using Renewable Fuels

Recommended Technologies
**Bold and Underlined**
Solar-Electric Technologies

- Two Major Types:
  - Photovoltaics (PV)
  - Solar Thermal Electric
Arizona Solar Thermal Resources
Supply Curve for Solar Thermal (Trough) Projects

2007 Supply Curve

- Wind
- Biomass
- Solar
- Hydro
- Geothermal

Levelized Cost, $/MWh

Generation, GWh

~4300 MW
Wind Project Screening

- Restricted Lands
- Environmentally Sensitive Areas
- Transmission Proximity
- Wind Resource
- Constructability

(Wind Map: AWS Truewind)
Supply Curve for Wind Power Projects

![2007 Supply Curve]

- **Wind**
- **Biomass**
- **Solar**
- **Hydro**
- **Geothermal**

**Generation, GWh**

- 0
- 2,500
- 5,000
- 7,500
- 10,000

**Levelized Cost, $/MWh**

- 0
- 50
- 100
- 150
- 200
- 250
- 300
- 350

~1000 MW
Supply Curve for Solid Biomass Projects

2007 Supply Curve

- Wind
- Biomass
- Solar
- Hydro
- Geothermal

Direct-Fired
Cofired

2 x 10 MW Cofiring
20 MW Direct

~40 MW

Generation, GWh
Levelized Cost, $/MWh
Supply Curve for Biogas Projects

2007 Supply Curve

- Wind
- Biomass
- Solar
- Hydro
- Geothermal

Generation, GWh

Levelized Cost, $/MWh

- Digester Gas (light green)
- Landfill Gas

~20 MW
Potential Hydropower Locations in Arizona
Supply Curve for Hydropower Projects

2007 Supply Curve

- Wind
- Biomass
- Solar
- Hydro
- Geothermal

Glen Canyon: ~80 MW
Supply Curve for Geothermal Projects

2007 Supply Curve

- Wind
- Biomass
- Solar
- Hydro
- Geothermal

~35 MW
Summary Arizona Renewable Resources

<table>
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<th>Resource</th>
<th>Levelized Cost of Energy ($/MWh)</th>
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<th>GWh/yr</th>
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Renewable Energy Integration Model

- Supply curves for all resources are combined
- Renewable energy demand for each year is forecast
- Each year least-cost resources are “built” (removed from supply curve) to meet demand
- Time effects:
  - Some projects can’t be built in near term
  - Certain technologies improve over time
  - Incentives change
Limitations of Integration Modeling

- Avoided costs (market value) not explicitly included
  - *Very important for solar*
- Out-of-state resources not considered
- Transmission assessment is simplified
- No integration costs for wind resources
- Not a production cost model
Total Arizona Renewable Supply Potential in 2025

2025 Supply Curve

- Wind
- Biomass
- Solar
- Hydro
- Geothermal

Generation, GWh

Levelized Cost, $/MWh

2025 Demand: 11210 GWh

~5500 MW

Note: 2025 assumptions exclude current tax incentives
2009 Mix

- Wind: 89%
- Biomass: 4%
- Solar: 7%
- Hydro
- Geothermal
- Planned / Existing
2017 Mix

- Wind: 19.3%
- Biomass: 6.3%
- Solar: 6.7%
- Hydro: 2.9%
- Geothermal: 1.3%
- Planned / Existing: 63.6%
2025 Mix

- Wind: 22.1%
- Biomass: 6.6%
- Solar: 65.0%
- Hydro: 1.7%
- Geothermal: 2.2%
- Planned / Existing: 2.3%
Key Conclusions

- Arizona appears to have sufficient in-state renewables to meet demand, except in the very near-term
- Non-solar resources limited
- Non-solar resources important
- Regional renewable energy markets should be considered
- Lowest cost resources are Glen Canyon hydro and biomass cofiring
- Solar about twice raw cost of other resources – but additional value not considered in this project
- Arizona’s reliance on solar is unique
What Next?

- Paul Smith (APS) – Value Adjusted Supply Curves

- Renewable Energy Transmission Initiative (RETI)
  - Transmission
  - Value
  - Regional

RETI Study Area
Questions

- Are there any questions?
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Full report available at: