Concentrating Solar Deployment Systems (CSDS) – A New Model for Estimating U.S. Concentrating Solar Power Market Potential

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CSDS (based on WinDS) is a computer model of expansion of generation and transmission capacity in the U.S. electric sector spanning the next 50 years. It minimizes system-wide costs of meeting loads, reserve requirements, and emission constraints by building and operating new generators and transmission in each of 26 two-year periods from 2000 to 2050. The CSDS model is focused on addressing the market issues of greatest significance to renewables – specifically issues of transmission and resource variability.

CSDS attempts to examine these issues primarily by using a much higher level of geographic disaggregation than other models. Other models (such as the NEMS model used by the U.S. Energy Information Agency) have only a few regions in the US (13 in the case of NEMS). These models have to make assumptions about the cost of transmission and resource variability on the electric grid. With a high level of geographic disaggregation, CSDS can model these distance effects directly within the model instead of making assumptions. CSDS uses 358 different regions in the entire United States. Much of the data inputs to CSDS are tied to these regions and derived from a detailed GIS model/database of the renewable resources, transmission grid, and existing plant data. The geographic disaggregation of solar resources allows CSDS to calculate transmission distances and the benefits of dispersed solar plants supplying power to a demand region.

In the United States, the viable solar resource areas are located primarily within the southwestern states. Therefore, in the model, only regions within the southwest are allowed to build CSP plant. Note that the entire country is still modeled and conventional generation and other renewables are built as needed outside this region.

Similarly to the models breakdown of wind resource into five classes, the solar resource appropriate for CSP systems has also been broken into five classes that are defined by the annual average direct normal radiation ranging from 6.75 KW/m2/day to 8.06 kW/m2/day. Additionally, there are a variety of exclusions applied to the solar resource areas.

Linear programs, such as WinDS and CSDS, work by minimizing an objective function while subject to constraints. The cost minimization that occurs is subject to over seventy types of constraints including transmission line access, physical resources, load constraints, and emission and policy constraints. The CSDS objective function is a minimization of all the costs of the US electric sector including the present value of the installation cost and anticipated O&M costs of both generation and transmission capacity, fuel costs, emission penalties and many more.

CURRENT CSP SYSTEM ASSUMPTIONS

Ideally, the model would compete solar-only, trough with storage, dishes, solar towers, etc. in an economically optimum portfolio. However, this first stage of development limits the situation to a single technology (parabolic trough Rankine cycle similar to the SEGS plants installed in California) with a pre-selected thermal storage level of six hours. These factors, combined with an assumed scale of 100 MW plant size, determine the initial cost and performance characteristics. The NREL CSP analysis tool, Excelergy[1], is a Microsoft Excel based performance and financing tool for parabolic trough systems with current costs and performance assumptions. The basic plant configuration, operating and financial assumptions and performance by solar class were based on Excelergy.

The storage assumption greatly simplifies the treatment of resource variability and allows an assumption of dispatchability.

BASE CASE ASSUMPTIONS AND RESULTS

In this analysis, the Base Case is a business-as-usual case that relies heavily on the Reference Case scenario of the US Energy Information Agency Annual Energy Outlook for

[1] Price, H. (2003). Parabolic Trough Solar Power Plant Simulation Model: Preprint. 12 pp.; NREL Report No. CP-550-33209.

2005[2] for inputs that fall outside the scope of WinDS. This includes electricity demand, fossil fuel prices, existing federal energy policies, and the cost and performance of non-renewable electric generating technologies.

With these Base Case inputs, CSDS projects that solar power will provide about 55 GW of capacity in 2050, far larger than today's 350 MW (see top slice of graph in Figure 4). Although this growth is largely attributable to improvements in the cost and performance of solar power plants, there are many other drivers.

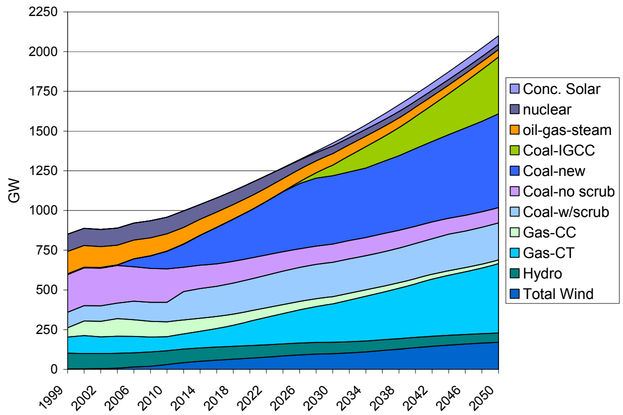

Figure 4: National Capacity for the CSDS Base Case

Another interesting question of deployment, which can be answered by CSDS, is where the future CSP capacity will be located. Based on the GIS inputs to CSDS, transmission, siting issues and load location and load growth, the model selects the economically best sites for each period to add new capacity. Figure 7 shows the location of CSP capacity in 2050. Expectedly, these are locations throughout the southwest with class 5 solar resource as well as locations that are close to large electric load growth (such as in southern California).

Figure 7: Projected CSP Capacity (MW) by region in 2050

[2] United States DOE, EIA, "Annual Energy Outlook 2005", January 2005, DOE/EIA-0383(2005)

Figure 8 maps where the power produced by the capacity is shipped and used to meet load. Notice that CSP generation is shipped significantly outside of the area in which the capacity is built.

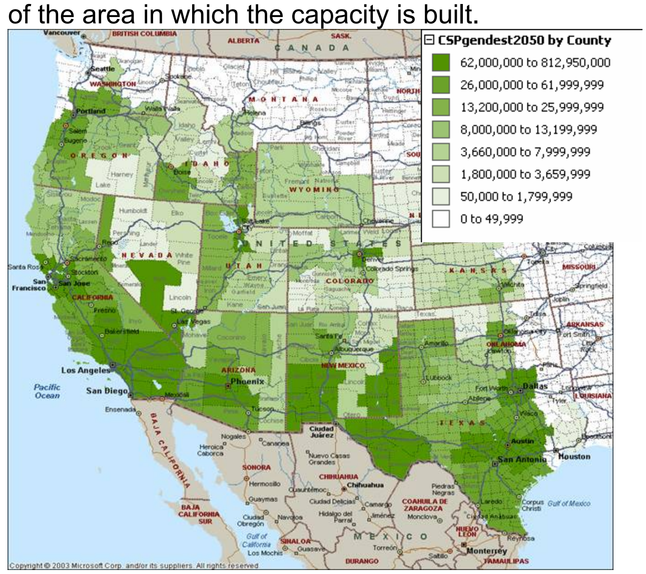

Figure 8: Projected Regions to which CSP Power (MWhr) is shipped.

SENSITIVITY CASES FOR FEDERAL POLICIES

The real power of this model is to examine the impact of various policies on the penetration of CSP into the U.S. electric market. To date, we have examined three federal policies:

- Continued Federal R&D Spending on CSP
- Extension of the Investment Tax Credit (ITC) to 2012 and 2020
- Extension of the Production Tax Credit (PTC) to 2012 and 2020

The results of these analyses are published elsewhere but demonstrate that a lack of R&D significantly limits penetration, an extension of the 30% ITC significantly enhances near-term penetration and using a wind-like PTC instead of an ITC does not enhance market growth until CSP costs have declined in the future.

CONCLUSIONS

- A tool has been developed to model the future capacity growth of CSP trough systems that incorporates detailed information about resource data, transmission and load.
- CSDS can give an idea of the location of future CSP deployment and CSP generation wheeling.
- CSDS is capable of examining the possibilities of a high-penetration CSP vision.
- This tool can be used to examine a variety of future federal and state policy impacts as well as technology and competitive market impacts.