National Renewable Energy Laboratory
Innovation for Our Energy Future

A national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy

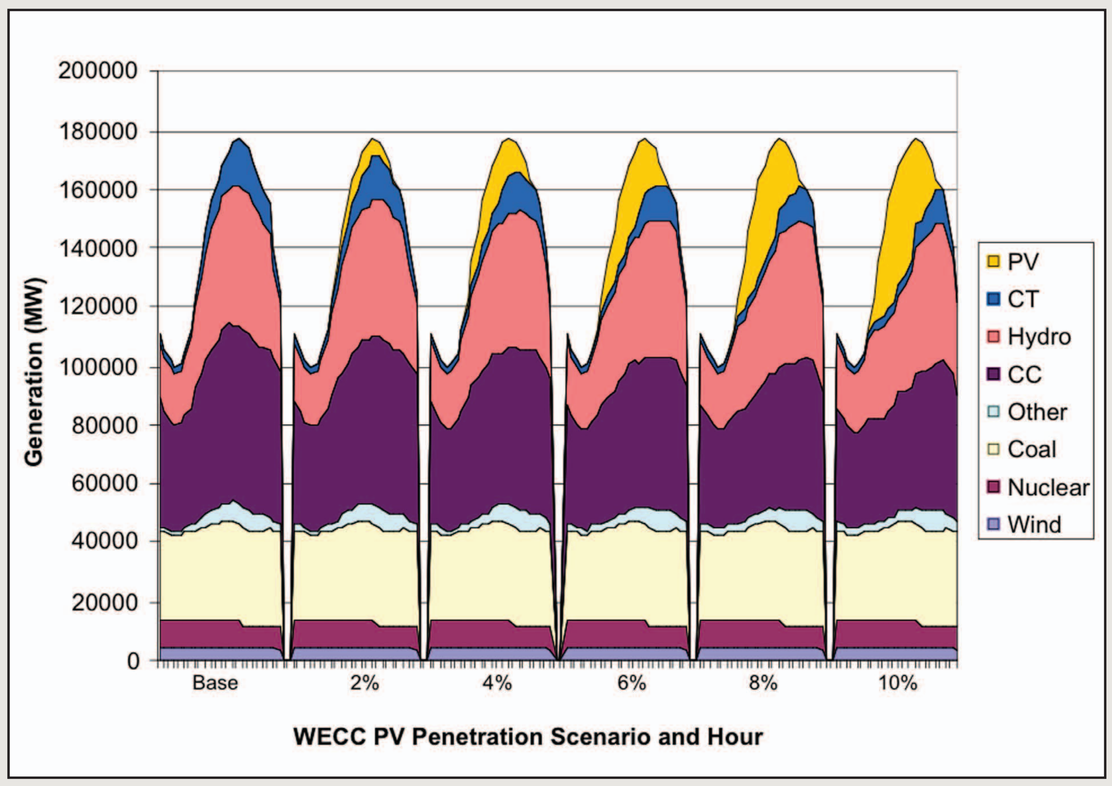
Modeling the Benefits and Limitations of Large-Scale Photovoltaic Deployment

BACKGROUND/OVERVIEW

The U.S. Department of Energy's Solar Program has launched the Solar America Initiative (SAI), and Renewable Systems Interconnection Study to support innovative research while accelerating the rate of deployment of PV technologies. Part of these efforts have been to examine the technical, regulatory, and business issues that have the potential to limit the market uptake of distributed photovoltaics (PV). NREL has used several tools to evaluate the impacts of PV on the grid as a whole, to examine both benefits and limits to PV deployment. These tools include a commercially available production cost model (PROSYM) and an NREL developed tool (PVFlex).

MODELING UTILITY SYSTEM IMPACTS OF PV DEPLOYMENT

- Use an existing commercially accepted tool for evaluating electric power system operation (PROSYM)
- Examine changes in load shape and power plant dispatch resulting from large-scale PV deployment
- Evaluate avoided generation, fuel use and emissions

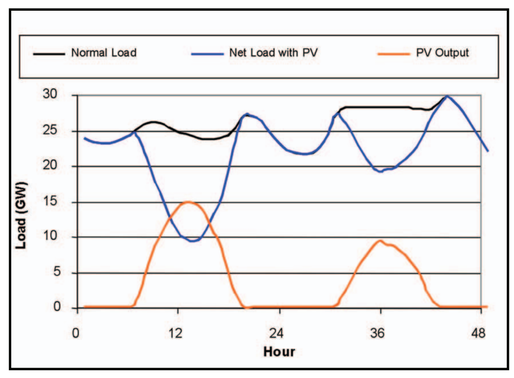


Simulated Generation Mix in the Western U.S. with Varying PV Penetration

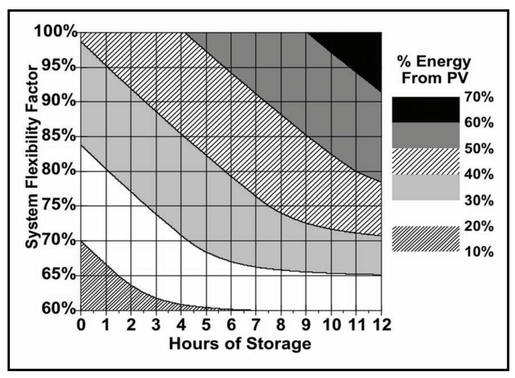
EXAMINING THE LIMITS OF PV DEPLOYMENT

Develop a new analysis tool (PVFlex) to evaluate the upper limits of PV deployment.

- Examine potentially unusable PV generation caused by intermittency and power plant operational limits
- Evaluate benefits of enabling technologies, such as load shifting, more flexible generation, and long distance transmission
- Quantify the amount of energy storage necessary to achieve very high penetration of PV, providing more than 20% of a region's energy.



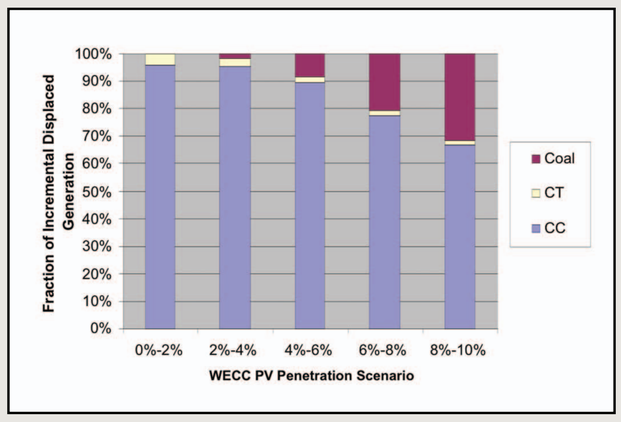
Impact of Large Deployment of PV on a Spring Day in Texas



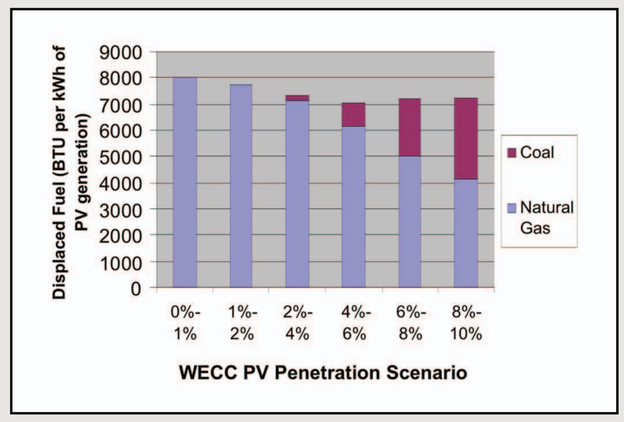
Storage Requirement to Meet a Large Fraction of a System's Energy

AVOIDED GENERATION AND FUELS

- Evaluate the mix of generation avoided by PV deployment in the Western U.S. Grid (WECC)
- Evaluate the avoided fuel rate (BTUs of gas and coal)
- Examine the impact of increased power plant cycling and load following



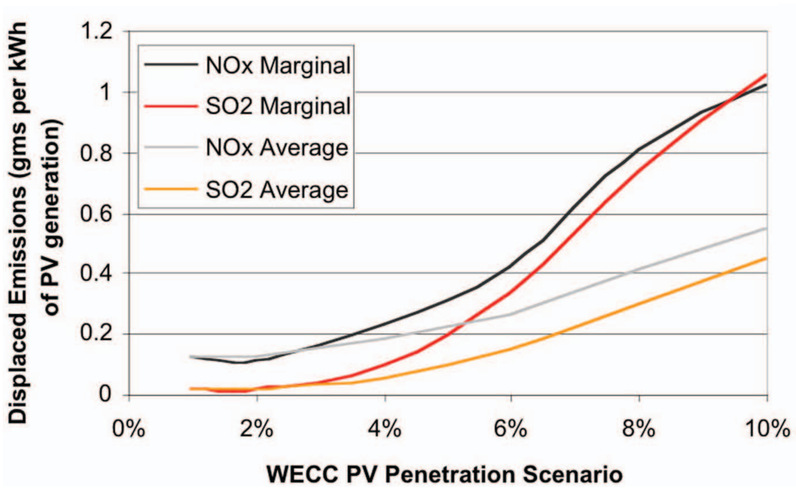
Mix of Displaced Generation Type in the Western U.S. with Varying PV Penetration



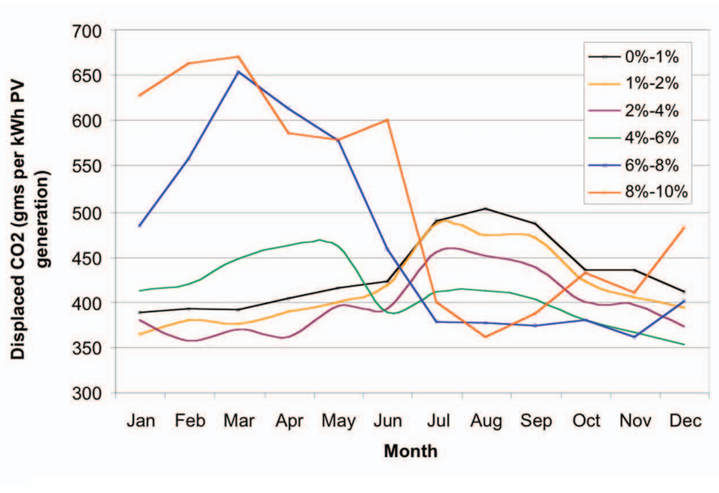
Displaced Generation Fuel with Varying PV Penetration

AVOIDED EMISSIONS

- Examine avoided emissions of NOx, SO2, and CO2



- Examine seasonal impacts



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