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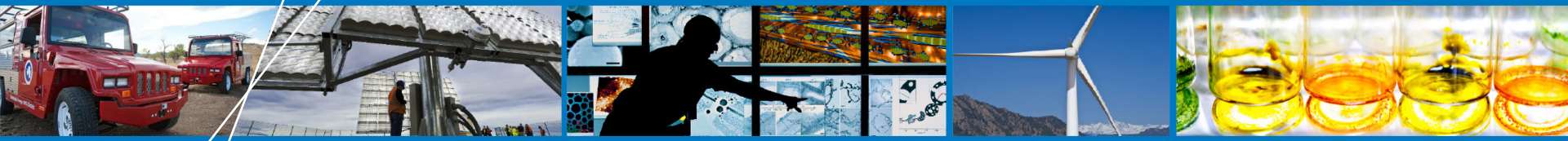
NATIONAL RENEWABLE ENERGY LABORATORY

# System Advisor Model
# Battery Storage



**Presenter: Nick DiOrio**

**September 17, 2015**

# Outline

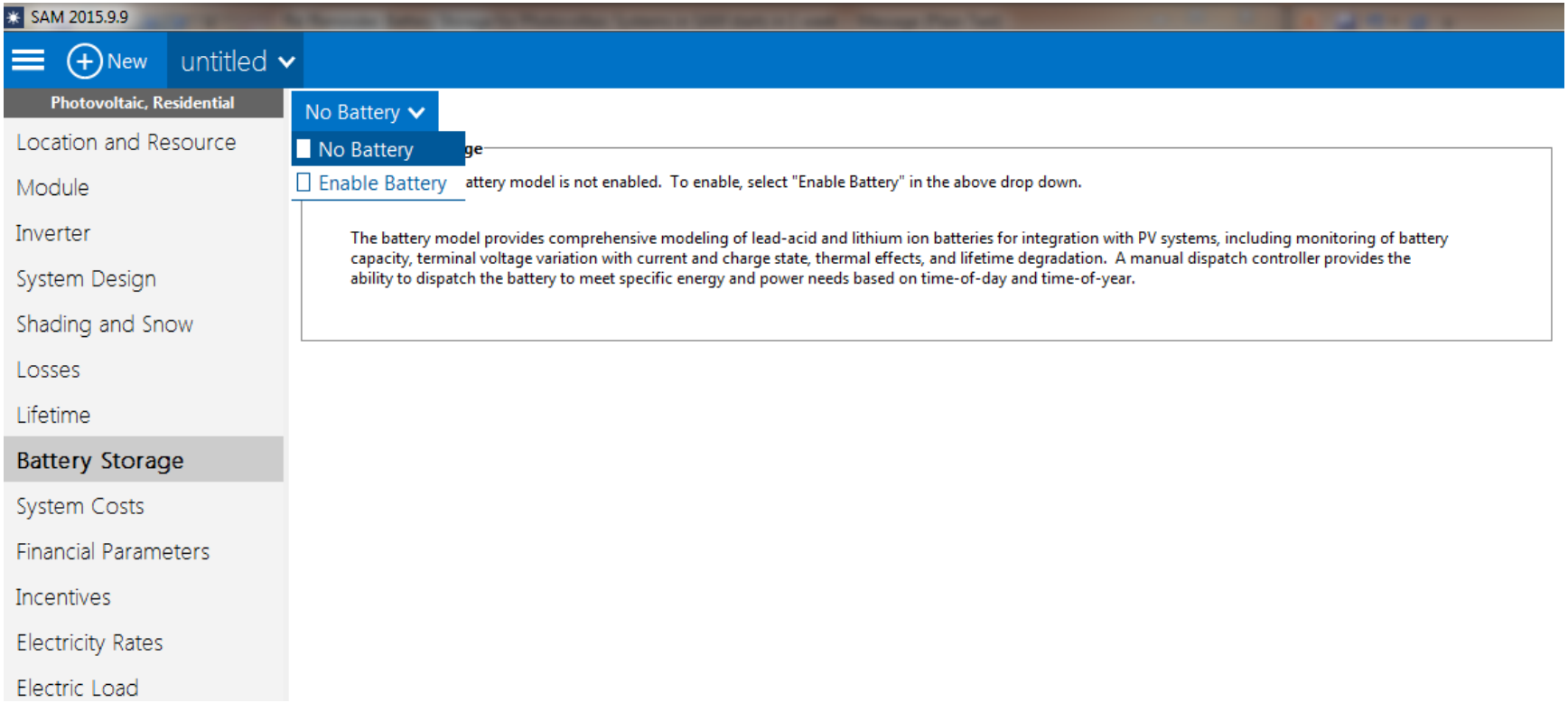
- Overview of battery model
- Battery financial inputs
- Battery technical performance
- Battery dispatch
- Upcoming features
- Demonstration
- Q & A

# Model Overview

- **Techno-economic model for behind-the meter residential, commercial, and third-party ownership systems**
  - Lead acid & lithium ion battery chemistries
  - System lifetime analysis including battery replacement costs
  - Models for terminal voltage, capacity, temperature
  - Manual dispatch controller

# Enabling Battery Model

- Must select **Start New Project** -> **Photovoltaic (detailed)** -> **Residential (distributed)** or **Commercial (distributed)** or **Third Party Ownership**
- Then, **Enable Battery** from the **Battery Storage** sidebar



# Battery Financials

- **System lifetime analysis**

Single year does not capture complexity of battery replacements

PV simulation over analysis period

**PV Array Performance Degradation**

Module degradation rate (Value) 0 %/year

Applies to the array's hourly DC output.

- **Upfront & replacement costs**

Battery bank capacity [kWh] * price [$/kWh]

**Direct Capital Costs**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Module | 928 | units | 0.2 | kWdc/unit | 199.8 | kWdc | 0.71 | $/Wdc |
| Inverter | 5 | units | 36.0 | kWac/unit | 180.0 | kWac | 0.21 | $/Wdc |
| | | | | Battery bank | 3.0 | kWh dc | 600.00 | $/kWh dc |

- **User specified replacement criteria**

When max capacity is *n* % of original maximum

- **Escalation/De-escalation**

Model battery replacement costs over time

**Battery Bank Replacement**

- (•) No replacements
- ( ) Replace at specified capacity
- ( ) Replace at specified schedule

Battery bank replacement threshhold 20 % capacity

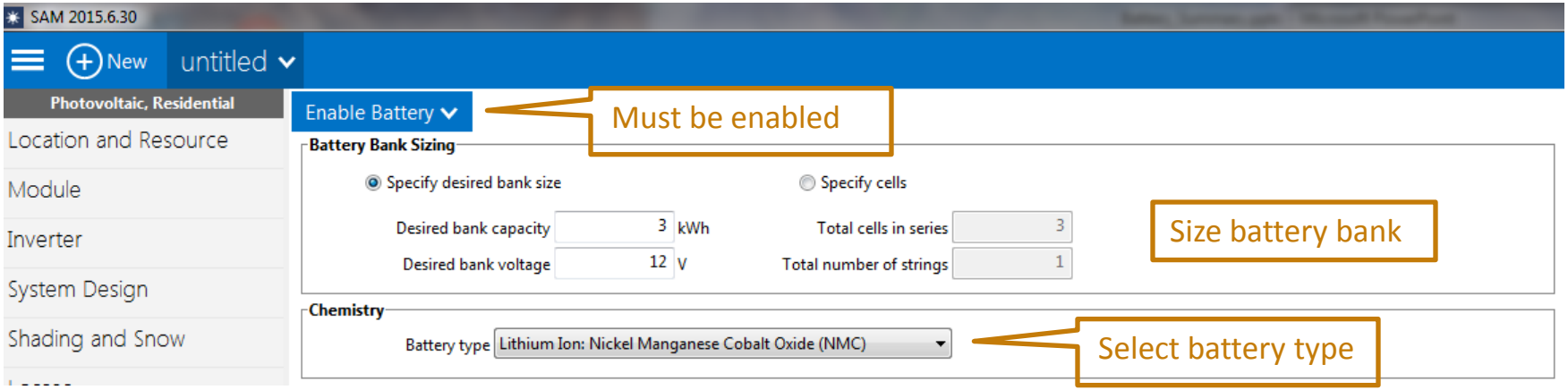
Battery bank replacement schedule [Edit data...]

Battery bank replacement cost (Value) 600 $/kWh

Cost escalation above inflation 0 % %/year

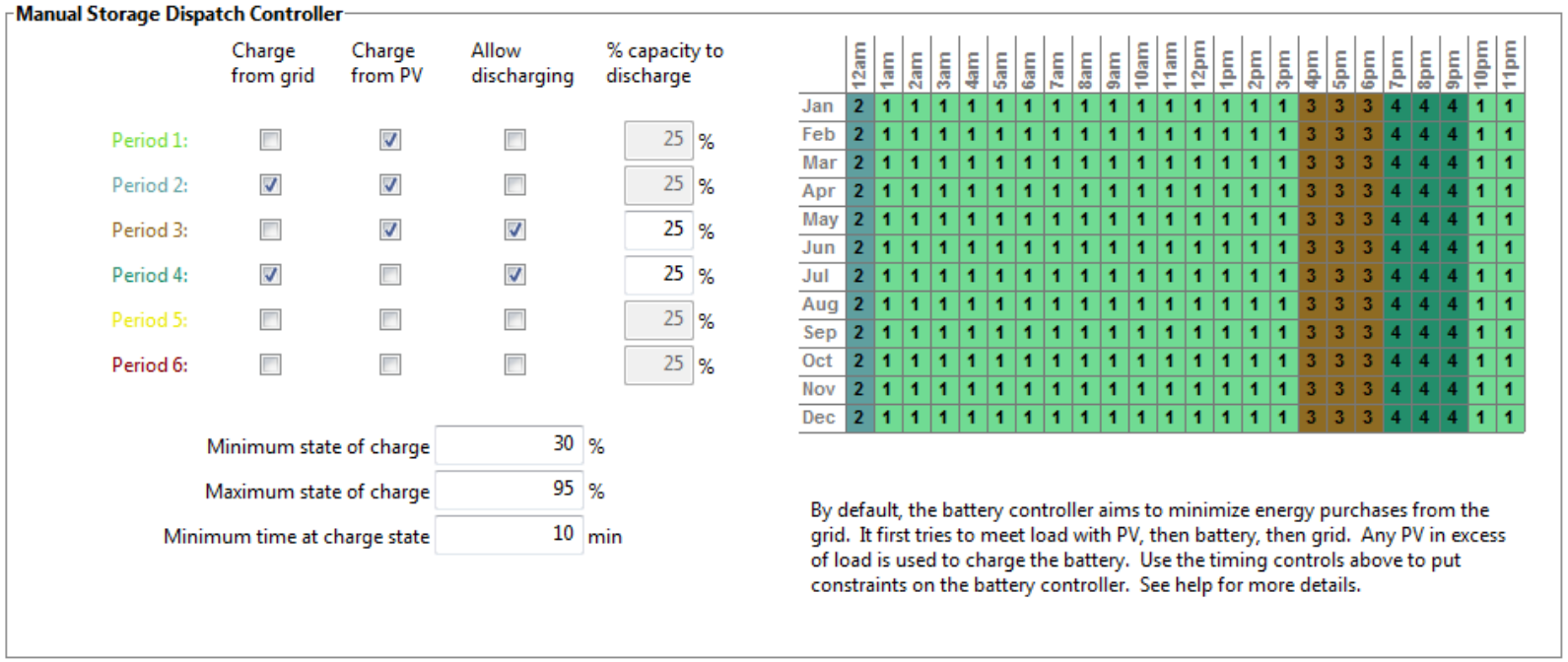
In Value mode, SAM applies both inflation and escalation to the first year cost to calculate out-year costs. In Schedule mode, neither inflation nor escalation applies. See Help for details.

# Battery Performance



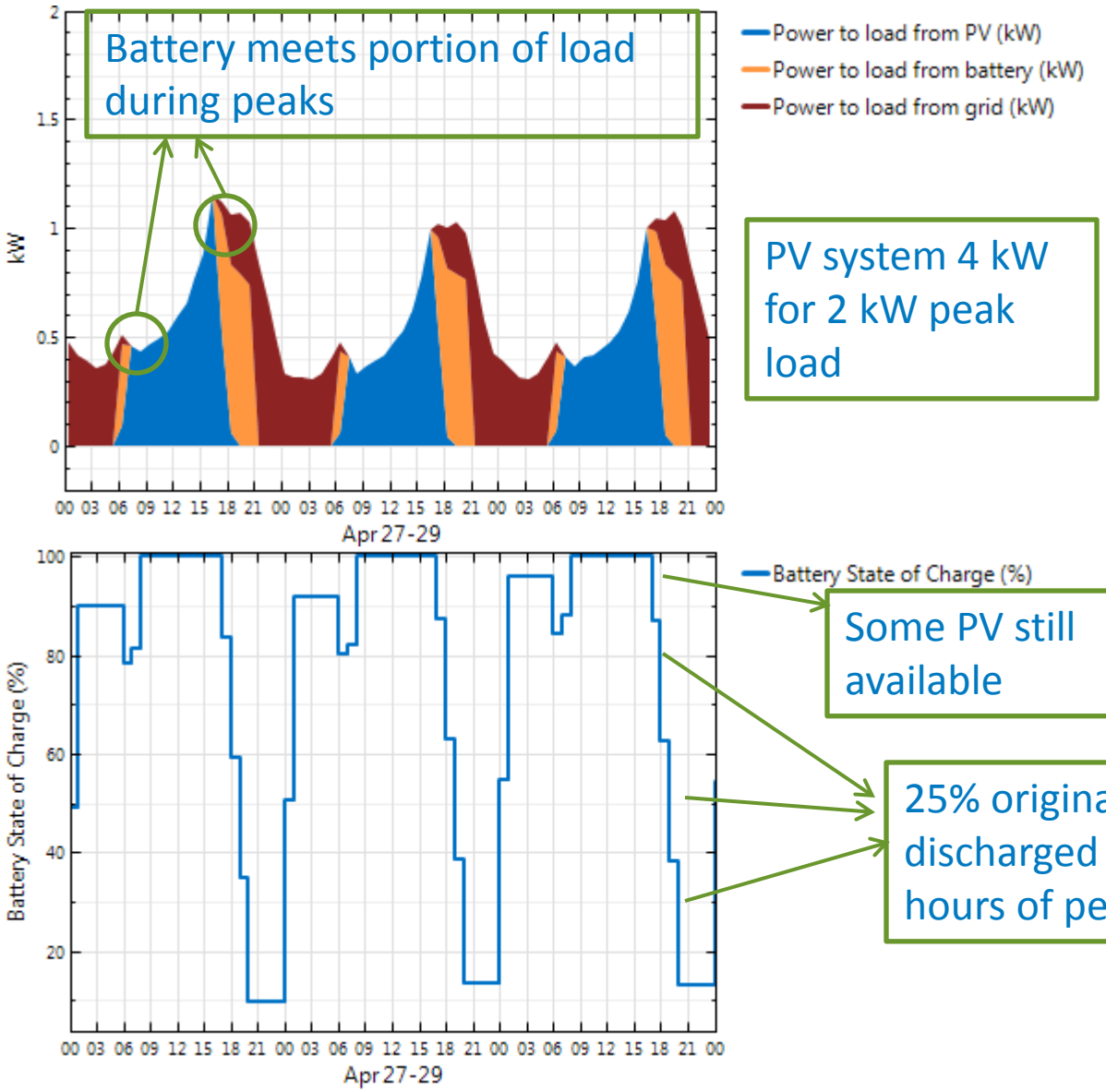

- Minimum necessary inputs for battery performance
- Other inputs can be populated by accepting defaults for battery chemistry type or manually input
- Remember to scale battery bank voltage as you increase capacity

# Battery Dispatch




- Can specify when to charge from grid, pv, and discharge, and max energy to discharge
- Limits for state-of-charge, rapid oscillations
- Grid recharge mode

# Dispatch Visualization




PV system 4 kW for 2 kW peak load

Some PV still available

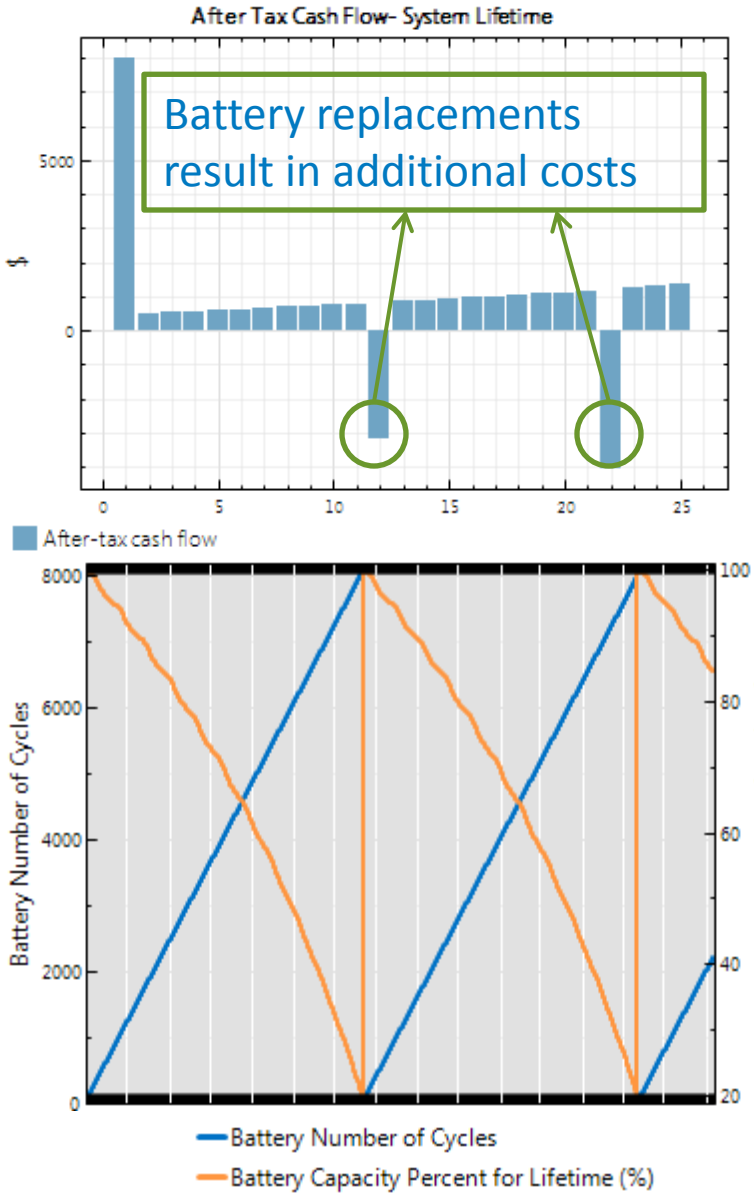
25% original available capacity discharged over remaining three-hours of peak

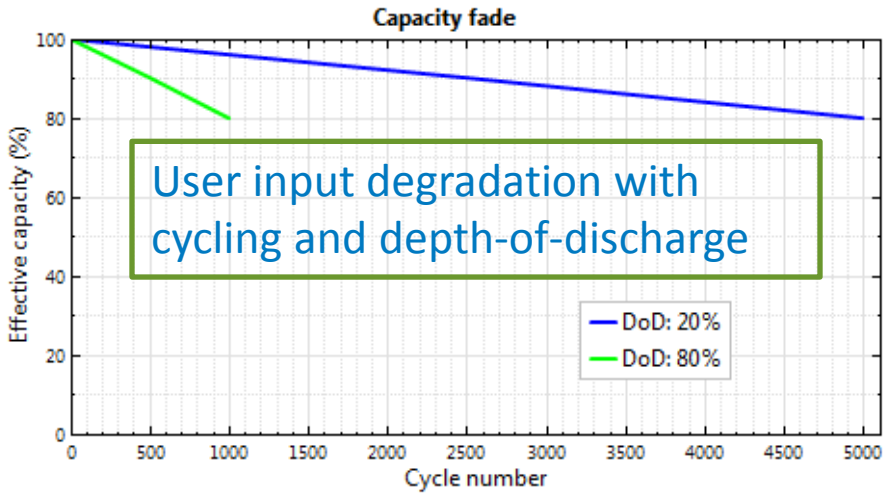
**Strategy**

- Charge from grid 12-2 am
- Charge from excess PV anytime available
- Discharge to meet load during morning peak
- Discharge to meet load during evening peak
- Minimum SOC: 5%

# Lifetime degradation and financials

- User input ***dispatch strategy***, ***degradation***, ***replacement criteria*** and ***costs*** result in tailorable replacement model.



# Upcoming features

- **Automated dispatch for peak shaving**
  - 24 hour look ahead
  - Shave peaks every day based on battery capacity and ability to recharge from grid, or specify target power to shave to.
  - Rate structure not considered in dispatch decisions. Every peak is considered equal valuable.
- **Tailor amount of power to charge from grid**
- **Expected in next release (late 2015 or early 2016**

# Demonstration

**Question: What is the benefit of adding batteries to PV for a commercial building in Los Angeles?**

**Steps:**

1. **Create a detailed PV case with Commercial financial model**
2. **Input details about location, PV system, battery system**
3. **Tailor dispatch strategy to electricity rates**
4. **Compare payoff period to no-battery case**

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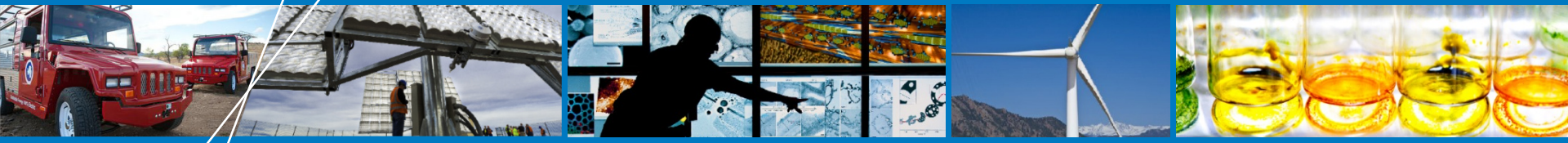

# Questions?