Solar Beyond Grid Parity Workshop

METRICS BREAKOUTS

Friday, April13

(Feedback consolidated from all breakouts)

Question 1

What *system level* metrics will best drive R&D toward new learning curves that enable both high efficiency and temporal flexibility of solar-generated *electricity dispatch*, while keeping solar energy costs low? What should the targets be for these metrics?

- **Efficiency**
  - State of the art *system* efficiencies: CSP – 20%, PV - 20%, thermochemical H_2 production – 19% (iron oxide/metal oxide) in lab experiments
  - To push current technology, need at least 30% total avg system efficiency goal; Target goal = 40%
  - Efficiency definition= Electricity out/Energy in photons incident on collector area
  - Annualized Photon to current efficiency might be useful
- **Scale**
  - Size/scale of the field (MW-scale much more attractive than >100MW)
    - Hard to iterate on designs with very large plants
  - Energy payback time
- **Dispatchability**
  - 20-30% dispatchable
  - short (min) to medium (diurnal) to long (seasonal) metrics
  - Hours of storage at name plate power level, at a particular leakage rate
  - Temporal response rate (spin up/down)

Question 1 (Continued)

What *system level* metrics will best drive R&D toward new learning curves that enable both high efficiency and temporal flexibility of solar-generated *electricity dispatch*, while keeping solar energy costs low? What should the targets be for these metrics?

- **Reliability**
  - A metric similar to resiliency in computing world is needed, build in redundancies
  - Uptime of at least 95% suggested
- **Deployability**
  - Can the system be implementated on a rooftop? Does it need to be located in a desert?
  - Distance from production to actual use ($ for infrastructure, is $0.06 not realistic?)
- **Costs**
  - Combined system needs to be cheaper than PV or CSP systems
  - Needs to be at grid parity
  - LCOE could be characterized in terms of losses
  - LCOE: 6¢/kWh too broad – provide template (ASPEN, etc) to explain LCOE calculation to avoid different methods – allows for design flexibility
  - Capex cost of CSP vs. PV vs. combined systems and payback time

Question 1 (Continued)

What *system level* metrics will best drive R&D toward new learning curves that enable both high efficiency and temporal flexibility of solar-generated *electricity dispatch*, while keeping solar energy costs low? What should the targets be for these metrics?

- **Emissions/Environmental**
  - Carbon footprint (x tons CO_2/MWh electric)
  - Net carbon production
  - Geographic usage/land area required/constraints
- **Power Output**
  - Require narrow range of power output vs. day or year (#Wh/day, Wh/yr)
  - Load profile and a resource model that system must be able to meet, specific to location/environment (local resources)
- **Other**
  - Project development time
  - System lifetime

Question 2

What *system level* metrics will best drive R&D toward new learning curves that enable high efficiency in the production of portable solar energy in the form of *energy dense transportation fuels*, while keeping solar energy costs low? What should the targets be for these metrics?

- **Efficiency of producing fuel (e.g., CO, H_2)**
  - Efficiency definition = HHV (or LHV)/input solar energy
  - 30-40% efficiency for fuel production
  - 75% electrical & thermal energy in to out in the chemical conversion of fuel
- **Feedstock source**
  - Need to consider type and availability (CO2?)
- **Scale of plant**
- **Cost**
  - $2-3/gge (and works with existing infrastructure)
- **Emissions/Environmental**
  - Carbon footprint (x tons CO_2/MWh electric)
- **Parity, drop in compatibility with present day fuels (including NG)**

Question 3

Aside from overall system metrics, what *component technology* metrics are universal and important enough to accelerate the development of the needed system-level solutions? What should the targets be for these metrics?

- **Photovoltaics**
  - Continue to drive down cost of PV (though this may be irrelevant at high concentration)
  - Component cells must have ≥50% efficiency for the band of incident light on the cell under AM1.5D at the concentration of the system.
  - High temperature PV
    - Annual degradation: at >200C, <1% relative to starting efficiency
    - Temperature dependency of efficiency: -0.05%/deg
- **Optics**
  - Heliostat cost < $70/m^2
  - Cost of concentration vs. cost of PV ($/m^2) – concentration cost must be significantly lower than PV cost to drive development toward concentrated systems
  - Concentration + spectrum splitting >90% optical efficiency
  - Degree of spectral splitting spillage into adjacent bands
  - Combining optical efficiency + concentration $/m^2
- **Thermal**
  - >95% heat exchanger effectiveness/efficiency at high-temp (>1200°C)

Question 3 (Continued)

Aside from overall system metrics, what *component technology* metrics are universal and important enough to accelerate the development of the needed system-level solutions? What should the targets be for these metrics?

- **Storage**
  - For dispatchable electricity: round trip efficiency (electricity to electricity) > 80% - captured in dispatch + LCOE
  - 25% dispatchability over a 24 hr period
  - Joint heat + electricity storage opens up larger grid storage applications
  - Benefits of combining storage + thermo generation cycle equipment.
  - ARPA-E GRIDS metrics may be a good starting point ($100/kWh$_e$)
  - Store 100x more energy over the lifetime of the equipment than needed to manufacture that equipment
- **Durability**
  - Component lifetime ≥ 20 yrs
- **Sustainability**
  - Toxicity, scarcity (leaning towards earth abundant materials), embodied energy
- **Other**
  - Would be difficult for teams to meet both system-level and component-level metrics
  - Component influence on balance of plant needs to be recognized
  - Electrical conversion efficiency for distribution systems (target= 95%)