Title: Install Rooftop PV on Campus Buildings

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Purpose: To install solar electric systems on suitable campus buildings, generate carbon free electricity, and reduce the consumption of grid electricity and associated CO2 emissions.

Description: Rooftop solar electric systems generate carbon free electricity where it is needed, on the rooftops of buildings. Solar electric system prices have dropped dramatically over the last few years, making solar power competitive with other power sources. Solar is now one of the fastest growing energy sectors and is a highly competitive and mature market. A substantial amount of solar power can be generated on HSU campus buildings. It can be installed with no upfront costs via a power purchase agreement and can be competitive with the price of standard grid power. Solar electricity is carbon free, and is therefore a key strategy for reducing HSU campus greenhouse gas emissions.

Recommendation: It is recommended that HSU explore opportunities to install solar electric arrays on the rooftops of the majority of campus buildings. A preliminary list of locations is included below. To minimize/eliminate upfront costs and maximize utilization of federal tax credits, it is recommended that HSU pursue a power purchase agreement ownership arrangement.

- ***System Description -*** Install rooftop PV systems on the following campus buildings:

Building	**Estimated Available Roof Area (sq.ft.)**
Athletic Complex Bldgs	31,000
Library	19,000
Sunset/Redwood Dorms	14,000
Plant Ops	11,000
Siemens Hall	10,000
Behavioral and Social Sci	6,000
University Center	6,000
Forestry	6,000
Theater Arts	5,000
Science A	4,000
Harry Griffith Hall	4,000
Music	3,500
Art A	3,000
Total	**122,500**

- ***GHG Reduction Potential -*** It is estimated that a total PV array capacity of approximately 520 kW_DC could be installed on the 13 buildings listed above. This would generate approximately 631 MWh/yr. Assuming a greenhouse gas emissions rate for the electricity that HSU is currently purchasing from Shell of 560 lbs CO2e/MWh, the solar electric generation would result in 161 MT/yr of CO2e.
- ***Cost/Financing -*** Upfront capital purchase or via Power Purchase Agreement (PPA). A PPA is recommended. The university would not incur any upfront cost. In addition, a PPA would allow a third party owner/lessor to take advantage of the 30% federal tax credit. It is expected that the

solar power purchased via a PPA would be competitive with or cheaper than power purchased directly from PG&E. It may be more expensive than the rates currently being paid via HSU's direct access contract with Shell. This will not be clear until contract details with the PPA provider are known.

- ***PPA's and risk –*** The Solar PPA model removes risk from the university. The university only pays for the electricity that is actually generated by the PV system. If the PV system underperforms, or in the worst case fails, the university pays accordingly. If no power is generated, the university pays nothing. All risk is placed on the company that owns the PV system and is providing the power under the PPA contract.
- ***RECS –*** Renewable Energy Credits are tradable commodities that represent the environmental benefits associated with renewable energy (i.e., greenhouse gas emission reduction, pollution reduction, improved sustainability, increased national security, etc.). RECs typically belong to the entity that owns the PV generator, but this can be negotiated in the PPA. If HSU wants to claim the GHG reduction associated with installing rooftop PV it will need to negotiate ownership of the RECs associated with the PV generator.
- ***Timing -*** Conduct planning and evaluation in 2016. Conduct project design, development and implementation in 2017. The 30% Federal Solar Investment Tax Credit is in effect through 2019 after which time the credit amount begins to drop.
- ***Key Participants -*** Facilities Management, Schatz Energy Research Center, HEIF, RESU, Environmental Resources Engineering Dept.
- ***Post* PPA -** If a PPA is the chosen route for financing, post PPA arrangements must be considered. Typically the investor takes the system away, renegotiates the PPA, or the university takes on ownership by purchasing the PV system (i.e., a lease to buy arrangement, typically the university can negotiate this 5 years into the PPA).
- ***Federal Support from NREL –*** A partnership between NREL, DOE and EPA offers technical assistance to universities wanting to pursue rooftop solar and PPAs, this will be a competitive program, must apply in 2016, see:
  http://www.nrel.gov/tech_deployment/tools_universities.html
  https://www.epa.gov/sites/production/files/2016-02/documents/webinar_20151216.pdf

Summary of Estimated Costs, Benefits and other Impacts:

- *Costs*
  - Estimated 25 year project lifetime
  - No initial startup costs if implemented via a PPA
  - Ongoing costs to purchase solar electricity may be slightly more than what is currently being paid.
- *Benefits*
  - 520 kW_DC of PV on 13 buildings would generate approximately 631 MWh/yr and would result in a greenhouse gas reduction of 161 MT/yr of CO2e.
  - Terms of PPA will need to be negotiated, but locking in a long-term rate can provide price stability and guard against rising electricity costs.
  - Hands-on learning opportunity for students to be involved in evaluating the opportunities to install PV arrays on campus buildings. If data monitoring equipment is included there could be on-going learning opportunities for students to assess and track system performance.
  - High profile project. On-site renewable power generation using solar electric technology can be featured and will give the HSU campus a feel of being both environmentally

sustainable and modern/high tech. These features can be used when marketing the university to prospective students and prospective donors.

- *Other Impacts*
  - Will cover a lot of roof space. Facilities management will have to make sure this doesn't cause any conflicts; none are expected.

Impact	Estimated Resource Costs	Estimated Benefits
Economic	The price of solar electricity via a PPA may be more expensive than the current price being paid for electricity from Shell via direct access.	A PPA would lock in energy prices over a long term (i.e., 20-25 years), thereby reducing the risk of volatile energy prices. Solar electric prices via a PPA should be fairly competitive with current utility prices.
Environmental	*N/A*	Reduction of 161 MT/yr of CO2e emissions, and approximately 3,800 MT over a 25 year lifetime. Reduction in other air emissions.
Social	N/A	Rooftop solar is generally perceived very favorably. It would significantly improve HSU's environmentally friendly image and could help with student recruitment and donor solicitations.

GHG Reduction/dollar spent: This will depend on the PPA contract terms.

Assumptions:

- Used rough estimate of rooftop area based on Google Earth satellite imagery. Assumed 70% of available area was usable for PV installation.
- Row-to-row spacing required for arrays based on NREL System Advisor Model (SAM)
- Estimated annual electrical energy generation (kWh/yr) estimated using SAM
- Assumed arrays were facing either south or west depending on building/roof orientation
- Assumed 20° slope for south facing array, 30° slope for west facing array
- Assumed emissions factor for electricity purchased from Shell Energy North America to be 560 lbs CO2e/MWh
- Assumed 25 year lifetime for PV system with a 0.5%/year system derate factor

References:

NREL info on solar PPAs
http://www.nrel.gov/docs/gen/fy16/65567.pdf,
http://www.nrel.gov/tech_deployment/climate_neutral/power_purchase_agreements.html,
http://www.nrel.gov/docs/fy10osti/46668.pdf

Solar PPA and Lease Providers in SF
http://sfenvironment.org/article/solar-electricity-photovoltaic/solar-ppa-and-lease-providers

NREL System Advisor Model (SAM)
https://sam.nrel.gov/