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Solar Professionals for the New Energy Era:

Activating engineering and business careers with online education

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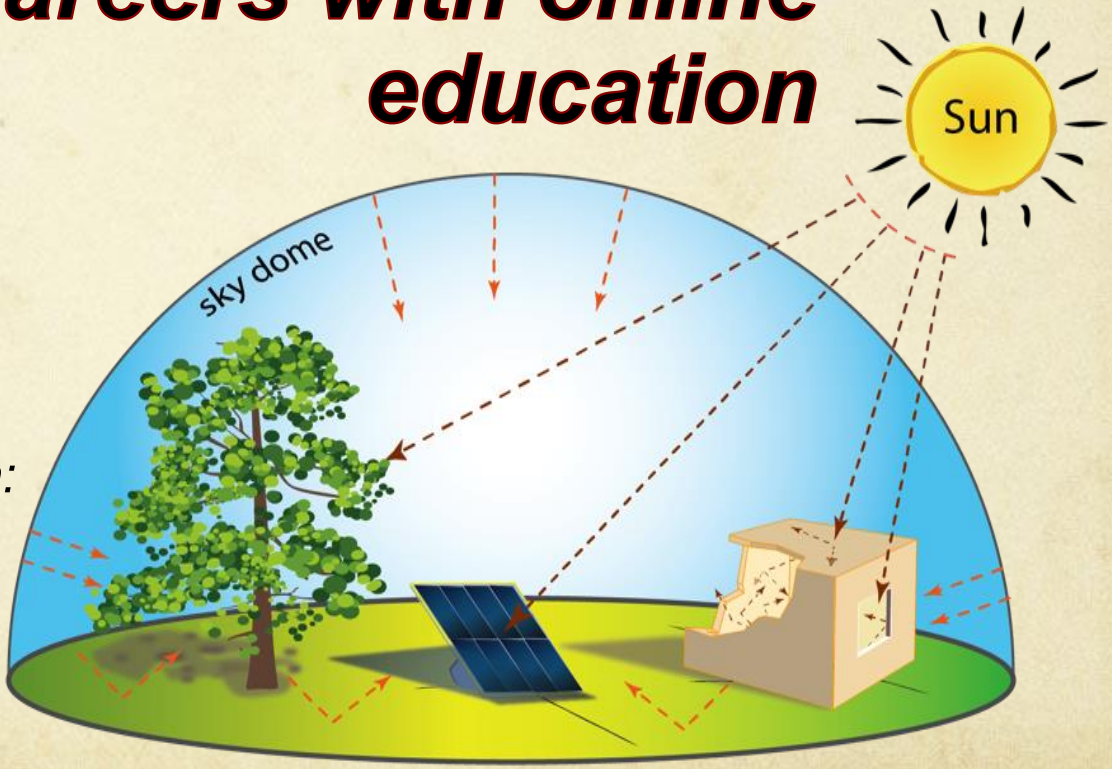
JOHN AND WILLIE LEONE FAMILY DEPARTMENT OF
ENERGY AND MINERAL ENGINEERING
COLLEGE OF EARTH AND MINERAL SCIENCES



Solar in Transition:
Connecting Opportunities with People

- "Solar" rides the wave of Photovoltaics
- PV is a global **commodity good**
- PV is a **bellwether for future opportunities** and value chains
- A future of solar as *goods* ***and services***
- **A future of rich solar exploration**

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Solar is filtering into our social systems

- Solar in Schools
- Law and Policy
- Communication of Solar
- Ethics of Solar

…revealing cultural barriers for change and adaptation

Bayville, NJ

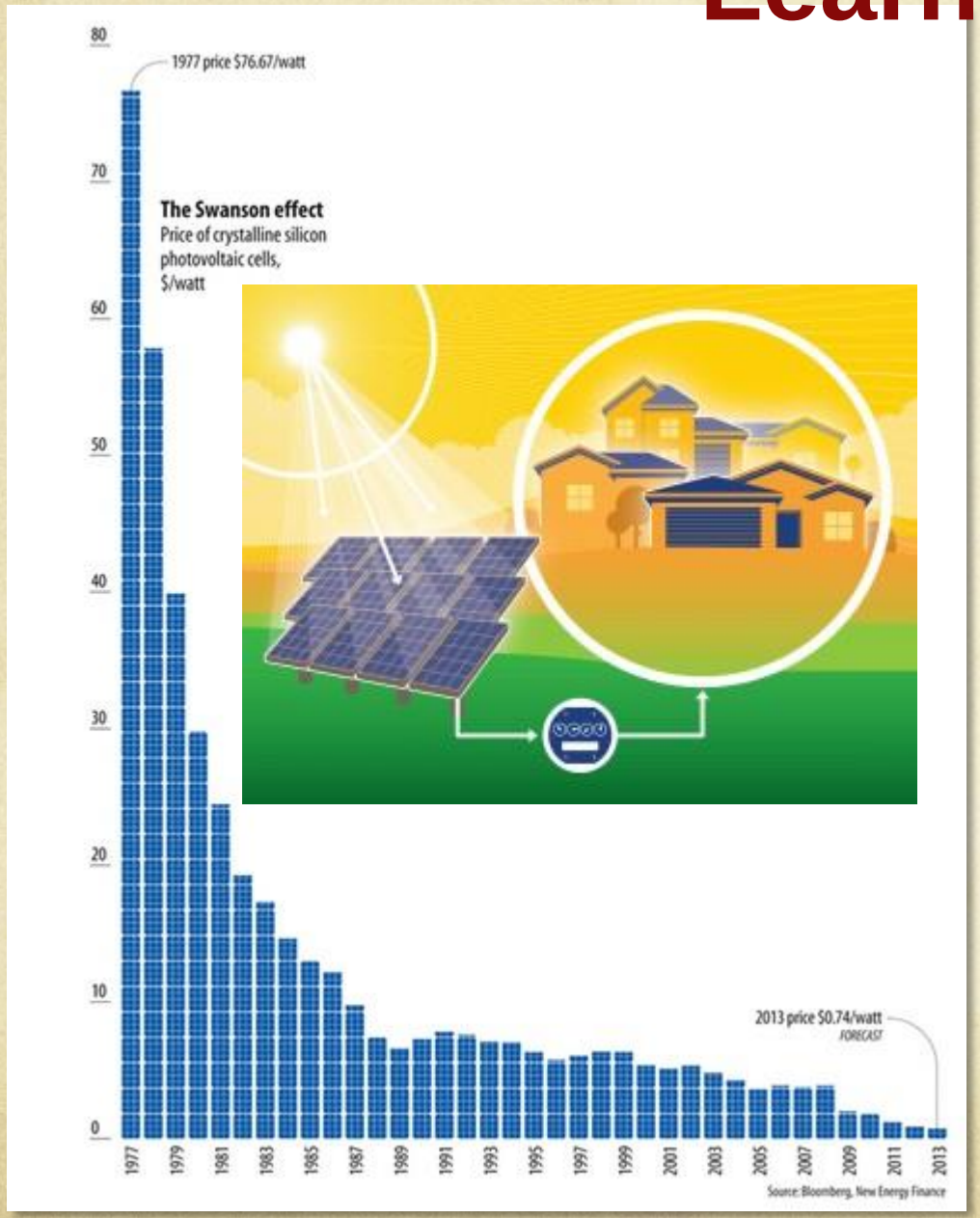
Bald Eagle Area Schools, Centre County, PA

Solar is already in the Schools

Nearly 3800 buildings now have solar installations
3 million students now attend K-12 with solar integrated

Source and Credit: NextEra Energy Resources Portfolio (Accessed Nov. 5, 2015)

Photovoltaics: Doubling and Learning



Credit: The Economist; "Sunny uplands" Nov. 21, 2012 www.economist.com

Growth Rate: 32-37% increase in PV installed globally

- PV industry doubles every 2 yrs
- Expanding Markets: Africa, Central/South America, Asia

Swanson Effect: 17-24% drop in manufacturing costs each doubling of cumulative production (learning curve)

- $76.67/watt in 1977 to $0.74/watt for 2014

pv magazine
PHOTOVOLTAIC MARKETS & TECHNOLOGY

BNEF: solar likely largest energy investment target 2015 – 2040

23. JUNE 2015 | APPLICATIONS & INSTALLATIONS, GLOBAL PV MARKETS, MARKET & TRENDS, INVESTOR NEWS, TOP NEWS | BY: JONATHAN GIFFORD

Solar will attract funding of around US$3.7 trillion of over the next 25 years, becoming the largest energy segment in terms of new investment. This is the key finding from Bloomberg New Energy Finance in its New Energy Outlook 2015 (NEO), published today, which estimates solar will generate 14% of the earth's electricity by 2040.

All solar is local.

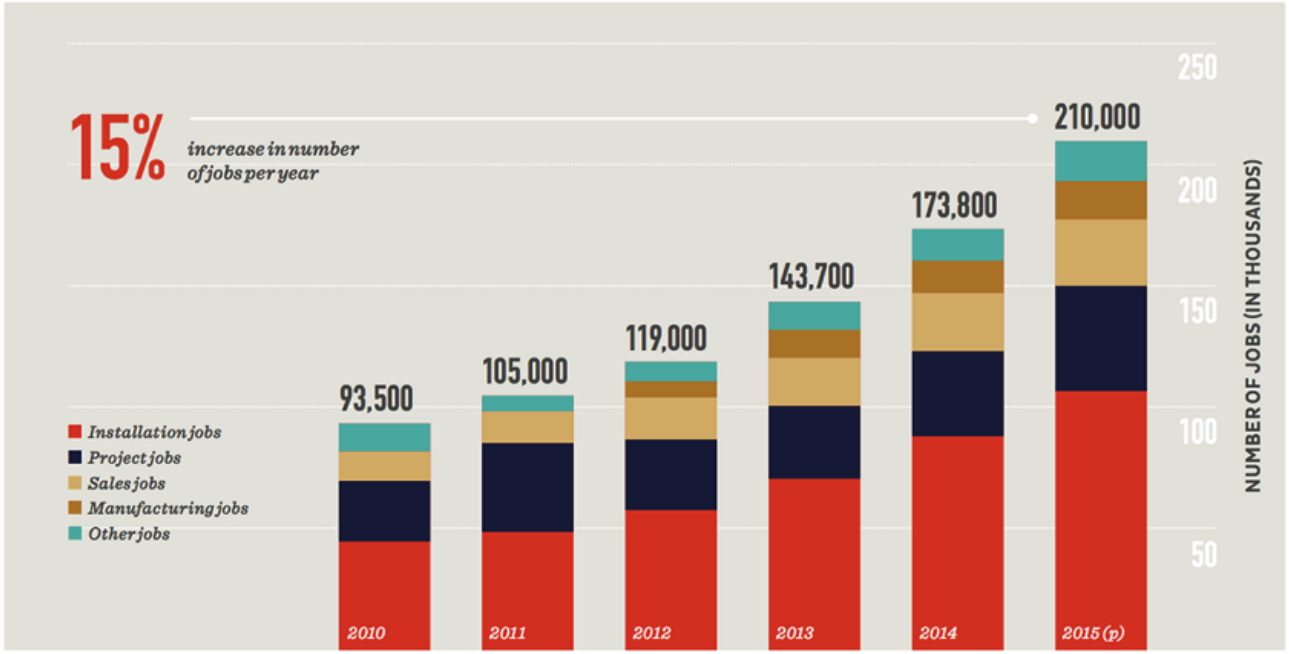
260,077 solar workers in USA (2016) up from 174,000 (2014)
>2800 solar jobs in PA

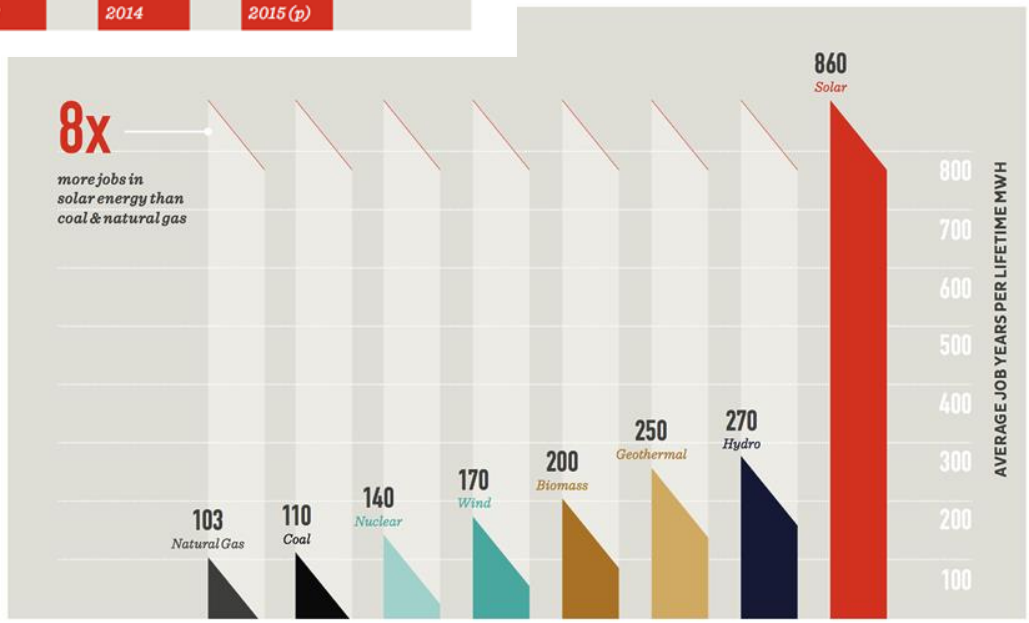
5 MW Keystone Solar Project: Lancaster, Community Energy (about 50 jobs)

Data Source: **The Solar Foundation**
http://www.thesolarfoundation.org/

[FIGURE 06]

Solar Jobs are Growing Faster Than the National Average





SOURCE: (FIG. 6) THE SOLAR FOUNDATION; (FIG. 7) RENEWABLE AND APPROPRIATE ENERGY LAB

Data Source: **The Solar Foundation**
http://www.thesolarfoundation.org/

Figure Credit:
"The Economic Case For Clean Energy"
NextGen Climate (Nov. 2015)

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Big Solar Goal: Activating engineering and business careers

We wish to grow communities of enthusiastic and informed solar agents across the globe

- **Online degree and certificates to build human capacity**
- **Uni Freiburg/Fraunhofer ISE Solar Energy Engineering**
- **Penn State RESS**
- **ISES: Young Professionals**

Solar Energy Engineering

Dr. Martin Heinrich

Uni Freiburg

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ENERGY AND MINERAL ENGINEERING

EME 810

SOLAR RESOURCE ASSESSMENT AND ECONOMICS

https://www.e-education.psu.edu/eme810/

Welcome to EME 810: Solar Resource Assessment and Economics

Print

New to EME 810?

Registered students should begin with the **Course Orientation**, located in the menu.

Not registered? Students who register for this Penn State course gain access to assignments and instructor feedback and earn academic credit. Learn more about our program and how to register here.

As a member of the inter-college Master of Professional Studies in Renewable Energy and Sustainability Systems, this course could count toward your RESS degree or toward a graduate Certificate in Solar Energy.

Quick Facts about EME 810

Instructor

Dr. Jeffrey Brownson, Associate Professor, Dept. of Energy & Mineral Engineering and Dept. of Materials Science & Engineering, College of Earth and Mineral Sciences, The Pennsylvania State University.

EME 810: **Solar Resource Assessment and Economics**

Search

LESSONS

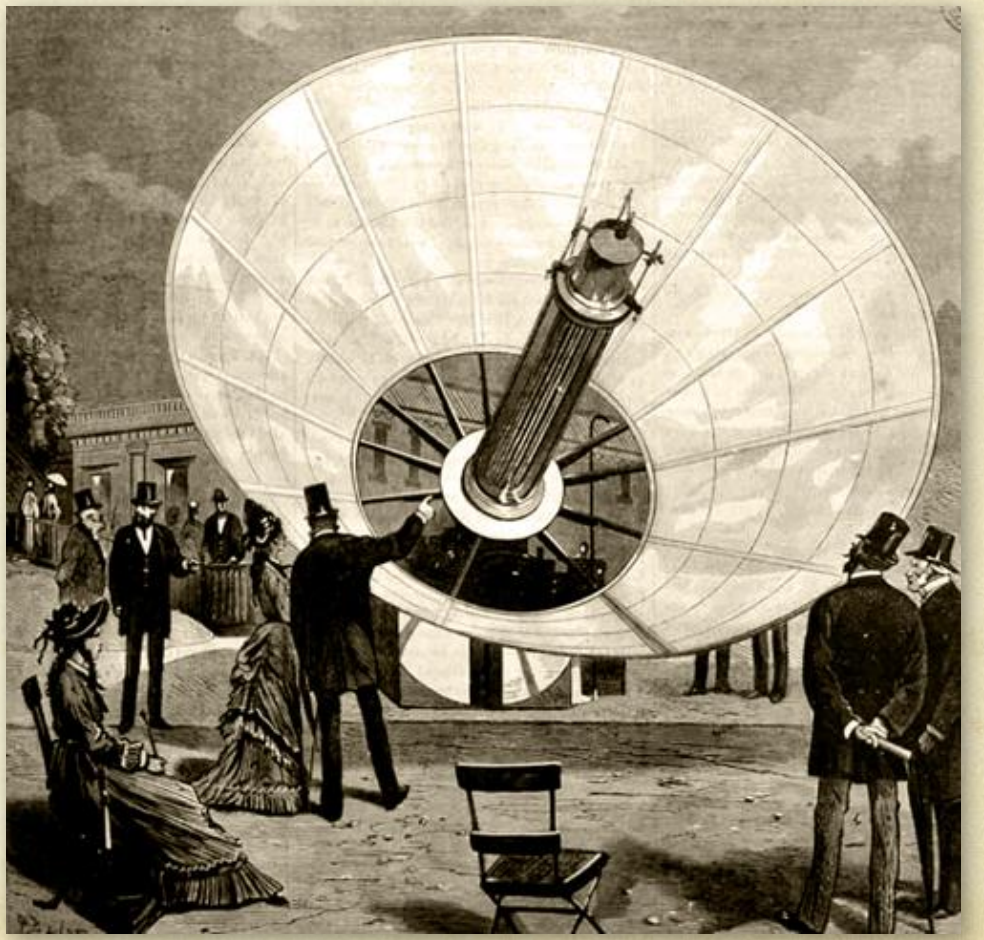
- Lesson 1 - The Historical Context of Solar Energy Valued in Society
- Lesson 2 - Tools for Time and Space Relationships
- Lesson 3 - Meteorology: the Many Facets of the Sky
- Lesson 4 - Measurement and Estimations of the Solar Resource
- Lesson 5 - Solar Economic Analysis
- Lesson 6 - Maximizing the Solar Utility for the Client in a

Solar Appears…and disperses

"One must not believe, despite the silence of modern writings, that the idea of using solar heat for mechanical operations is recent. On the contrary, one must recognize that this idea is very ancient and its slow development across the centuries it has given birth to various curious devices."

–Augustin S. Mouchot.

Universal Exposition: Paris, France (1878)



…and then solar reappears in Paris: 137 years later for COP21

Energy Constraint Response

Fuel Constraints:

1. Physically inaccessible
2. Limited access from policy/law
3. Economically inaccessible (high cost fuel)
4. High risk for access

- **For periods when fuels were constrained locally, societal innovation led to solar systems solutions**
- **Constrained Fuels**
  - **Solar → Ubiquitous**
- **Unconstrained Fuels**
  - **Solar communicated as diffuse/ intermittent/ weak / insufficient**

Value and Quantity of Light

Mineral economics of commodities states: the value of resource units varies with respect to

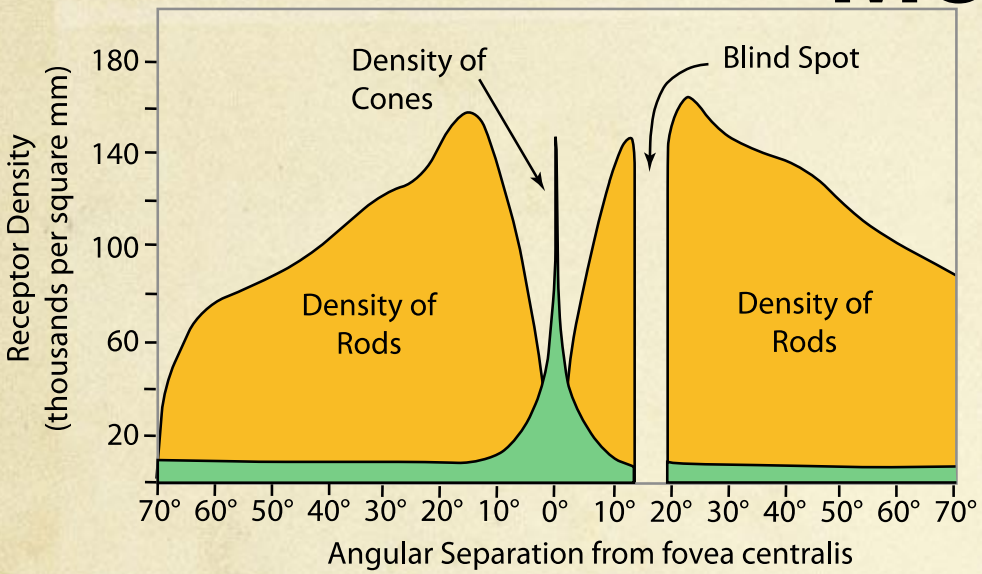
1. Demand for the good or service
2. Cost of alternatives

- The **value** of an unconverted photon is also a variable quantity.

Three drivers affect valuation of light as a quantified reserve:

1. Increased demand by clients seeking to avoid fuel costs (choosing an alternative to fuel);
2. Technological advances that reduce material costs and/or installation costs;
3. Presence of incentives

Vision: Values and Measures



- Color: **Cones**
- Dim light: **Rods**
- Lens works with cones
- Big range of operation

- **Embedded Ethics: *Values affect our choice of measurements and the design of experiments.*** We measure that which we value.
- SI unit of luminous intensity: **Candela (cd) [photometry]**
- **Light emitted** from a **combustion source** of rendered sperm whale fat called the "Standard Candle" *and* **received** by the "average" **human eye.**

- Human vision: Great for **information signals,** poor for **power signals**
- ***Not like a PV panel***
- Creates biased cognition of risk

http://hyperphysics.phy-astr.gsu.edu/hbase/vision/rodcone.html

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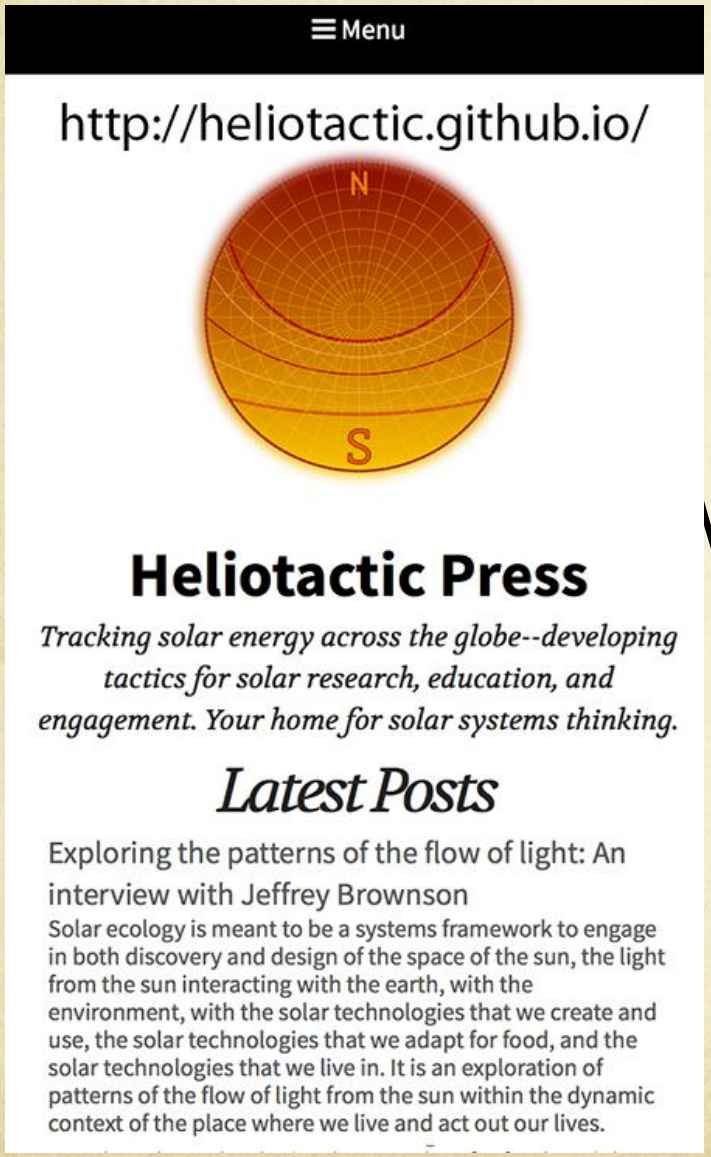
"Imagine a World without Thermometers"



Twitter: @Heliotactic

Values affect our choice of measurements and the design of experiments.

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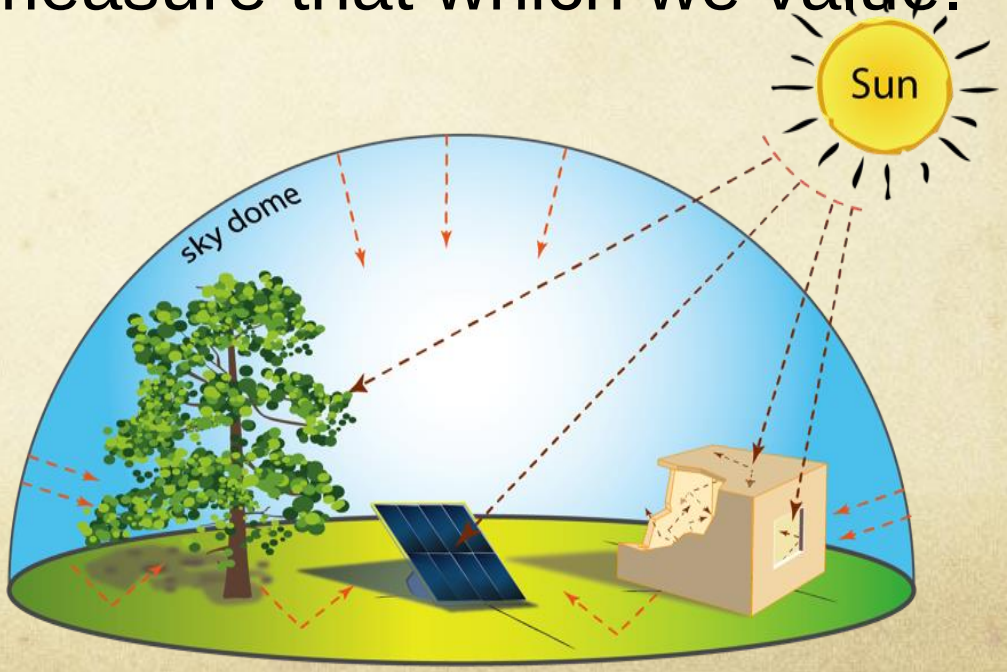

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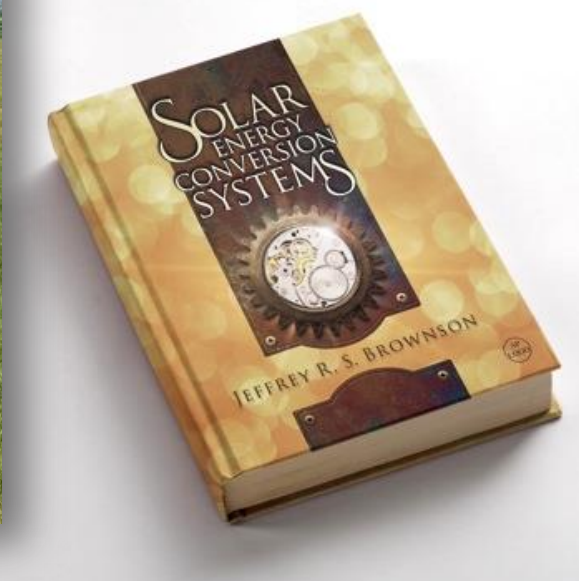
All-Seeing Eye (Solar ASE)

New device could unlock information potential of sunlight

Bug-like features enable researchers to collect information from sunlight to improve solar energy, landscape architecture, farming, and other industries

Liam Jackson
June 23, 2016



Solar as Pattern, Solar as Pattern with a Purpose

As science is the exploration of **patterns** in our universe, then **design** can be specified as pattern with a purpose

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Solar Vernacular describes local intertemporal/generational solar design strategies and solar-related cultural behaviors

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Technological goods only part of the message.

Services, and processes of exchange and discovery are required to develop higher value systems.

Solar Energy Conversion Systems

Solar **project development** is systemic and integrative.

Locale: Project solutions each have a **local nature** There is no “turn key”

Clients are core. Anticipate their needs in their space…

We seek out Solar Utility: Client preference for

Conceptual Shifts

Context: **Where and when is “solar”?**

Locale describes dynamic contextual constraints in space/time from the solar resource, ecosystems, local energy costs, and local policies

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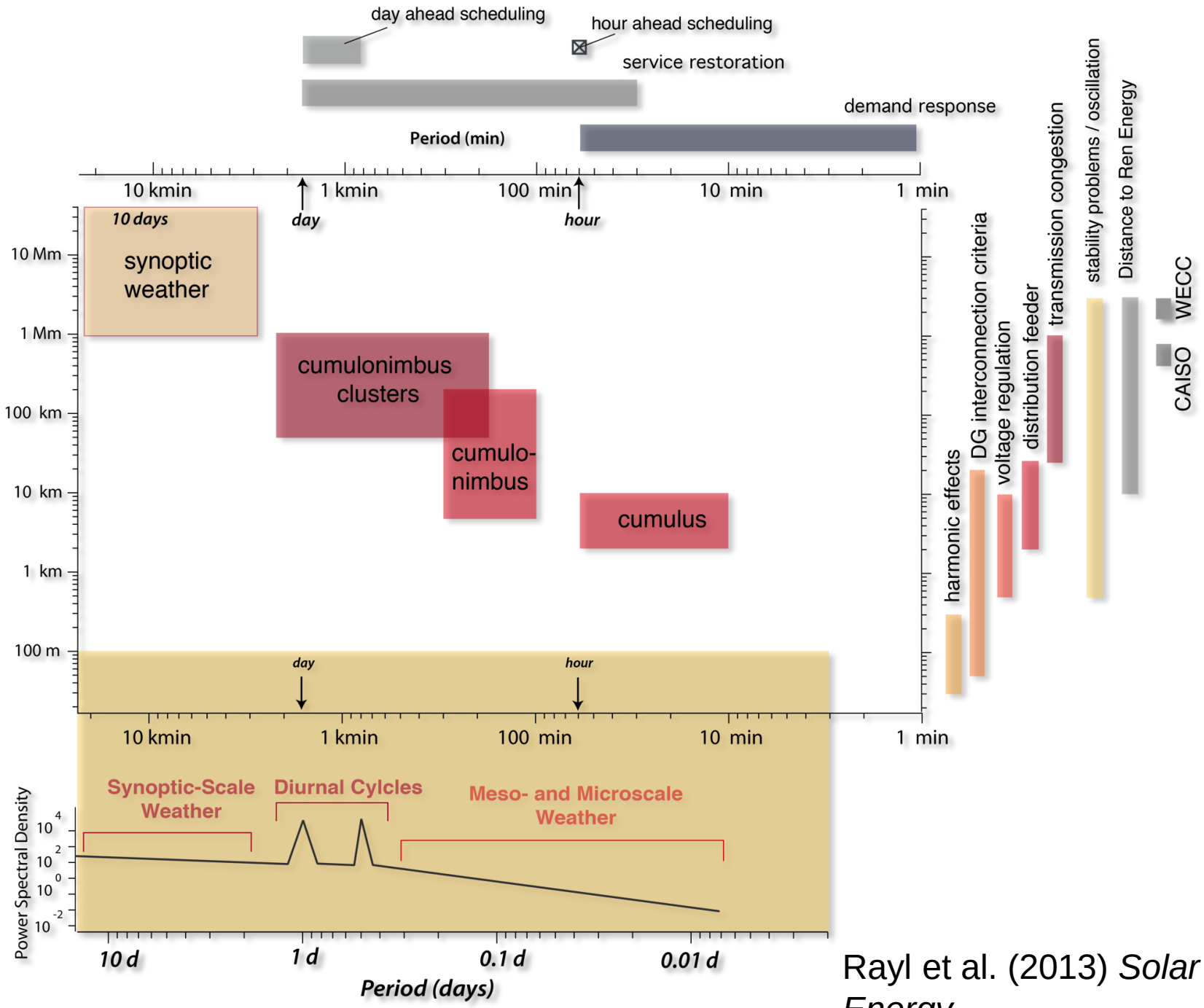
Locale in Solar

- **Solar resource is dynamic:**
  - Meteorology and diurnal/annual cycles
  - Emergent ecosystems services dynamic too
  - Time + Space



Rayl et al. (2013) *Solar Energy*

Locale in Solar

- **Solar resource is dynamic:**
  - Meteorology and diurnal/annual cycles
  - Emergent ecosystems services dynamic too
  - Time + Space

- **Culture is dynamic:**
  - Policy, Code, and Law
  - Elasticity of Demand and Finance
  - Cultural Cognition of Risk

Conceptual Shifts

Framing: **What does it mean to be "doing solar"?**

Solar Utility describes client/stakeholder preference for solar goods and services

"Solar utility" guides design

- *Utility: client/stakeholder preference for goods and services*
- **Solar Utility:** *preference for* ***solar goods and services***
- **Anticipate the needs of clients in their space, and co-produce adaptive sustainable solutions…**

We need the creativity to understand the lives of customers/communities in the way they are actually lived

Goal of Solar Design:

- Maximize *solar utility*
- for *clients and stakeholders*
- in a given *locale*

Solar Farm *or* Solar Farm?

Rule of thumb*: 8 acres/MW_{ac} (3.2 hectares per MW_{ac})

NOT Sunshine Hours
NOT Efficiency
NOT Cost

*Ong et al. (2013) **"Land-Use Requirements for Solar Power Plants in the United States"** NREL Technical Report: NREL/TP-6A20-56290

Solar Ecology

Visual Shifts

How do we communicate the idea?

Ecology: a study of the “home”

Solar Ecology frames systemic interactions of humans and biota and their surrounding environments, and results from the local and dynamic flow of sunlight to Earth’s surface

Localized Systems Integration

Solar Ecology has a framework

Exploration of Pattern (Discovery)

- **Science:** Anthropology, Sociology, Ecology, Environ. Sciences, Geography, Materials, Meteorology
- **Arts:** Story, Song, Dance; Visual, Aural, Kinesthetic
- **Communication, Ethics, Education**
- **Locale:** context, time, place, people, biome, ecosystems services
- **Stakeholders:** Community, Individuals

Pattern with a Purpose (Design)

- **Material Design:** Agriculture, Architecture, Device Engineering, Systems Engineering
- **Energy Policy / Law :** Markets, Regulation, Economics
- **Planning / Adaptation**
- **Solar Utility:** preference for solar goods and services

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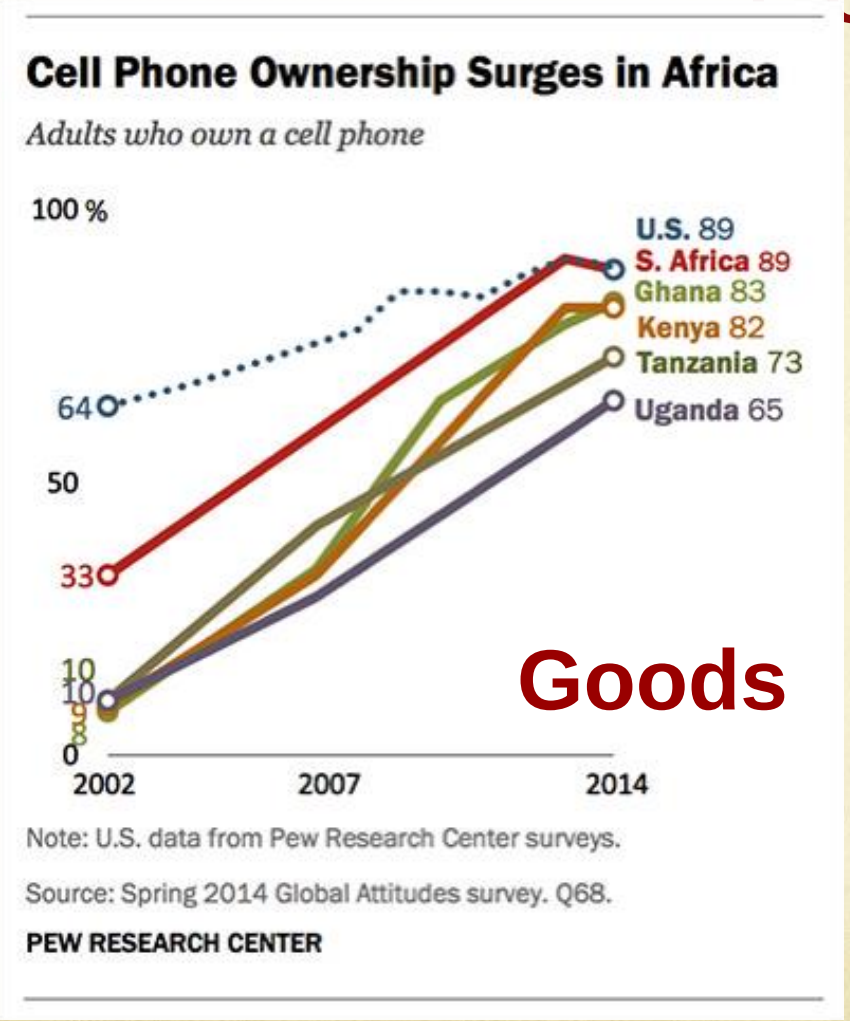
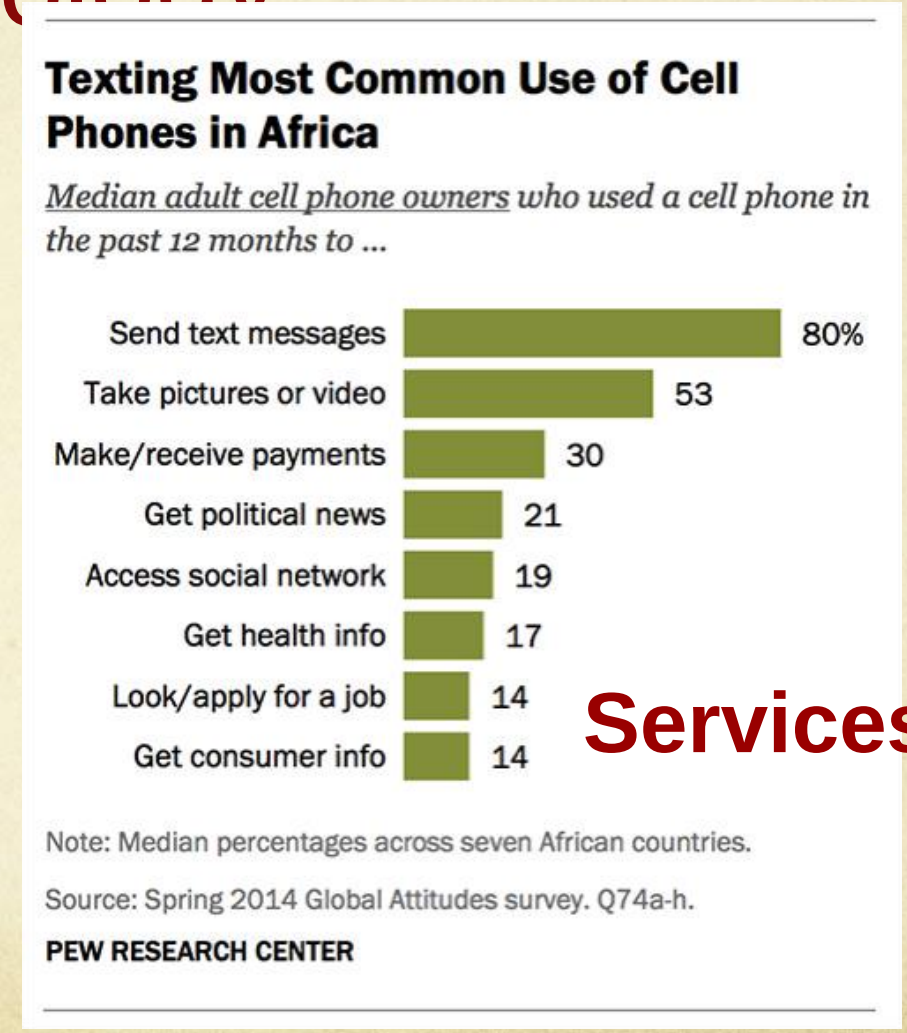
Communication Ecology

- **1980s: Telecommunication was a "wired" phone, a phone "grid", and an analog signal.**
- **Now: Digital phone networks are everywhere**
  - Mobile Phones / WiFi / Social Networks
- **We no longer really use phone "calls"**

  (except calling mom and dad)
  - Texting
  - Weather up

Shift to Communication Ecology





Pew Research Center, April, 2015, “Cell Phones in Africa: Communication Lifeline”

IN A NUTSHELL

- **Solar photovoltaics (a commodity) have transformed the global energy landscape**
- **Solar Project Development** couples together economics, stakeholder engagement, and quantitative resource assessment.
- **Locale** describes dynamic contextual constraints in space/time from the solar resource, ecosystems, local energy costs, and local policies.
- **The Goal of Solar Design** is to satisfy client/stakeholders' preference for solar goods and services (**solar utility**) within the broad portfolio of options, fit within the perspective of the **locale**
- **Solar ecology** (a systems framework) is poised to

Acknowledgements:

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Back to Freiburg

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