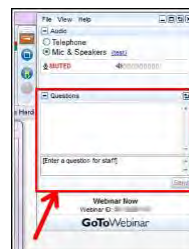
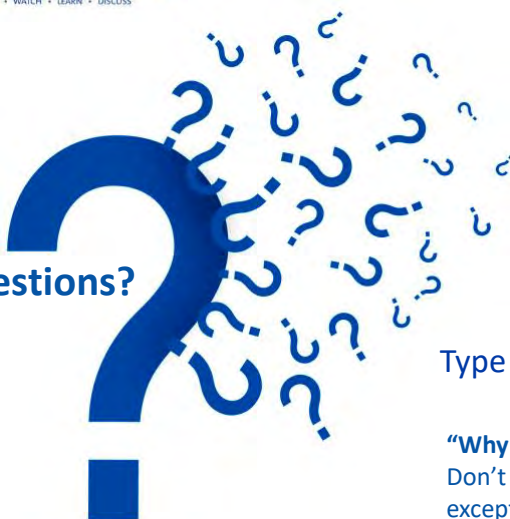




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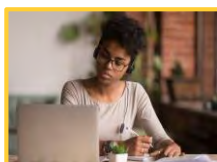


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Moderator: Kaushik Mitra, Janssen Research & Development

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What You Will Learn

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Here Comes the Sun: Advances In Solar Power

November 17, 2020

Vijay Kapur

CEO (retired), International Solar Electric Technology

Here Comes the Sun: Advances in Solar Power



Vijay Kapur
CEO (retired), International Solar Electric Technology



Bill Tuszynski
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Vijay Kapur

CEO (retired),
International Solar Electric
Technology

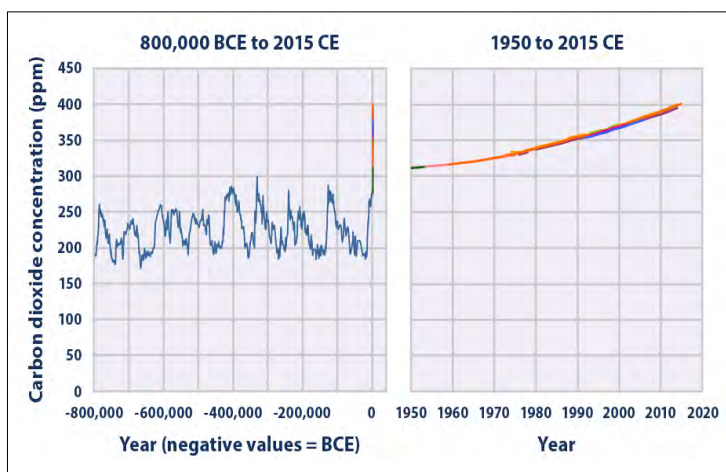
Sustainability Challenges *(similar to UN SDGs)*

- Climate Change
- Access to Clean Water
- Eco-friendly Agriculture
- Zero Emission Transportation
- Access to Digital Information
- Education
- Economic Opportunities
- Health Care
- Affordable and Comfortable Habitats
 - Heating and Cooling
 - Cooking Facilities
- Poverty Eradication

Abundant and low -cost solar energy provides possible solutions to all of these challenges

15

Historic and Current Level of CO₂ in the Atmosphere and the Impact of Climate Change



Oct.2020 CO₂ Level 411 ppm

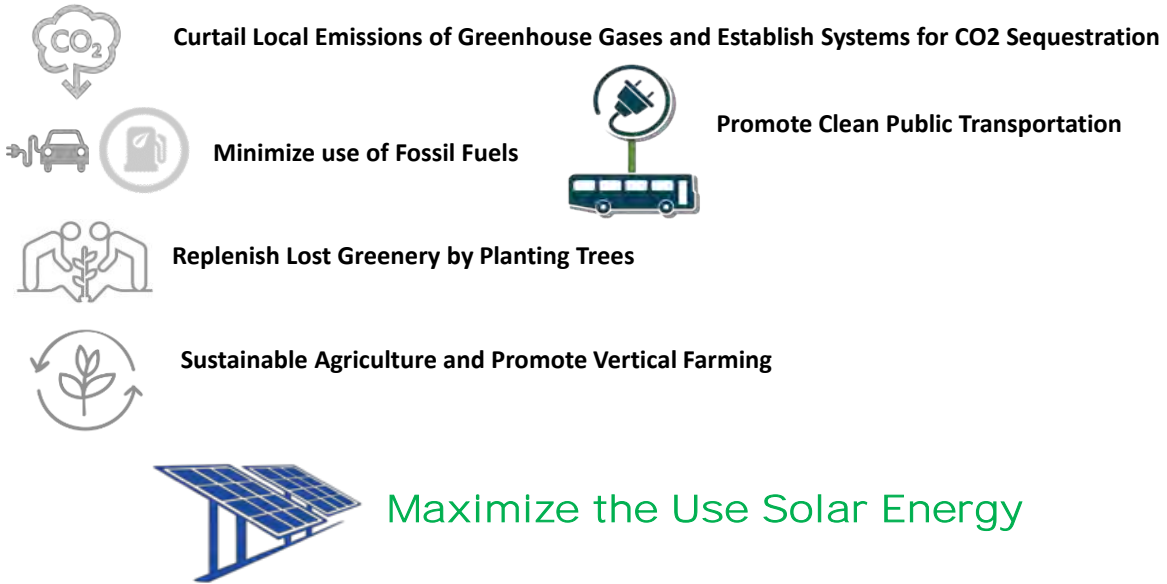
**Cumulative CO₂ in Atmosphere about 3200 Billion MT
Annual Increase in CO₂ about 40 Billion MT**

Major Climate Change Impacts

- More Frequent Extreme Weather Events
- Curtailed Fresh Water Resources (Melting of Glaciers)
- Rising Sea Levels
- Mass Migration of Climate Refugees

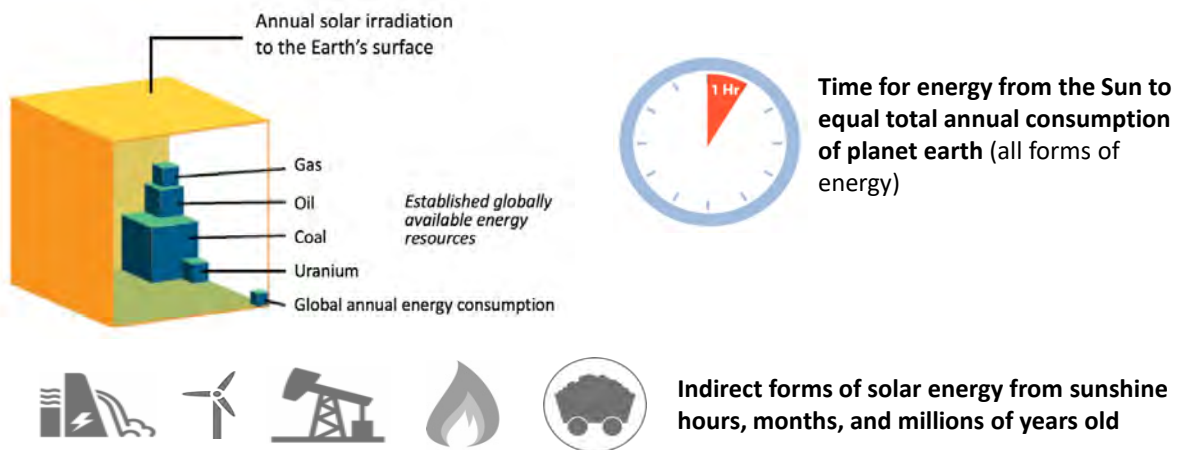
16

Urgent Actions Needed to Correct Climate Change



17

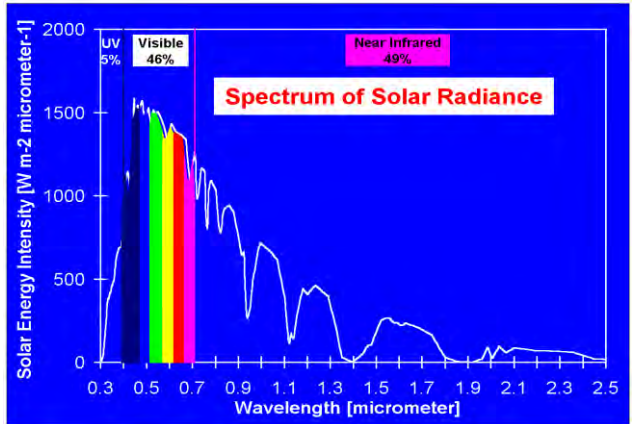
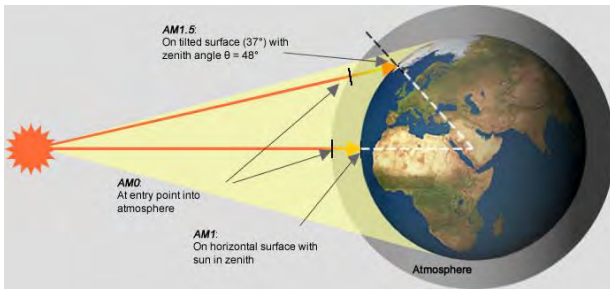
Solar Abundance



- Ubiquitous sunshine has sustained life on earth for billions of years
- The challenge we face now, is to use it wisely without polluting the Environment

18

Solar Energy Spectrum

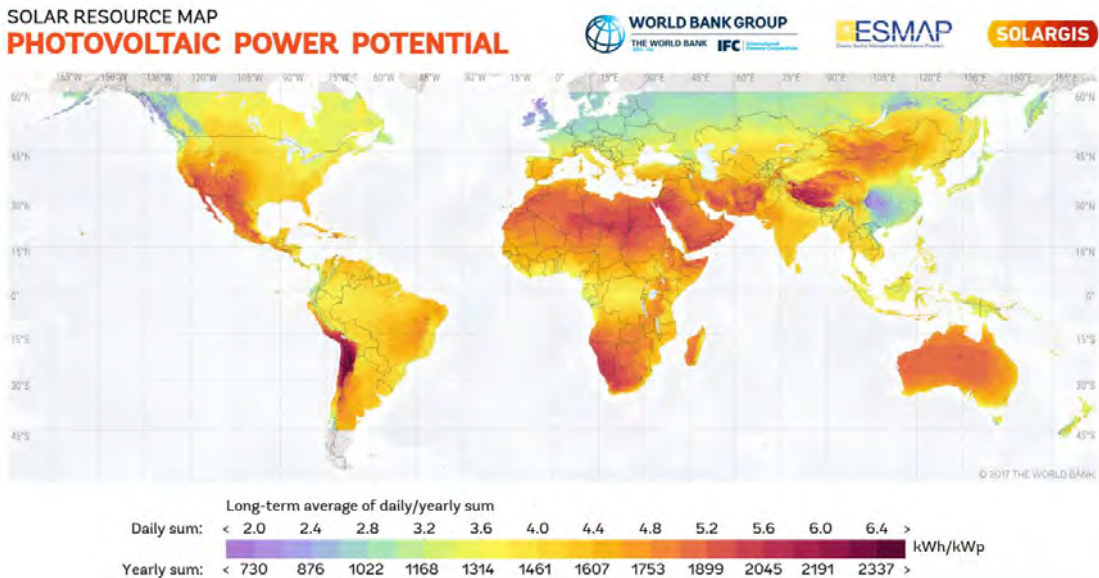


→ AM0 = 1.37 KW/ M2

→ AM1.5: = 1.0 KW/M2

19

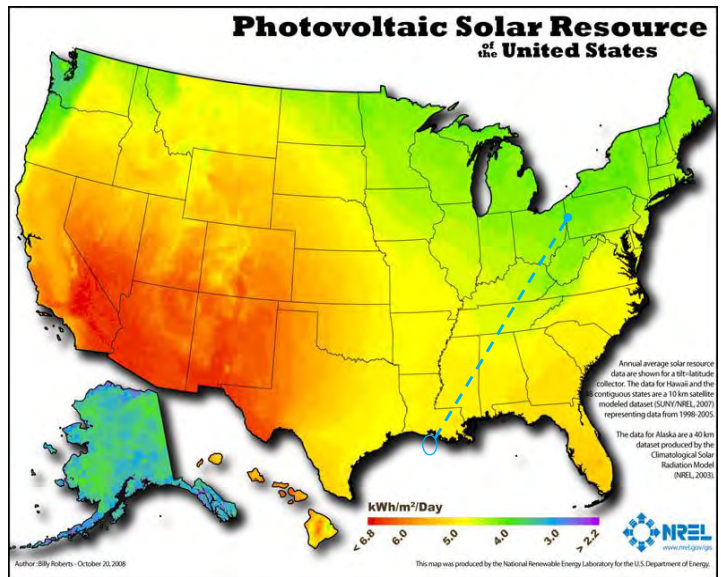
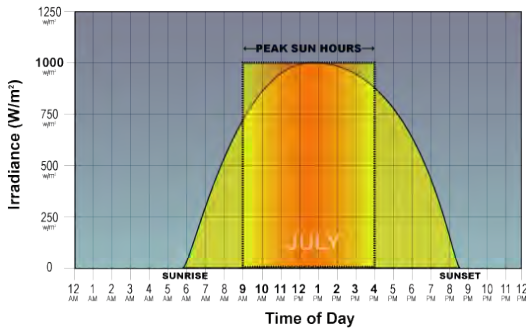
Available Solar Resource: Worldwide



This map is published by the World Bank Group, funded by ESMAP, and prepared by Solargis. For more information and terms of use, please visit <http://globalsolaratlas.info>

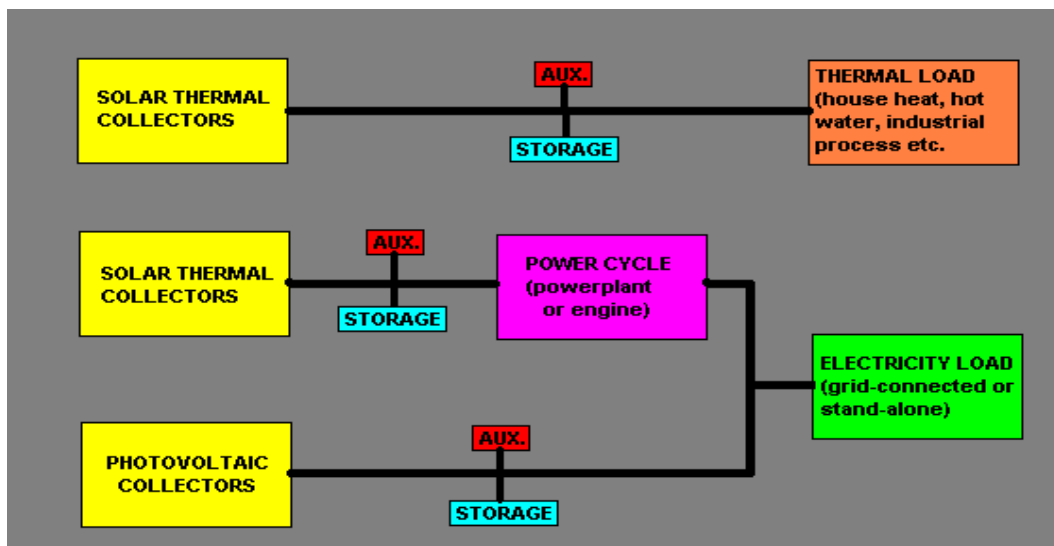
20

Available Solar Resource: USA



21

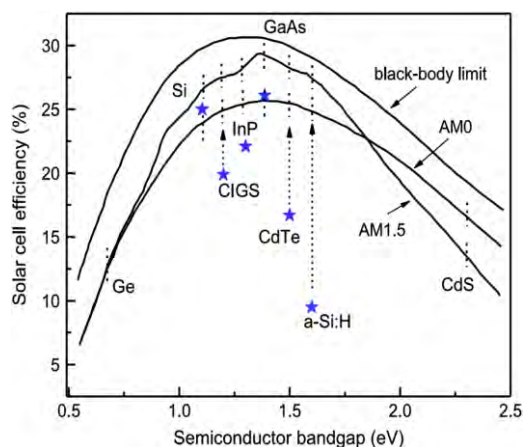
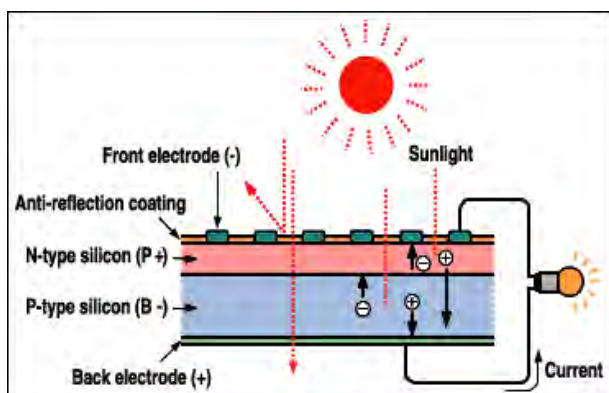
Harnessing Solar Energy



22

Photovoltaics (Direct Conversion of Sunlight to DC Electric Power)

Cross-Section & Semiconductor Band-gap vs. Solar Cell Conversion Efficiency



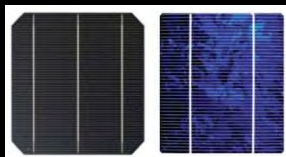
PV

23

Types of PV Cells—Classified by Absorber Material

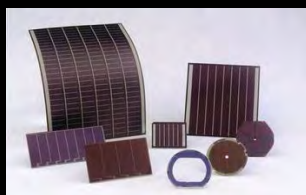
First Generation:

- Monocrystalline Si
- Polycrystalline Si
- III-V Compound semiconductors (GaAs)



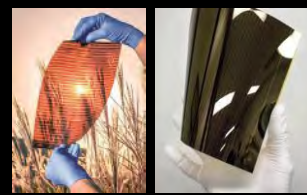
Second Generation:

- Amorphous Si
- CIGS (CuInGaSe_2)
- CdTe
- Multi-junction



Third Generation:

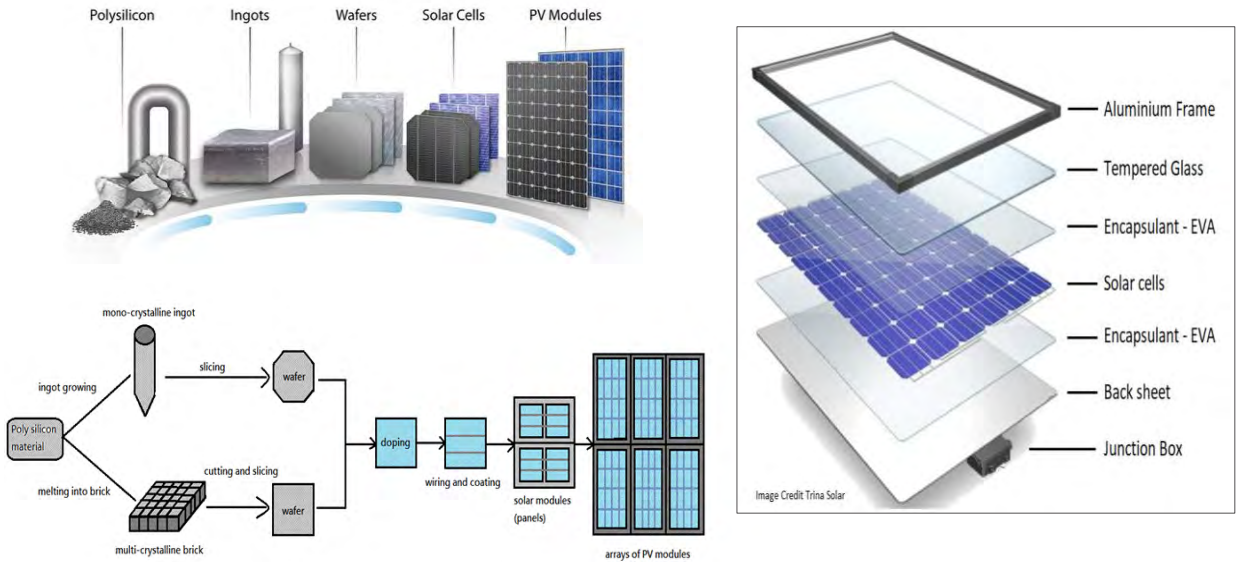
- Perovskite
- Organic PV
- Dye-sensitized cells
- Quantum Dot



PV

24

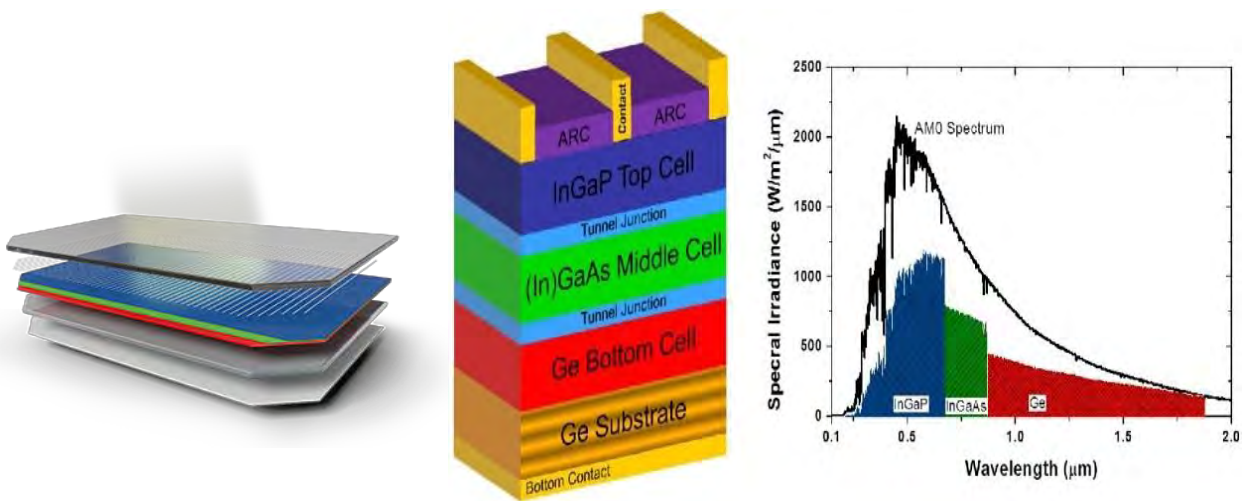
Processing Silicon into PV Cells & Modules



PV

25

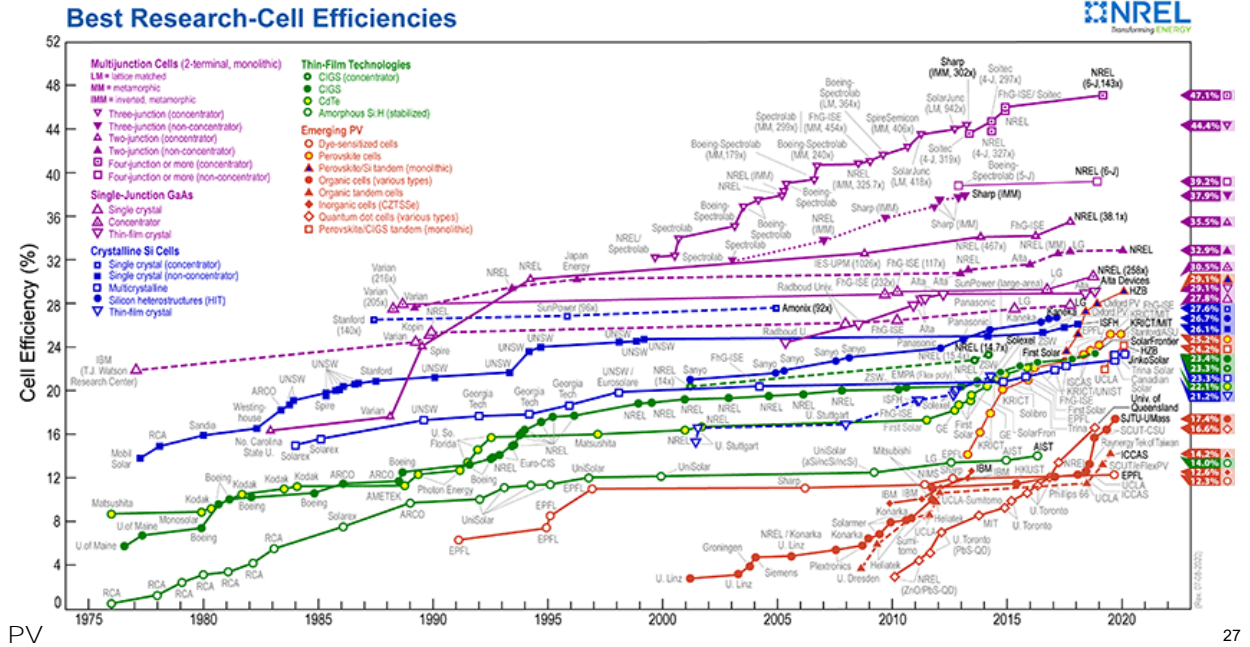
Multi-Junction “Rainbow Cell”



PV

26

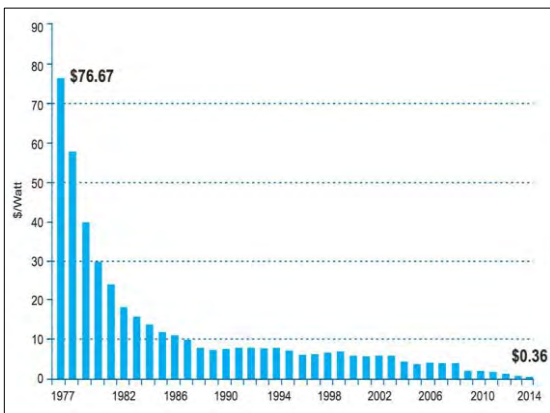
Best Efficiencies



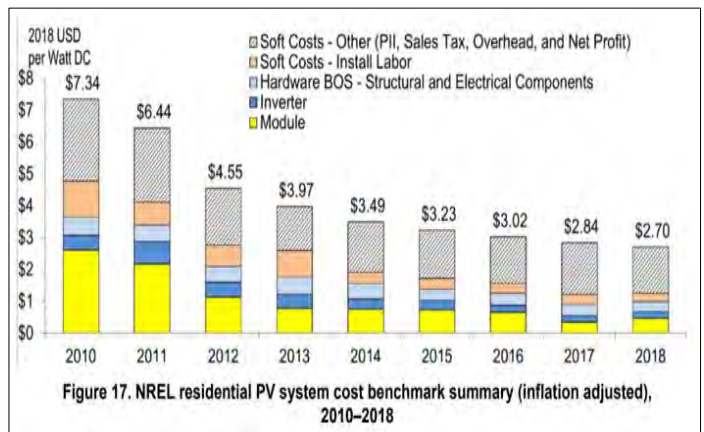
PV

27

Historical Cost Lowering Milestones: 1977-2018



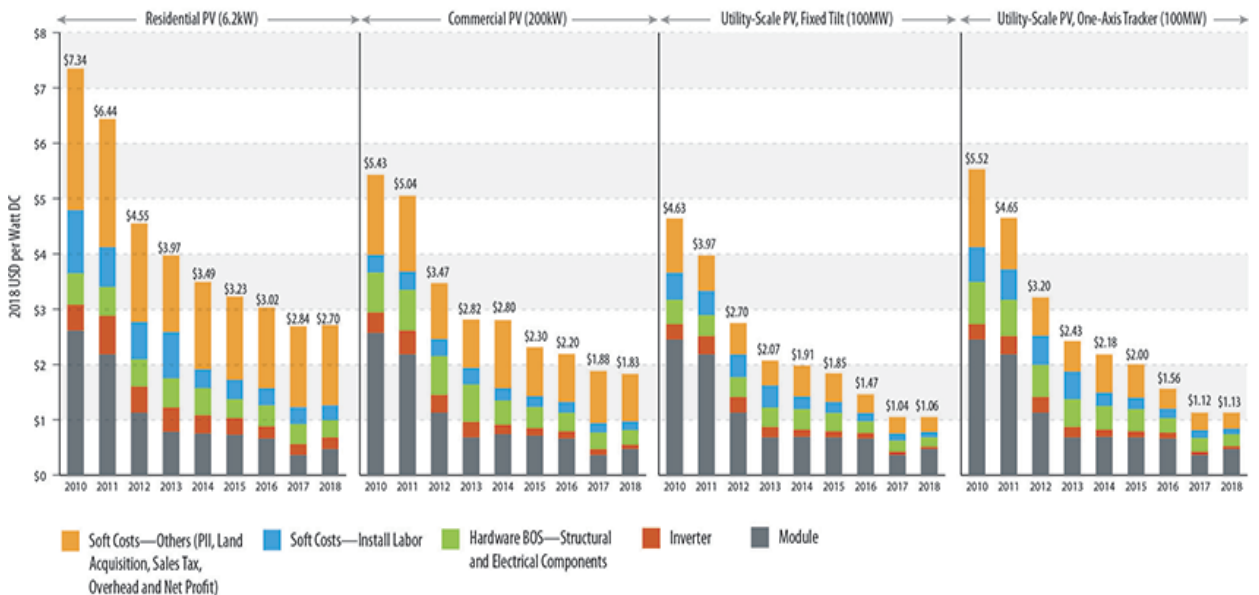
Cell Manufacturing Cost(\$/Watt)



PV

28

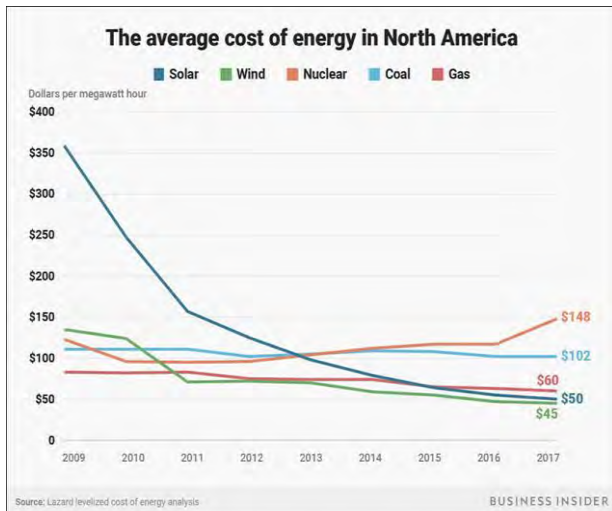
Installed Cost of PV Systems at Various Scales



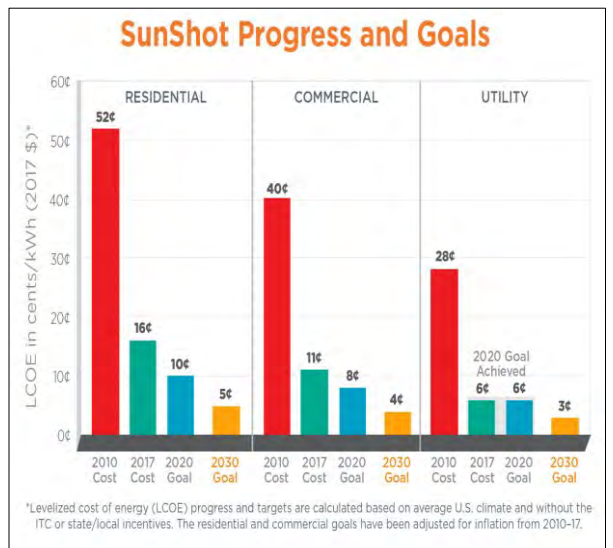
PV

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Price of Electricity

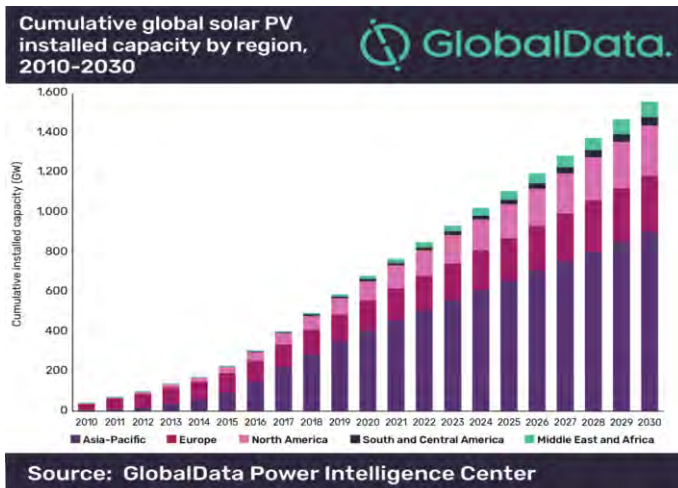
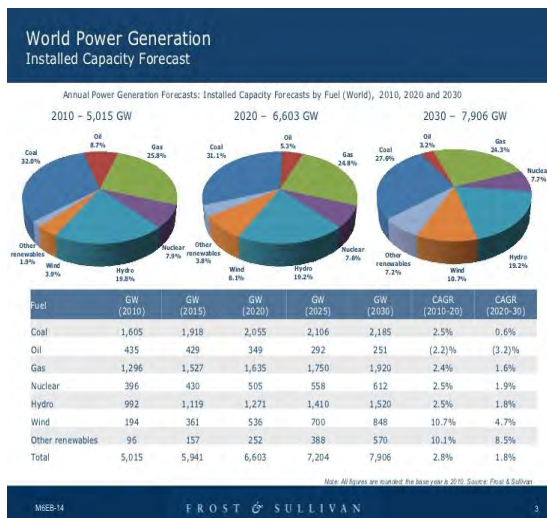


PV



30

Projections of World Power Generation & Cumulative Installed PV (2010 – 2030)



Advantages of Solar PV Systems

Advantages of Solar PV System

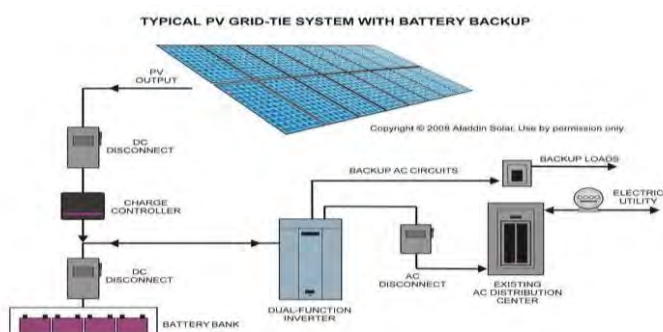
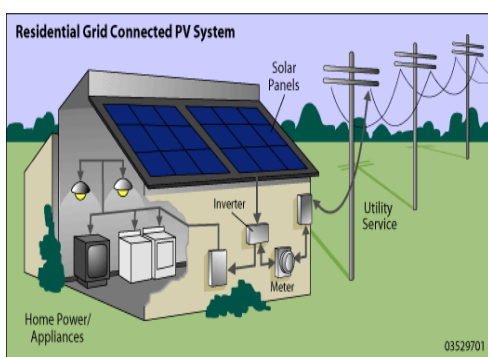
- ❑ It converts solar energy directly into electrical energy without going through thermal-mechanical link. It has no moving parts.
- ❑ Solar PV systems are reliable, modular, durable and generally maintenance free.
- ❑ These Systems are quiet, compatible with almost all environments, expected life span of 20 years or more.
- ❑ It can be located at the place of use and hence no distribution network is required.

Energy Storage

- **Batteries** – a range of electrochemical storage solutions, including advanced chemistry batteries, flow batteries, and capacitors
- **Thermal** – capturing heat and cold to create energy on demand or offset energy needs
- **Mechanical Storage** – other innovative technologies to harness kinetic or gravitational energy to store electricity
- **Hydrogen** – excess electricity generation can be converted into hydrogen via electrolysis and stored
- **Pumped Hydropower** – creating large-scale reservoirs of energy with water

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Grid-connected & Battery-Backed PV Systems



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Vertically mounted PV Systems



Philadelphia 39.9 N

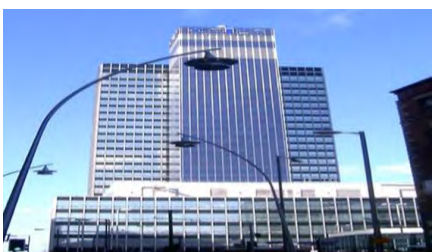


New York 40.7 N

South and west facing vertically mounted PV systems, at locations of latitudes 40 N or higher, yield 60% of the max. output.

At 20 N the output is about 50%.

With very low PV system prices competing with the high price of land in big cities, the ROI of vertically mounted PV systems is quite attractive.



London 51.5 N



Mumbai 19.1 N

35

Flotovoltaics



- Water provides natural cooling of arrays and enhances their output
- Large PV systems placed on an ocean surface provide a convenient means of producing clean water via desalination

36

Agrivoltaics

Agrivoltaics is co-developing the same area of land for both solar photovoltaic power as well as for agriculture.



Benefits:

- Dual use of land
- Reduced electricity cost
- Diversification of revenue stream
- Control of wind and soil erosion
- Water saving
- Improved crop production

37

Remote Applications



Village Water Pumping



Power for Cellular Towers



LED Street Lights



Parking Meters



Trash Compactors

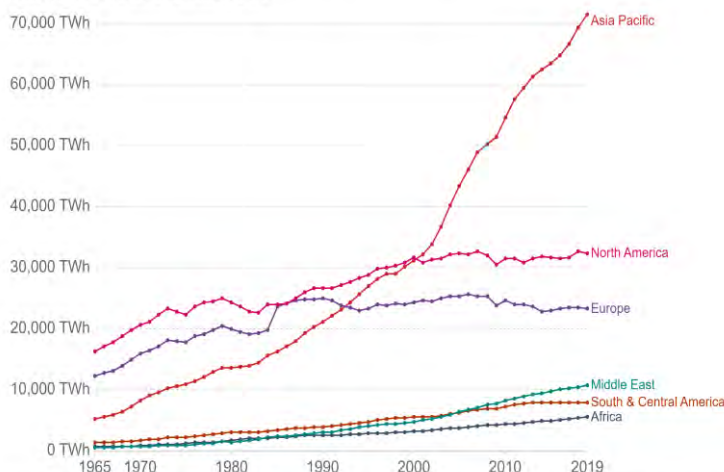
38

Global Energy Consumption

Primary energy consumption by world region

Primary energy consumption is measured in terawatt-hours (TWh). Note that this data includes only commercially-traded fuels (coal, oil, gas), nuclear and modern renewables used in electricity production. As such, it does not include traditional biomass sources.

Our World
in Data



Source: BP Statistical Review of World Energy (2019)

OurWorldInData.org/energy • CC BY

- **World's Daily Power Consumption: 15.8 TW**

- **US Daily power consumption: 3.35 TW**

- **Daily Incident Power on Planet Earth: 174,000 TW**

1 Terawatt (TW) = 1 Trillion Watts

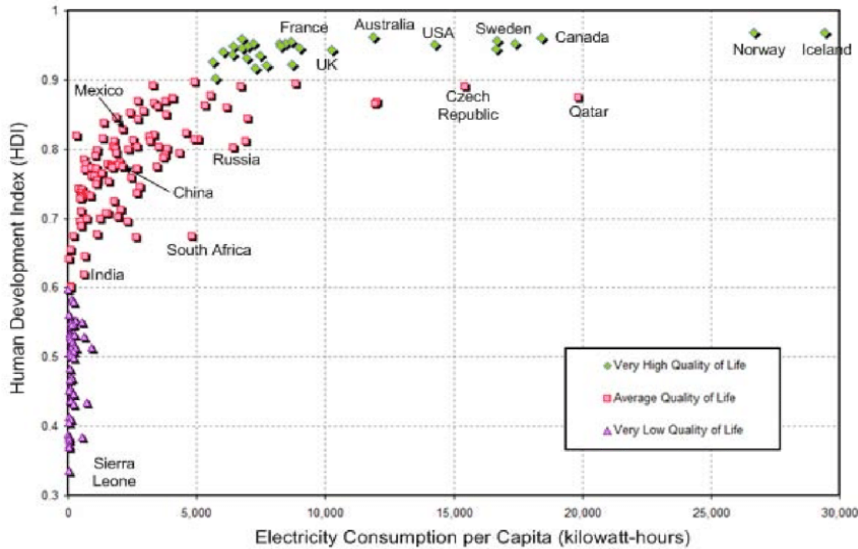
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Energy Access

- **940 million (13% of the world) do not have access to electricity.**
<https://ourworldindata.org/energy-access#access-to-electricity>
- **3 billion (40% of the world) do not have access to clean fuels for cooking. This comes at a high health cost for indoor air pollution.**
<https://ourworldindata.org/energy-access#access-to-clean-fuels-for-cooking>
- Per capita electricity consumption varies more than 100-fold across the world. <https://ourworldindata.org/energy-access#how-does-per-capita-electricity-consumption-vary-across-the-world>
- Per capita energy consumption varies more than 10-fold across the world. <https://ourworldindata.org/energy-access#how-does-per-capita-energy-consumption-vary-across-the-world>
- Energy access is strongly related to income: poorer households are more likely to lack access. <https://ourworldindata.org/energy-access#low-income-households-lack-access-to-electricity-and-clean-fuels>

40

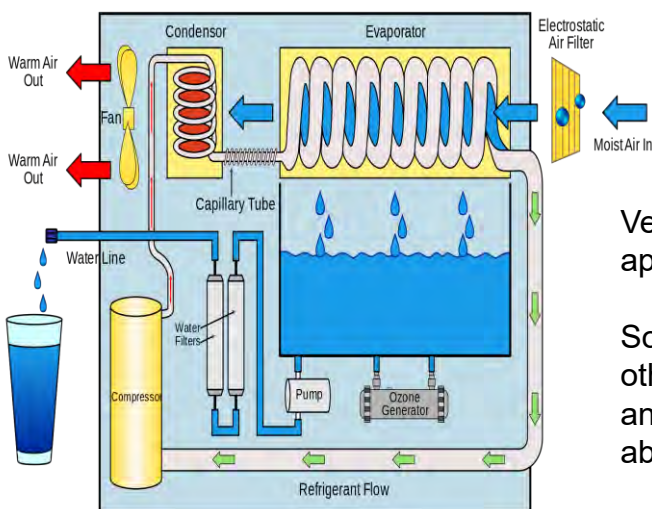
HDI vs. Annual Electricity Consumption per Capita (KWh)



Providing an affordable 0.5 to 1.0 KW PV system to people living in sunny countries, can improve the quality of their life significantly.

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Solar Powered Extraction of Potable Water from Air

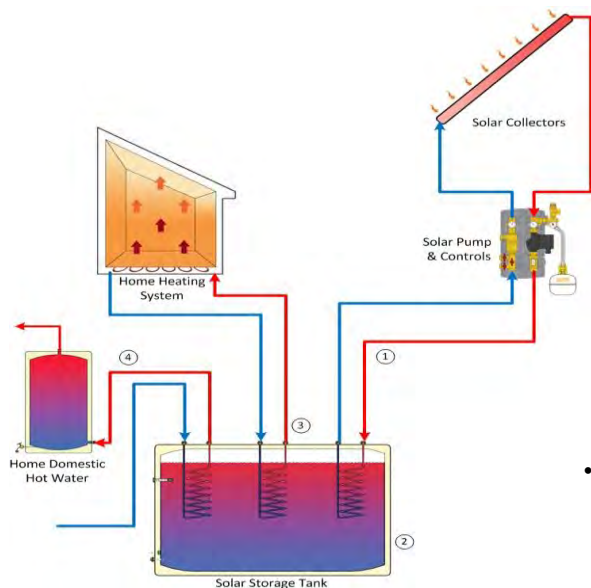


Very active field. A variety of different approaches have been developed.

Some require electric power while others work on a temperature gradient and choice of a number of efficient absorbers.

42

Solar Water and Space Heating



Evacuated tube solar collector

- Space heating can be done with fan coil heat exchanger or by radiant heat from the embedded hot water pipes in the floor

43

Solar Cooking - Sun Oven and Go-Sun

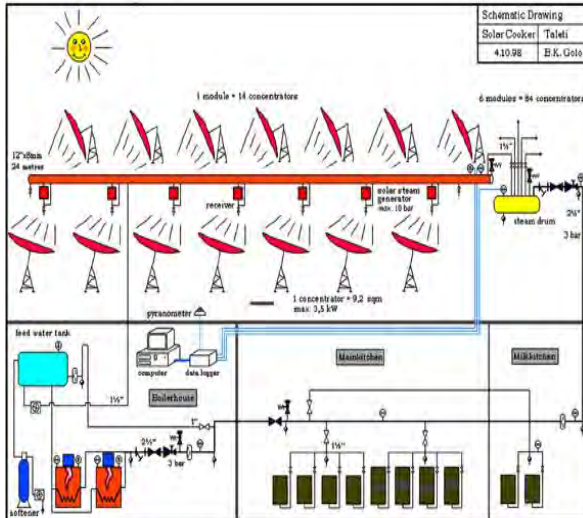


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- Reaches Temperatures of 360 to 400 Degrees Fahrenheit!
- Bake, Boil or Steam Foods — Boil or Pasteurize Water!
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- Dehydrate Fruits, Vegetables or Jerky!
- Slow cook or cook in comparable time to conventional stove tops or ovens!
- Totally Safe — No Danger of Fire!
- As Portable as a Small Suitcase — Only 23 lbs!
- Ruggedly Built for Years of Trouble-Free Use!
- Everything you need to cook, dehydrate, bake and pasteurize water with the power of the sun.



44

Community Cooking with Solar Generated Steam



45

Solar Steam Cooking Facility at Mt Abu India



Cooks **20,000 Meals Daily** with little carbon foot print.

A number of other religious centers in India have established similar facilities and are preparing **> 30,000 meals a day**.

46

Jobs in Renewable Energy



- People can be trained in a short time to work on projects in solar energy
- Advanced college degree is not required for this training
- Focused and accelerated training programs can help reduce the poverty level

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*Thank you for your
interest and attention.*

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See you January 21, 2021

Fluid Movements: Interpreting the History, Present, and Future of Water

Jahnvi Phalkey

Founding Director, Science Gallery
BengaluruResearch

Jesse Smith

Research Curator, Science History Institute



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Vijay Kapur
CEO (retired), International Solar Electric Technology



Bill Tuszyński
Partner, The Unami Group LLC

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 Ponente: Juan Raúl Álvarez Idaboy, Universidad Nacional Autónoma de México
 Moderadora: Lene Ruiz Azuara, Sociedad Química de México

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Lo Que El Público Aprenderá

- How to become aware why healthy competition is the key to a healthy work-life balance and job satisfaction
- Understanding the value of mentorship and openness to reverse-mentoring
- How to discover ways to pursue a research problem beyond your comfort zone

Co-producido con: Sociedad Química de México y *Chemical & Engineering News*

* This ACS Webinar is produced for Spanish speaking target audience.



Thursday, November 19, 2020 at 2-3:30pm ET
 Speakers: Michael Hefey, Merck / Jim Monroe, Merck / Wen Kang, Merck
 Moderator: Kaushik Mitra, Janssen Research & Development

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What You Will Learn

- The role of key hepatic transporters in drug-induced liver injury and strategies to derisk molecules with transporter-inhibition liability
- Development of a bioactivation gene signature-based model in detecting hepatotoxicants and its in vivo application in real time to make safe drugs
- Establishment of an In Vitro transcriptomic signature of bioactivation using a micropatterned coculture system (HEPATOPAC®) to derisk compounds early in discovery

Co-produced with: ACS Division of Chemical Toxicology, ACS Division of Medicinal Chemistry, American Association of Pharmaceutical Scientists, and ACS Publications



Tuesday, December 1, 2020 at 2-3pm ET
 Speakers: Jim Skinner, Terregina, Inc. and H.N. Cheng, 2020 ACS President-Elect
 Moderator: Diane Grob Schmidt, 2015 ACS President

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What You Will Learn

- The many sources of funding and their impact on ownership
- The importance of milestone achievements for valuation purposes
- The criteria and terms that investors use to make investing decisions

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