Solar Photovoltaics

Presented by:
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Video: How do solar panels work? - Richard Komp

HTTPS://WWW.YOUTUBE.COM/WATCH?V=XKXRKHT7CPY

Initial Development of Solar Power

- The development of photovoltaic (PV) technology, began during the Industrial Revolution when French physicist Alexandre Edmond Becquerellar first demonstrated the photovoltaic effect, or the ability of a solar cell to convert sunlight into electricity, in 1839

- About four decades later, American inventor Charles Fritts created the world's first rooftop solar array in New York in 1883, one year after Thomas Edison opened the world's first commercial coal plant.

- Fritts coated the panels with selenium to produce a very weak electric current. However, the process of how light produces electricity wasn't understood until Albert Einstein wrote a paper explaining the photoelectric effect in 1905

- Becquerellar's and Einstein's research formed the basis of future developments in solar technology.

http://instituteforenergyresearch.org/analysis/history-of-solar-power/

- The modern photovoltaic (PV) cell was developed by Bell Labs in 1954

- while solar power remained too costly for commercial use, the U.S. military funded research on PV technology's potential to power satellites in the 1950s

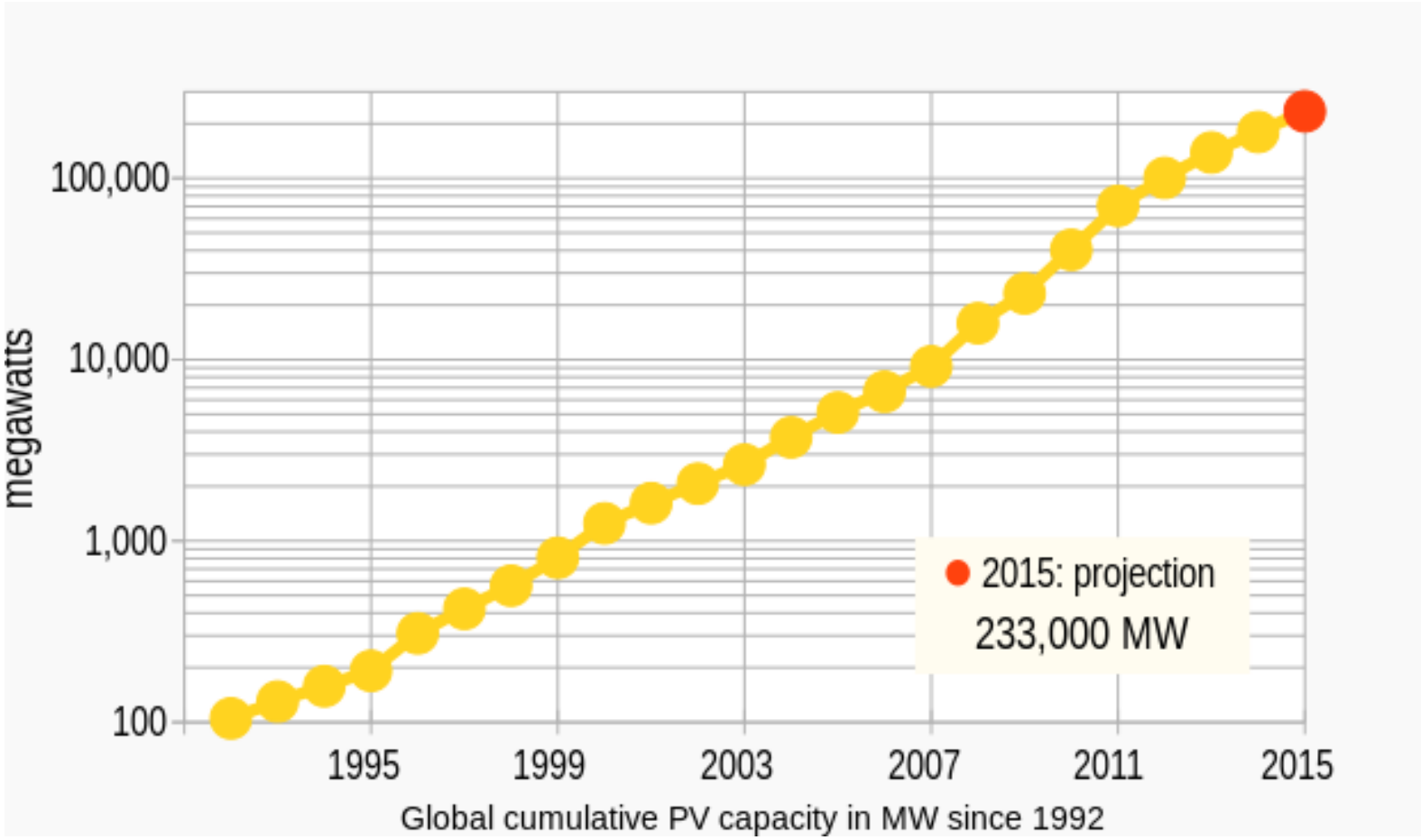
- The U.S. Naval Research Laboratory launched Vanguard I, the first spacecraft to use solar panels, in 1958

- NASA launched the first satellite equipped with panels that tracked the Sun, Nimbus I, in 1964.

- The U.S. government pioneered much of the early PV technology.

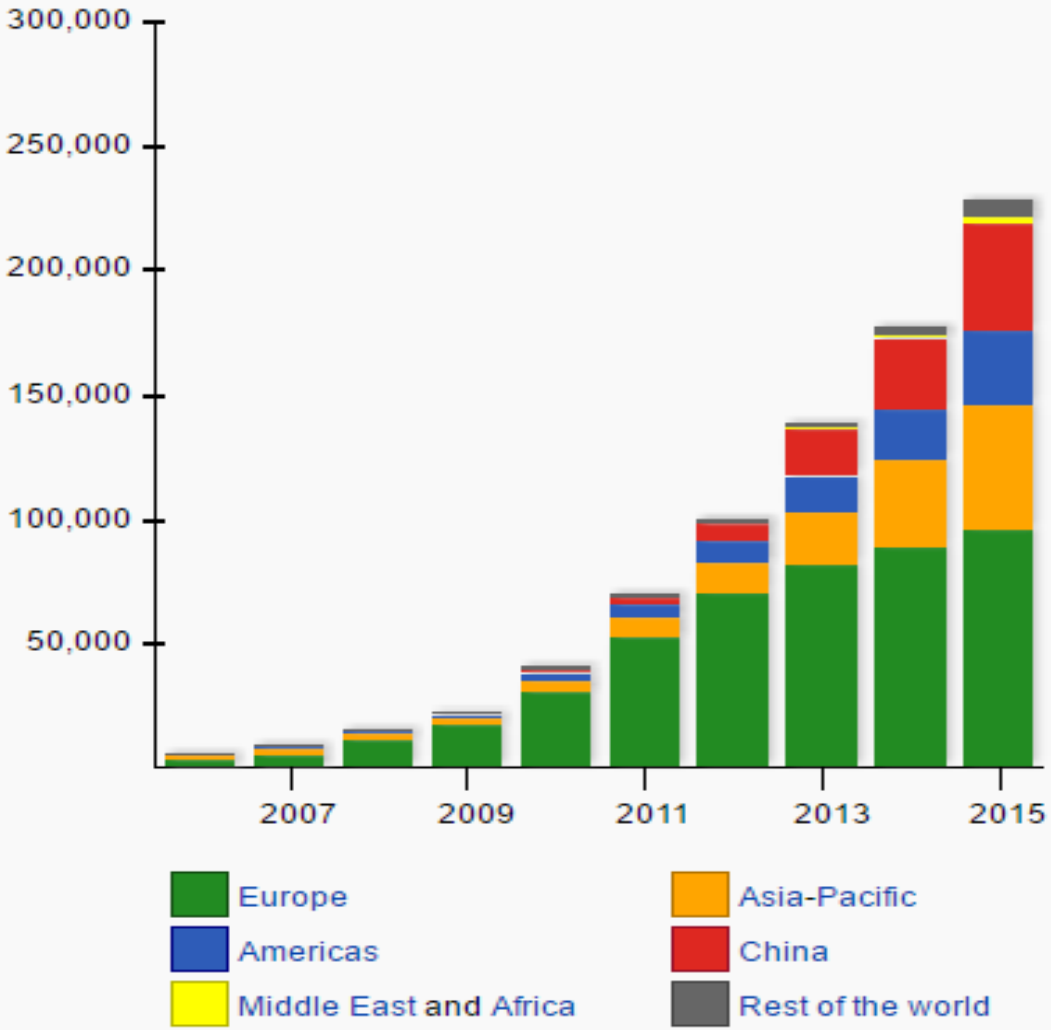
- Congress passed five energy bills in 1974, two of which cited solar power as a potential solution to the energy crisis

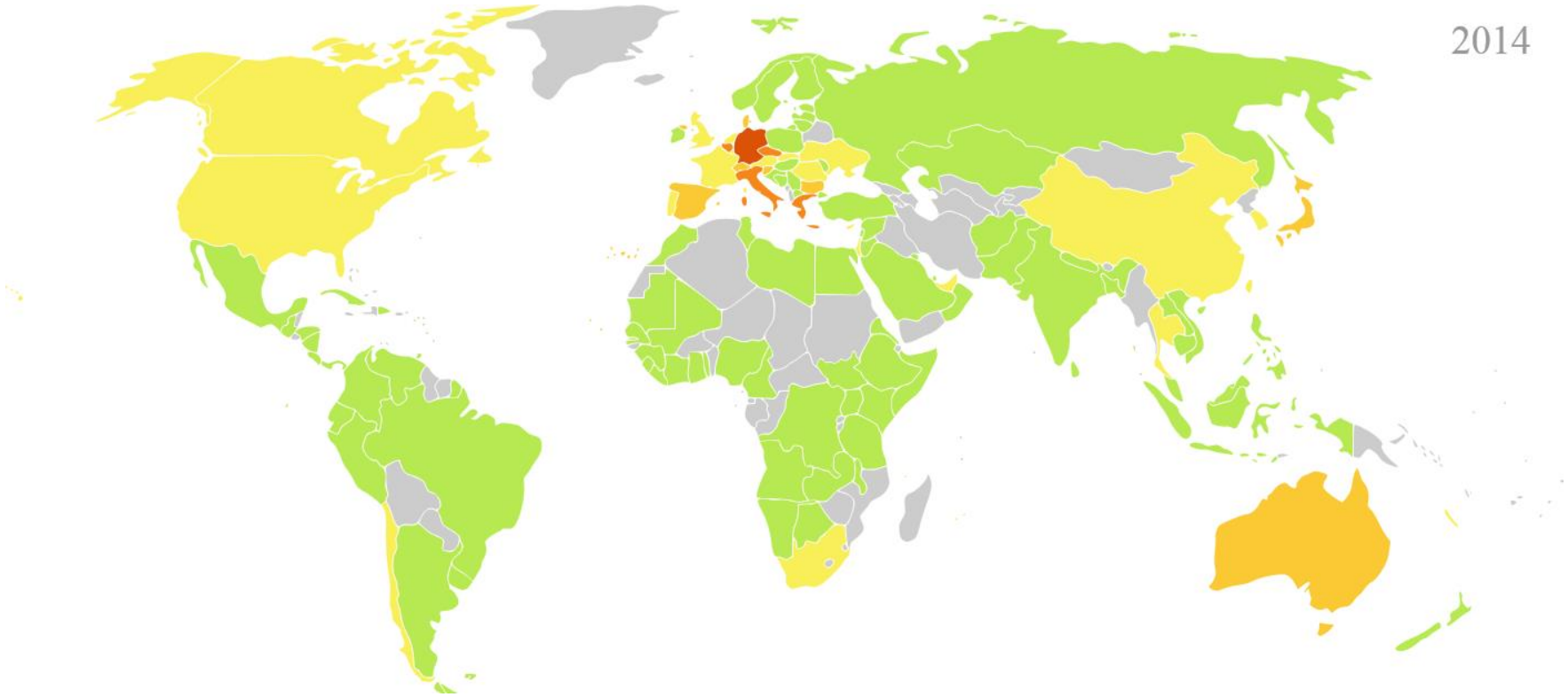
- PV first mass-produced in 2000, when German environmentalists and the Eurosolar organization got government funding for a ten thousand roof program


100,000
10,000
1,000
100
megawatts
1995
1999
2003
2007
2011
2015
2015: projection
233,000 MW
Global cumulative PV capacity in MW since 1992

Worldwide growth of photovoltaics

Cumulative capacity in megawatts [MW_p] grouped by region[1][2][3][4][5]





Worldwide installed photovoltaic capacity in "*watts per capita*" by country. Estimated figures for year 2014 (see details in *File history* below). none or unknown <10 watts per inhabitant 10–100 watts per inhabitant 100–200 watts per inhabitant 200–400 watts per inhabitant >400 watts per inhabitant As of the end of 2014, world leading nations in terms of installed PV capacity per capita were Germany (474), Italy (308), Belgium (275), Greece (235), Czech Republic (203), Japan (183), Australia (179), Bulgaria (140), Switzerland (133), Slovenia (124), Spain (115), and Denmark (107). For comparison: Canada (48), Chile (20), China (21), France (86), India (2), Ireland (0.2), Malaysia (5), Mexico (1.5), South Africa (17), South Korea (47), Thailand (19), Turkey (0.7), United Kingdom (80), United States (57).

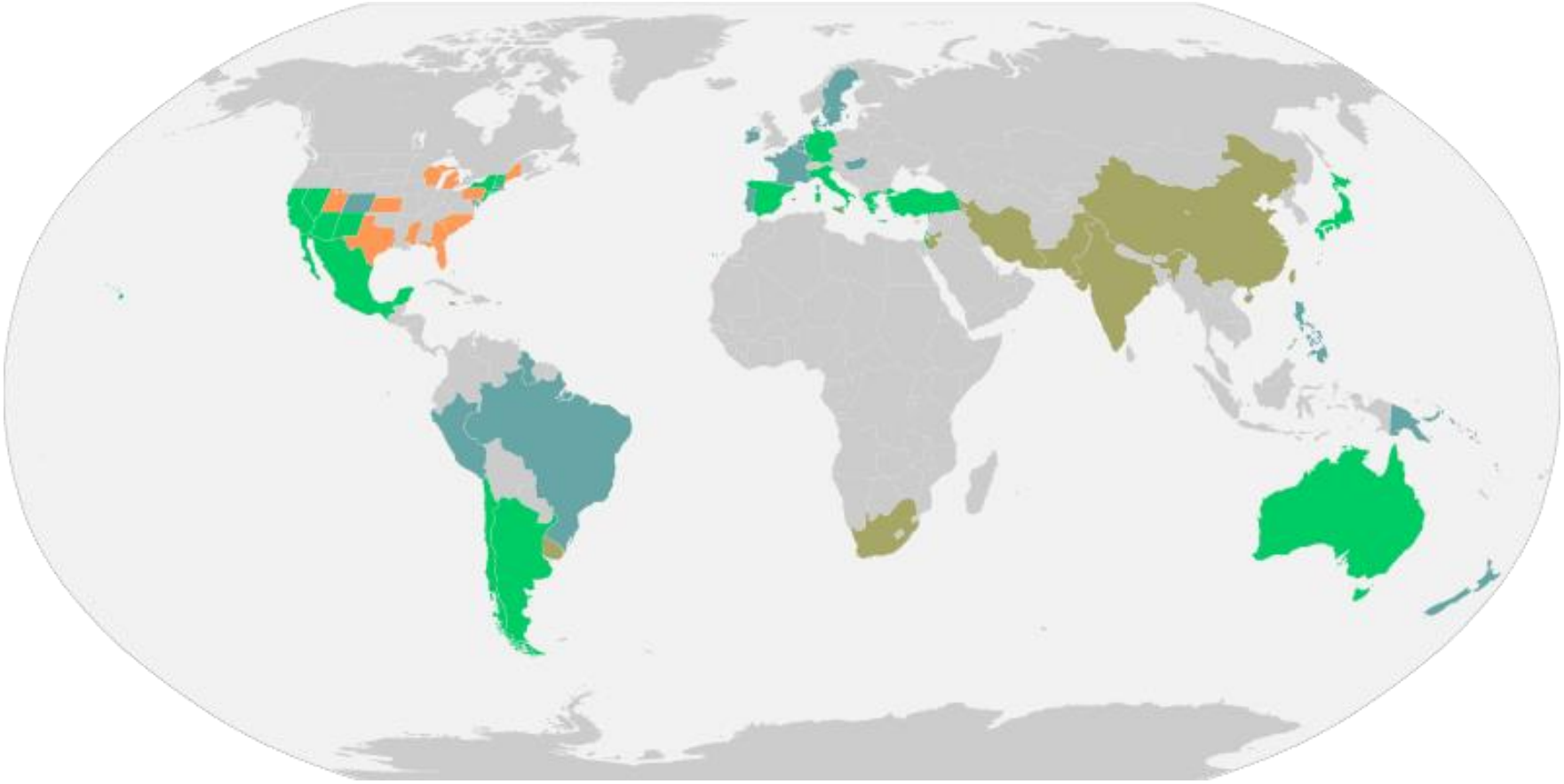
grid parity

- ✓ The term “grid parity” is meant to describe the point in time, at which a developing technology will produce electricity for the same cost to ratepayers as traditional technologies.

- ✓ That is, when the new technology can produce electricity for the same cost as the electricity available on a utility’s transmission and distribution “grid”.

http://www.renewable-energy-advisors.com/learn-more-2/what-is-grid-parity/

Countries where solar PV achieved grid parity (residential, industrial or commercial)



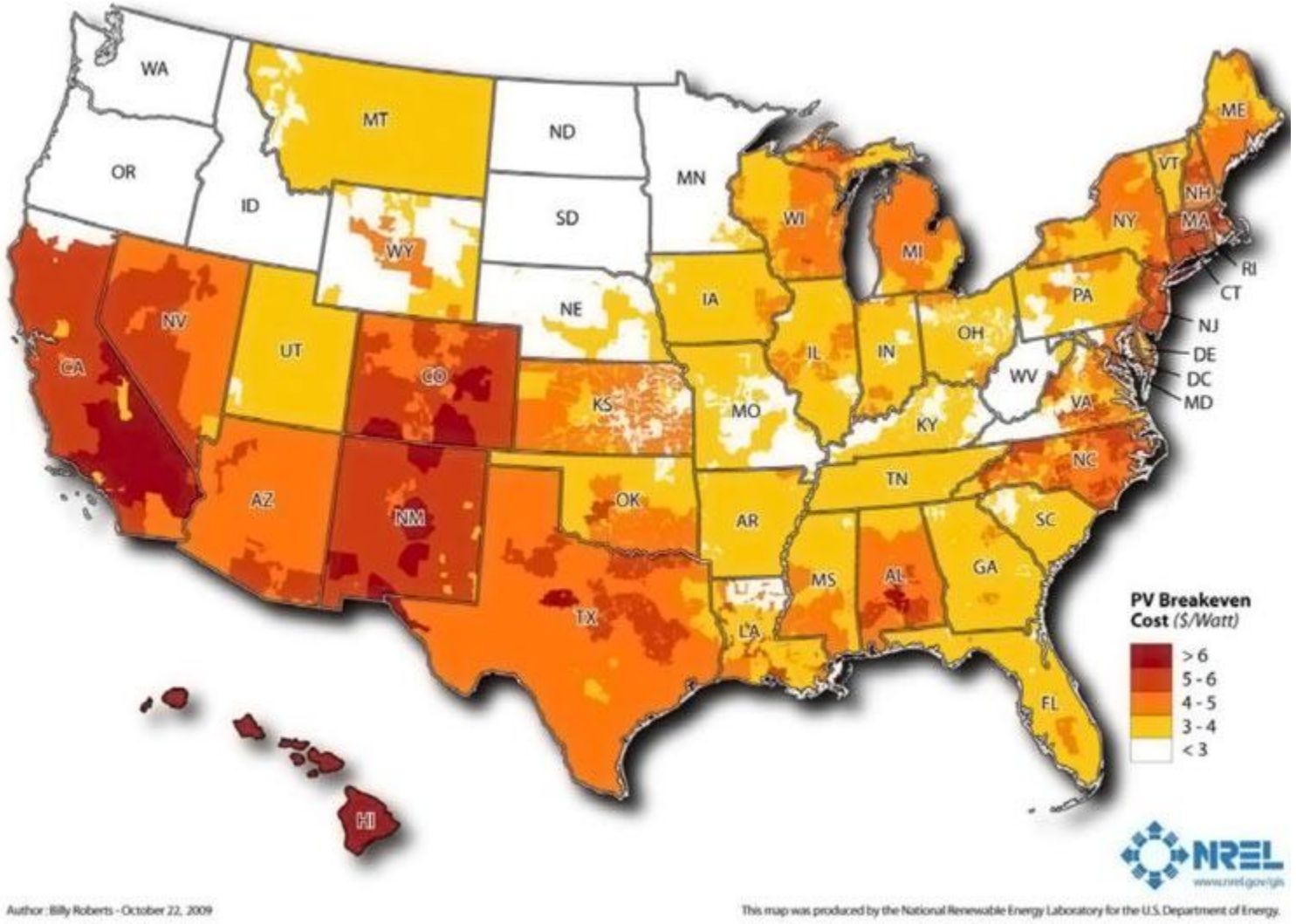
grid parity for a particular technology differs widely from location to location.

- A technology that produces power at a given cost is likely to be above grid parity in some locations and below grid parity in others

- Wind, Solar and Geothermal produce power at different costs in different locations. Solar power is less effective in Germany, for example, than in Utah because Utah gets more sun than Germany. Solar power in Northern Utah may be less effective than solar power in Southern Utah

- Installation costs vary from location to location. Because of higher labor and permitting costs, it is more expensive to build a renewable energy plant in California for example than in Utah

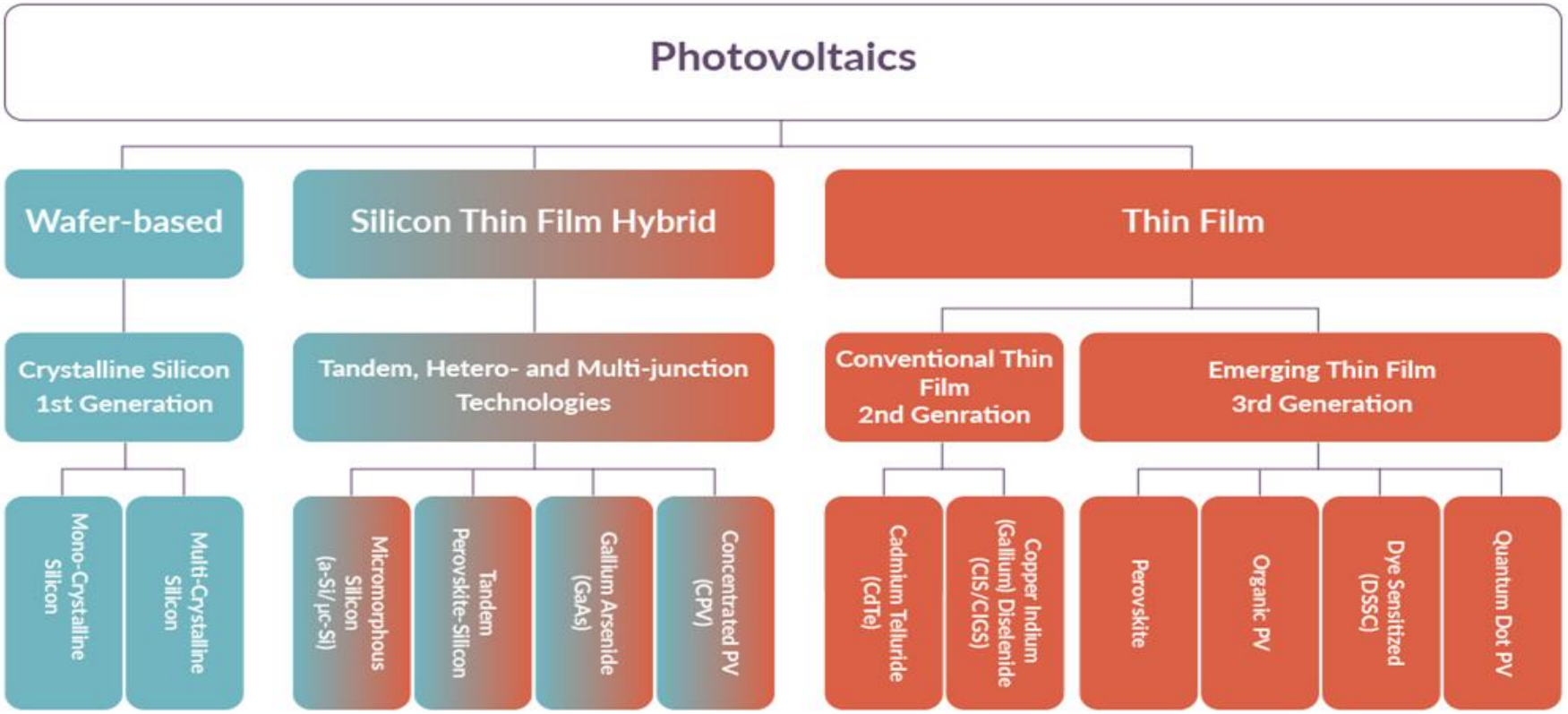
- The value of variable power sources like wind or solar depends in part on the amount of correlated capacity already installed in the region.



Grid Parity" price/installed watt for various U.S. locations

http://www.renewable-energy-advisors.com/learn-more-2/what-is-grid-parity/

Types of Photovoltaics



http://pvthin.org/technology

International Energy Agency Photovoltaic Power System Programme's (IEA PVPS)

- As of April 8, 2016,
  - China remains the world's biggest market, with 15.3 GW
  - EU and the U.S. with more than 7 GW each
  - India, with 2 GW, as "the rising star in the PV sector."
- The PV market grew by 50 GW while total capacity has reached at least 227 GW around the globe

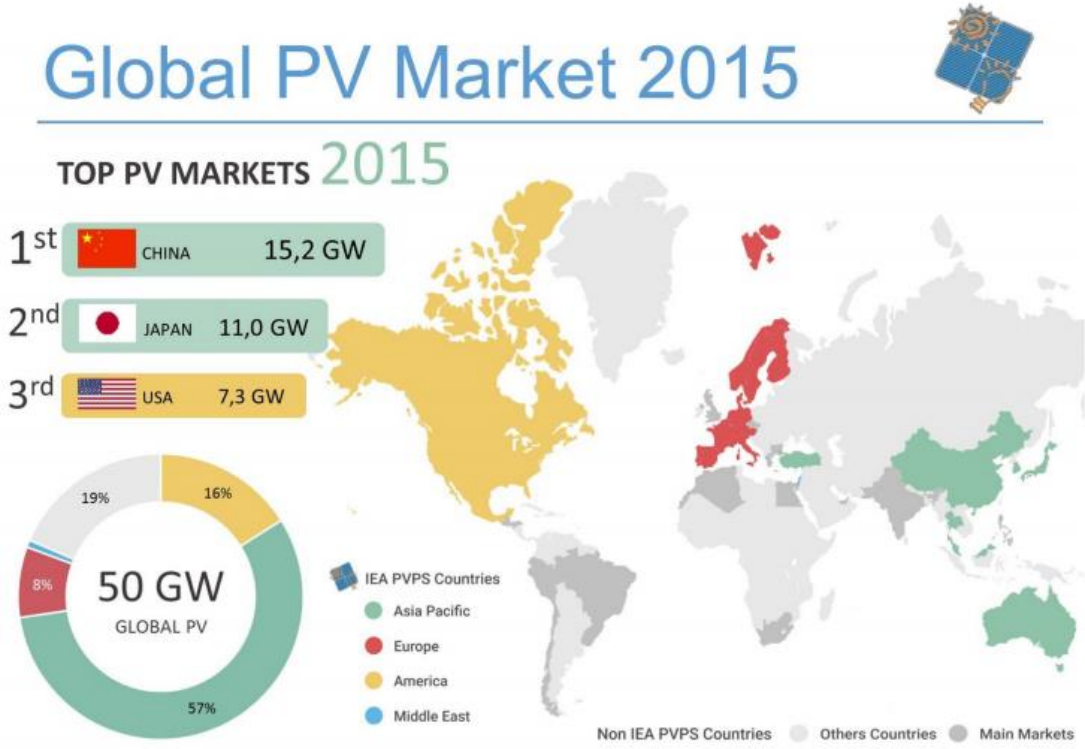
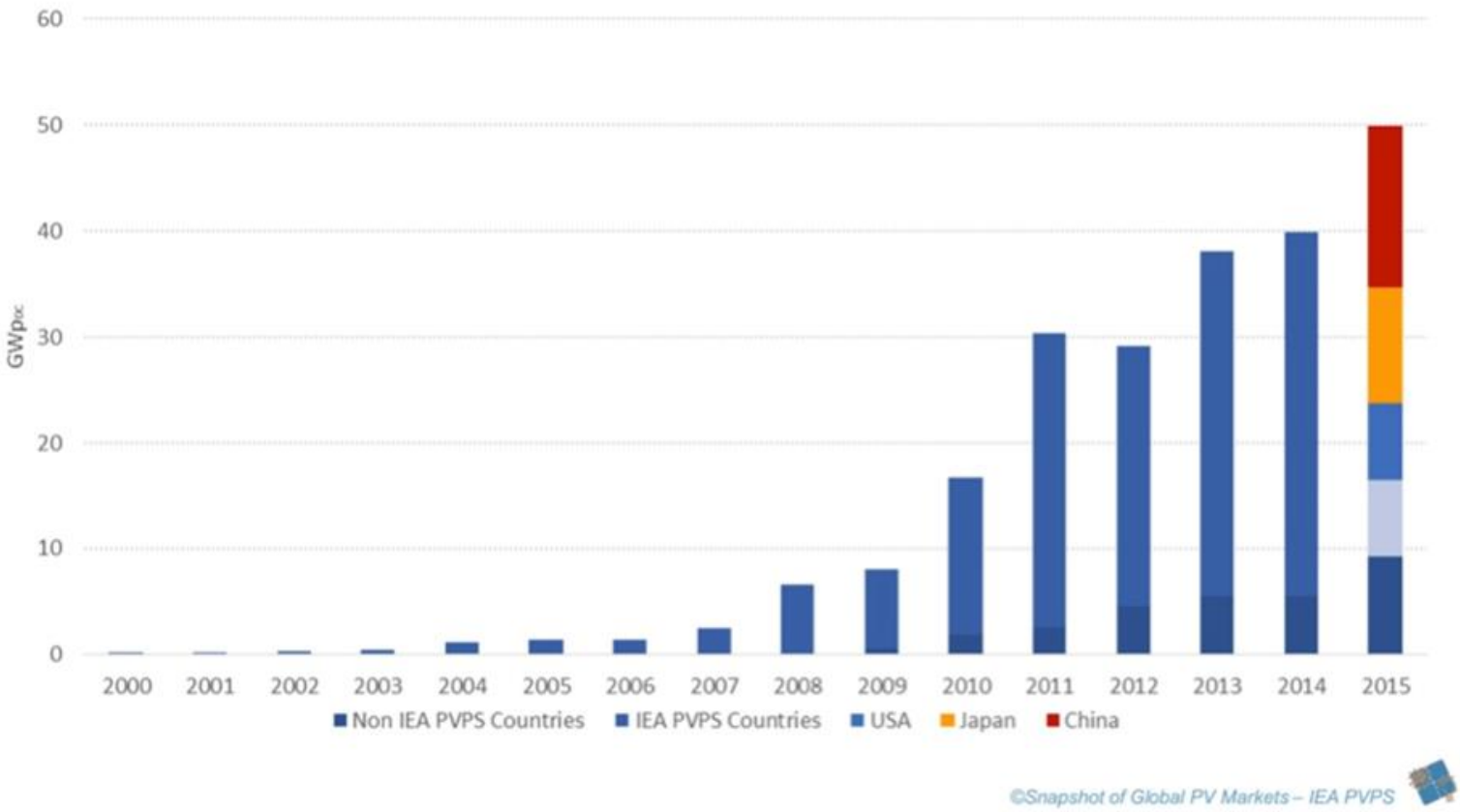
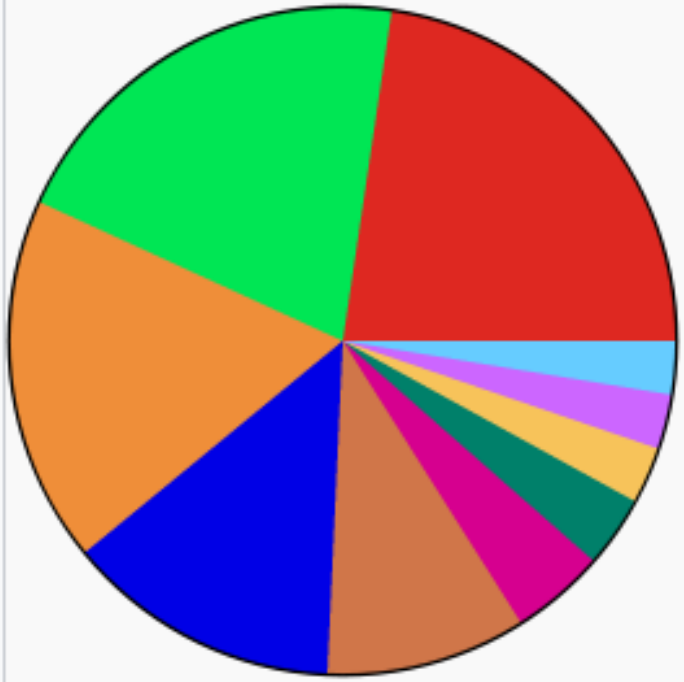


FIGURE 2: EVOLUTION OF ANNUAL PV INSTALLATIONS (GW - DC)

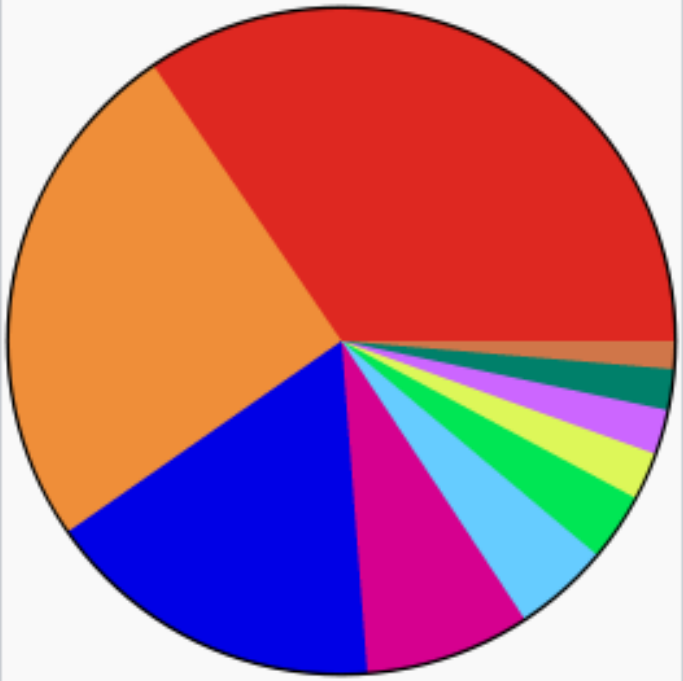


Top 10 countries in 2015 based on total PV installed capacity (MW)[7]



- China: 43,530 MW (22.5%)
- Germany: 39,700 MW (20.6%)
- Japan: 34,410 MW (17.8%)
- United States: 25,620 MW (13.3%)
- Italy: 18,920 MW (9.8%)
- United Kingdom: 8,780 MW (4.5%)
- France: 6,580 MW (3.4%)
- Spain: 5,400 MW (2.8%)
- Australia: 5,070 MW (2.6%)
- India: 5,050 MW (2.6%)

Top 10 countries based on added PV capacity in 2015 (MW)[7]



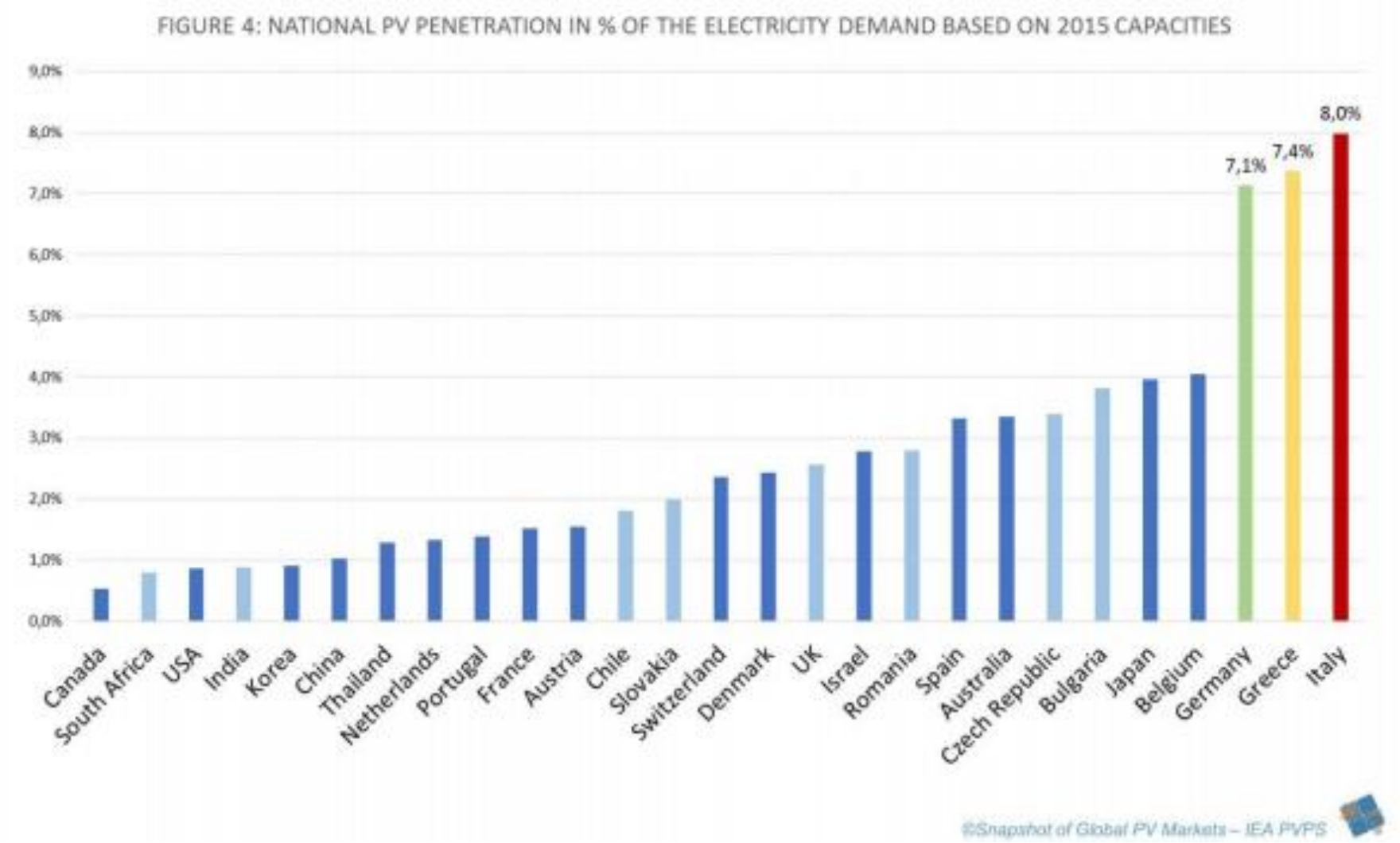
- China: 15,150 MW (34.6%)
- Japan: 11,000 MW (25.1%)
- United States: 7,300 MW (16.7%)
- United Kingdom: 3,510 MW (8.0%)
- India: 2,000 MW (4.6%)
- Germany: 1,450 MW (3.3%)
- South Korea: 1,010 MW (2.3%)
- Australia: 935 MW (2.1%)
- France: 879 MW (2.0%)
- Canada: 600 MW (1.4%)

TABLE 1: TOP 10 COUNTRIES FOR INSTALLATIONS AND TOTAL INSTALLED CAPACITY IN 2015

	TOP 10 COUNTRIES IN 2015 FOR ANNUAL INSTALLED CAPACITY				TOP 10 COUNTRIES IN 2015 FOR CUMULATIVE INSTALLED CAPACITY		
1		China	15,2 GW	1		China	43,5 GW
2		Japan	11 GW	2		Germany	39,7 GW
3		USA	7,3 GW	3		Japan	34,4 GW
4		UK	3,5 GW	4		USA	25,6 GW
5		India	2 GW	5		Italy	18,9 GW
6		Germany	1,5 GW	6		UK	8,8 GW
7		Korea	1 GW	7		France	6,6 GW
8		Australia	0,9 GW	8		Spain	5,4 GW
9		France	0,9 GW	9		Australia	5,1 GW
10		Canada	0,6 GW	10		India	5 GW

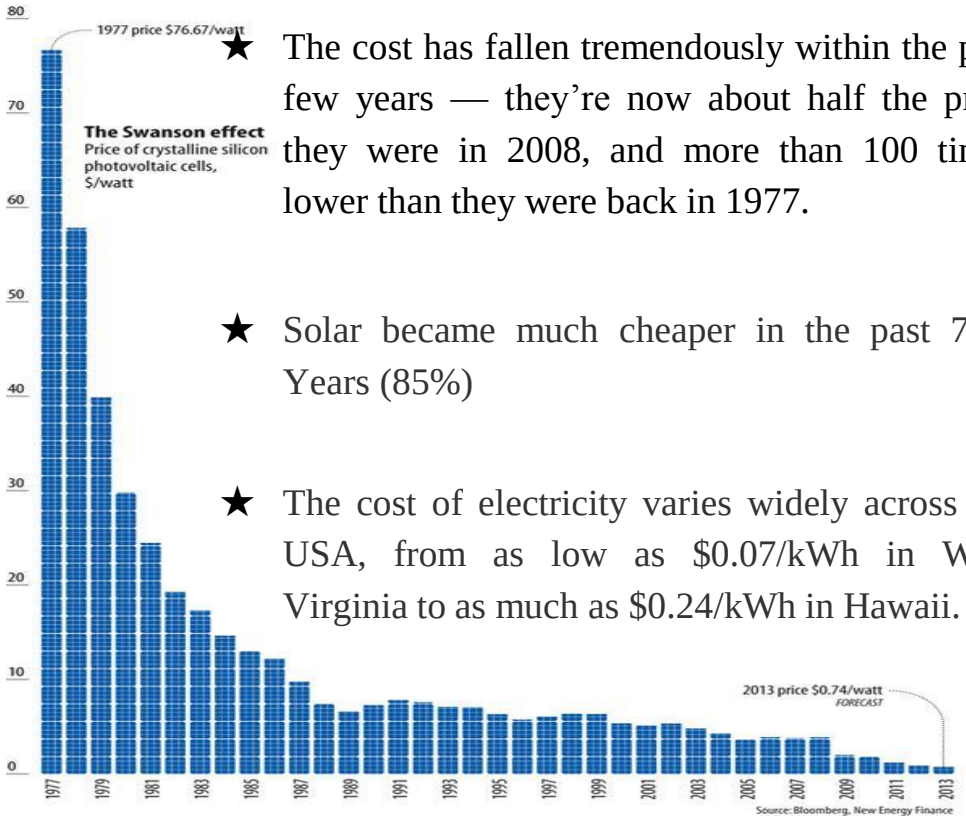
©Snapshot of Global PV Markets – IEA PVPS

http://www.iea-pvps.org/fileadmin/dam/public/report/PICS/IEA-PVPS_-__A_Snapshot_of_Global_PV_-_1992-2015_-_Final_2_02.pdf

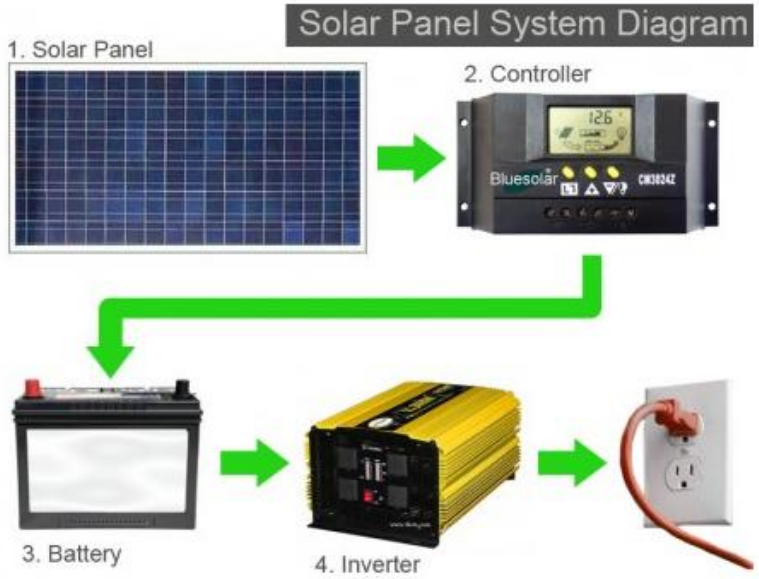


http://www.iea-pvps.org/fileadmin/dam/public/report/PICS/IEA-PVPS_-__A_Snapshot_of_Global_PV_-_1992-2015_-_Final_2_02.pdf

How Much Do Solar Panels Cost Today?



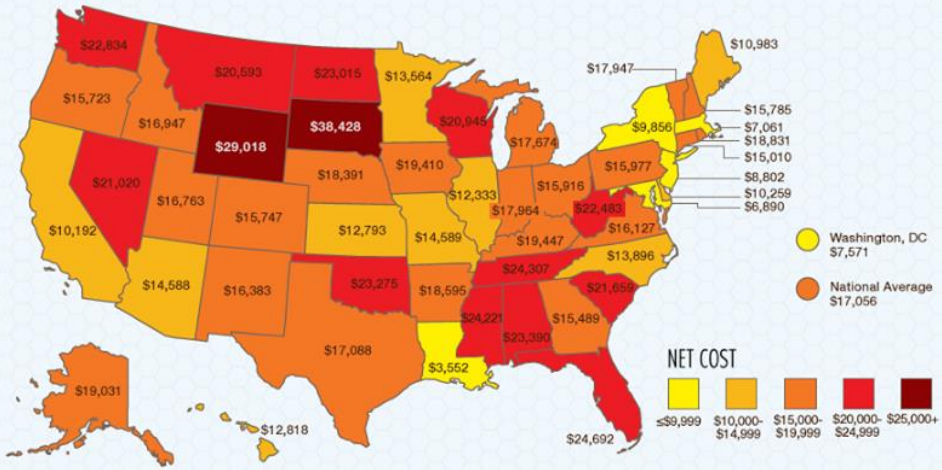
- ★ The cost has fallen tremendously within the past few years — they're now about half the price they were in 2008, and more than 100 times lower than they were back in 1977.
- ★ Solar became much cheaper in the past 7-10 Years (85%)
- ★ The cost of electricity varies widely across the USA, from as low as $0.07/kWh in West Virginia to as much as $0.24/kWh in Hawaii.



https://cleantechnica.com/2014/02/04/current-cost-solar-panels/

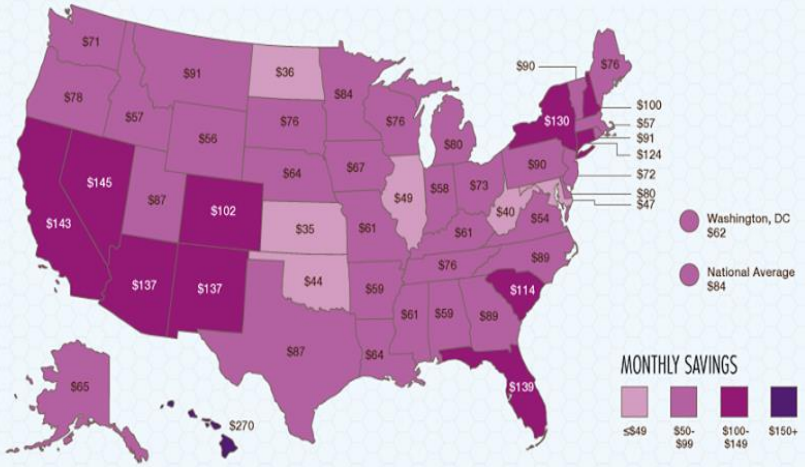
HOW MUCH SOLAR COSTS IN YOUR STATE

Think solar is out of reach? Think again. Real solar estimates show state, regional, and local incentives are helping bring the cost way down. In many states, you can go solar for less than $10,000. Here's a look at the average cost to go solar in each state.



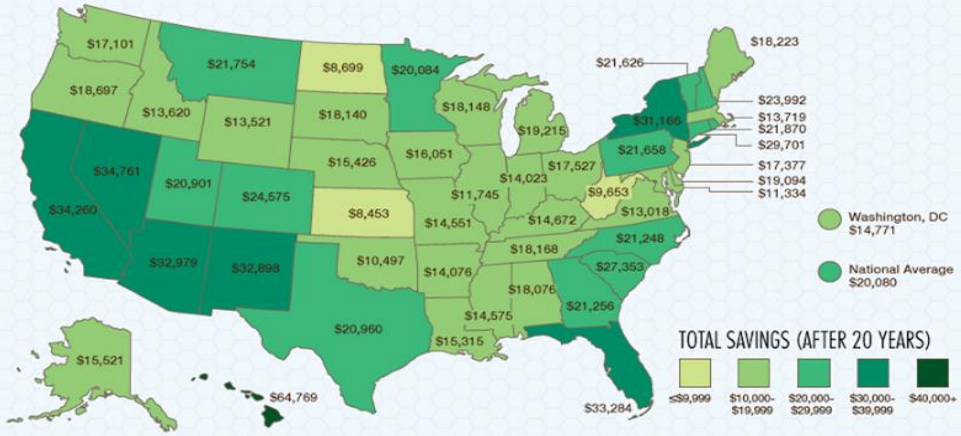
WHAT YOU COULD SAVE EVERY MONTH

By going solar, people around the country are saving money each month that would have gone to utility companies. Just how much are they saving? In some places, over $100 each month.



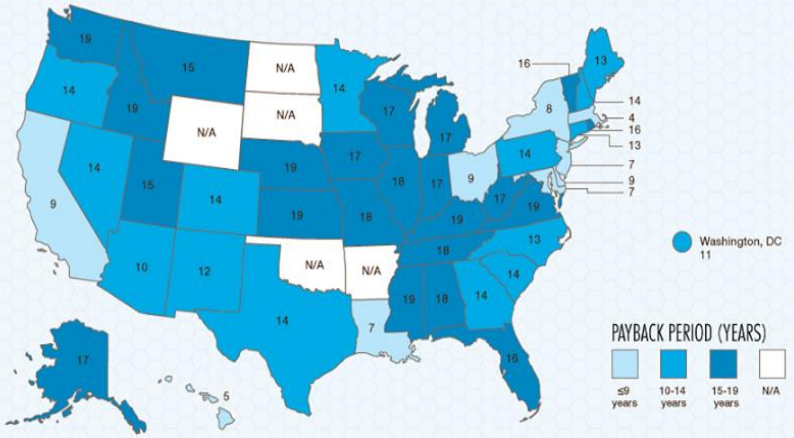
WHAT YOU COULD SAVE OVER TIME

What would you do with an extra $20K? That's how much the average solar system will save you over 20 years. Residents in some states with high electricity prices can expect to save much more than that—consider Hawaii, where residents save on average $64,000 after 20 years.



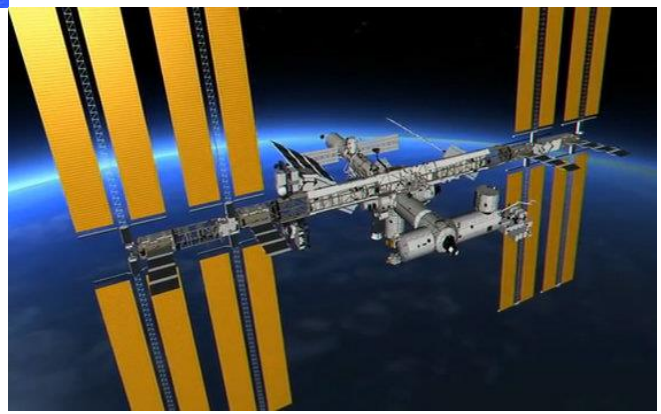
HOW LONG IT'LL TAKE TO PAY FOR ITSELF

Seems like a no-brainer: High cost equals long payback time, right? Not exactly. A state with good incentives can mean a low net cost, but if electricity is cheap in that state (like Arizona or Louisiana), the payback period can still be pretty long. Conversely, a system may cost more in a given state, but if electricity prices there are high, the payback period may actually be pretty short.



https://cleantechnica.com/2014/02/04/current-cost-solar-panels/

- ★ Intensification of space race in the late 50’s, three American space orbiting satellites, Vanguard I, Vanguard II and Explorer III as well as the Russian Sputnik-3 were launched into space fitted with solar PV arrays.
- ★ In 2000, astronauts at the International Space Station (ISS) began installing new solar panels on what is now the largest solar PV array ever installed in space.
- ★ A crew aboard the ISS is continuing this spirit, by testing out a new 3D solar PV cell, which it hopes to have higher efficiency than current solar cells.



1. https://blog.urthecast.com/company/international-space-stations-solar-panels-have-a-no-fail-mission/
2. http://www.solarsystems-usa.net/the-fascinating-history-of-solar-photovoltaics/

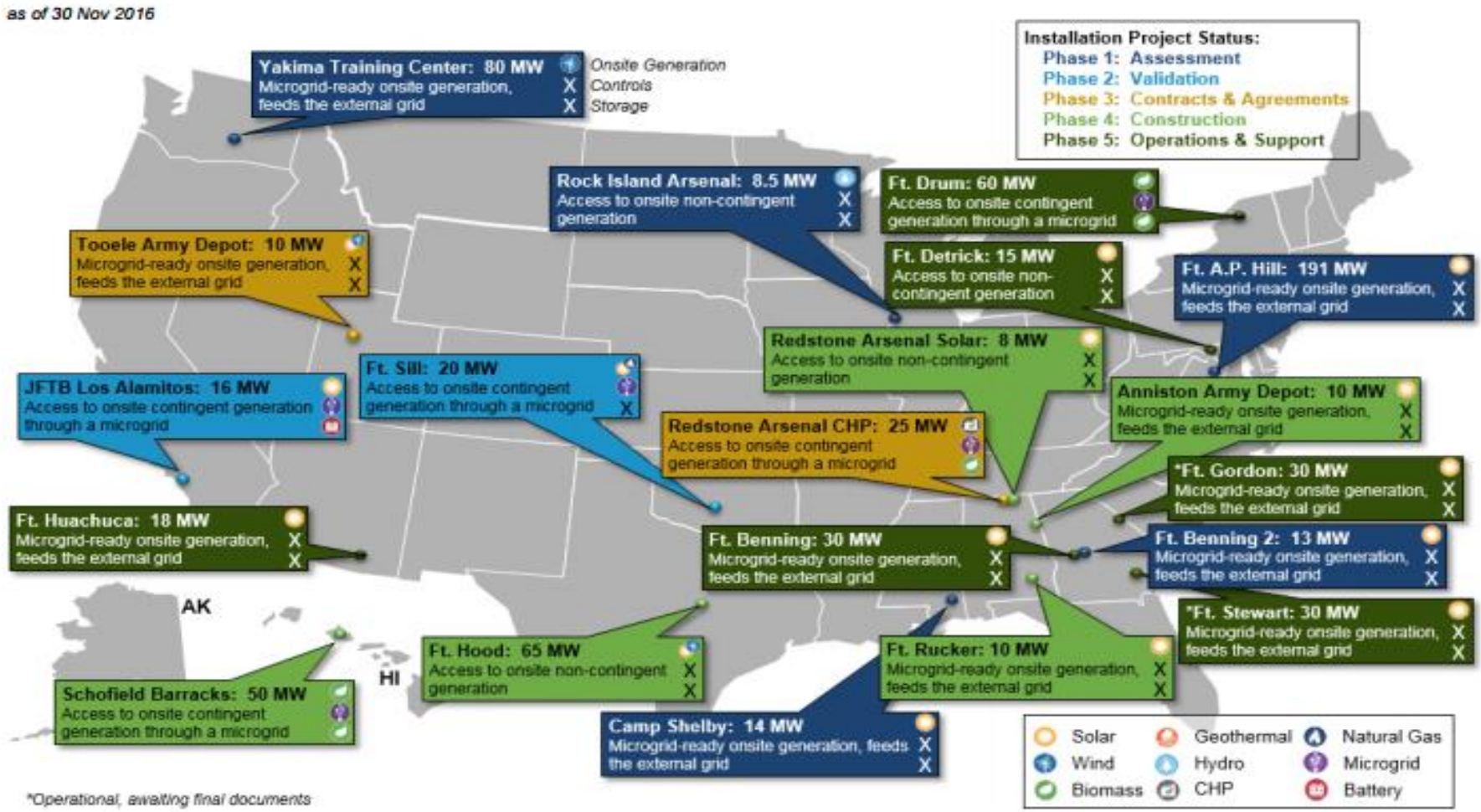
The 2 MW photovoltaic system at U.S. Army Fort Carson. *Photo courtesy of U.S. Army Fort*

The energy management system installed at the Navy's Pacific Missile Range Facility in Hawaii holds the system's main controller, advanced batteries (inset),

- NREL and the U.S. Department of Defense (DOD) working together on energy projects that demonstrate and validate energy efficiency and renewable energy technologies
- NREL is helping the Army assess and deploy energy efficiency and renewable energy technologies in support of nine Net Zero Energy Installation (NZEI) pilot programs. Energy managers at each Army installation are working to achieve net zero energy use by 2020 by working with NREL
- The National Center for Photovoltaics (NCPV) at the National Renewable Energy Laboratory (NREL) focuses on technology innovations that drive industry growth in U.S. photovoltaic (PV) manufacturing
- Army Office of Energy Initiatives (OEI) was established by the Secretary of the Army to serve as the central management office for partnering with U.S. Army installations to implement cost-effective, large-scale renewable and alternative energy projects, 10 megawatts or greater, leveraging private sector financing.
- As of early 2013, there were more than 130 megawatts (MW) of solar photovoltaic (PV) energy systems powering Navy, Army and Air Force bases in at least 31 states and the District of Columbia.

http://www.nrel.gov/defense/projects.html

OEI Large-Scale Energy Security Projects



http://www.asaie.army.mil/Public/ES/oei/docs/Industry%20Day_ArmyEnergy_Final.pdf

Advantages

- Helps to slow/stop global warming
- Saves society billions or trillions of dollars
- Saves you money
- Provides energy reliability
- Provides energy security
- Provides energy independence
- Solar power creates jobs

Disadvantages

- Some toxic chemicals, like cadmium and arsenic, are used in the PV production process. These environmental impacts are minor and can be easily controlled through recycling and proper disposal.
- Solar energy is somewhat more expensive to produce than conventional sources of energy due in part to the cost of manufacturing PV devices and in part to the conversion efficiencies of the equipment.
- Solar power is a variable energy source, with energy production dependent on the sun. Solar facilities may produce no power at all some of the time, which could lead to an energy shortage if too much of a region's power comes from solar power.

http://www.energybc.ca/cache/solarpv/www.cetonline.org/Renewables/PV_pro_con.html

Iacharya

CERTIFICATION BY SRRA,NIWE,UNIT OF MNRE @ JUST RS 599 / -

OUR PARTNERS

Solar Radiation Resource Assessment & Advance Measurement Station

Government of India
Ministry of New and Renewable Energy

Renewable Energy is Green,Clean and Sustainable

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www.iacharya.in

Course On Solar Design & Installation

Training Methodology

The course will be delivered online in a combination of lecture/PPT/multimedia/video formats, including design exercises, case studies and virtual onsite installation videos.

Who Should Attend ?

People already working in the solar industry, new enterpreuners, students and graduates looking to update themselves with current best practices.

Installers, engineers, ITI/diploma holders, project managers and electricians.

Medium of Instruction

The course is currently being offered in Hindi and English.

Highlights of the Course Programme

- Basics of photovoltaic systems
- Basics of electromagnetic spectrums and radiation study
- Shading analysis
- Designing of solar power systems
- Grounding and bonding concepts
- Civil construction and lightening protection
- Testing and commissioning of solar power plants
- Operations and maintenance
- Personal protective equipment
- Virtual onsite training

About Iacharya Silicon Limited

IACHARYA SILICON LIMITED (ISL), Chennai is a solar energy engineering, consultancy and training company. The training division works with National Institute of Solar Energy (NISE) for the Suryamitra programme and SRRA, NIWE for online training programmes.

Overview of the course

The two-week course covers various aspects of solar PV feasibility studies, basics of design, installation, operation and maintenance of solar power plants.

Successful candidates shall have vast opportunities for employment in the solar industry. The course will enable participants to effectively work on design, integration and management of solar power projects. It also prepares candidates to become new entrepreneurs in the Solar Energy sector.

Assessment and Certification

Successful candidates will receive a joint certificate from MNRE and Iacharya.

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THANK YOU