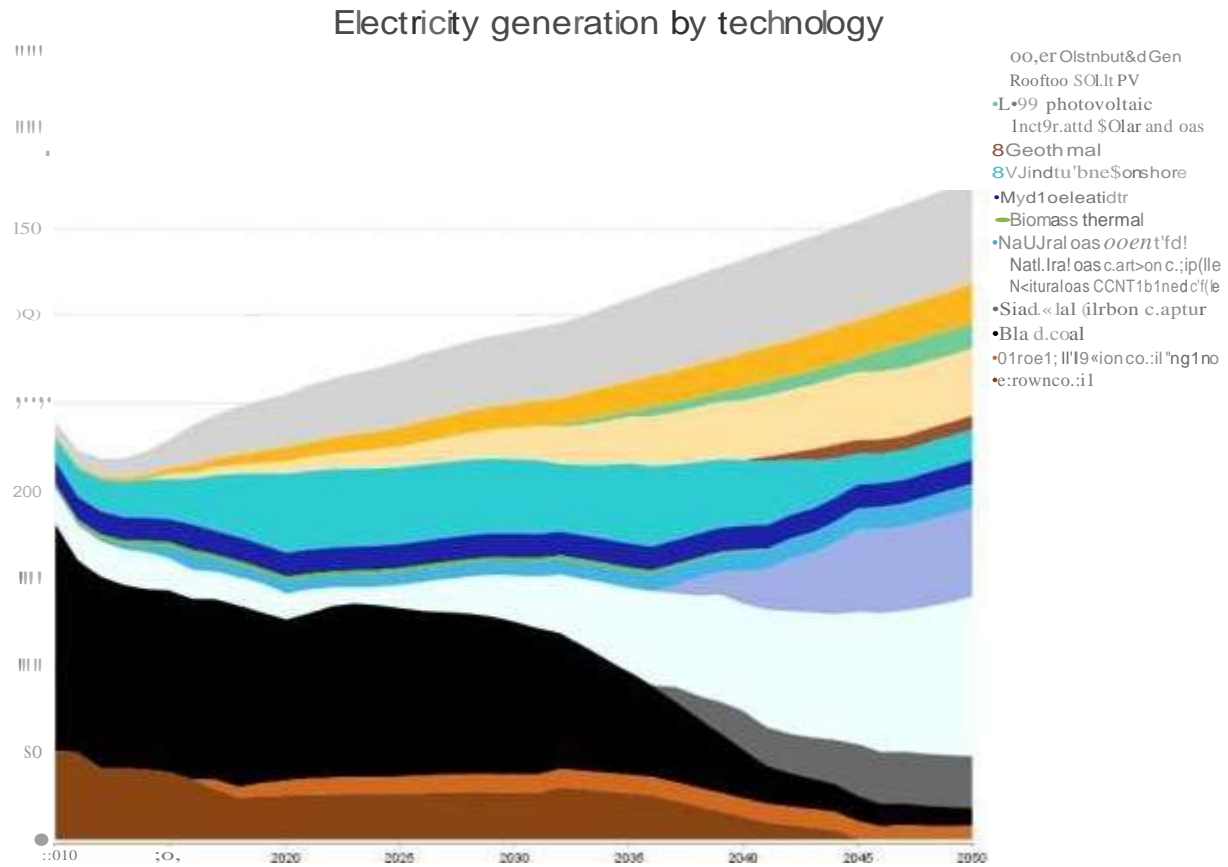


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# Issues with Nuclear

- **Long lead time to build** ---15 to 20 years
  - **Expense** to build current generation nuclear reactors...billions of dollars. Needs govt subsidy
  - Emits large amount **CO2 during construction**
  - **Spent fuel** from **444 current global reactors** needs to be cooled for eons...with a melt down potential in the future if can't be cooled .
  - Some countries use nuclear for **weapons**....  
concern with increasingly unstable countries
  - **Uranium... limited supply**
-

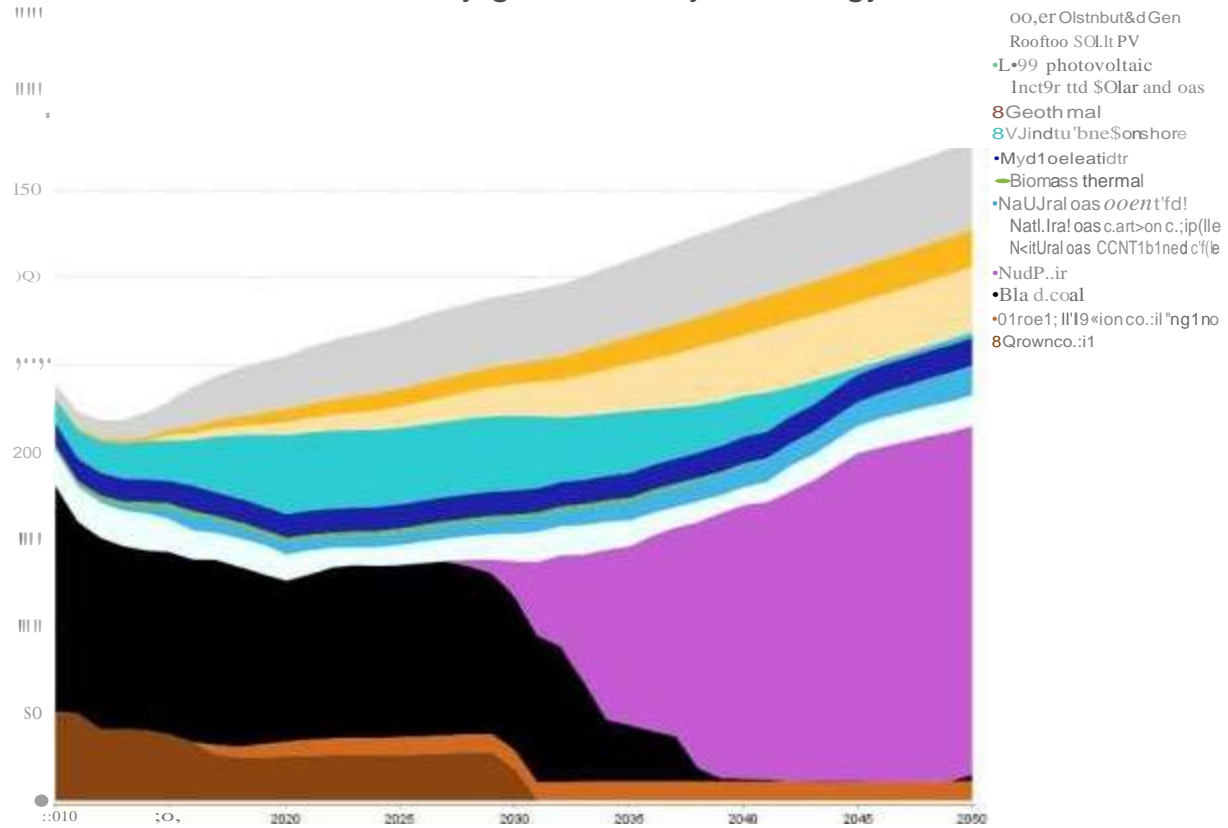
# Energy Mix \ Without Nuclear Energy



Source: Copyright Commonwealth Scientific and Industrial Research Organisation 2012. Chart based on our scenario assumptions and developed by CSIRO's eFuture. For more information, see our website: [www.csiro.au](http://www.csiro.au) (5ad..01bund).

# Energy Mix \With Nuclear Energy

Electricity generation by technology



Source: Copyright Commonwealth Scientific and Industrial Research Organisation 2012.  
 Chart based on our scenario assumptions and developed by CSIRO's eFuture; EJ/Modeling Simulation MG4/1/1953. Conditions of use, see www.efwle.csiro.au (5ad..01bund).

# The 2050 Challenge:

**9.5 billion people  
living out of poverty  
and at Western levels  
of consumption**



**Without destroying  
the climate/ acidifying  
the oceans**



## Carbon-free energy options

- **Renewables**: wind, solar, water efficient, cost effective, desirable
- **Biofuels**: land-intensive, harm biodiversity/food production
- **Carbon-capture and storage**: still not scaled-up, serious technical challenges, expensive
- **Nuclear fission**: major public acceptability/political challenges



## Nuclear's present day problems

- Nuclear waste disposal
- Proliferation
- Fuel supply
- Safety
- Cost

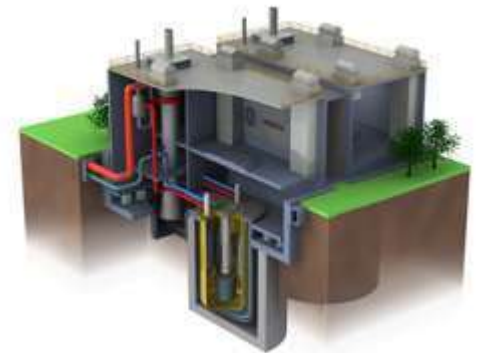


**These problems are not 'real' in any technical sense, but are political, and must be seen to be solved for public acceptance of nuclear power**



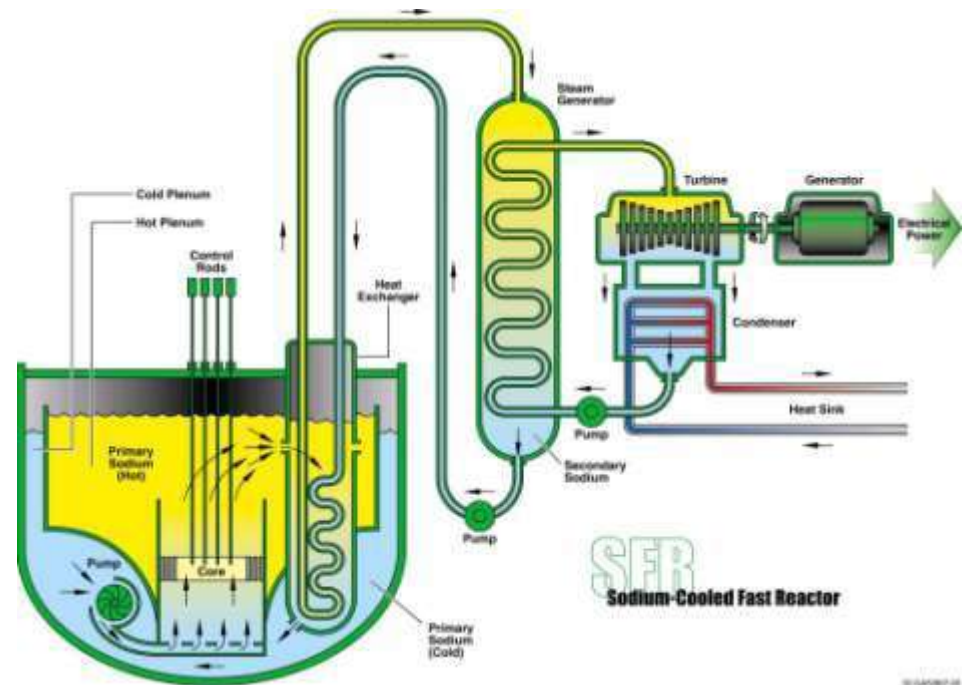
# The Integral Fast Reactor/PRISM

- Developed at Argonne National Laboratory, based on EBR-II
- Cancelled by Clinton/Gore administration/Congress in 1994-lost 20 year lead advantage
- Now marketed worldwide by GE-Hitachi as the PRISM (**Power Reactor Innovative Small Module**)
- Currently considered by UK, Russia, China, South Korea for deployment



# IFR/PRISM technical specifications

- Liquid sodium-cooled fast reactor
- Can be operated as breeder or burner
- Reactor core sits in pool of coolant
- Power generation from secondary (non-radioactive) coolant loop
- Two units per PRISM of 300MWe = 600MWe



SFR  
Sodium-Cooled Fast Reactor



## Problem solved: nuclear waste

- **IFR can ‘burn’** all actinides/transuranics because of energy of fast neutrons
- **Turns ‘waste’ into ‘fuel’** as in the UK system
- Residual radiotoxicity of waste declines to level of original uranium ore in 300 years
- No need for geological repository with 1 million-year design life



## Problem solved: proliferation

- **No need to enrich uranium for fission**
- Continual plutonium breeding essential however
- Potential Pu danger addressed by reprocessing technology called 'pyroprocessing'
- Fuel reprocessing done remotely in hot cell – extremely radioactive therefore fissile material self-protecting
- Separating bomb-grade Pu would require PUREX reprocessing: massive plant which is easily detected



## Problem solved: fuel supply

- Fast reactor uses 99% energy in uranium; LWRs use 0.7%
- UK has spent fuel for 500 years of operation of fleet of IFRs, generating entire 80GW national electricity supply
- US has enough for around 1000 years with no uranium mining



- Subsequently **thorium** provides abundant fuel
  - After thorium we should have problem of nuclear fusion  
~~solved!~~
-

## Problem solved: safety

- Fukushima demonstrated safety concerns of BWRs/PWRs
- **IFR/PRISM designed for full passive safety-it requires no power or cooling for shutdown**
- Sodium 90x as effective in conducting heat than water and safe because it is at atmospheric pressure
- 1986 EBR-II experiment switched off coolant pumps, reactor shut itself down in 300 seconds
- ~~● **Meltdown impossible** due to core design & metal (not oxide) fuel and core are at atmospheric pressure~~



## Problem solved: cost

- **Single, fully modular design**, made on factory assembly line and shipped to site
- Costs offset by nuclear waste disposal



- GE-Hitachi proposal to UK: plutonium stockpile 'disposition' instead of MOX reprocess; no upfront costs
- But costs always uncertain until deployment!
- Deployment may take 30 years—time to start: **NOW!**

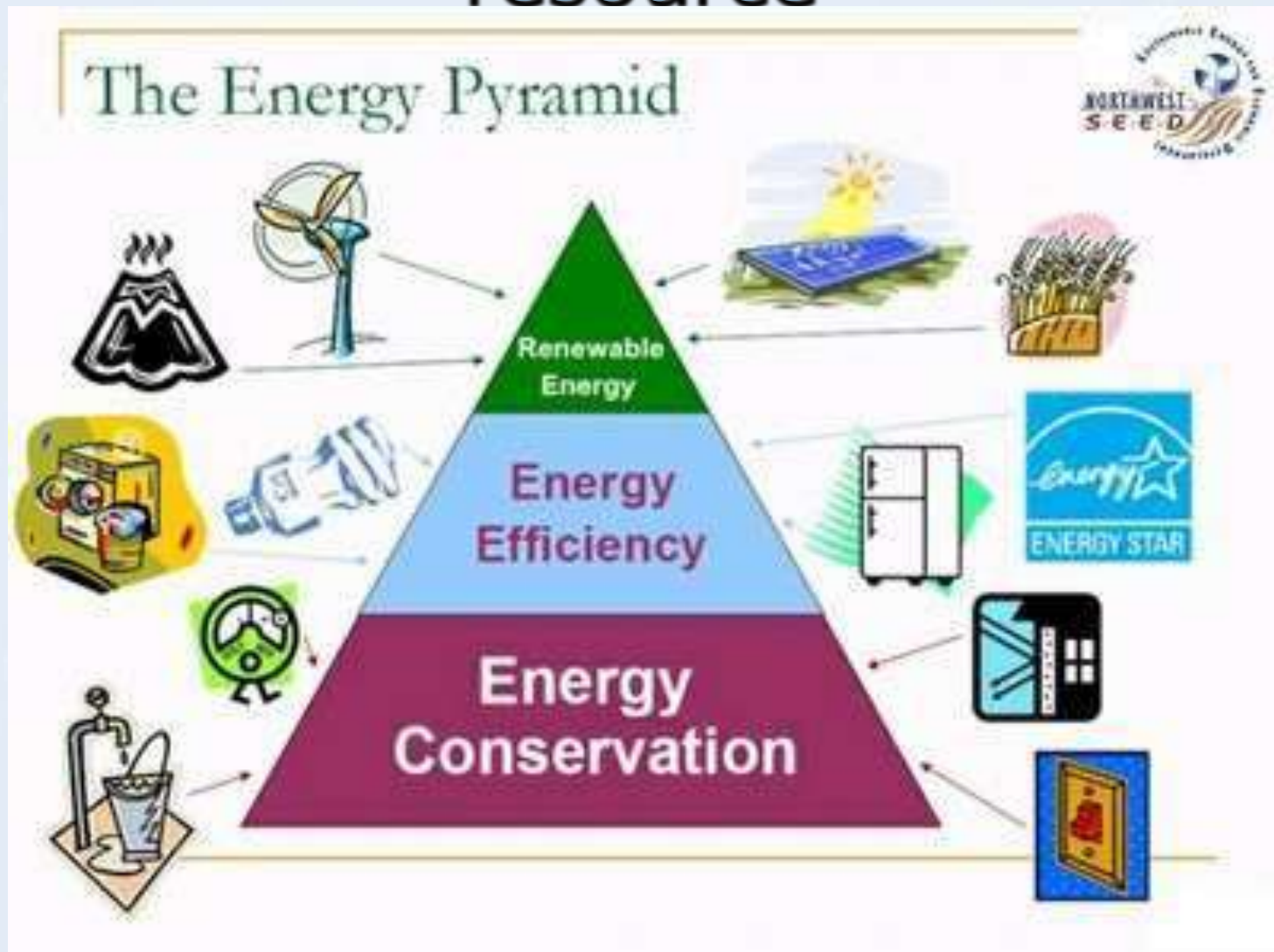
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## Conclusions

- All the supposed 'unsolved' problems of nuclear power have actually been solved or are soluble
  - The problems are only 'unsolved' in the minds of anti-nuclear activists and beneficiaries of carbon fuel money
  - IFR/PRISM just one of a variety of competing 4<sup>th</sup> Gen designs; other fast reactors, SMRs, thorium LFTRs also important
  - And Gen III+ also needs deploying at scale. We need 1000's of new reactors to solve climate change and to deploy Gen IV reactor startups
-



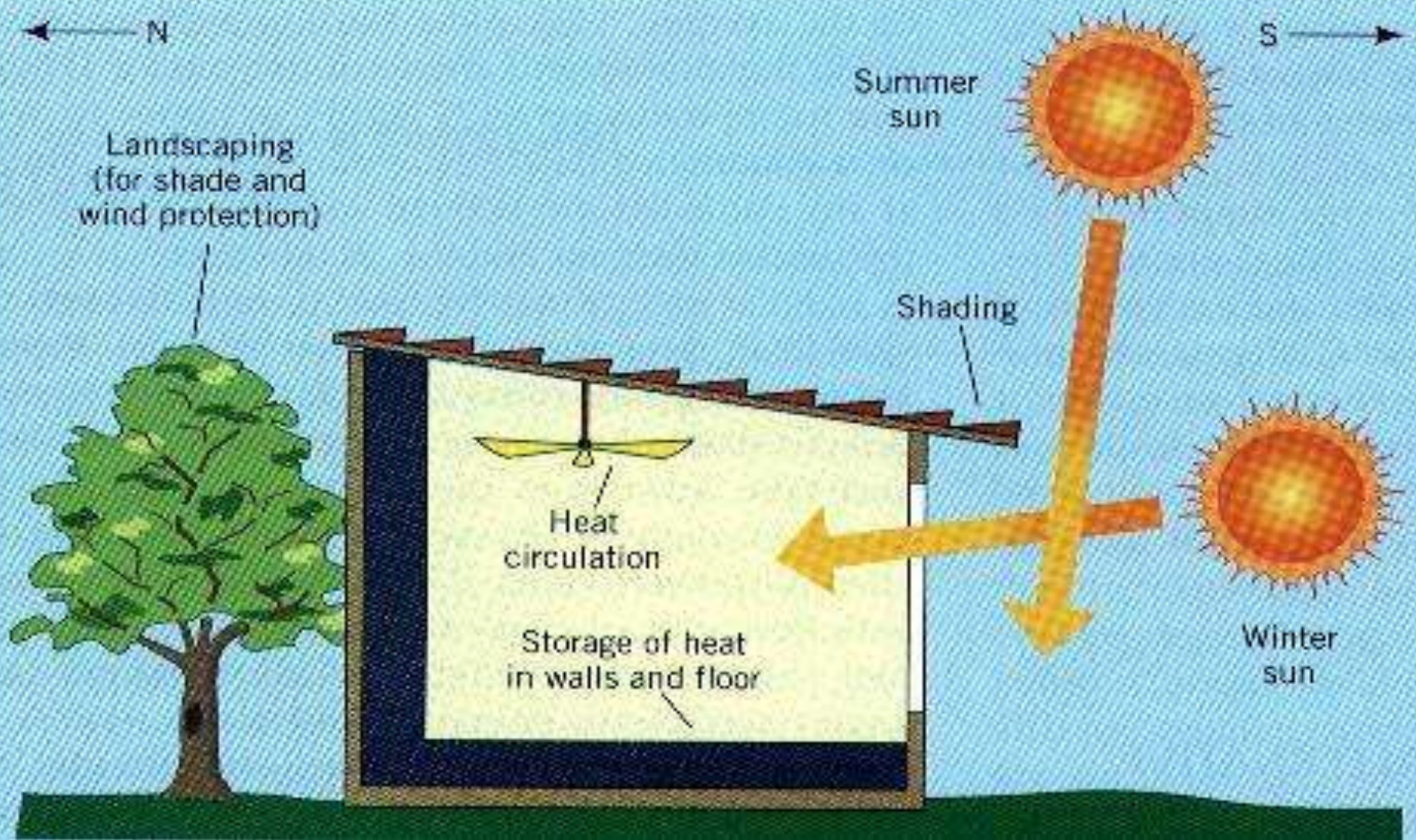
# MOST cost effective and environmental friendly energy resource



# SOLAR Jo Walker

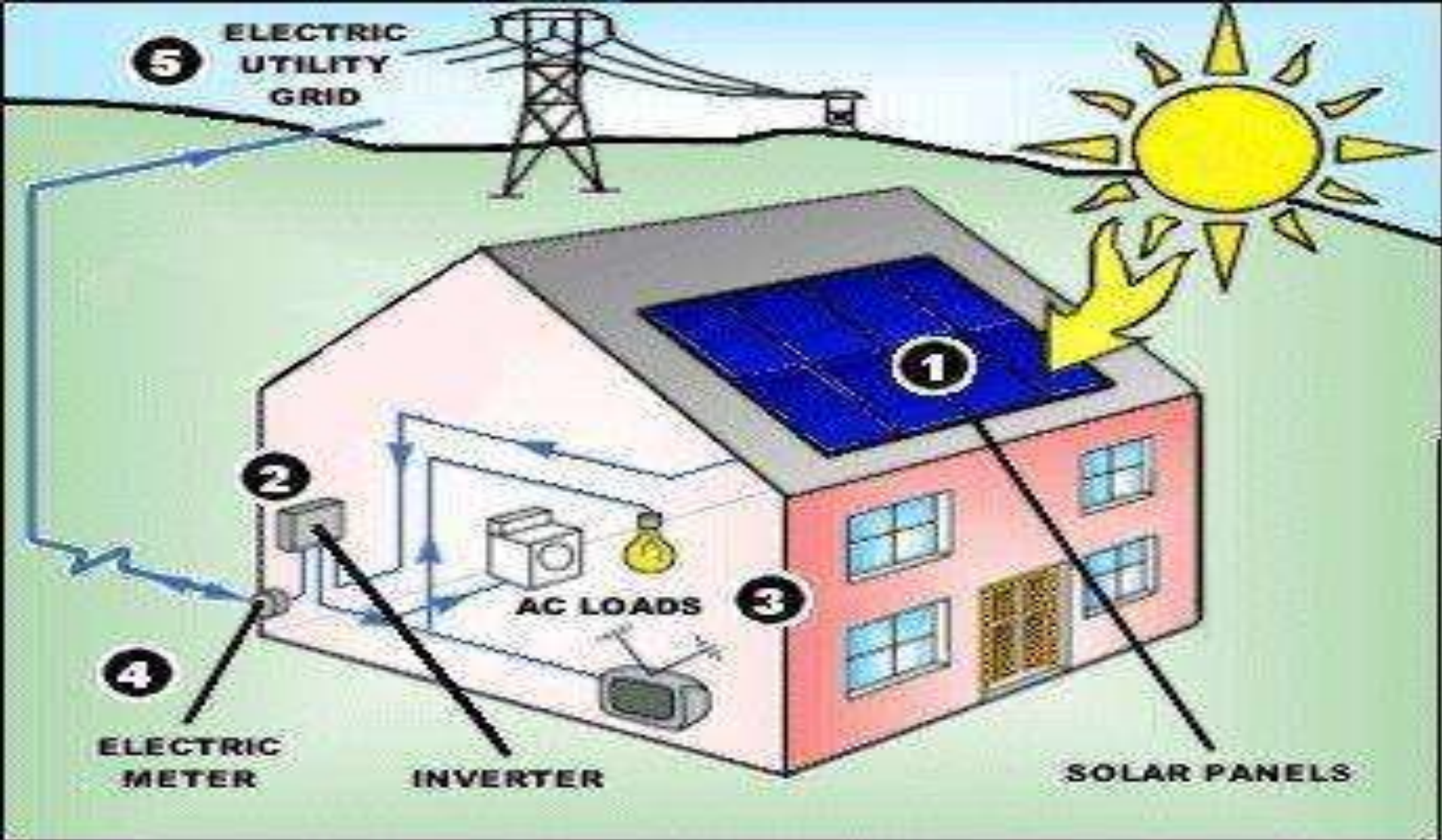






**Passive Solar** – Making use of building materials and design while considering the position of the sun.





**Active Solar** - Involves the use of solar panels, kits, batteries and other equipment that convert sunlight into functional outputs.

# ***SOLAR ENERGY***

***Solar Thermal*** - Solar Thermal Energy involves converting energy from the sun into heat.





# ***SOLAR ENERGY***

***Photovoltaics (PV)*** - Involves converting energy from the sun directly into electricity.

- Promising alternative – NO harmful by-products - NO water contamination





# SOLAR ENERGY

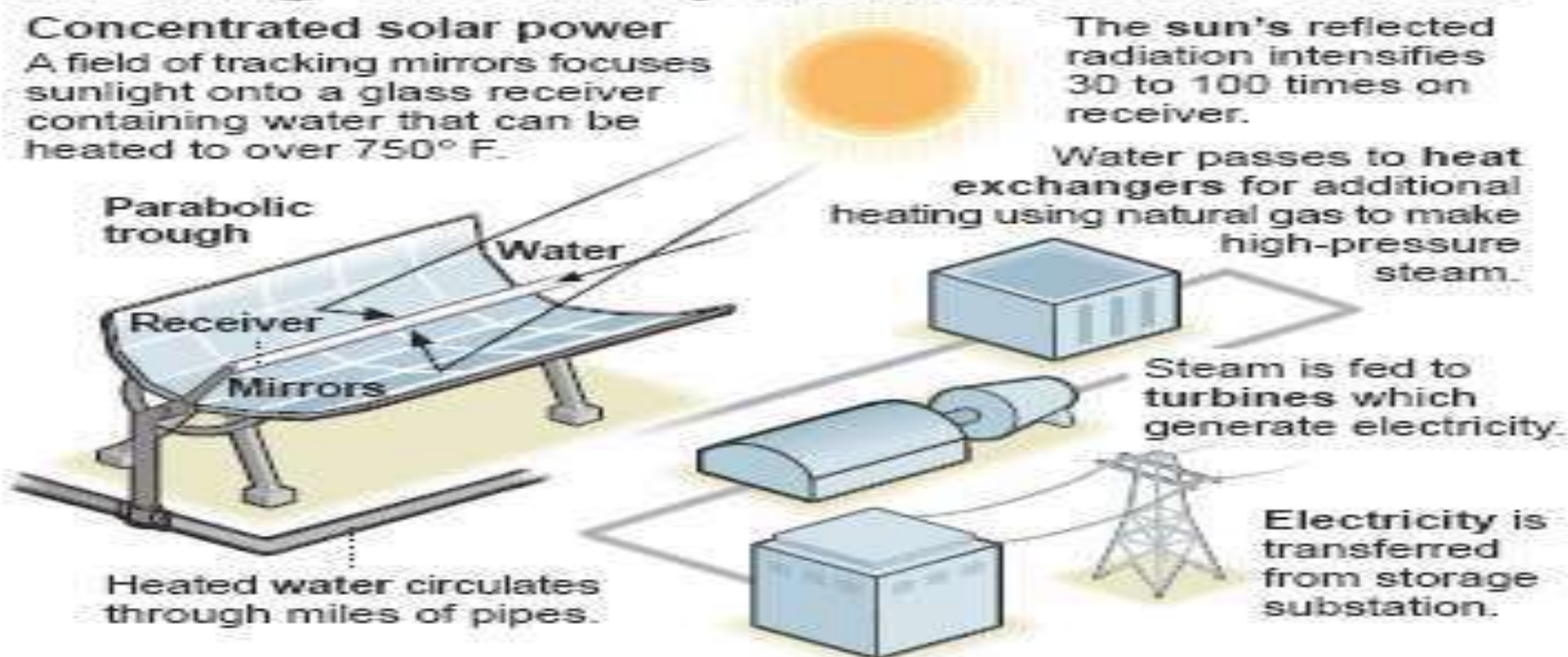
## Concentrated Solar Power (CSP) –

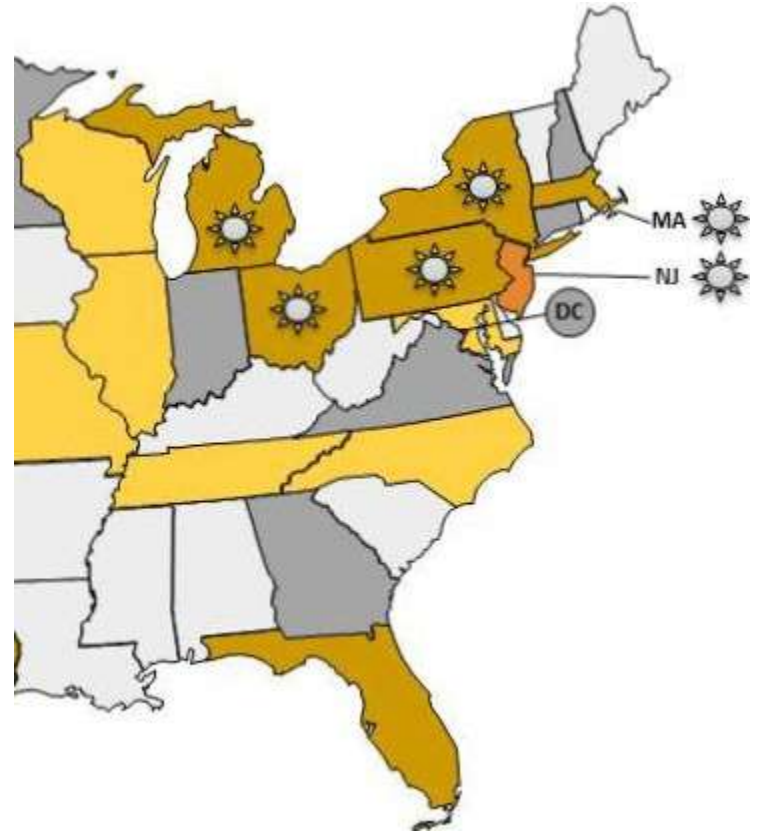
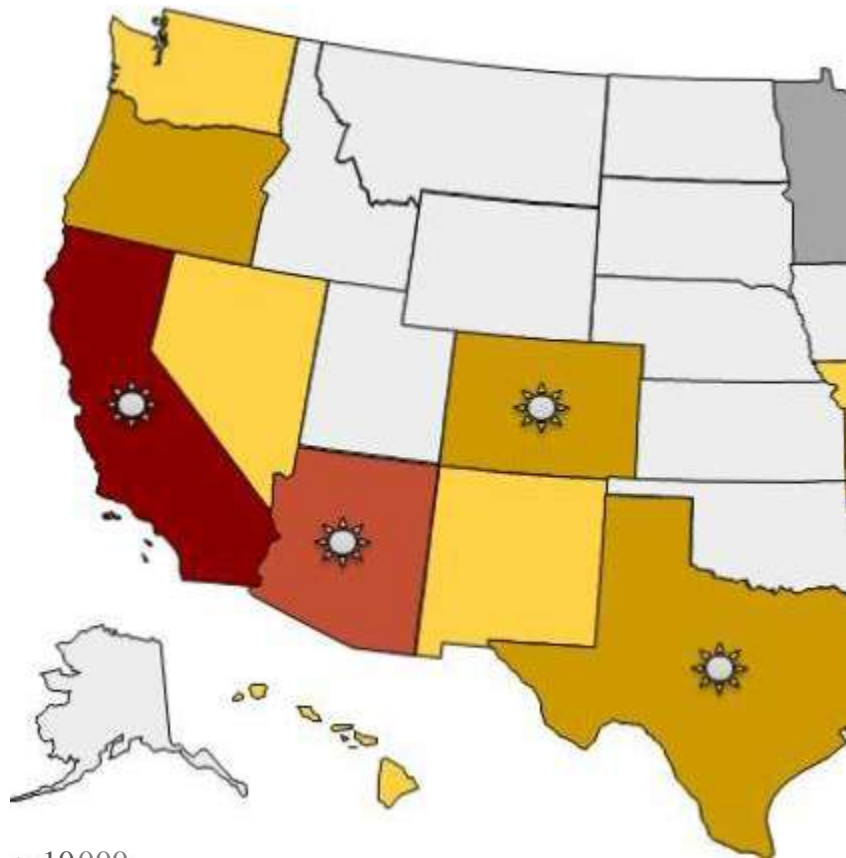
Uses an array of lenses or mirrors to focus on a large area of sunlight.....

### Making electricity from the sun's heat

**Concentrated solar power**  
A field of tracking mirrors focuses sunlight onto a glass receiver containing water that can be heated to over 750° F.

The sun's reflected radiation intensifies 30 to 100 times on receiver.





> 10,000  
 7,500 to 10,000  
 5,000 to 7,499  
 2,500 to 4,999  
 1,000 to 2,499  
 500 to 999  
 < 500

Top Ten Solar Jobs State

THE solar FOUNDATION

TheSolarFoundation.org  
 @SolarFound

# Solar Worker Highlights

## The United States

employs more workers than coal mining <sup>111</sup>



### Linda Cinque

Quality Systems Engineer, SMA America

My commitment to a sustainable earth brought me to the world of solar. In the two years that I've been working in the solar industry, I've been amazed to watch its growth and the ever-changing, innovative products and solutions that companies like SMA have developed. This is truly energy that changes!

### Susan Hollingshead

Chief People and Corporate Services Officer, Sungevity

"When I left the brownfield redevelopment business, I had three key criteria for what I wanted to do next: to be part of creating a new market sector, to use my long corporate experience to help lead an emerging company's success, and to go home at night knowing that what I was doing meant something. The solar industry and Sungevity met these criteria in a big way.

### Jack Nichol

Electronics Technician, AI/Earth Renewables

"I am excited to be using the skills I learned in the U.S. Marine Corps now in the solar industry. In my earlier career, I helped maintain the electronics in helicopters in support of Operation Iraqi Freedom and now I'm helping homeowners and businesses go solar. It's great work and incredibly rewarding to be part of advancing our clean energy future."



## California

has more solar workers than actors <sup>121</sup>

### Kelcy Pegler, Jr

Co-founder, Raaf Diagnostics Safar

"Our explosive growth has provided some awesome opportunities, not the least of which is being able to provide so many meaningful careers to people who are so enthused to be working in a renewable energy field. Having such an engaged team makes our mission all the more rewarding."

### Angela Domagalski

Inside Sales, Helios Solar Works

"For me, solar not only exemplifies energy security and energy stability, it's also an emblem of revitalization for America. Helios Solar Works, the Milwaukee-based PV manufacturing facility, is surrounded by other solar companies. As a native Milwaukeean, it's inspiring to not only be part of this growing industry, but to also witness the transformation it's having in my community."

### Seth Stulgis

Vice President, Kenergy Safar

"Since working in solar in 2008, the number of solar panels installed annually has increased 1100%. Solar currently employs 119,000 solar workers in the U.S. & the solar industry continues to grow. It will require additional human and financial innovation and capital to exceed grid parity by 2016."

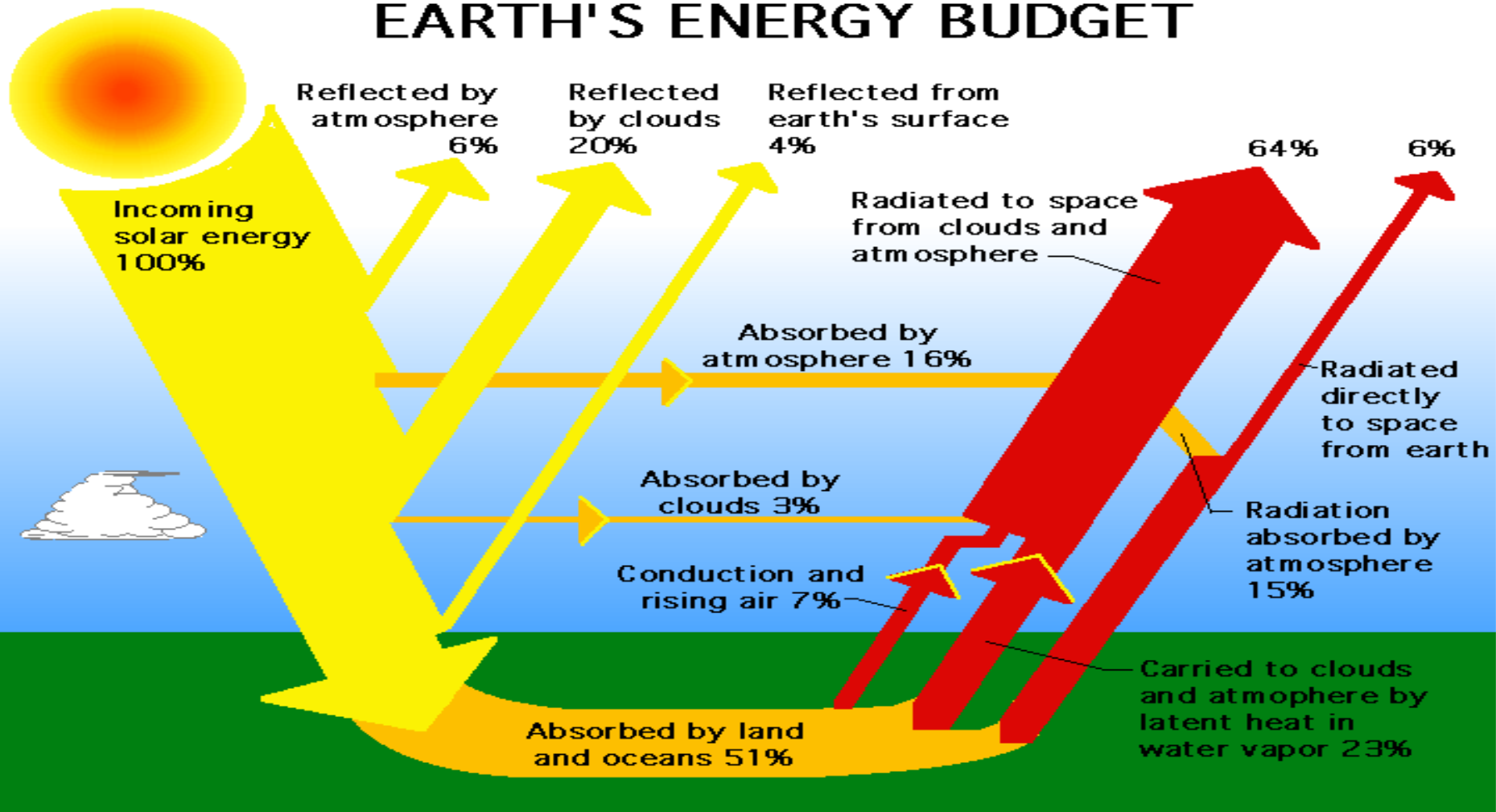


More Texans work in solar than in ranching <sup>131</sup>

THE SOLAR FOUNDATION™

TheSolarFoundation.org  
@SolarFound

# EARTH'S ENERGY BUDGET



Much of the sun's energy is reflected (by clouds or reflective surfaces like snow) or absorbed before it hits the earth's surface. To get an idea of how much energy makes it through our protective atmosphere: it's more energy than is currently stored on the planet in all fossil fuels.

