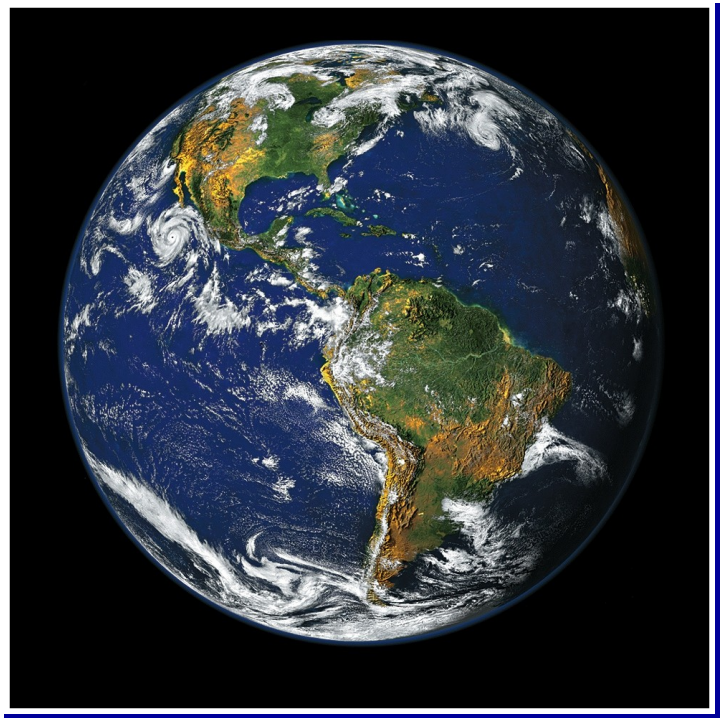


What to do?
What's being done.

Academy of Lifelong Learning
Denver, CO
Nov. 17, 2016
Jonathan F. Ormes
JFOrmes@comcast.net

Why can't we convince everyone about climate change?

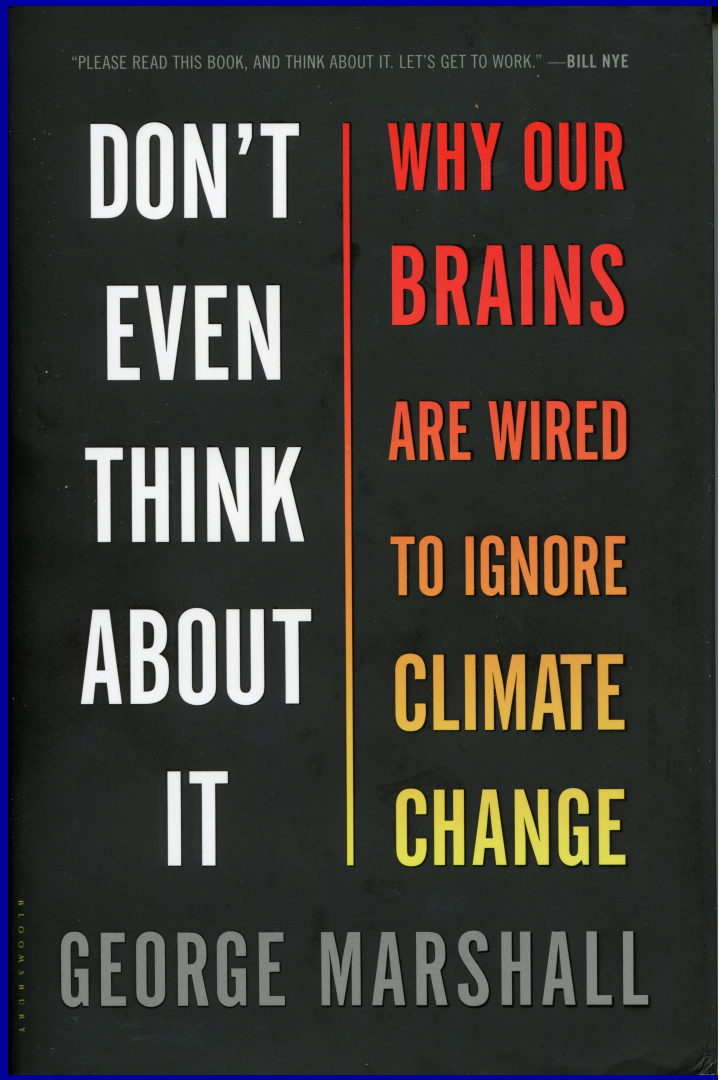
For this see the book

Don't Even Think About It; Why Our Brains Are Wired to Ignore Climate Change

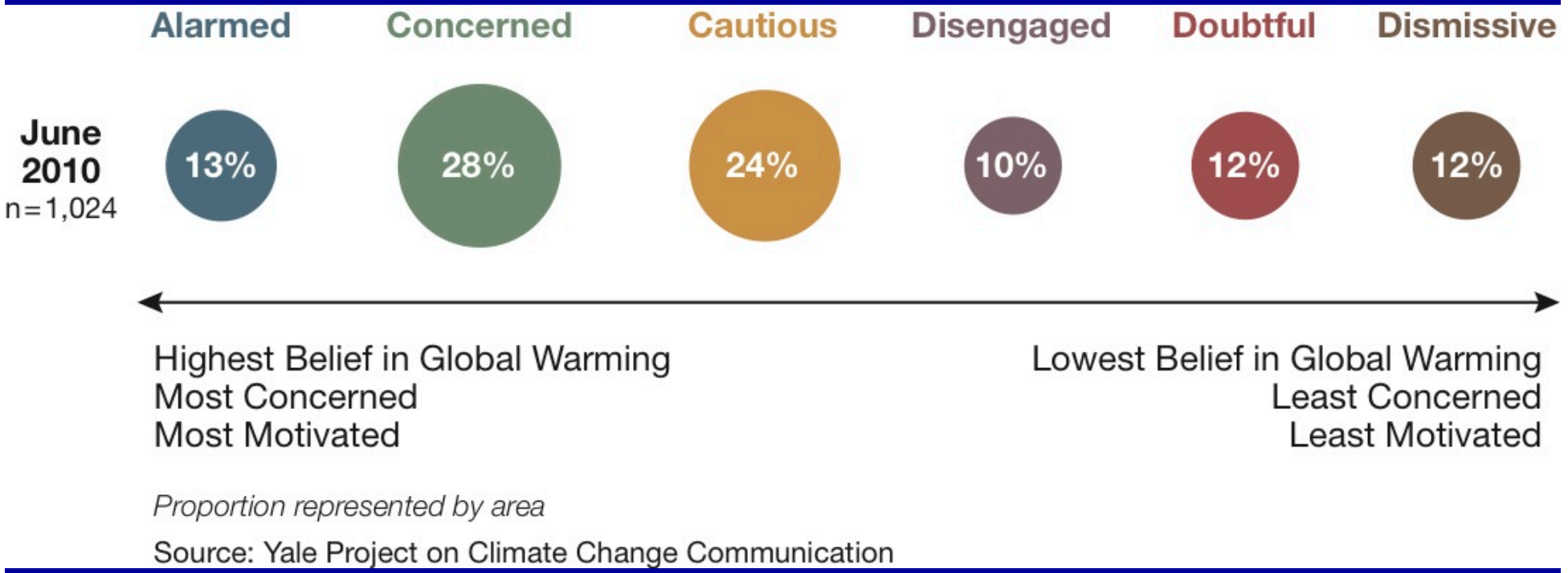
by George Marshall

(2014, Bloomsbury)

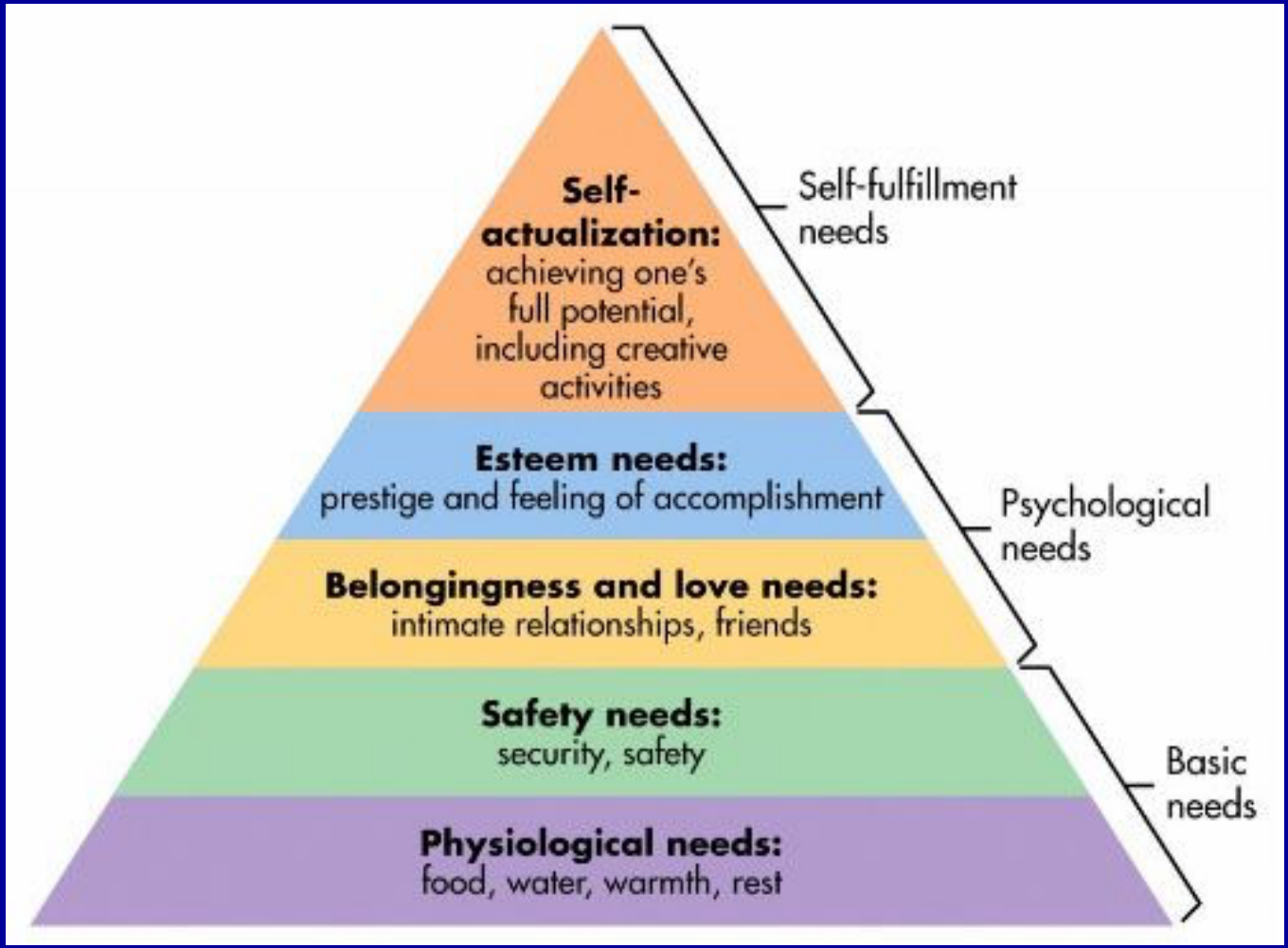
It's a fascinating read and sociologically important.



Where are you on this scale?



Maslow's Hierarchy of Needs



Differential psychology

Thanks to Kathleen Wells, Case Western Reserve

I. **What Do US Citizens Think About Climate Change**?

Profiles of Six "Attitude Types": The Six "Americas"

II. **What are the Communication Challenges? (Psychological Processes that Influence How Individuals Cope with Climate Change)**

Inhibitors of Taking Action

Complications of Assessing Risk

Difficulties Persuading the Doubters and Dismissives

III. **What Lessons Can Be Drawn from Psychology Regarding Climate Communication?**

The Six Americas Differ With Respect Key Beliefs About Climate Change and :

Demographic characteristics
Political ideology, behavior, and party identification
Cultural values
Involvement with the issue
Inclination to accept or reject climate science

Figure 6: *Alarmed* Key Beliefs & Issue Involvement

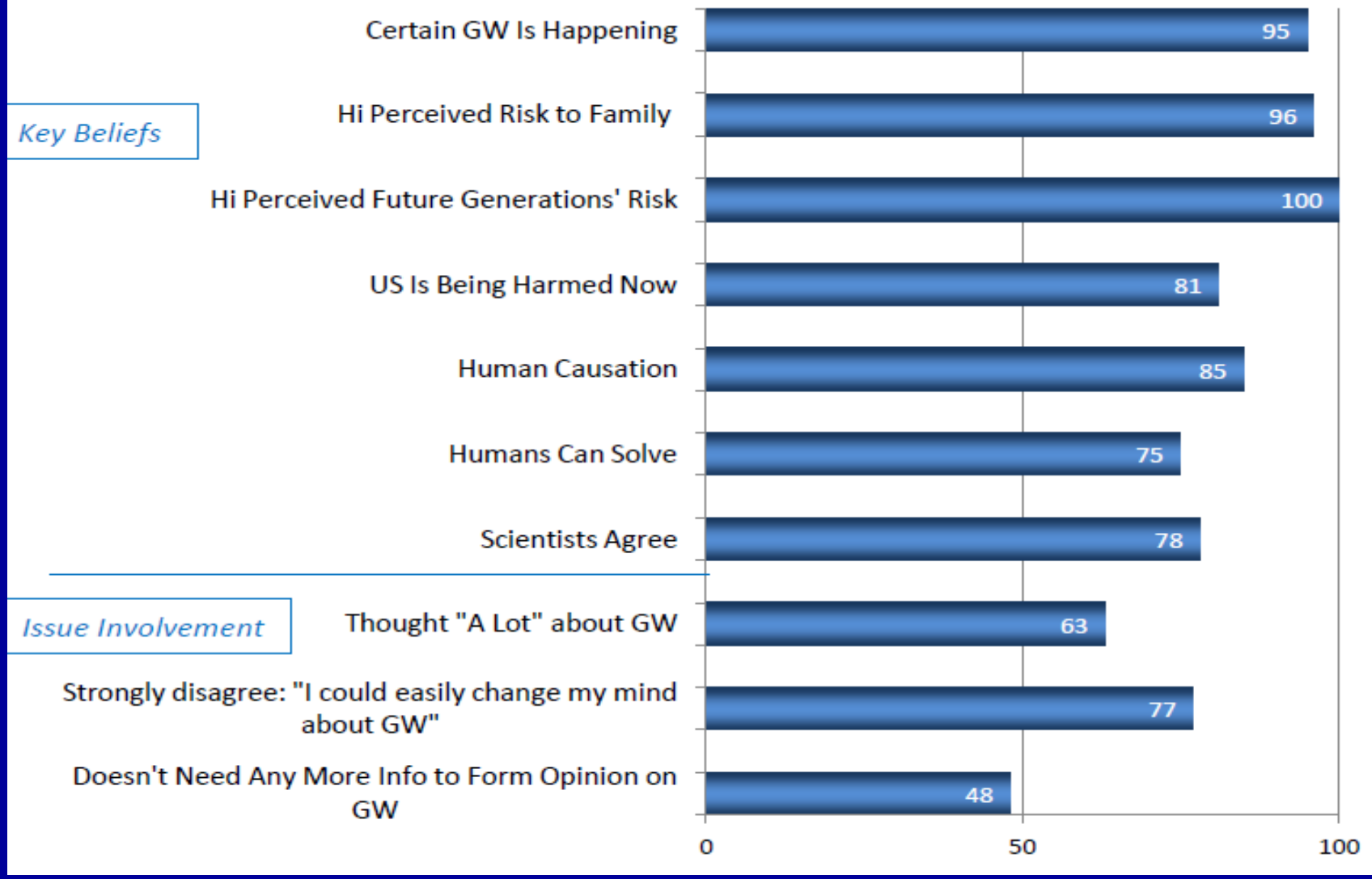


Figure 7: *Concerned* Key Beliefs & Issue Involvement

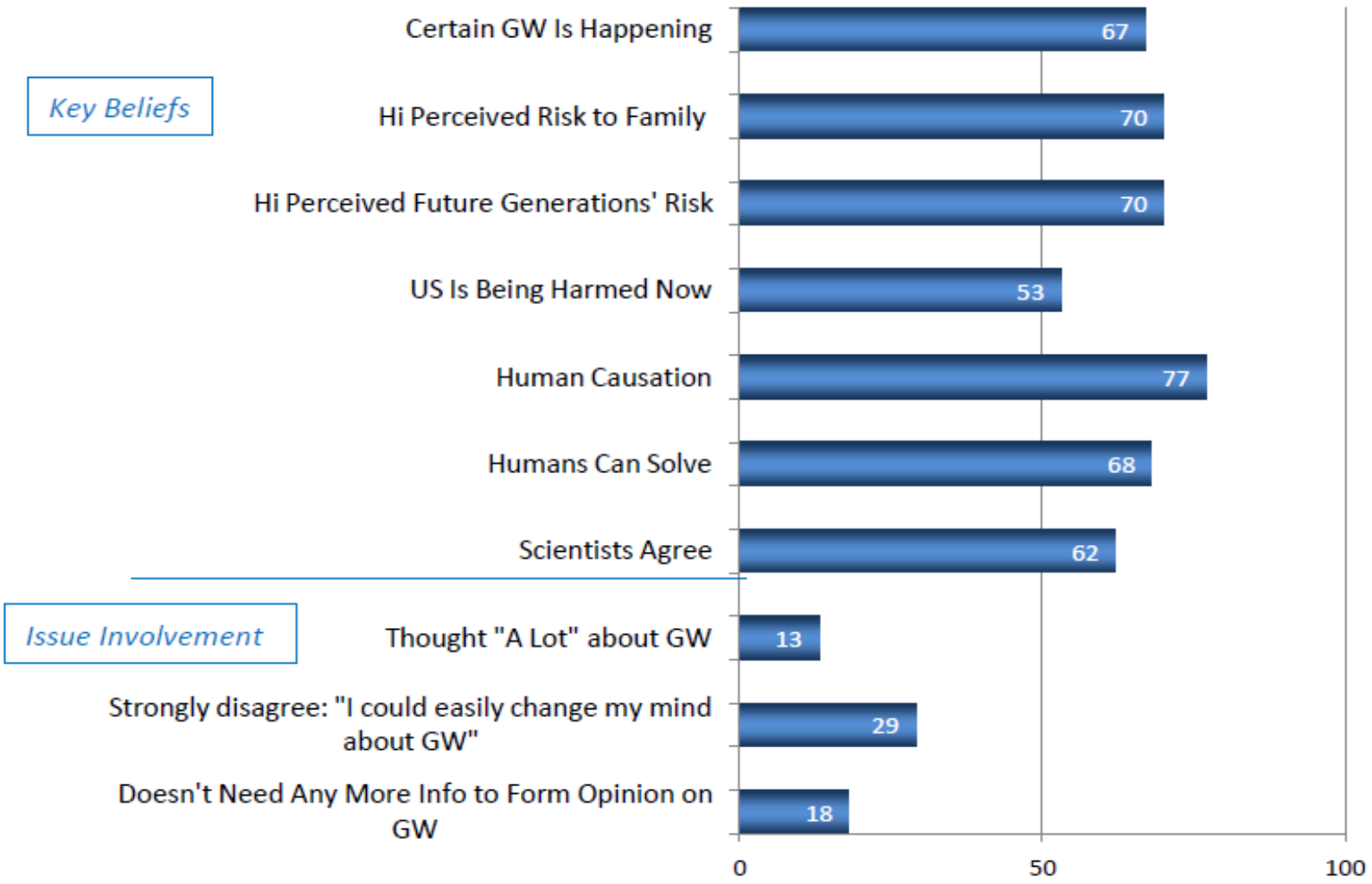


Figure 8: *Cautious* Key Beliefs & Issue Involvement

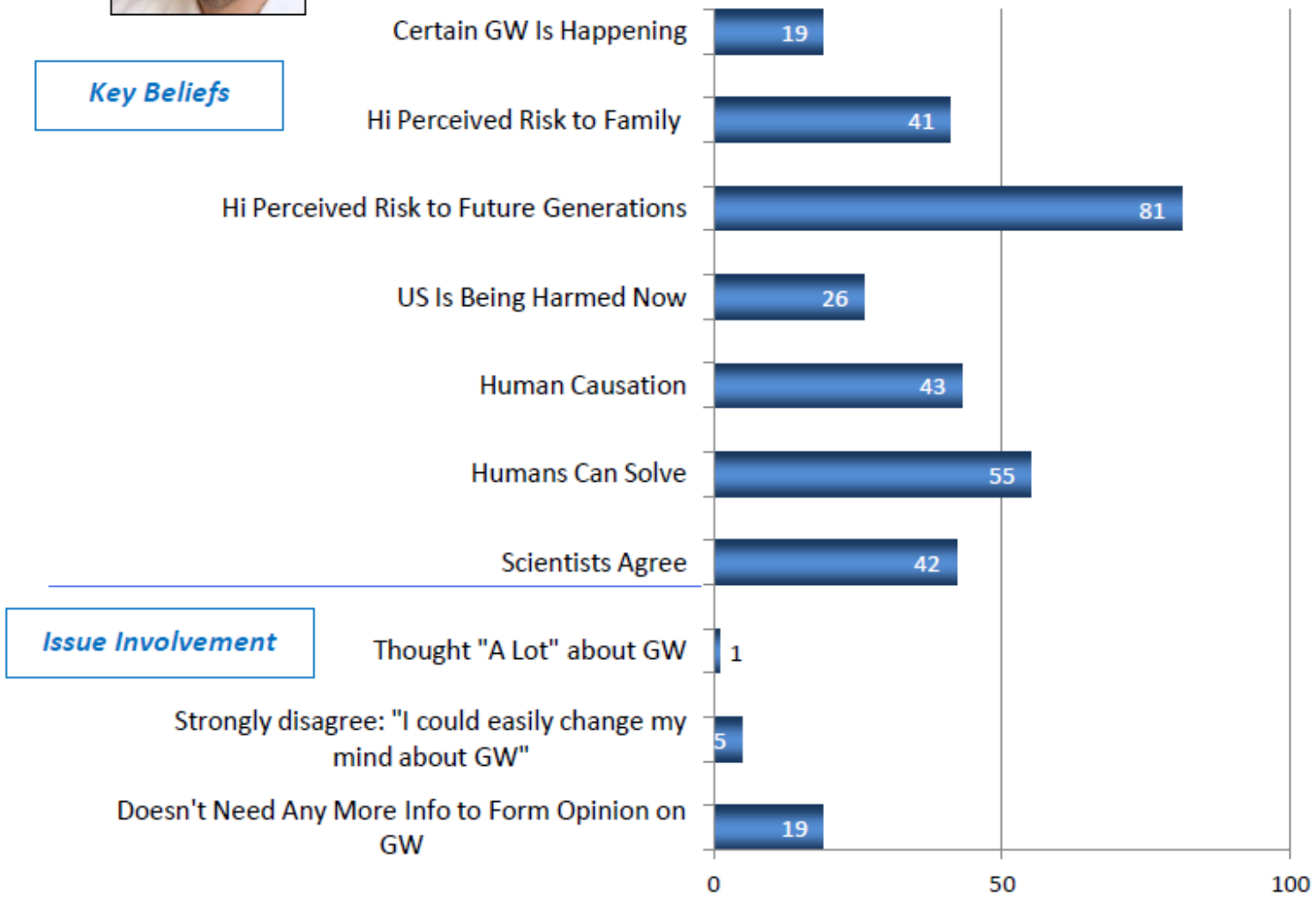


Figure 9: *Disengaged* Key Beliefs & Issue Engagement

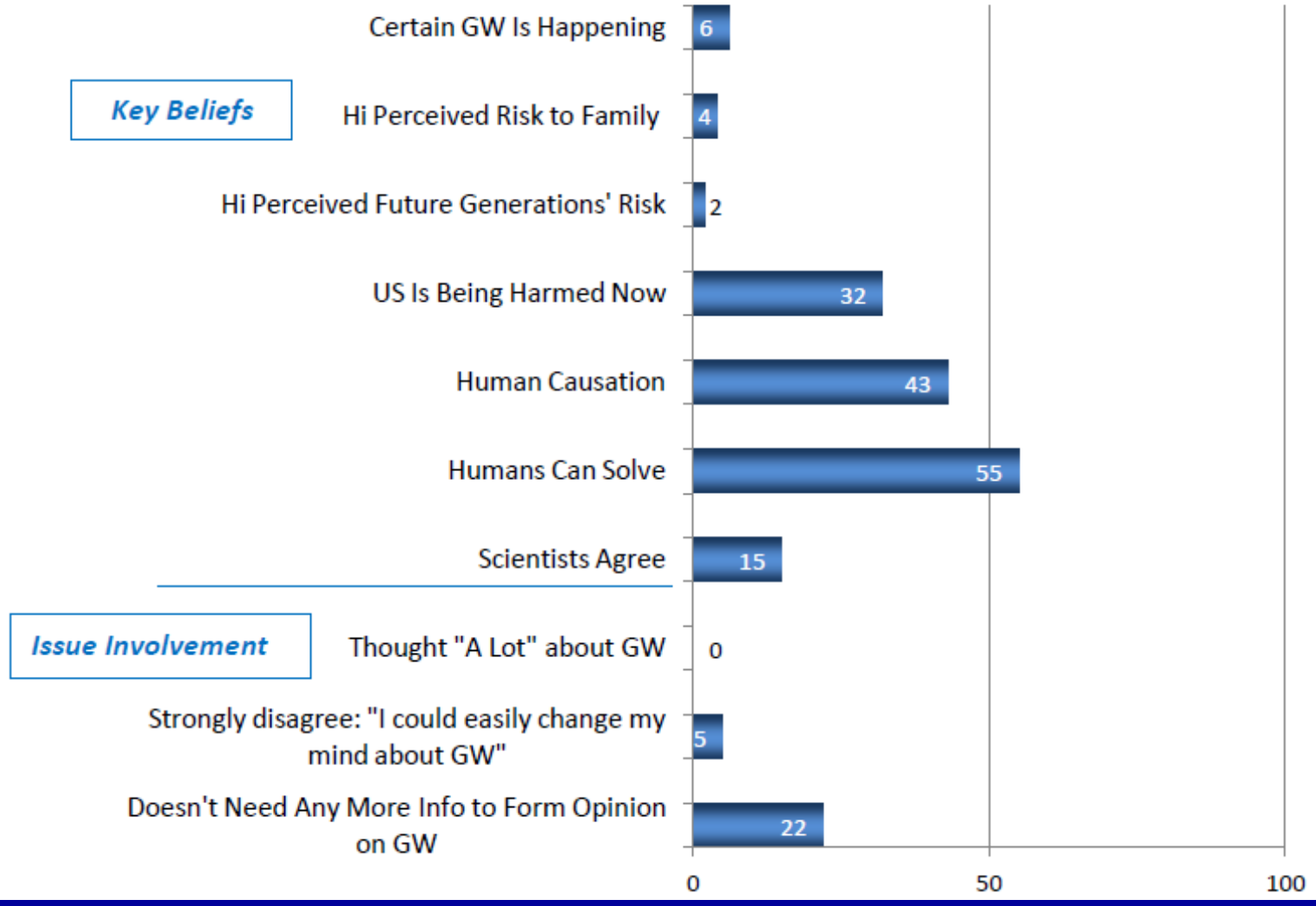


Figure 11: *Doubtful* Key Beliefs & Issue Involvement

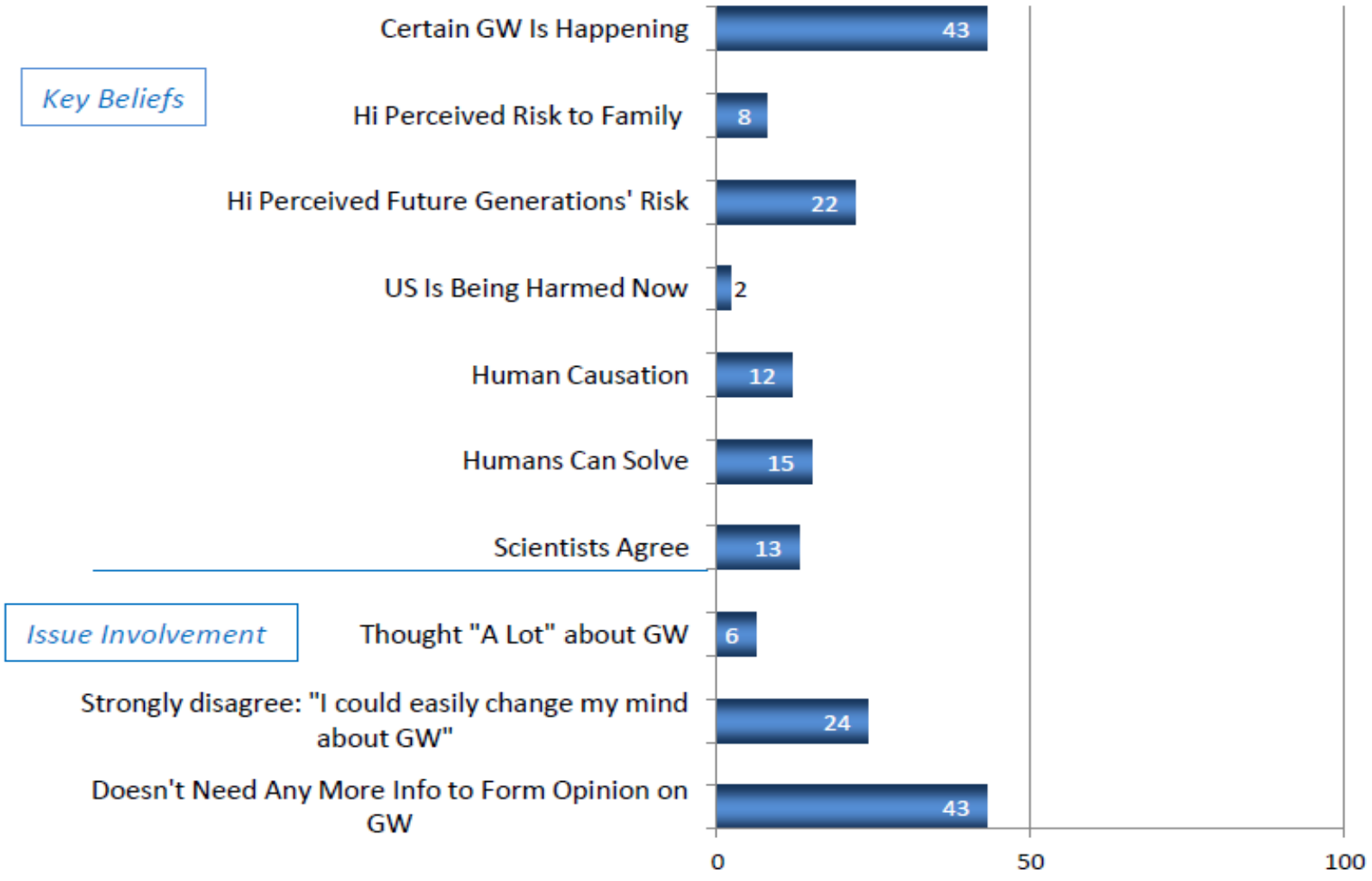
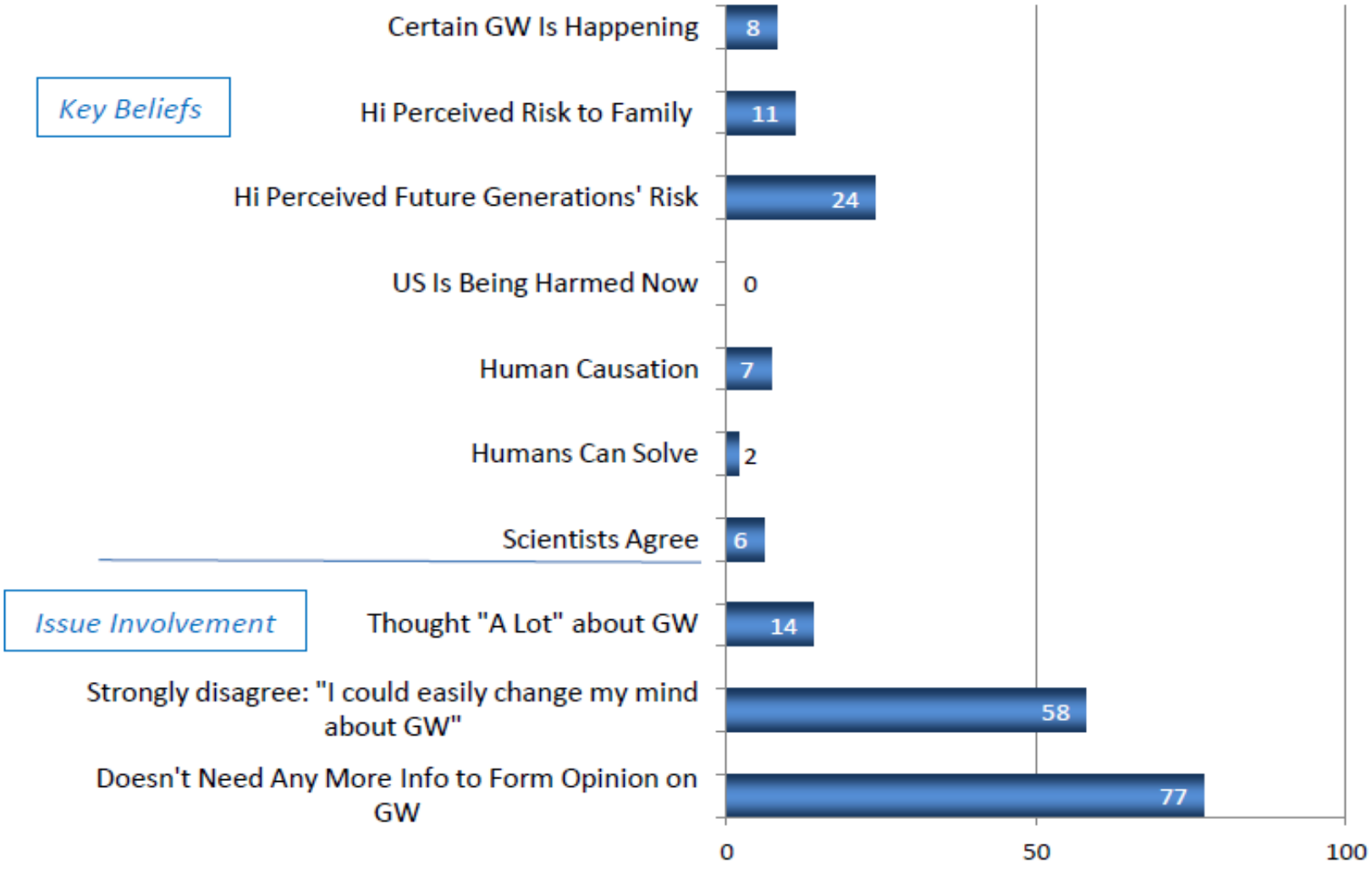


Figure 12: *Dismissive* Key Beliefs & Issue Involvement



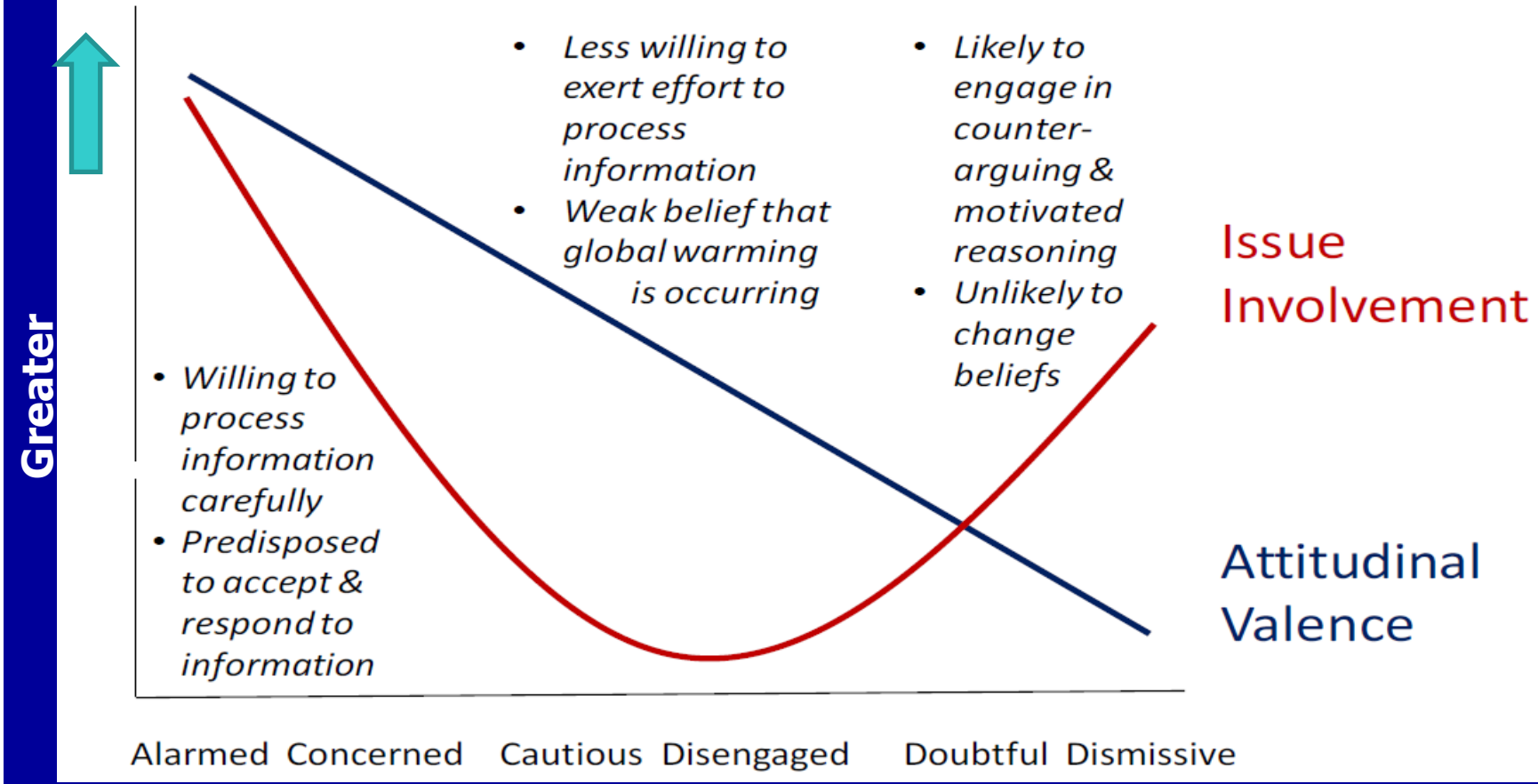
Two Examples:
Senator Bernie Sanders
President Elect Donald Trump

Listen for Attitudes About Science, Willingness to Process Information, Engagement with Climate Issue, Moral Presuppositions

Bernie Sanders YouTube clip

Donald Trump YouTube Clip

Figure 2: Information-Processing Propensities Among the Six Americas



What are the Key Communication Challenges for Three Groups

1. High Involvement Public/Accept Climate Change:
The Alarmed and the Concerned (**45%**)

2. Low Involvement Public:
The Cautious and the Disengaged (**34%**)

3. High Involvement Public/Reject Climate Change:
The Doubtful and the Dismissive (**21%**)

Communication Challenges:

Group 1: Highly attentive to information, want to know what they can do to reduce global warming

KEY Challenge: Motivating them to take action

Group 2: Uncertain about reality of climate change, but unlikely to find answers, as they pay little attention to information about issue

KEY Challenge: Reaching them with information

Group 3: Fairly certain climate change is not happening

KEY Challenge: Understanding the motivational structure behind views and promoting the adoption of new views

Group 1: The Alarmed and the Concerned

Why motivating them to take action is difficult:

Nature of the phenomena: Everyone is to blame

Social construction of climate change: Social norms have developed that exclude climate change from what can be addressed and/or discussed publicly

Passive bystander effect: Management of conflict between wanting to act and wanting to protect the self by claiming to know less than one does and waiting for others to act first

Negative psychological effects of climate change: Gradual, accumulative, paralyzing

Group 1: The Alarmed and the Concerned

Communication Strategies to Promote Engagement:

- Employ messages with information and complexity
- Use strong logically-sound arguments for actions
- Focus on solutions to climate change
- Build perceptions of collective- and self-efficacy
- Help Group 1 to become opinion leaders

Group 2: The Cautious and the Disengaged

Why risk of climate change is difficult to apprehend and reaching this group with information is a challenge:

Nature of the phenomena: Invisible, result of systemic rather than direct causes, described in terms of variables distributed over time

Requires cognitive rather than primarily emotional processing and making concrete abstract events that will occur in the future

Influenced by generalized expectations of stability and change, pre-existing frames of reference

Group 2: The Cautious and the Disengaged

Significant percentages don't understand news or seek information about climate change:

"I have difficulty understanding news reports about global warming."
Cautious= 44% and Disengaged=77%

"In general, I don't like to read or hear anything about global warming."
Cautious=37% and Disengaged=59%

Group 2: The Cautious and the Disengaged

Communication Strategies to Promote Acceptance of Information

Unlikely to attend to information that requires cognitive effort

More likely to attend to messages that:

Rely on peripheral/**heuristic information processing** (e.g., humor)

Demonstrate that appropriate climate change views are respected and advocated by sources credible to the target audience (**social norms**)

Show rather than tell what is happening

Personalize the threat so that the information provided is emotionally significant

Generate involvement through story (**narrative strategies)**

Group 3: The Doubtful and the Dismissive

Why persuading others to adopt counter-attitudinal views is difficult:

Information may trigger counter-arguing

Information casting doubt on the seriousness of climate change may be accepted uncritically whereas the opposite message (climate change is a serious threat) may be rejected uncritically

Group 3: The Doubtful and the Dismissive

Climate change may be perceived as a threat to pre-existing cultural values making it especially challenging to reach these groups

Direct engagement may result in a boomerang effect such that pre-existing attitudes are strengthened

However:

For the Doubtful, emphasis on personal experiences with climate change may be helpful

For both groups, a focus on public health effects of climate change may work

Key Communication Strategies From Psychology

Five lessons from Psychology that policy-makers can use to engage a significant portion (but not all) of the general public:

Privilege experience over analysis

Link message to group norms

Reduce psychological distance

Frame the big picture: Nobody likes losing but everyone likes gaining

Play the long-game: Tap the potential of human motivation

The EEE seminar disrupts silence and interrupts despair over climate change, encourages a culture of urgent engagement, and helps us to develop narratives of hope.

Thank you.

Citizens Climate Lobby **Proposal**

Collect fee
$15 per ton of
CO_2 at wellhead
or port of entry
[fee rises $10/yr]

U S Dept. of the Treasury: Trust Fund

All monies returned to households
1 share per adult
0.5 shares per child <18yrs
maximum 3 shares per family

Net + $

Net - $

Net +$

2 of 3 households have net gain of $.

CO_2 emissions are reduced

Renewable energy sources are stimulated. Market will choose the best.

What's being done.

It's not hopeless.

We have transformed our energy before.

COP21, Paris, Dec. 2015

Success stories: What we need to do has been done before.

- Reforestation in South Korea
- Rooftop solar water heating in China
- Crop residues to feed animals
  - Milk production via fodder in India
  - Feeding beef in China
- Geothermal energy in Iceland
- Wind farms in Denmark
- Soil conservation tillage in the USA (but fertilizer)
- Population stabilization in Eastern Europe, Russia
- Ozone hole treaty

Energy — How Much is There?

Sustainable

Inexhaustible Energy Resources

ANNUAL SUPPLY

Solar 23,000 TW-yr

- Sun (Indirect)
  - Wind 75-130
  - Hydro 3-4
  - Biomass 2-6
  - Waves 0.2-2
- Earth
  - Geothermal 0.2-3
  - OTEC 3-11
- Moon
  - Tides 0.3

$1\ kWh \times 10^9 \times 24 \times 365 = 1\ TW\text{-}yr$

Global Energy ANNUAL CONSUMPTION

18.5 TW-yr

91 years Remaining

Inexhaustible

Unsustainable

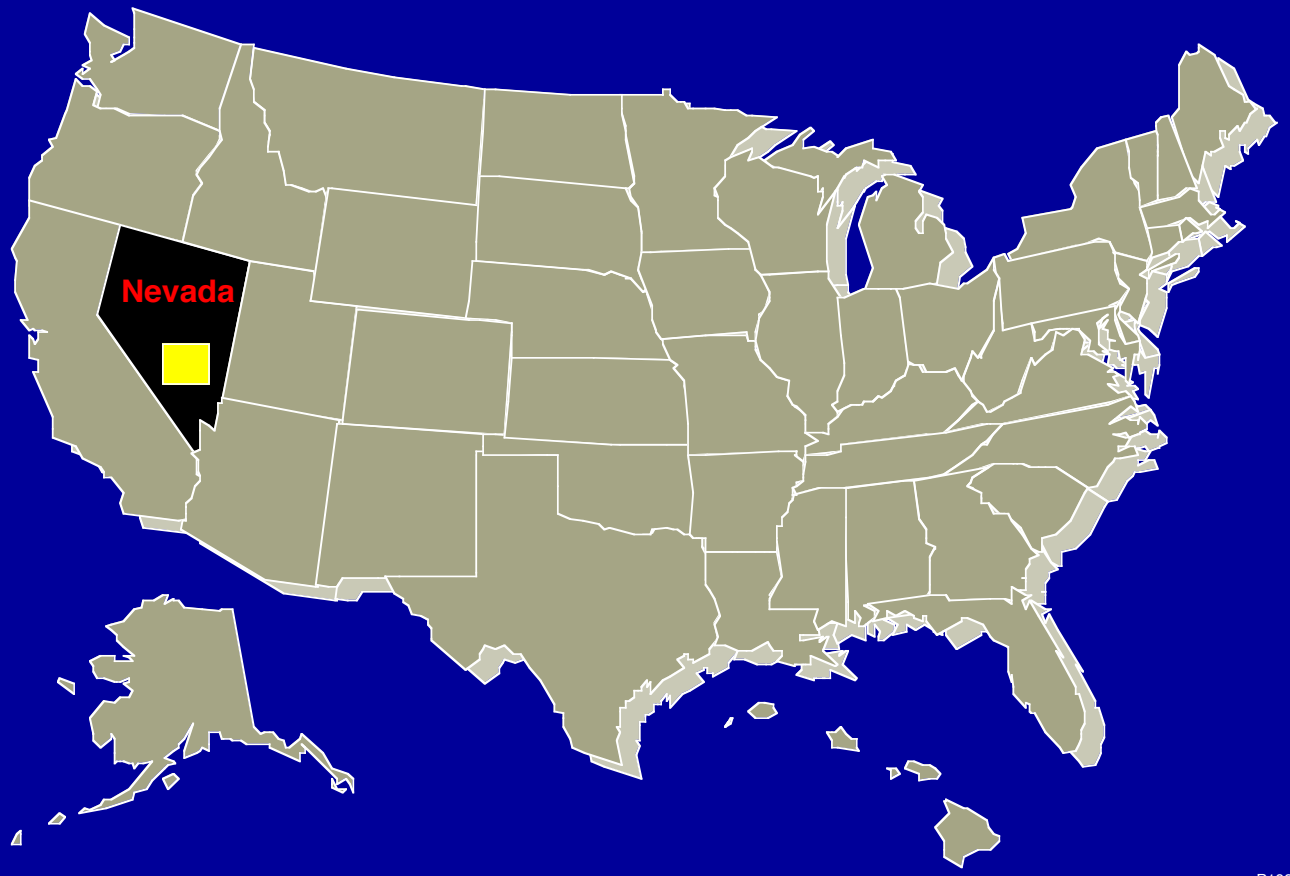
Finite Energy Resources ONE TIME ONLY SUPPLY

OBSOLETE

- Ancient Hydrocarbons
  - Natural Gas 220 TW-yr
  - Petroleum 235 TW-yr
  - Coal 830 TW-yr
  - Shale /Tar Sands Oil 210 TW-yr
- Pre-Hadean Nuclear
  - Uranium 185 TW-yr

Adapted from: "Update 2015 - A Fundamental Look at Supply Side Energy Reserves for the Planet"
Marc Perez & Richard Perez, IEA-SHCP-Newsletter Vol. 62, Nov. 2015.
http://asrc.albany.edu/people/faculty/perez/2015/IEA.pdf

Total Area Required for a Photovoltaic Power Plant to Produce the Total U.S. Annual Electrical Demand



P109-G1055201

J. A. Turner, "A Realizable Renewable Energy Future", Science, 285, p 5428, (1999).

‘Geoengineering’ is the deliberate modification of an element of the climate system on a large scale to avoid dangerous impacts of climate change.

AMS, AGU, UK RS

Strategies

Mitigate: intervene to reduce the sources or enhance the sinks of greenhouse gases

Adapt: Adjust in response to actual or expected climatic stimuli or their effects

Climate Intervention: Plenty of incentive

Increase understanding:
- **Research: measure and model**
- **Technology development**

Credit: Paul Higgins, *Physics Today* Oct. 2014

National Academy of Sciences

Detailed in depth look at ways for humans to cool the planet, which is being increasingly proposed for a variety of reasons

0. **Mitigate and Adapt; first and most important**
1. Carbon Capture and removal
2. Albedo Modification

What's In a Name

geo-engineering -> climate intervention

solar radiation management -> albedo modification

engineering implies we know how to do it well (as in bridges)
intervention is done with the intention to improve something (health)

NAS Recommendations

- Mitigate and Adapt first and foremost
- Albedo modification at scales sufficient to alter climate should not be deployed at this time
- Research of albedo modification should continue (emergency, use by other countries, etc.)
- Carbon capture has more promise, is already in R&D, and has less down side.

Mitigation

- **Wind energy**
- **Solar cells**
- **Solar power plants**
- **Nuclear power**
- **Energy storage**
- **Geothermal**

Wind Electricity

Wind generated energy is cost competitive!

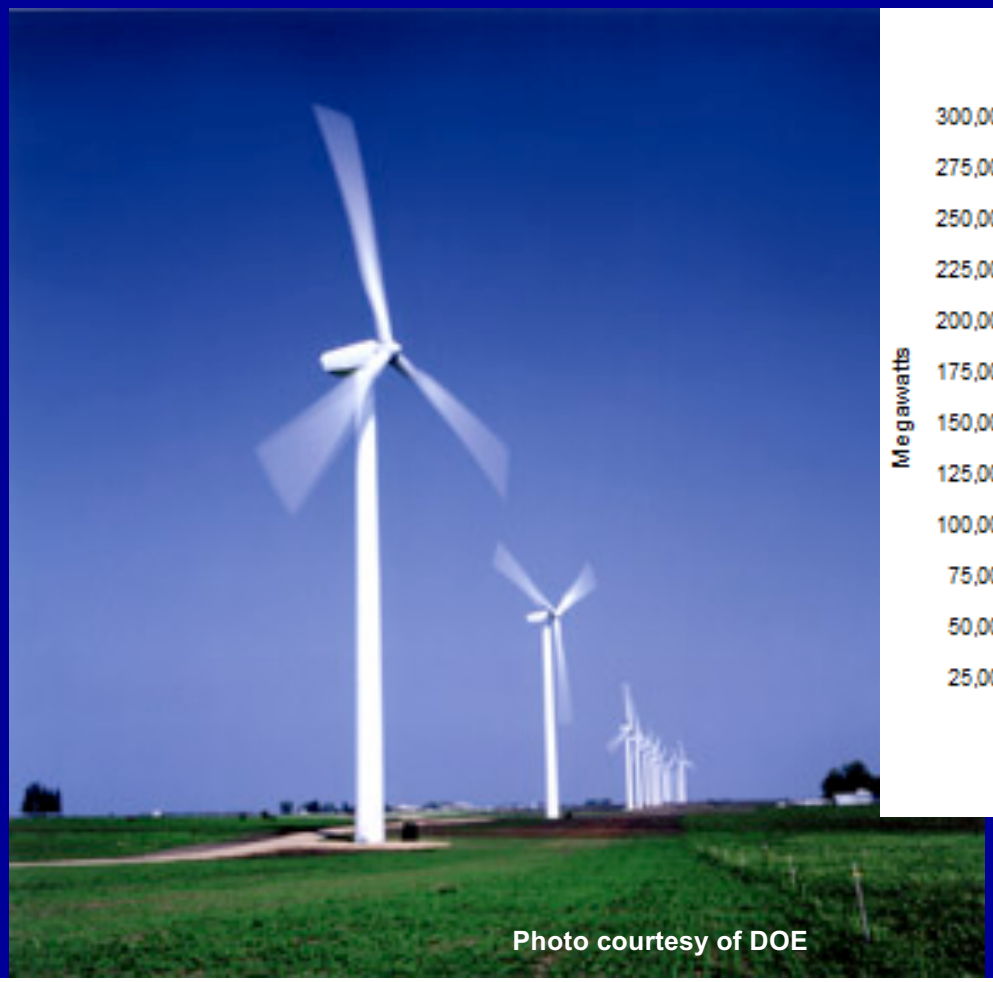
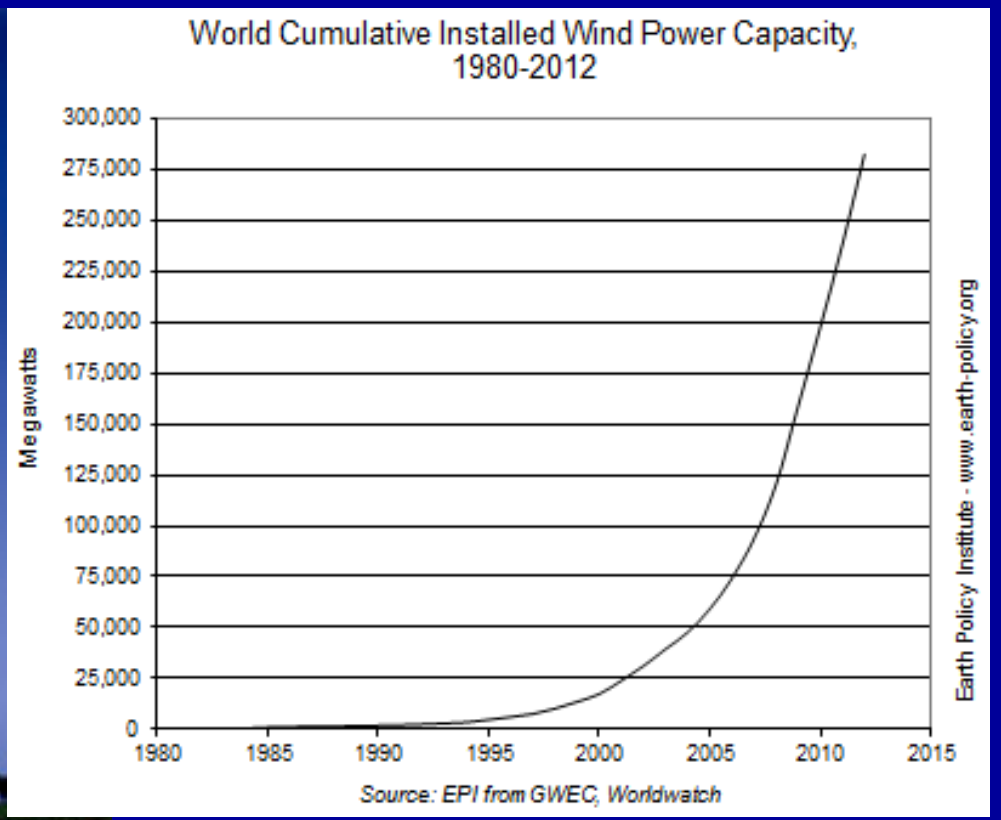


Photo courtesy of DOE

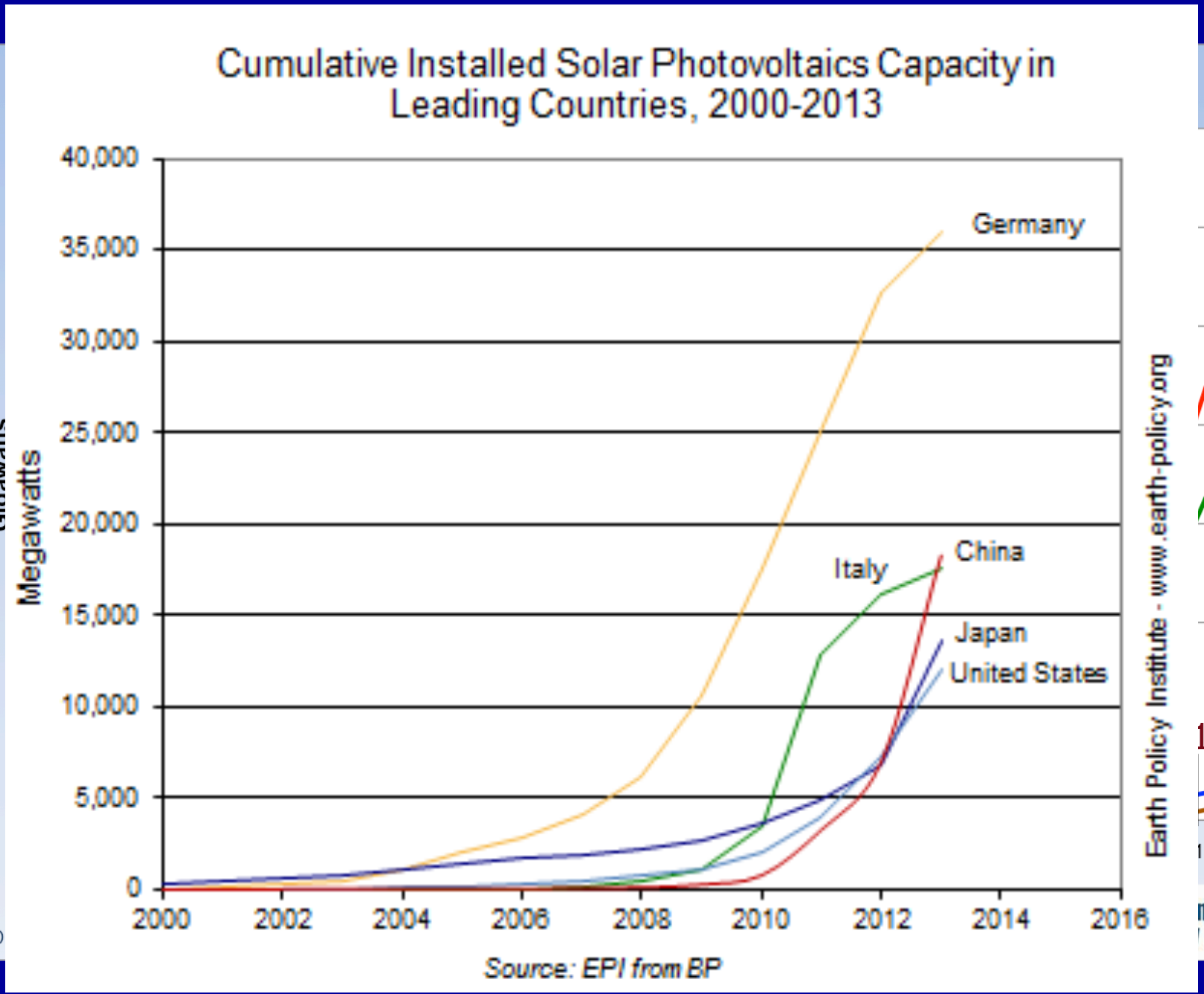


2012: 225,000 wind turbines

Solar Electricity

Photos courtesy of DOE Photovoltaics Program

Goal: Install 20,000 square kilometers for dedicated use by 2054
Rooftops about 15,000 km^2.


Cumulative Installed Solar Photovoltaics Capacity in Leading Countries, 2000-2013
Megawatts
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
2000
2002
2004
2006
2008
2010
2012
2014
2016
Germany
Italy
China
Japan
United States
Source: EPI from BP
Earth Policy Institute - www.earth-policy.org

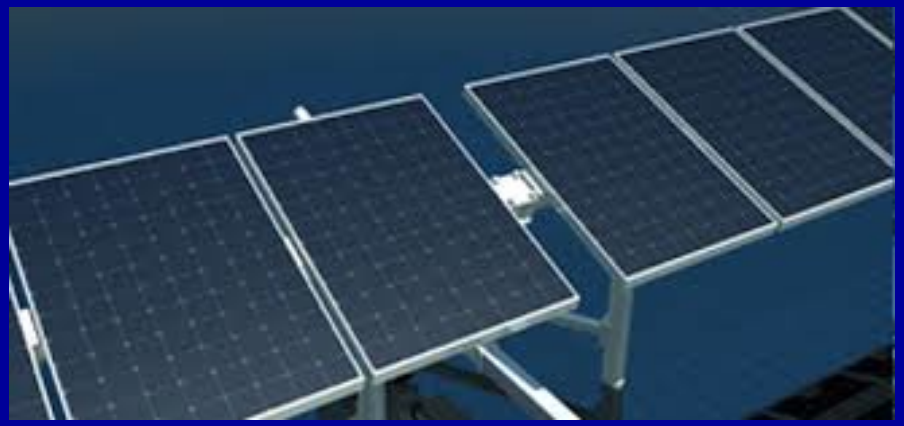
Xcel Energy and SunPower Corp.

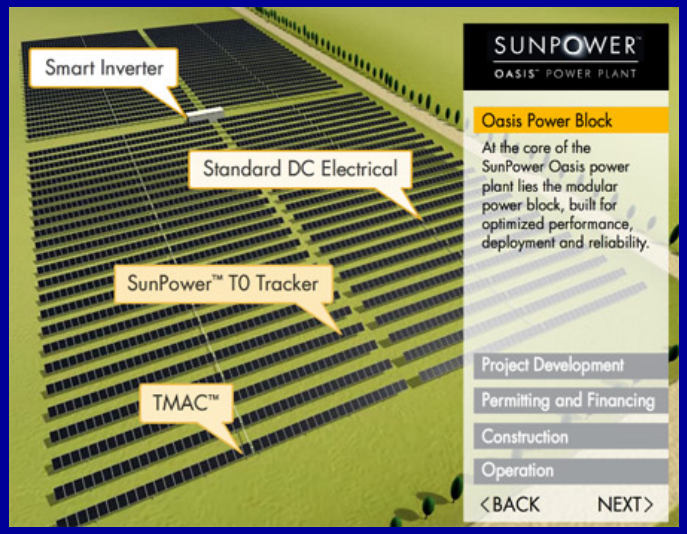
19 MW Greater Sandhill plant has been operating 2010
30 MW San Luis Valley Solar Ranch since 2011

Building a 3rd plant in San Luis Valley 50 MW
Construction 2015, full commercial in 2016
all 3 support 26,500 homes (aka a Littleton, CO)

Uses photo voltaic cells with sun tracking

Need 500 for the full USA





California leads

World's largest solar power plant
392 MW Ivanpah Solar Power Facility

CA has 1.5 GW of capacity now

2 million tons of CO_2 avoided/year (of 30 billion tons)

0.007 % of global CO_2

We would need almost 20,000 of these plants globally.

Nuclear Electricity

2012: 12% world's energy
435 reactors worldwide
72 under construction in 15 countries

Graphic courtesy of NRC

Expand use of small nuclear reactors such as those used on ships and satellites.

Energy storage

Mechanical:

- Flywheel
- Gravitational potential
- Pumped-storage hydroelectricity
- Compressed air

Highview Power Storage Ltd.'s pilot plant in Slough, UK

Chemical:

- Battery
- Hydrogen
- Power to gas

Electromagnetic:

- Superconducting magnet

Thermal:

- Thermal
- Cryogenic
- Molten salt

Gemasolar Thermosolar Plant in Spain

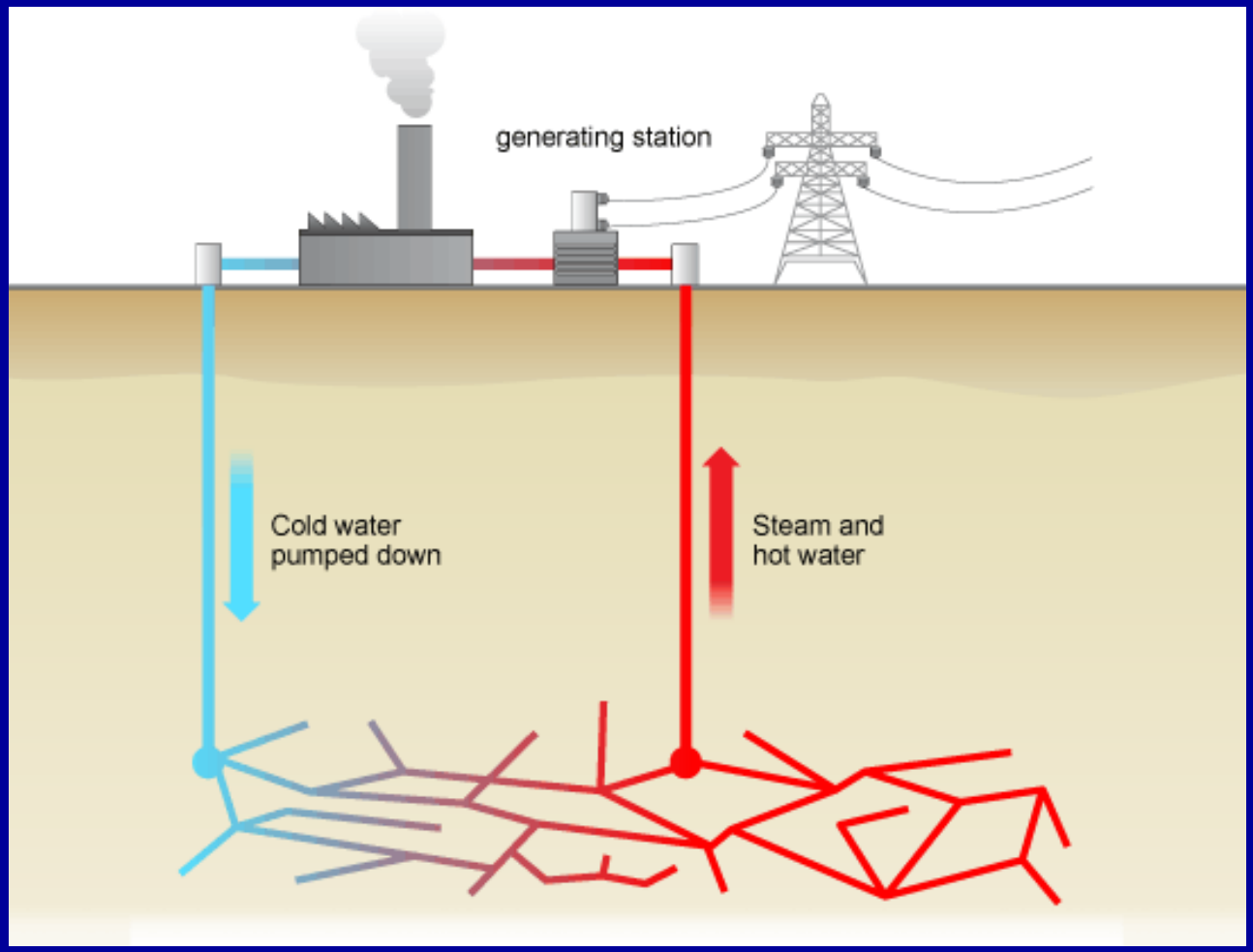
Rooftop wind

- Quieter systems being developed
- Vertical axis wind turbines (VAWT)

Helix Wind

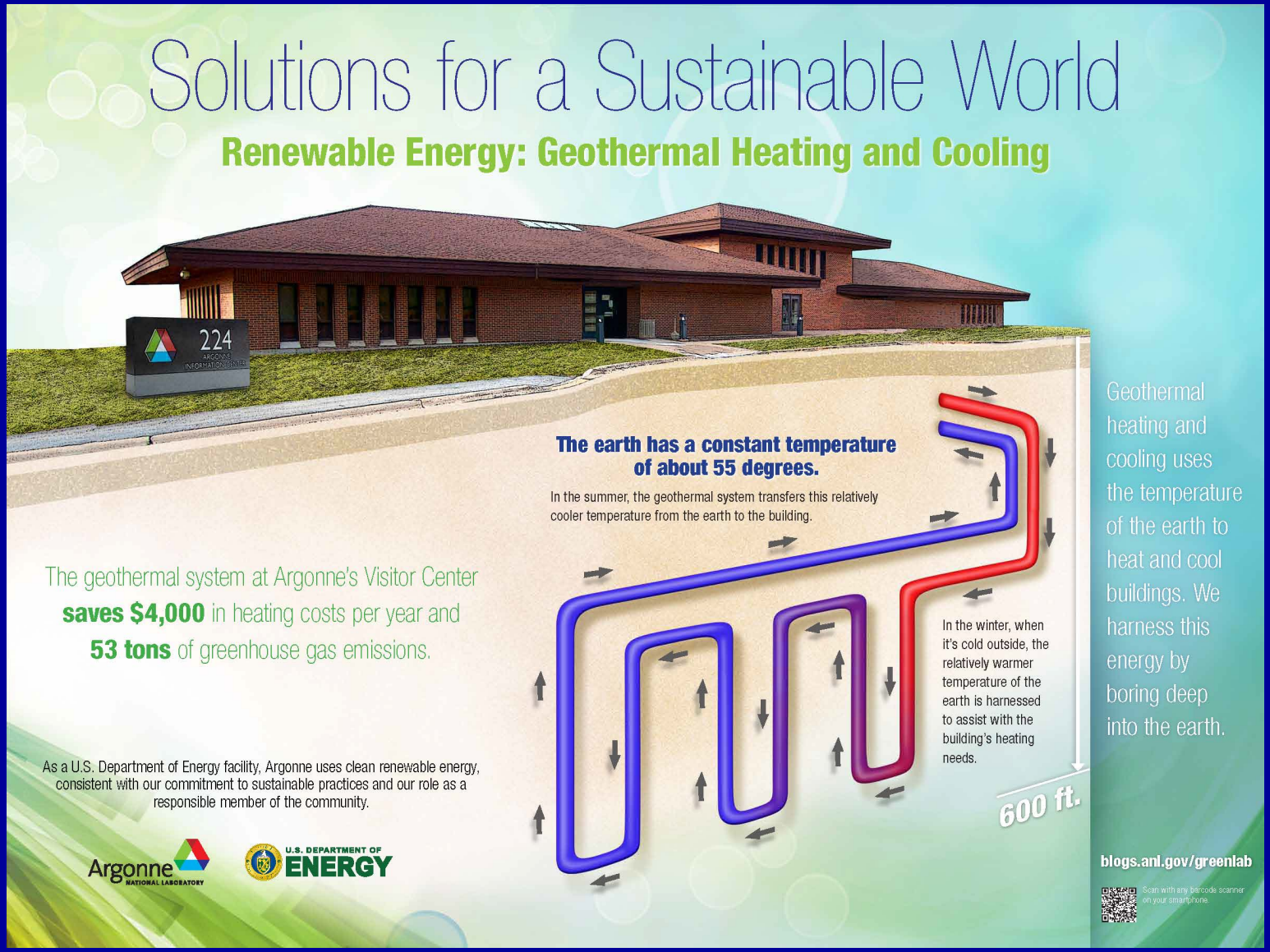
Sunforce 45444
600 Watts, 12 or 24 volts

Geothermal (mining)

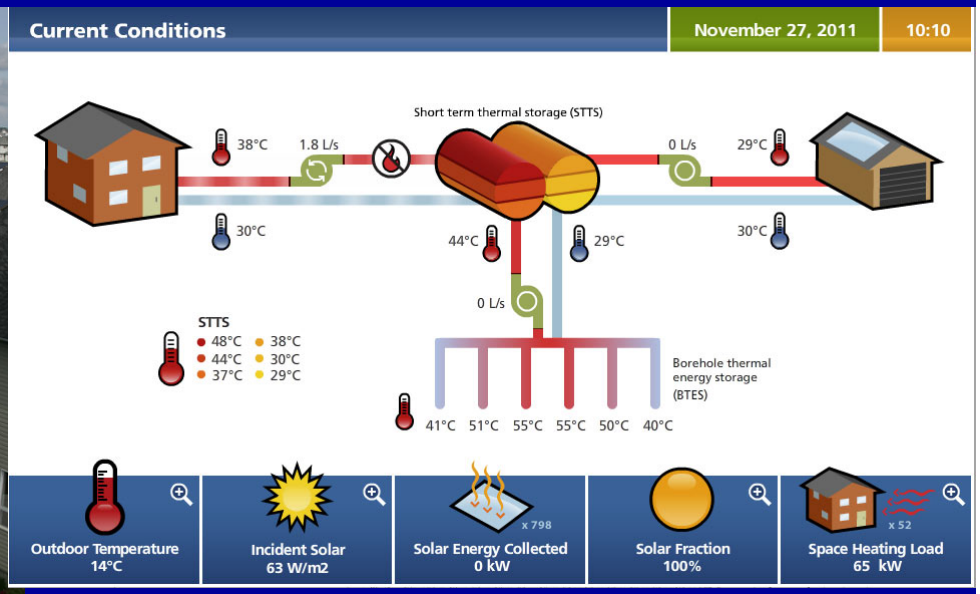


Let's mine heat instead of oil and gas

Geothermal (heat reservoir)



Drake Landing Solar Community, Alberta, Canada



52 homes
heat capture in summer on garage roofs
seasonal storage in the rock under a community park
provides 97% of the community's heating energy requirements

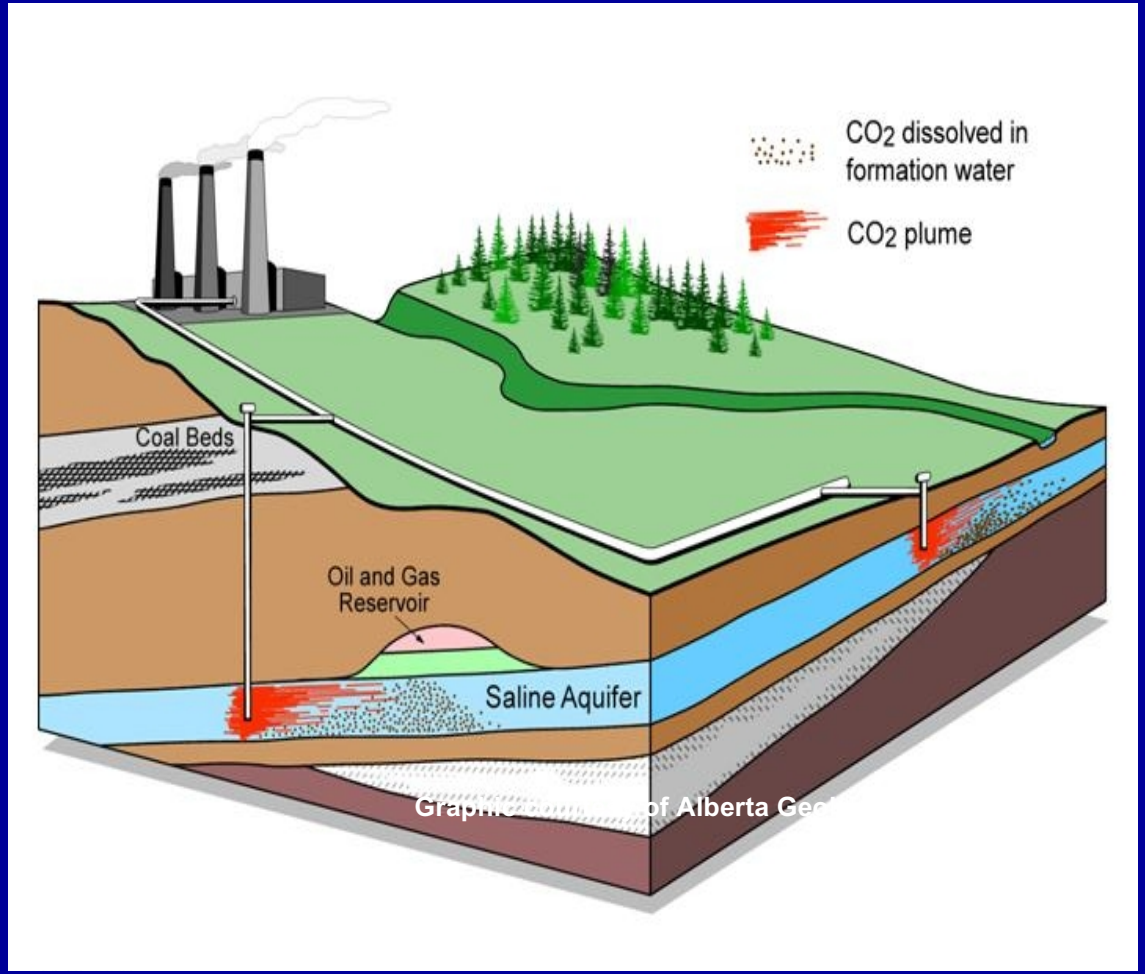
Adaptation

- **Dikes, sea walls, artificial reefs**
- **Electric cars**
- **Paint roofs white**
- **Recycle, recycle, recycle**
- **Buy boat and generator**
- **Move north, buy sweater**

Carbon Capture & Storage

There are currently three storage projects that each inject
1 million tons of CO_2 per year.

Well, they're trying.



CO_2 Removal

Bio-removal:

- Plant trees and other land management
  - Wetland restoration and sustainable agriculture
- Use biofuel (e.g. algae), burn and recycle the CO_2
  - BECCS (bio energy, carbon capture storage)
- Biochar (burning in O_2 free environment)

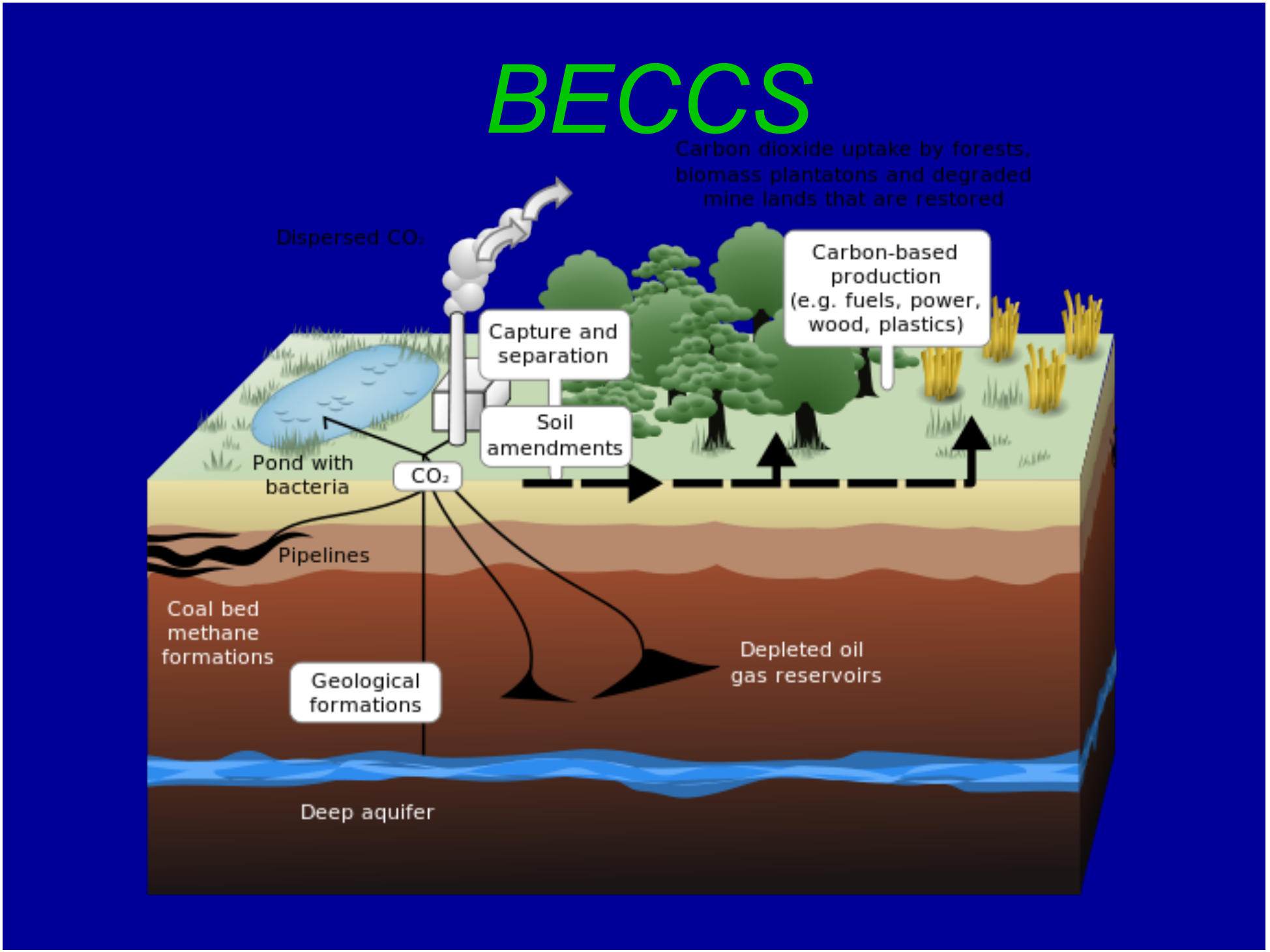
Carbon capture and sequestration (CCS)
(popular with energy giants like Shell)

- There are 2-3 pilot CCS plants now
- It will take thousands of plants to make a difference

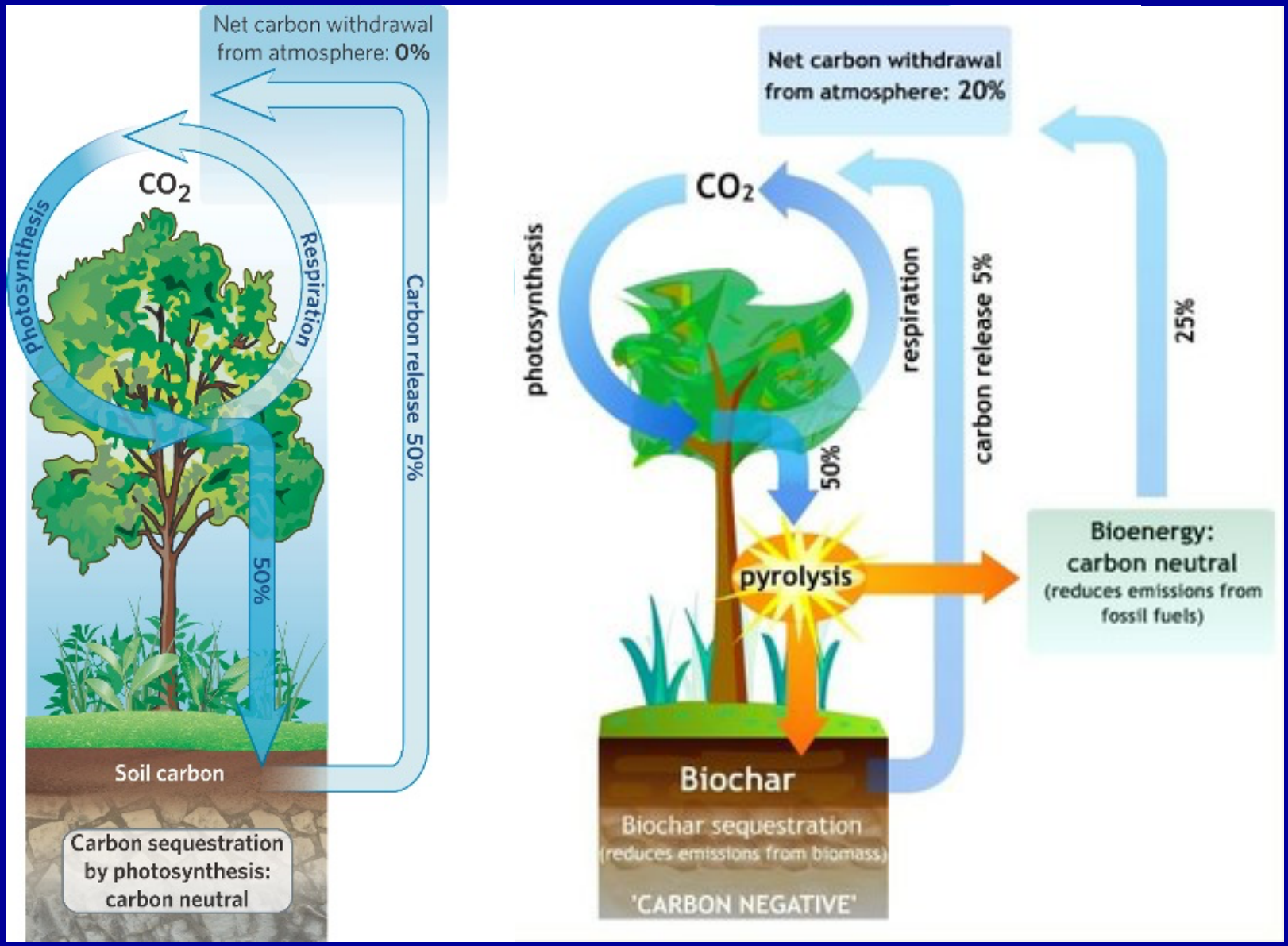
Artificial weathering

Many other ideas

BECCS


Carbon dioxide uptake by forests, biomass plantatons and degraded mine lands that are restored
Dispersed CO_2
Carbon-based production (e.g. fuels, power, wood, plastics)
Capture and separation
Soil amendments
Pond with bacteria
CO_2
Pipelines
Coal bed methane formations
Geological formations
Depleted oil gas reservoirs
Deep aquifer

Biochar


Net carbon withdrawal from atmosphere: 0%
CO_2
Photosynthesis
Respiration
Carbon release 50%
50%
Soil carbon
Carbon sequestration by photosynthesis: carbon neutral
Net carbon withdrawal from atmosphere: 20%
CO_2
photosynthesis
respiration
carbon release 5%
25%
50%
pyrolysis
Bioenergy: carbon neutral
(reduces emissions from fossil fuels)
Biochar
Biochar sequestration
(reduces emissions from biomass)
'CARBON NEGATIVE'

Manage the sea

Dikes in the Netherlands

Windmills of Holland pump water from behind the dikes.

Netherlands lies primarily on the river delta of the Rhine (and the Meuse) river

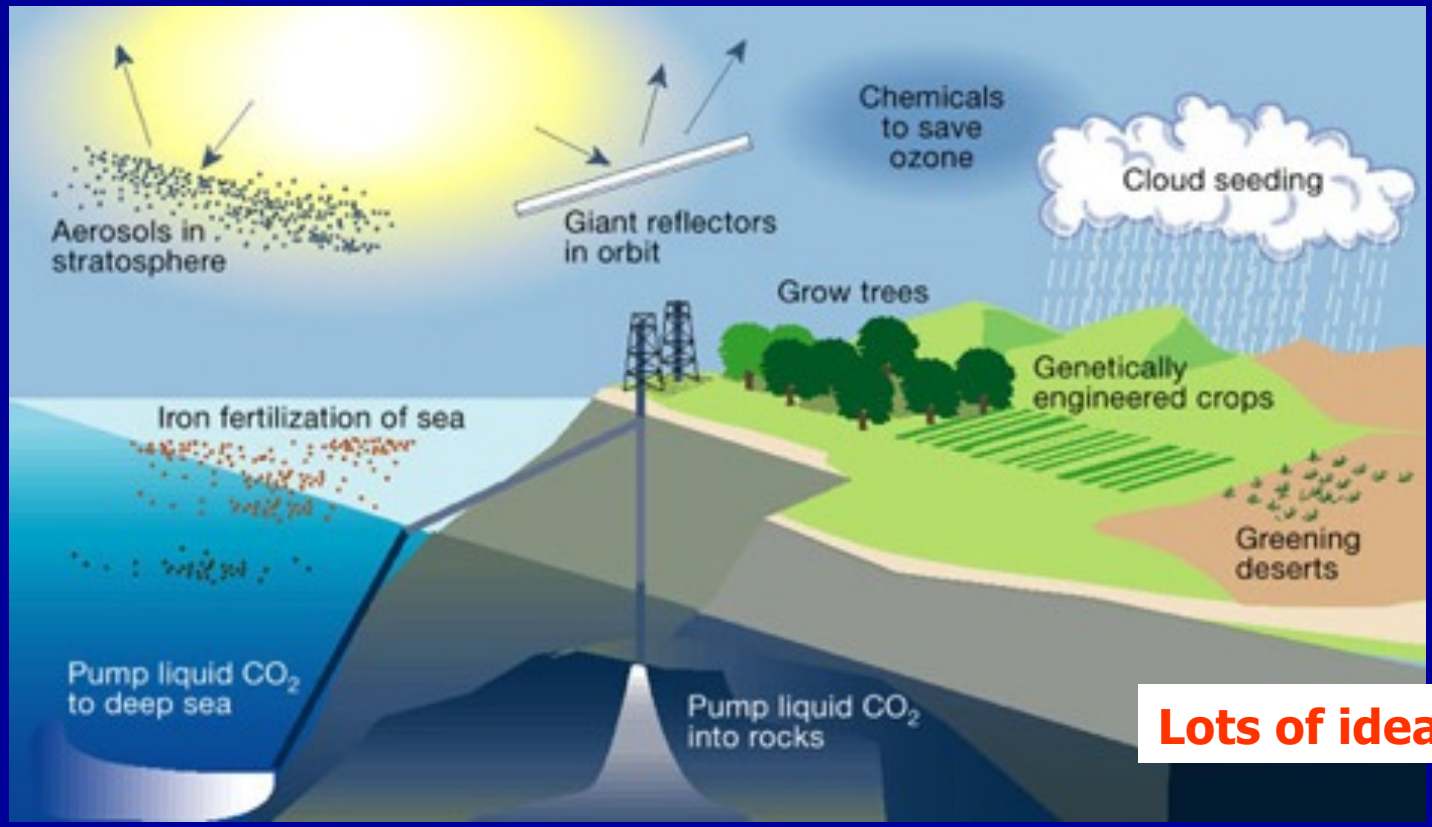
27 percent of the Netherlands is actually below sea level

60 percent of the country's (15.8 million people) live below sea level

Climate Intervention:
Planetary scale

http://earthobservatory.nasa.gov/Features/Aerosols/

‘Climate Intervention’ is the deliberate modification of an element of the climate system on a large scale to avoid dangerous impacts of climate change.



Lots of ideas!!

Mineral Carbonation of CO_2

Eric H. Oelkers[1], Sigurdur R. Gislason[2] and Juerg Matter[3]

TABLE 1 SOME POTENTIAL SOURCE MINERALS FOR CARBON MINERALIZATION

SOLID	CHEMICAL FORMULA	Tons required to sequester 1 ton of carbon
Wollastonite	$CaSiO_3$	9.68[a]
Forsterite	Mg_2SiO_4	5.86[b]
Serpentine/ chrysotile	$Mg_3Si_2O_5(OH)_4$	7.69[b]
Anorthite	$CaAl_2Si_2O_8$	23.1[a]
Basaltic glass	$Na_{0.08}K_{0.008}Fe(II)_{0.17}Mg_{0.28}Ca_{0.26}Al_{0.36}Fe(III)_{0.02}SiTi_{0.02}O_{3.45}$	8.76[c]

[a] as calcite; [b] as magnesite; [c] assuming all Ca, Mg and Fe are converted into calcite, magnesite and siderite

Artificial weathering

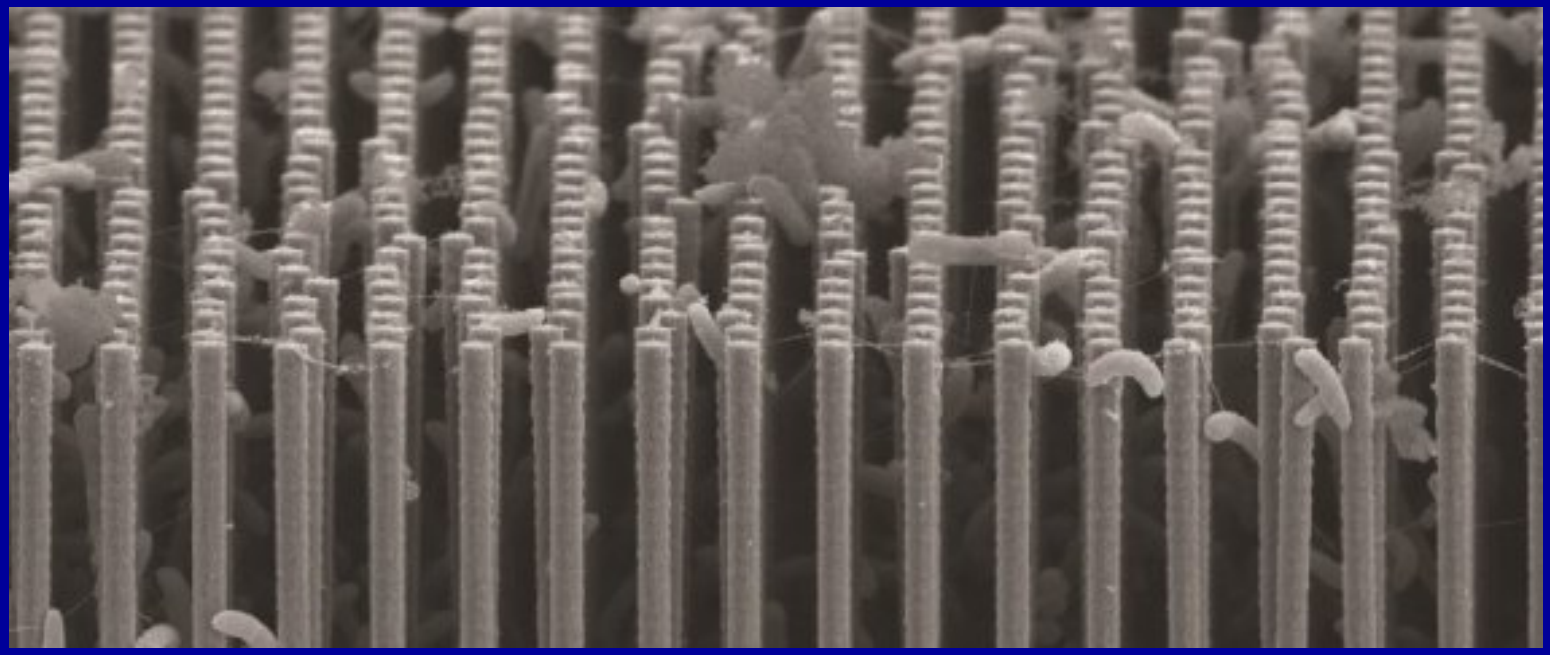
Costs:

1. Collect and transport CO_2
2. Grind the mineral to increase binding sites
3. Dispose of store the CO_2 rich mineral that results.

Artificial weathering

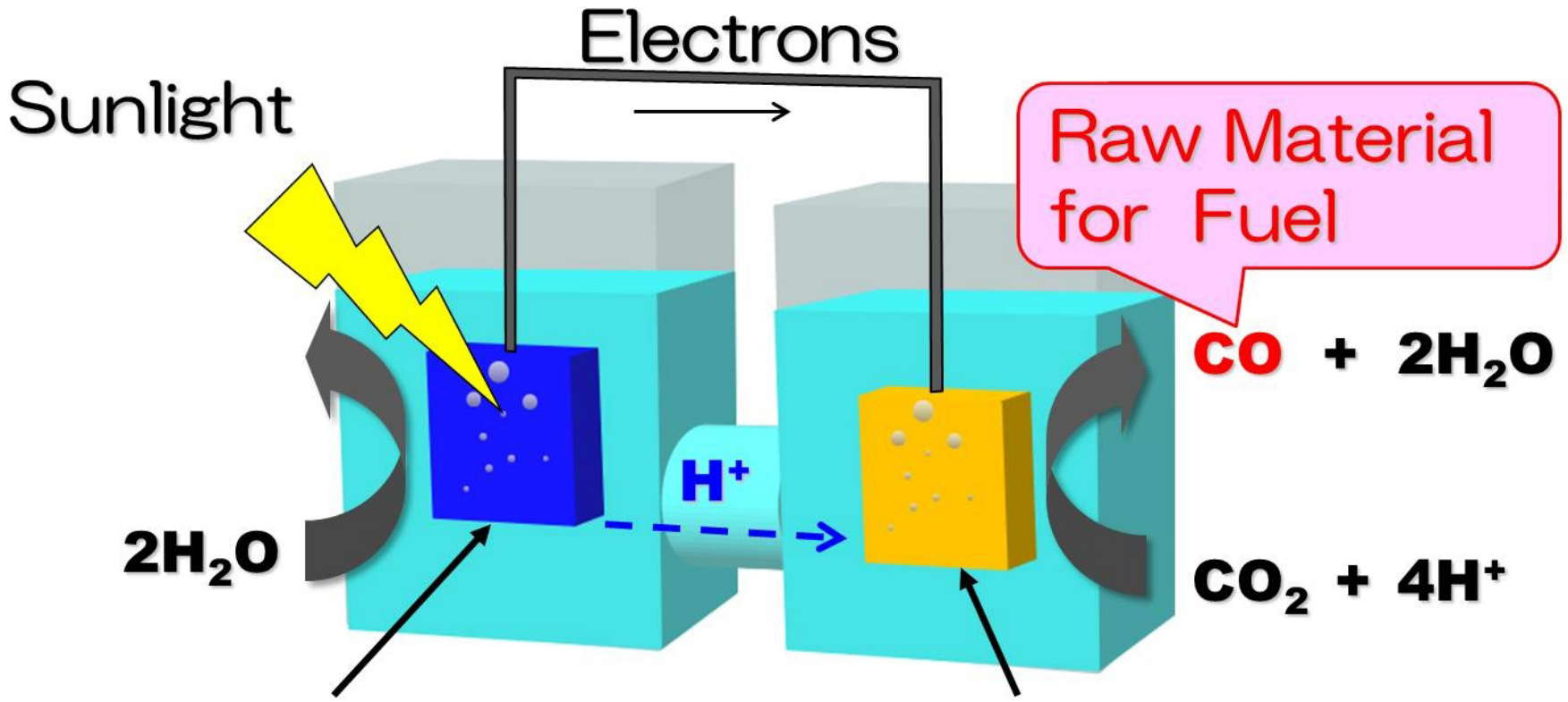
- Turn CO_2 to carbonate
  - $CO_2 + CaSiO_3 \rightarrow CaCO_3 + SiO_2$
  - carbon dioxide + calcium silicate -> calcium carbonate + silicon dioxide
  - alkaline clay-like soils
  - Endorheic Basin (closed to water outlet) Alkaline Deposits

Artificial photosynthesis



A system that can capture carbon dioxide emissions before they're released into the atmosphere and convert them into fuels, pharmaceuticals, plastics, and other valuable products.

Various schemes being tried



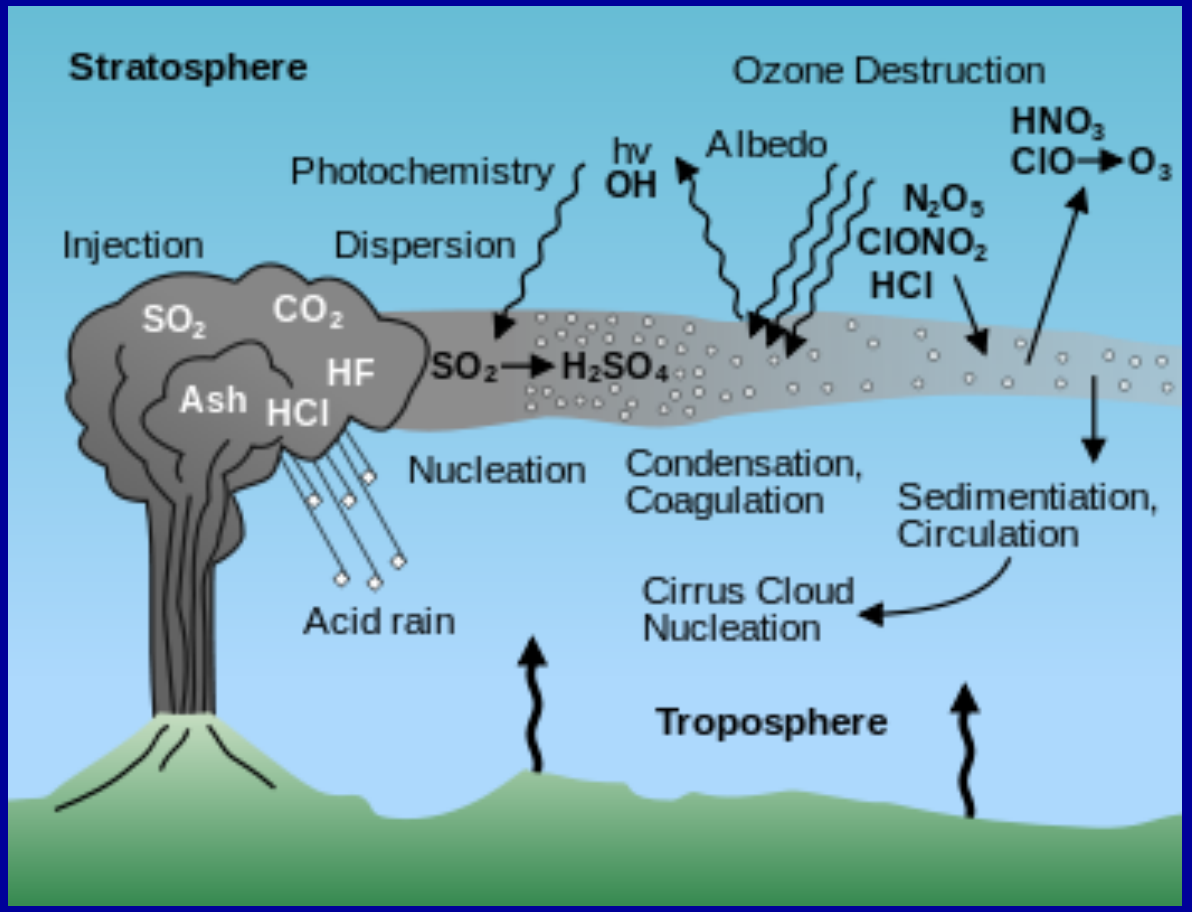
Multijunction Semiconductor that Absorb Light in the Visible Range with High Light Utilization Efficiency

Gold Nanocatalyst via Nanoscale Structural Control Technology

Artificial volcanoes

Volcanic sulfates end up here as sulfuric acid droplets and have a strong cooling effect (aka global dimming) on the planet until they fall out over a few years.

Mt. Pinatubo, June 1991

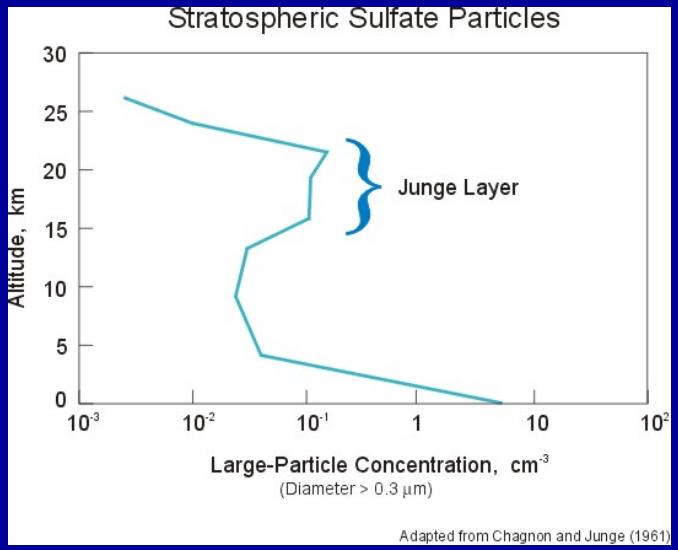


Poorly understood:
Imitate the natural volcanic action by shooting H_2S and SO_2 into the stratosphere: artillery shells, aircraft or stratospheric balloons.

Junge Layer

Volcanic sulfates end up here as sulfuric acid droplets and have a strong cooling effect (aka global dimming) on the planet until they fall out over a few years.

Mt. Pinatubo, June 1991



Geo-engineering:
Imitate the natural volcanic action by shooting H_2S and SO_2 into the stratosphere:
artillery shells,
aircraft or stratospheric balloons.

- Not recommended until further research
- Unintended consequences
- How to manage
- Once started, forever committed?
- Does not solve the ocean acidification.

Personal

My own “to do” list

- 40 year old house with shake roof (not good)
  1. insulate
  2. new roof (wait for the hail storm from hell?)
  3. rooftop solar cells (solar shingles?), wind?
- Divest of ancient hydrocarbon fuel stocks
- Buy an electric car
- Replace old appliances
- Continue giving “global warming” talks
- Continue recycling

Ratchet tax

- When the price of gas goes down $0.02, gas tax goes up $0.01
- When the price of gas goes up, tax stays constant (becomes lower percentage)

- Federal gas tax is now $0.184 (since 1993)
  - CO state tax $0.220 (one of lower in nation)
- Improves price stability
- Invest in renewable energy technologies

The Path Forward (1)

- Keep pressure on for Zero Population Growth
  - Eliminate poverty
  - Educate and empower women
- Implement carbon tax
- Reforest and stop deforestation
- Eliminate subsidies for ancient hydrocarbon fuels
- Push Renewable (e.g. wind, solar) against coal and oil.
- Solar Cells on homes, roof tops of businesses, warehouses, develop solar distribution infrastructure ….
- Geothermal home and industry heating
- Incentivize conservation and energy efficiency.
- Look seriously again at nuclear, low waste, fuels.

The Path Forward (2)

- Land conservation; access to water is a human right
- Rethink economic and political incentive systems
- Implement adaptation strategies
  - Sea walls and artificial reefs, wetlands
  - Expect floods; Move people from low lying areas
- Set aside & protect environments for species
- Go after the engineering problems in a serious way.
  - Higher efficiency solar cells
  - Energy storage systems
  - Biofuels from inedible sources
  - Capture and sequestration of CO_2
- Continue improving the science (e.g. aerosols, clouds, ocean circulations and heat transfer)

Good news

29 September 2014 Paris

"The sun could be the world's largest source of electricity by 2050, ahead of fossil fuels, wind, hydro and nuclear, according to a pair of reports issued today by the International Energy Agency (IEA)."

- solar photovoltaic 16%
- solar thermal 11%

http://www.iea.org/newsroomandevents/pressreleases/2014/september/how-solar-energy-could-be-the-largest-source-of-electricity-by-mid-century.html

Closing

- After we are gone, may our lives have made a difference.
- May those who come after us enjoy the quality of life we cherish.

Miscellaneous

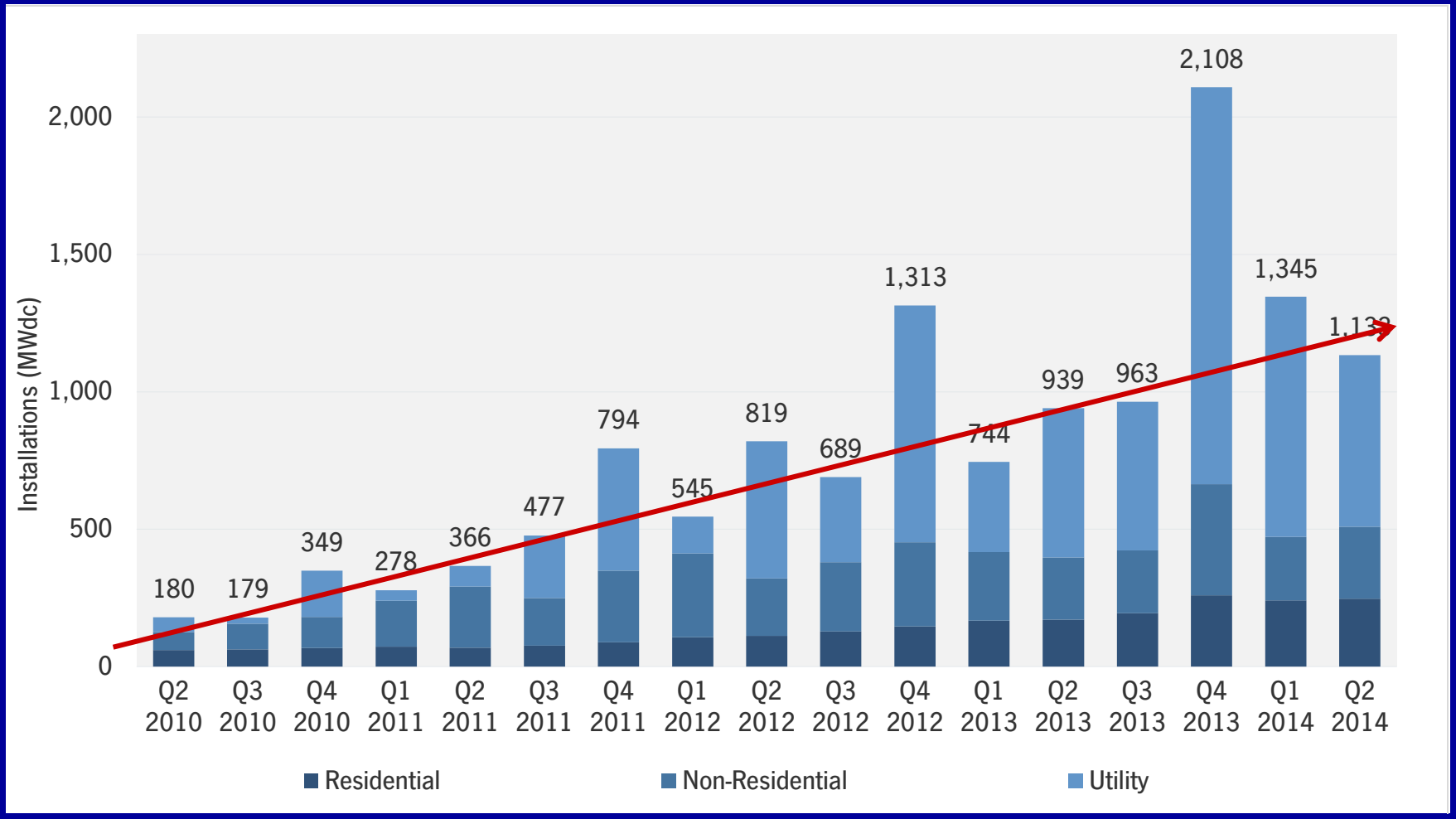
What to do?

Stop hunting for and burning fossil fuels already!

Home, Transportation, Food, Investments and Policy

- Convert to wind and solar
- Carbon tax to help incentivize renewables
  - Citizen's Climate Lobby (CCL) Carbon fee and dividend
- Use less energy (your favorite here)
  - LED bulbs
  - Eat vegan, eat local, grow local
  - Recycle
- Develop sustainable economics

Photovoltaic growth in the USA



http://www.seia.org/research-resources/solar-market-insight-report-2014-q2

Leave ancient hydrocarbons in the ground!

- No Arctic exploration
- No offshore drilling
- No coal mining permits
- No transporting of fossil fuels on railroads
- No more pipelines
- No more oil spills
- No fracking

We will need these ancient hydrocarbons for other priorities for a long time.

Creative obsolescence for the ancient hydrocarbon industries.

Lest you think I'm too negative

There is a plethora of new opportunities.

- Yes to wind power
- Yes to rooftop solar
- Yes to solar collectors (with energy storage)
- Yes to reforestation
- Yes to geothermal
- Yes to nuclear energy (carefully)
- Yes to research (e.g. into CO_2 capture)

Continue antipoverty work (empower women)

Summary

- That CO_2, methane, other greenhouse gases are warming the planet is well established.
  - Keep an eye on news about Greenland and Antarctica - if the ice sheets on these land masses start to move, we will have significant rise in sea level.
  - Aerosols and the carbon cycle are poorly understood and require more study.
- Improved management of water and land resources is essential
- There are things we can do if we have the will.
- Expect the unexpected
  - Predictions and planning are adiabatic (e.g. slow cookin')
  - Changes tend to be catastrophic (Katrina, Sandy)

I’m not an economist

- This never stops a physicist.
  - We think we understand everything!

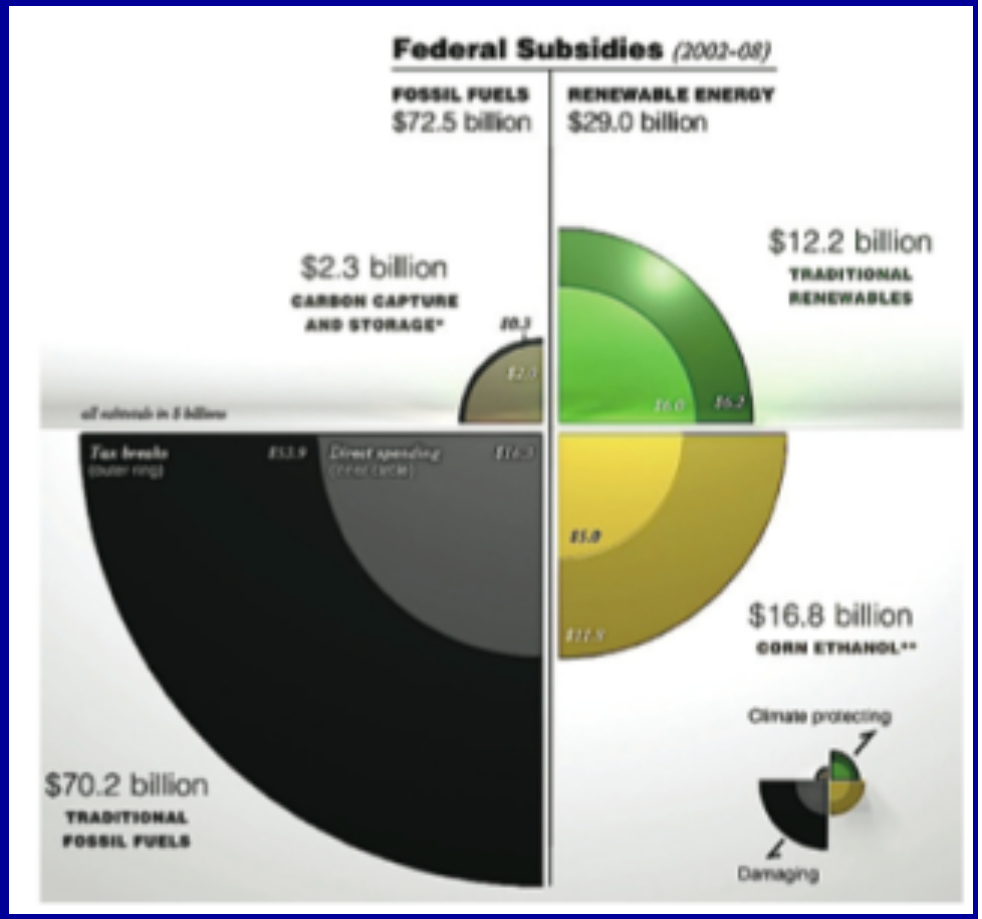
- I guess I’m entitled to an opinion.
- And, of course, you will make your own judgment.

Rooftop Revolution

http://grist.org/article/how-to-phase-out-incentives-and-grow-solar-energy/

This web site has good info on the solar panel electricity.

The success of solar is remarkable, no less because the amount of federal subsidy in absolute terms has been far less for renewable energy than for fossil fuel resources (see graphic).



Great article!!!
http://lnkd.in/bJPkmFX

The future

Regarding the future, there are no guarantees.
As they used to say in the Soviet Union:
"The past is uncertain but the future is bright."

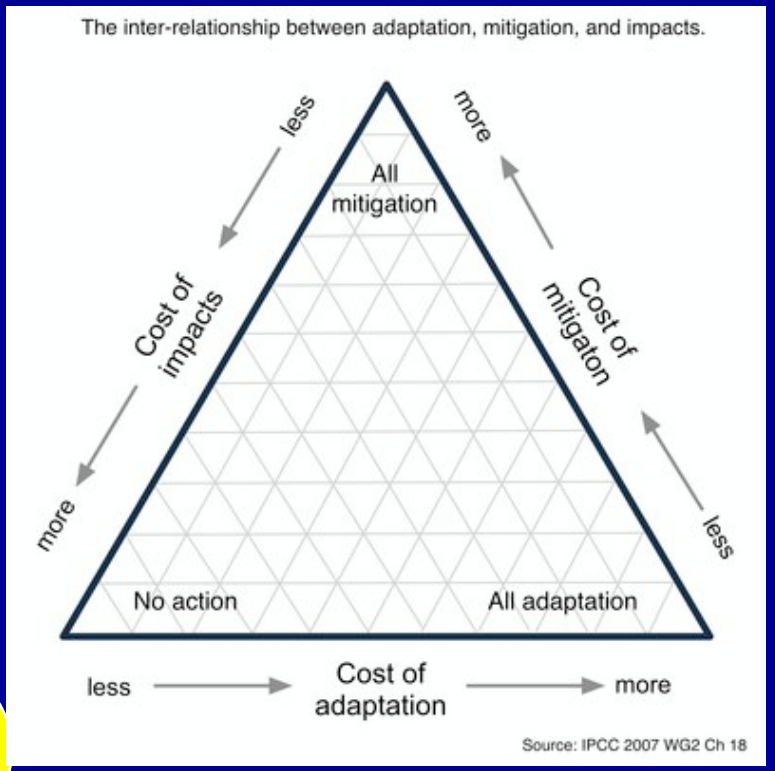
"To live without hope is to cease to live." Fyodor Dostoyevsky

"Action is the antidote to despair." Joan Baez

"Do something wonderful, people may imitate it." Albert Schweitzer

Mitigate: intervene to reduce the sources or enhance the sinks of greenhouse gases

Adapt: Adjust in response to actual or expected climatic stimuli or their effects



Climate Intervention: Plenty of incentive

Increase understanding:
- **Research: measure and model**
- **Technology development**

Credit: Paul Higgins, *Physics Today* Oct. 2014

Wind energy capacity