

Earth's Climate: Past, Present and Future; Concerns and Solutions

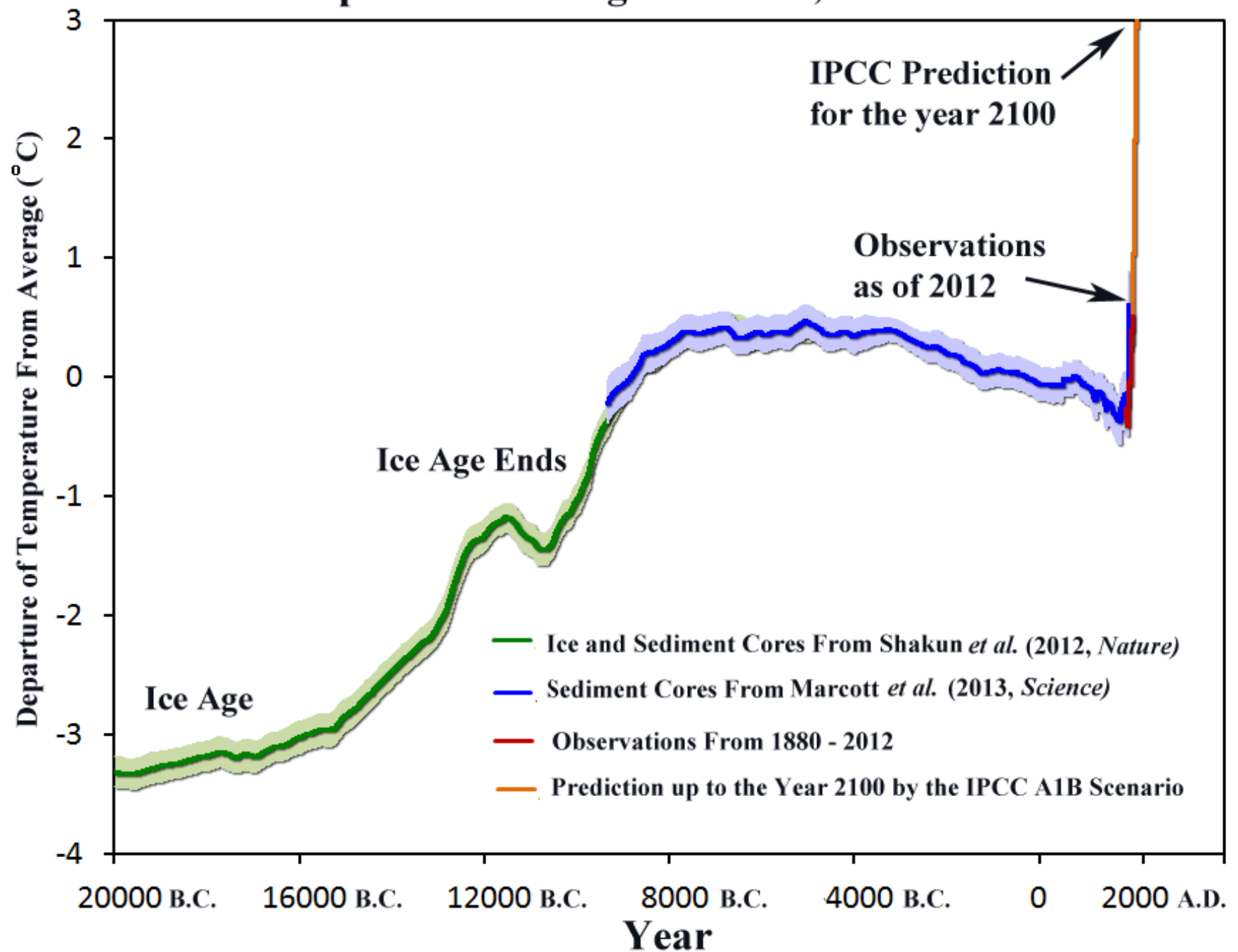
Week 6: Wednesday February 28th, 2019

Paul Belanger

Solutions

And to review the data

Global Temperature Change From 20,000 B.C. to 2012 A.D.



Climate Connections

click on link for more

Worrisome first quarter of 2017 climate trends

The year is off to a toasty start globally ... and not in a comforting way for those concerned about another year of high temperatures, sea ice record lows at both Poles, and mounting risks to coral reefs.



By [Zeke Hausfather](#)

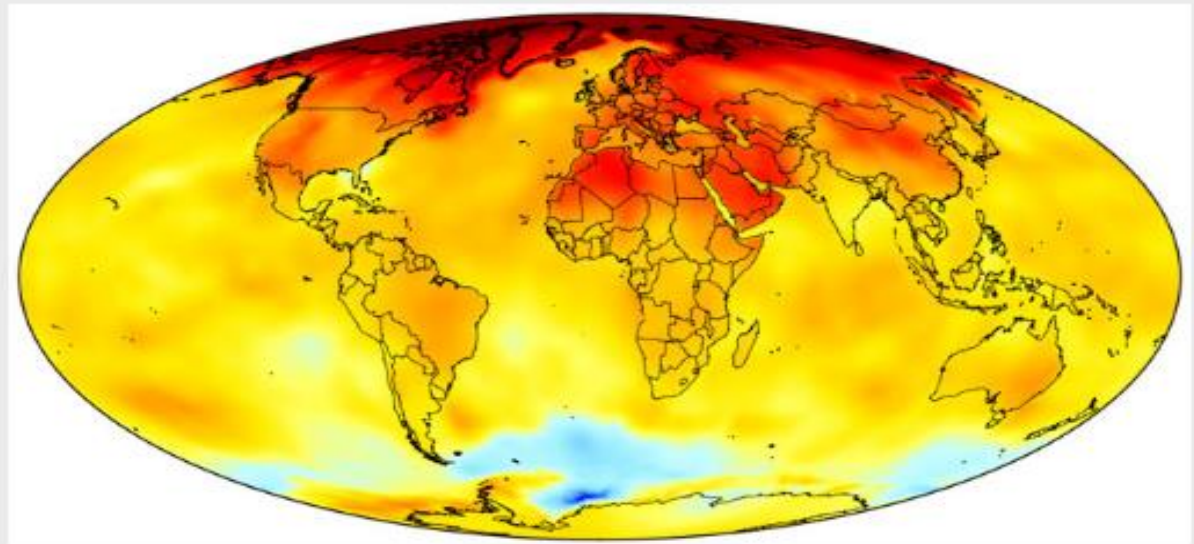
Thursday, April 27, 2017

TOPICS

[Oceans](#), [Polar Ice](#), [Science](#)

Recent Posts

- [Reversing climate change](#)
- [Columnist: 'Swamped' coastal Louisiana](#)
- [Georgia island confronts 'blue](#)

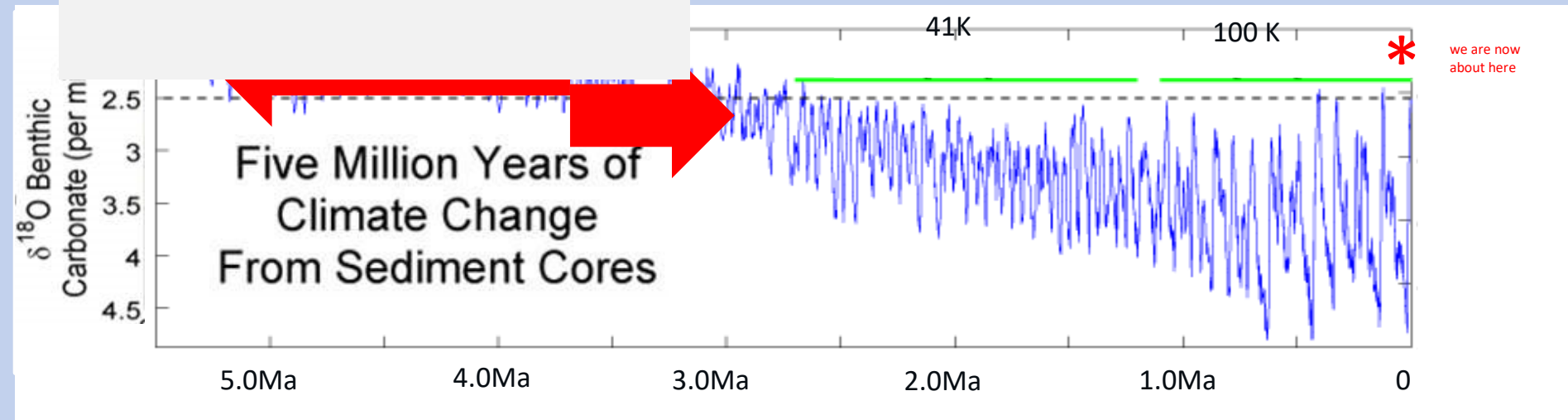


With the first quarter of 2017 now past, the year is shaping up to be one of climate extremes: high temperatures, low sea ice, and coral bleaching.

<https://www.yaleclimateconnections.org/2017/04/worrisome-first-quarter-of-2017-climate-trends/>

Climate Changes from Ocean Sediment Cores, since 5 Ma. Milankovitch Cycles

the last time inferred temperatures will have been this high – once equilibrium is reached, will have been 3-5 million years ago or more



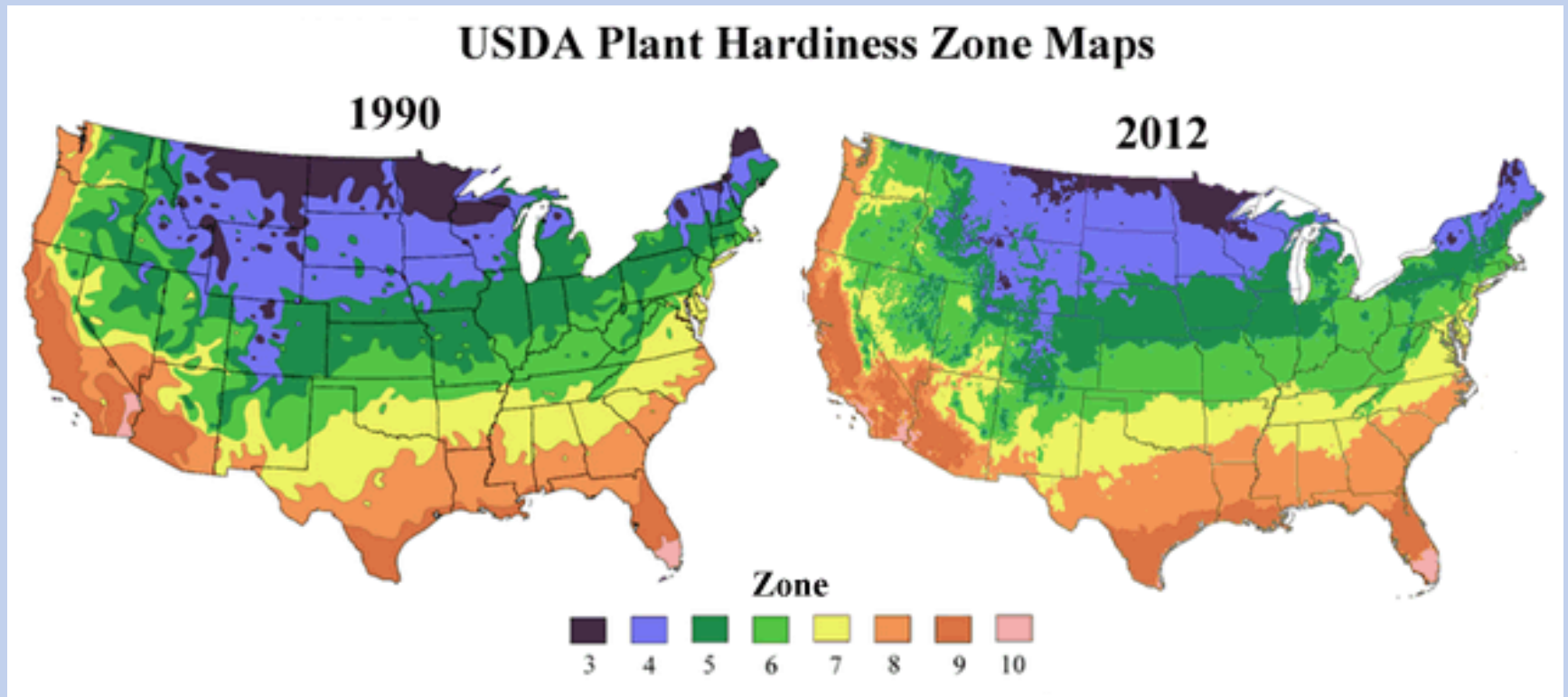
When CO₂ levels get below ~400-600 ppm Orbital parameters become more important than CO₂

Compare next 2 slides

- Notice the difference between 2012 and 2015
– 3 YEARS!

Plants and Animals are Responding to a Warming Climate

1990 vs. 2012



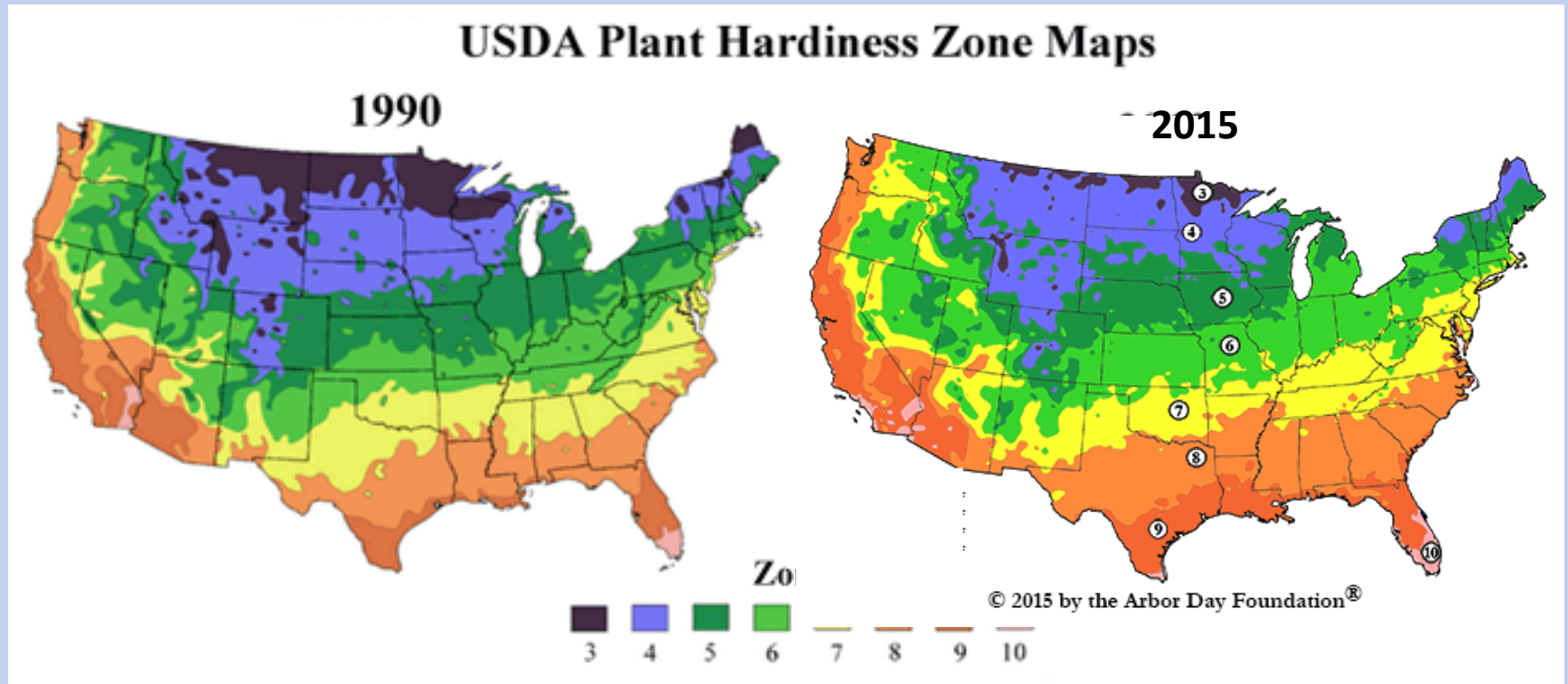
Spring is springing forward: Spring events, like bird and butterfly migrations, flower blooming times, and frog mating, have been advancing by about three days per decade over the past 30 years.

Source: Jeong et al., 2011, "Phenology shifts at start vs. end of growing season in temperate vegetation over the Northern Hemisphere for the period 1982–2008"

<https://www.arborday.org/media/zones.cfm>

Plants and Animals are Responding to a Warming Climate

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Revised syllabus

6. Wednesday 1-3, February 27th:

A work in progress – how can we achieve solutions needed

Solutions Part A (continued):

- Climate Intervention Proposals aka Geoengineering:
 - Solar Radiation Management (SRM)
 - and Carbon Dioxide Removal (CDR)
- Economics:
 - economics of doing nothing vs. the economics of mitigation: Lomborg, Stern, Nordhaus
- **Game changers for taking Carbon out of the atmosphere**: existing technologies/promise, but at what cost? (One might be surprised).
- Biochar vs. BECCS solutions

7. Wednesday 1-3, March 6th:

Welcome to the Anthropocene

Guest speaker, Bob Raynolds: The Anthropocene

8. Wednesday 1-3, March 13th:

Solutions, part B; conclusion

- It's not about climate change as much as sustainability
- **Game changers: Energy solutions**
- Urban heat islands
- Food security
- Population growth; potential refugee issue of climate change
- Your carbon footprint; what can YOU DO
- Wrap-up

OLLI West – Spring 2017

- Spent 6 of the 8 weeks on solutions
- https://denverclimatestudygroup.com/?page_id=2224

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MONDAYS: 2017 OLLI WEST – ADAPTING TO CLIMATE CHANGE: Extreme Weather Events, Worldwide Energy Revolution, and Geoengineering Options – Particularly BIOCHAR -Paul Belanger and Phil Nelson
week 1 March 27, 2017

- WEEK 1-adapt intro
- WEEK 2-heat extreme wx
- Week 3-too much water
- Week 4 - carbon tax Energy intro
- Week 5 - Wind and Solar
- Week 6 - nuclear grid vs storage
- Week 7 20170508 NREL VISIT
- Week 8 - solutions BIOCHAR

Earth's Climate: Past, Present and Future

OLLI South Spring 2017:

week 7 (May 11th) & week 8

Paul Belanger

Solutions – part A

The Ultimate Primary Focus: Energy and Sequestration of CO₂

1. Economics
 - of doing nothing (solely adapting) vs. the economics of mitigation
 - Actuality: it WILL be a combination
2. Capitalism, GDP/growth based economics vs. “Herman Daly” economics (no-growth/steady-state)
3. Solutions? Paradigm shift? From we can't/too expensive to WE CAN
4. There is promise, but at what cost? (One might be surprised).
 - Energy
 - Mitigation – Agricultural revolution/biofuels: Biochar for Carbon Dioxide Removal (CDR)

The economics/the solutions?

Continued

Next week: Solutions – part B

5. Geoengineering:
 - Solar Radiation Management (SRM) and
 - Carbon Dioxide Removal (CDR)
6. Biochar vs. BECCS solutions SEE MY BIOCHAR LINK IN OTHER PAGES:
http://denverclimatestudygroup.com/?page_id=28
7. Efficiency – the single quickest way to reduce:
 - What NREL is doing: Efficiency, Solar, wind, other
8. Other strategies:
 - CCL – carbon fee/dividend
 - Cap and trade?
9. Gloom and Doom? NO! IT'S A CHALLENGE, and humanity has always been challenged and we are an adaptable species that has met the challenge over and over again!

Youth Movement – addressed last week

- See

<https://denverclimatestudygroup.com/wp-content/uploads/2019/02/OLLI-East-week-5-slides-FINAL-NXPowerLite-Copy.pdf>

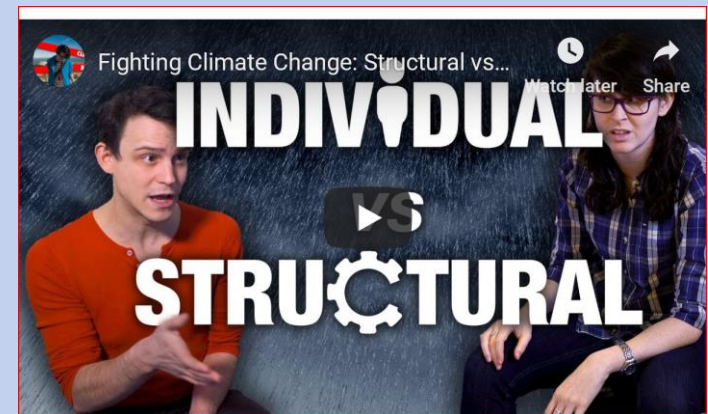
Fighting Climate Change: Structural vs. Individual Action: Climate Adam

SkS (Skeptical Science) posted a video yesterday at <https://www.skepticalscience.com/structural-vs-individual-action>. Trying to address the need to stop emitting greenhouse gases to stop global warming, but how do we get there? :

- Should we be cutting our own emissions
- or pushing for systemic change?

Climate Adam battles it out with a very special guest - who looks just a little bit different...

<https://www.skepticalscience.com/structural-vs-individual-action.html>



Fighting Climate Change: Structural vs. Individual Action: Miriam's channel discusses it with Climate Adam

The background from this video - 7 steps:

1. Intro – How does the world reduce it's carbon footprint:
 - a. Large scale structural and societal shifts?
 - b. Or individual actions?
2. Pleasantries – Adam who are you and what do you do?
 - a. Youtubery/humorous way starting when he was working on his Ph.D. in climate science
 - b. 4 years ago

Fighting Climate Change: Structural vs. Individual Action: Miriam's channel discusses it with Climate Adam

7 steps (continued):

3. The Debate – What is a better way to mitigate climate change:
 - a. Individual actions
 - b. Something you do in daily life
 - c. Structural changes/government policy, industry overhaul, or cultural shifts?
 - d. What happens outside climate-nerd world = false debate about whether happening or not
 - i. For which they discuss what type of action needs be done (Adam – individual)
 - ii. Miriam pushing for large-scale structural shifts
4. BOTH? MAYBE?
 - a. Individual actions – issue of “telling” people what to do
 - b. Individual circumstances vary
 - c. Only so far consumer choices go: e.g. depend on efficiency or truck or Amazon's server
 - d. Affordability
 - e. Paris agreement – limit to 1.5° C: need to do everything possible to do so
5. More Roadblocks
 - a. Confusing other environmental issues with the climate change environmental issue – i.e. UNRELATED; helps the plastic-environment issue but not the climate change issue AT ALL

Fighting Climate Change: Structural vs. Individual Action: Miriam's channel discusses it with Climate Adam

7 steps (continued):

6. What do we need to do?

- a. Not to be “absolutists”
- b. Extreme end actions
- c. Diet, reduce trips
- d. Ingrained in us – ‘STUFF’ – become more minimalists
- e. Repair
- f. Ingrained limitations that make it impossible to fix/repair things
- g. Throw away society
- h. Just because you can attitude – think sustainability!
- i. Things that benefit you in many ways

7. The End

GND – the Green New Deal

Understanding the Green New Deal – 6 ½ minutes:

<https://www.youtube.com/watch?v=QLxzAaQILvY>

A no binding resolution

<https://youtu.be/QLxzAaQILvY>

This Monday: Ethics and Ecological Economics Forum (EEEEF)

Ethics and Ecological Economics Forum (EEE)

THIS PAGE WAS UPDATED 2/17/2019

NEXT MEETING: February 25th, 2019 1:30 – 3:00 p.m. –

**THE GREEN NEW DEAL: IS IT NEW? IS IT VITAL FOR OUR
FUTURE?**

WHEN: Monday, February 25th, 1:30 – 3:00pm

WHERE: Library Portico, Iliff School of Theology (2323 E. Iliff Ave.)

SPONSORED BY: Ethics and Ecological Economics (EEE) Forum at Iliff

On February 7th, Rep. **Alexandria Ocasio-Cortez** (D-N.Y.) and Sen. **Edward Markey** (D-Mass.) introduced resolutions in the House and Senate, calling for the “Federal Government to create a **Green New Deal** [GND].”

In brief, the GND proposes that the federal government take the lead in responding comprehensively to the growing threats of climate change, wage stagnation, income inequality, and the inaccessibility of basic needs (“such as clean air, clean water, healthy food and adequate health care, housing, transportation, and education”) for “a significant portion of the

https://denverclimatestudygroup.com/?page_id=683

This Monday: Ethics and Ecological Economics Forum (EEEF)

- **February 25th, 2019**
- **THE GREEN NEW DEAL: IS IT NEW? IS IT VITAL FOR OUR FUTURE?**
- **SLIDES/COMMENTS:**
 - Peter Sawtell: [Sawtell 2-25-19](#)
 - Sheila Davis: [Sheila Davis 2019.02.25 A Green New Deal as a Vehicle....](#)
 - Phil Nelson: [Phil Nelson GND-EIC Data talk](#)
- On February 7th, Rep. **Alexandria Ocasio-Cortez** (D-N.Y.) and Sen. **Edward Markey** (D-Mass.) introduced resolutions in the House and Senate, calling for the “Federal Government to create a **Green New Deal** [GND].”
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- Three panelists will share perspectives on the proposed GND before group discussion:
 - **Rev. Peter Sawtell**, founder and Executive Director, Eco-Justice Ministries;
 - **Dr. Sheila Davis**, MD, and Assistant Research Professor, University College, University of Denver;
 - **Phil Nelson**, Ph.D., Citizens’ Climate Lobby chair, Golden chapter

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Social Justice and Economics

Past: April 23rd, 2018: Monday, April 23rd, 1:30 – 3:00pm

Behavioral Economics and the Prospects of a New Economic System Based on Wellbeing

BY: Prof. Paul Sutton, DU Dept. of Geography and the Environment Paul Sutton

Slides and links:

- Presentation – PowerPoint: [Sutton_Toward_A_Sustainable_Wellbeing_Economy](#)
- Presentation – PDF: [Sutton_Toward_A_Sustainable_Wellbeing_Economy](#)
- Handouts:
 - 2018.04.23p Assessing Human and Ecological Wellbeing for Colorado concept paper
 - 2018.04.23 Half-page Doughnut Economics Models
- Links:
 - **Kate** Raworth: Donut Economics video: Why it's time for 'Doughnut Economics' | **Kate** Raworth | TEDxAthens: <https://www.youtube.com/watch?v=1BHOflzxPjI&feature=youtu.be>
 - **Kate** Raworth homepage (TEDtalk and doughnut model): .
: <https://www.kateraworth.com/doughnut/>
 - A good life for all within planetary boundaries; O'Neill et al.: [nature.com/articles/O'NEILL ET AL.](https://www.nature.com/articles/O'NEILL_ET_AL)
 - Related; allow interactive comparison of countries to one another: <https://goodlife.leeds.ac.uk/>
 - <https://www.nationalreview.com/corner/environmentalists-push-global-wealth-redistribution/>

Monday January 14th.

REGENERATIVE ECONOMICS AND COLORADO OPPORTUNITIES

SPEAKER: HUNTER LOVINS, President & Founder, Natural Capitalism Solutions

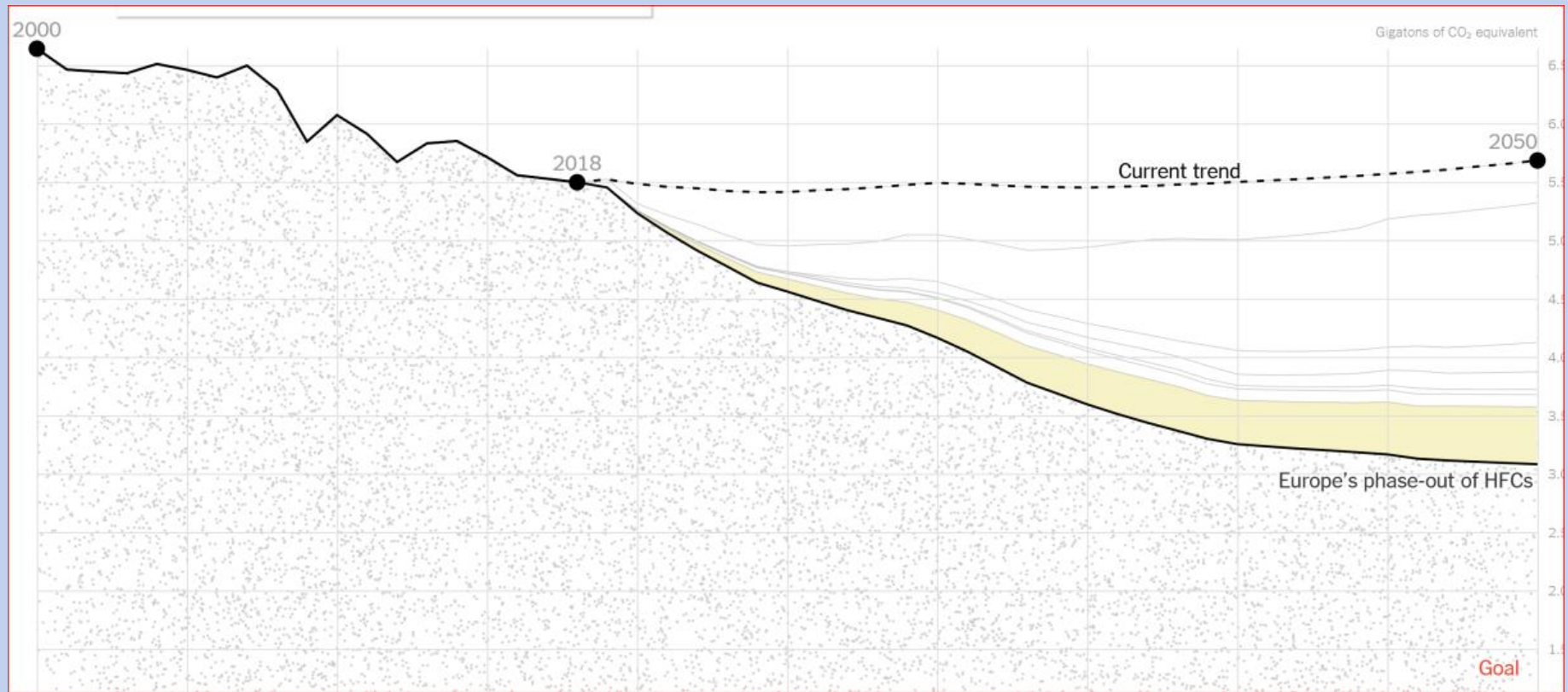
SLIDES: [Hunter Lovins20190114OPT – PDF](#)

WHERE: Library Portico, Iliff School of Theology (2323 E. Iliff Ave.)

SPONSORED BY: Ethics and Ecological Economics (EEE) Forum

"Humanity's collision with planetary boundaries requires a radical rethink of economic theory and practice." –*A Finer Future: Economics in Service to Life* (2018)

Solutions - Adoption of 7 policies



- https://www.nytimes.com/interactive/2019/02/13/climate/cut-us-emissions-with-policies-from-other-countries.html?smid=fb-nytimes&smtyp=cur&fbclid=IwAR13rNqUxYrKOomsaKQKotuuYQ1SBUK_IldhZbL0E9INp70f9NHhuy8_Nw

Adoption of 7 policies

- **Carbon tax:** The tax on coal, oil and natural gas starts at \$7.50 per ton of carbon dioxide in 2020 and reaches \$37.50 per ton **by 2033**. This is based on the rates and schedule for [British Columbia's carbon tax](#), which began in 2008. ...
- **Clean electricity standard:** This policy is partly modeled after existing state-level standards. It requires utilities to increase the amount of electricity they produce from carbon-free sources — including wind, solar, nuclear, hydro, geothermal and biomass — until they reach 100 percent clean electricity in 2050. For comparison, California is steadily increasing its [clean electricity requirements](#) to **100 percent by 2045**, while New York has [announced a 2040 goal](#).
- **Electric vehicle push:** Rather than model Norway's [specific set of electric vehicle tax incentives](#), this scenario assumes that the United States makes a push to match the rapid recent growth in Norway's electric vehicle sales over the next eight years. (Between 2011 and 2018, electric vehicles and plug-in hybrids went from 1.6 percent of new sales in **Norway to 49 percent**.) After 2027, ...
- **Industrial efficiency standards:** The industrial efficiency gains are based on a 2016 Department of Energy [study](#)
- **Building codes:** This policy reduces energy use in new homes and buildings. In 2016, the California Energy Commission [calculated](#) that the state's stricter building codes would reduce energy-use intensity by 29 percent for residential buildings and 13 percent for commercial
- **Methane standards:** Canada's [methane rules](#) aim to reduce emissions from oil and gas operations 40 to 45 percent below 2012 levels by 2025. ...
- **HFC phaseout:** This....

Why it's not enough

PAST: MONDAY March 26TH: CO2 Removal and Nature Conservancy presentation by Betsy Neely + What is and the Need for Biochar by Paul Belanger

slides and links added below

Handout: [2018.03.26x Nat Climate Solutions Forum handout half-page](#)

Part A: Why PRICING IS NOT ENOUGH & WHY WE NEED SEQUESTRATION! – Paul Belanger

- Pptx: TROUBLE LOADING contact me pebelanger@glassdesignresources.com if copy desired
- Pdf: [2018.03.26 Belanger-why pricing is no enough EEEF](#)

Part B: NATURAL CLIMATE SOLUTIONS – Betsy Neely

*How great a contribution can **nature itself**—e.g., forests, grasslands, wetlands, etc.—make to storing and reducing global carbon emissions?*

https://denverclimatestudygroup.com/?page_id=683

IPCC — Intergovernmental Panel on Climate Change

IPCC — Intergovernmental Panel on Climate Change -- <https://www.ipcc.ch/>

IPCC — Intergovernmental Panel on Climate Change

<https://www.ipcc.ch> ▼

The **Intergovernmental Panel on Climate Change** The **Intergovernmental Panel on Climate Change** (**IPCC**) is the United Nations body for assessing the science related to climate change.

Publications and Data

The IPCC prepares comprehensive Assessment Reports about knowledge on ...

Fifth Assessment Report

The Working Group I contribution to the Fifth Assessment Report of the ...

Organization

The IPCC is an organization of governments that are members of the United Nations or ...

Mitigation of Climate

AR5 Climate Change 2014: Mitigation of Climate Change The Working Group III ...

Report

AR5 Synthesis **Report**: Climate Change 2014 The Synthesis **Report** (SYR) of the **IPCC** Fifth ...

Data

IPCC Data The Task Group on Data and Scenario Support for Impact and Climate ...

IPCC REPORTS

Assessment reports (AR #) with 3 working groups:

The screenshot shows the IPCC website with a navigation bar at the top containing links for REPORTS, WORKING GROUPS, ACTIVITIES, NEWS, and CALENDAR. On the right side of the navigation bar are icons for FOLLOW and SHARE. The main content area is divided into three columns. The first column, titled 'LATEST AND UPCOMING REPORT', lists four reports: 'Global Warming of 1.5°C', '2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories', 'Climate Change and Land', and 'The Ocean and Cryosphere in a Changing Climate'. The second column, titled 'SIXTH ASSESSMENT REPORT', lists three reports: 'AR6 Synthesis Report: Climate Change 2022', 'AR6 Climate Change 2021: Impacts, Adaptation and Vulnerability', and 'AR6 Climate Change 2021: Mitigation of Climate Change'. The third column, titled 'FIFTH ASSESSMENT REPORT', lists three reports: 'AR5 Synthesis Report: Climate Change 2014', 'AR5 Climate Change 2013: The Physical Science Basis', and 'AR5 Climate Change 2014: Impacts, Adaptation, and Vulnerability'. The words 'SIXTH' and 'FIFTH' in the column headers are highlighted with red boxes.

ipcc REPORTS WORKING GROUPS ACTIVITIES NEWS CALENDAR FOLLOW SHARE

LATEST AND UPCOMING REPORT

- Global Warming of 1.5°C
- 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories
- Climate Change and Land
- The Ocean and Cryosphere in a Changing Climate

SIXTH ASSESSMENT REPORT

- AR6 Synthesis Report: Climate Change 2022
- AR6 Climate Change 2021: Impacts, Adaptation and Vulnerability
- AR6 Climate Change 2021: Mitigation of Climate Change
- AR6 Climate Change 2021: The Physical Science Basis

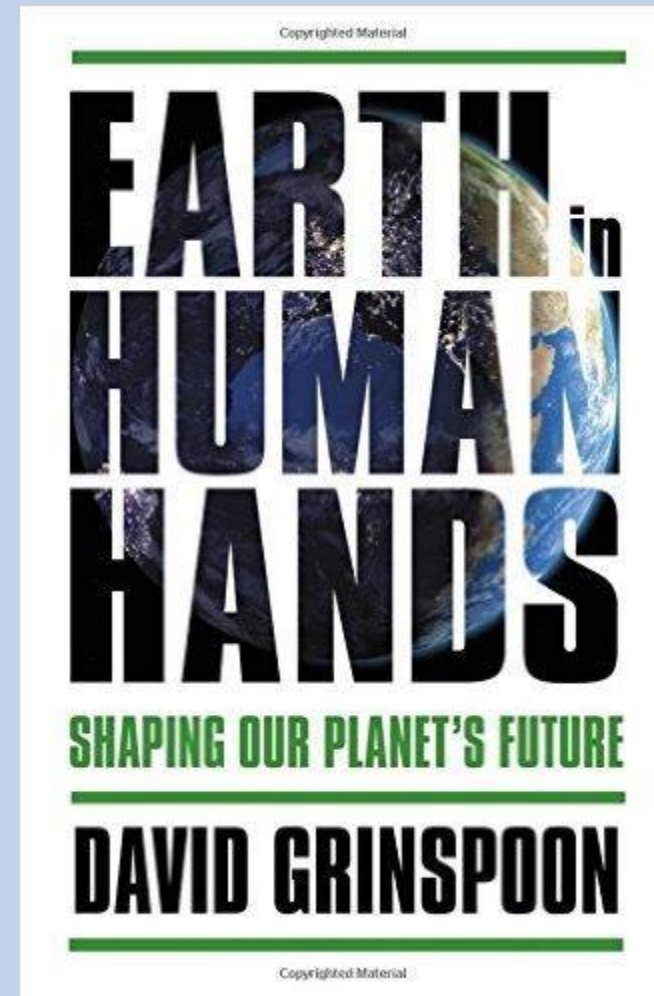
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We are a planet with brains

- Climate change is only the most visible of the modifications we've made--up until this point, inadvertently--to the planet.
- And our current behavior threatens not only our own future but that of countless other creatures.
-shows what a strange and novel development it is for a species to evolve to build machines, and ultimately, global societies with world-shaping influence.

BTW – David Grinspoon will be at Conf. World Affairs (CWA), Boulder NEXT week of 4/8: <http://www.colorado.edu/cwa/>



SOLUTIONS – Energy, Transportation and Geoengineering Options

Changing our energy needs

- Economize ANY Energy usage: insulate, reduce trips
- Decarbonize Energy for Generating Electricity
 - Electrify everything for cooking, heating, manufacturing – EVERYTHING
- Decarbonize Energy for Transportation
 - EVs, Fuel cells,
- Why that is not enough = Geoengineering options
 - SRM – SOLAR RADIATION MANAGEMENT
 - CDR – CARBON DIOXIDE REMOVAL

Solutions

What's it take? A very complex issue

- Policy changes – How to Effect change?
- Cooperation and Resolve – How to agree – COP = Conference of Parties (COP21 = aka Paris agreement)
- Economic changes
- Sustainable practices – large and small scale
- Lifestyle changes

Sustainability Economics

- Herman Daly – Steady State Economics
- Alec Tsoucatos – OLLI instructor; also involved EEEF
- Kate Raworth – Doughnut Economics
- Paul Sutton – DU Sustainability and EEEF

CRES YouTube Channel:

<https://www.youtube.com/channel/UCr81EUb2qVJVfmmlJMXEHVw/videos>

CRES YouTube Channel:

<https://www.youtube.com/channel/UCr81EUb2qVJVfmmlJIMxEHVw/videos>

- Tony Seba: Clean Disruption - Energy & Transportation
 - <https://youtu.be/2b3ttqYDwF0>
- Ramping Up Solar to Power the World - Greg Wilson, NREL
 - <https://youtu.be/7CDPHxcnq4c>
- Driverless Cars and the Environment - Rutt Bridges, Futurist
 - <http s://youtu.be/0BWJcpesr6A>
- Bill Ritter - Powering Forward. The Clean Energy Revolution can't be stopped
 - <https://youtu.be/agowW1QKwms>
- Drawdown: 60 Minutes with Paul Hawken
 - <https://www.youtube.com/watch?v=4XrFnK1RrLE>
- Can Hydrogen Save our Energy System Mark Ruth, NREL
 - <https://www.youtube.com/watch?v=4u93y-l0cwM&t=199s>
- 100% Renewables: Let's Go! (Ken Regelson - 2/6/16)
 - <https://youtu.be/xDBPE6ZUGXQ>
- Why Storage is Key for a Renewable Energy Future
 - https://youtu.be/Yc_hULwykvQ

Colorado Renewable Energy Society – YouTube of selected talks: Clean Disruption – Energy and Transportation by Tony Seba:

Tony Seba: Clean Disruption - Energy & Transportation

<https://youtu.be/2b3ttqYDwFO>



Colorado Renewable Energy Society

– YouTube of selected talks:

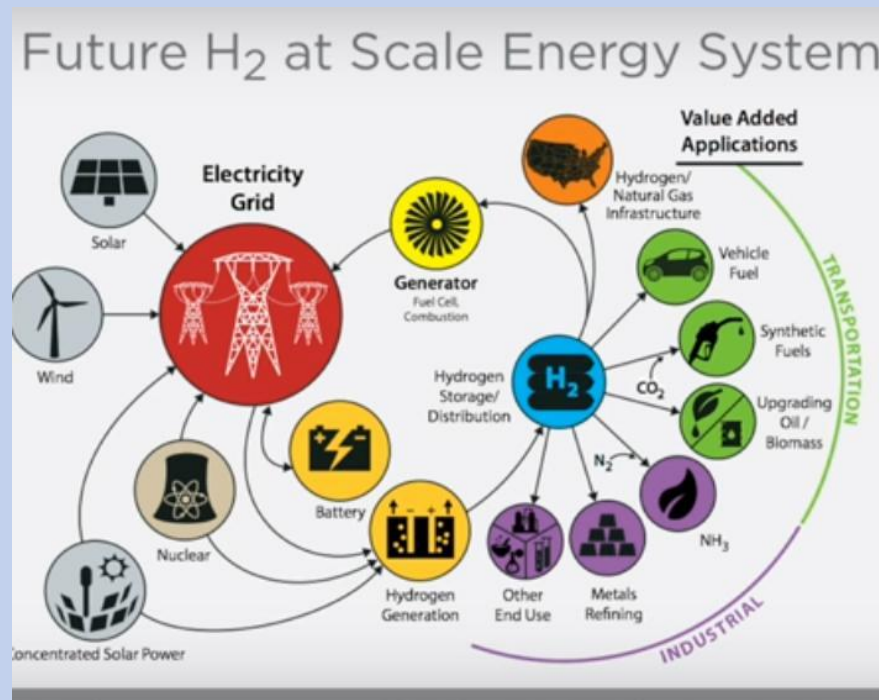
ON Hydrogen:

Ramping Up Solar to Power the World - Greg Wilson, NREL:

<https://www.youtube.com/watch?v=7CDPHxcnq4c>

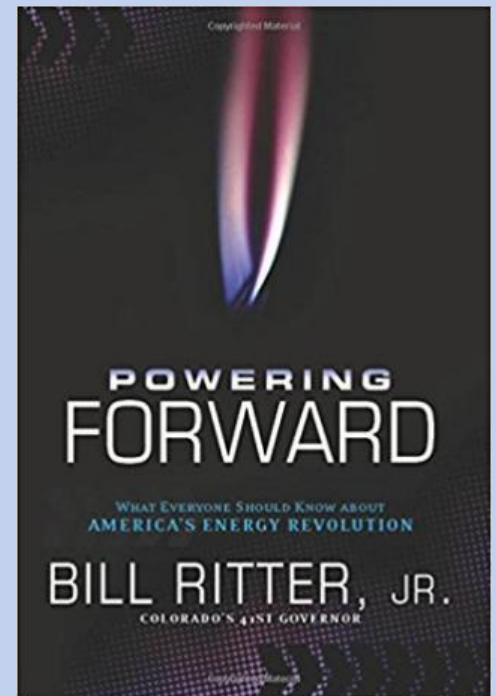
Can Hydrogen Save our Energy System? Mark Ruth, NREL

<https://www.youtube.com/watch?v=4u93y-10cwM>



Powering Forward: ...America's Energy Revolution

- A historic energy revolution is underway in the United States & THE WORLD:
 - Wind, sunlight, and other sustainable resources
 - Power plants on their roofs
 - Entire communities are switching to 100 percent renewable energy; Hawaii has such a commitment!
 - Urgent need to prevent climate change is causing people around the planet to question their reliance on carbon-intensive oil, coal, and natural gas.





Ken Regelson links

- EnergyFreedomCO.org
 - Innovation and lower costs through competition.
- **Beginners, start here**
 - [The U.S. electricity system](#)
 - [Energy Freedom basics](#)
 - [Why restructure monopolies?](#)
 - [Terms and definitions](#)
- EnergyShouldBe.org - 100% Renewables
 - **Penguins & 100% Renewable Energy in 20 Years** - <https://youtu.be/sRJquTFAGVU>
 - **To Allow Lots of Renewables, Baseload Coal & Nuclear Must Go** <https://youtu.be/deWtgpheDJM>
 - **Modeling Electric Load & Renewables. Video and free spreadsheet model to download** (scroll down for the link to the spreadsheet itself). (13 minutes) <https://youtu.be/RVdJeAcuUZI>
 - others

— **Energy Freedom Colorado** —
Cheaper & cleaner electricity with retail competition & consumer choice

Home About Main Menu Community Electricity Options project

We need to think differently about electricity.

Colorado is an electricity monopoly state.

In Retail Choice states — Many electricity suppliers compete for customers based on cost and energy source. Individuals, businesses & communities can choose.

Electricity competition states



Full retail choice
Limited retail choice
No retail choice (monopoly)

Why electricity choice over monopoly? (more...)

- Lower electricity costs
- Promotes cheaper & cleaner renewable energy
- Companies locate where they have lower costs & choice
- Competition drives innovation
- Shifts risk from consumers to generators
- Electricity is no longer a "natural monopoly"

Energy Freedom Colorado is working to bring more Electricity Choice to Colorado.

Click Here for

- [General Audience Videos](#)
- [Mildly Technical Videos](#)
- [Technical Audience Videos](#)
- [Newest Videos](#)
- [Most Popular Videos](#)

Renewables:

- Photovoltaics (PV)
- Concentrated solar power (CSP)
- Wind
- Geothermal
 - Ground source
 - Deep thermal

Hawaii becomes First State to Mandate 100% Renewable Energy.

See NREL slides for more details:

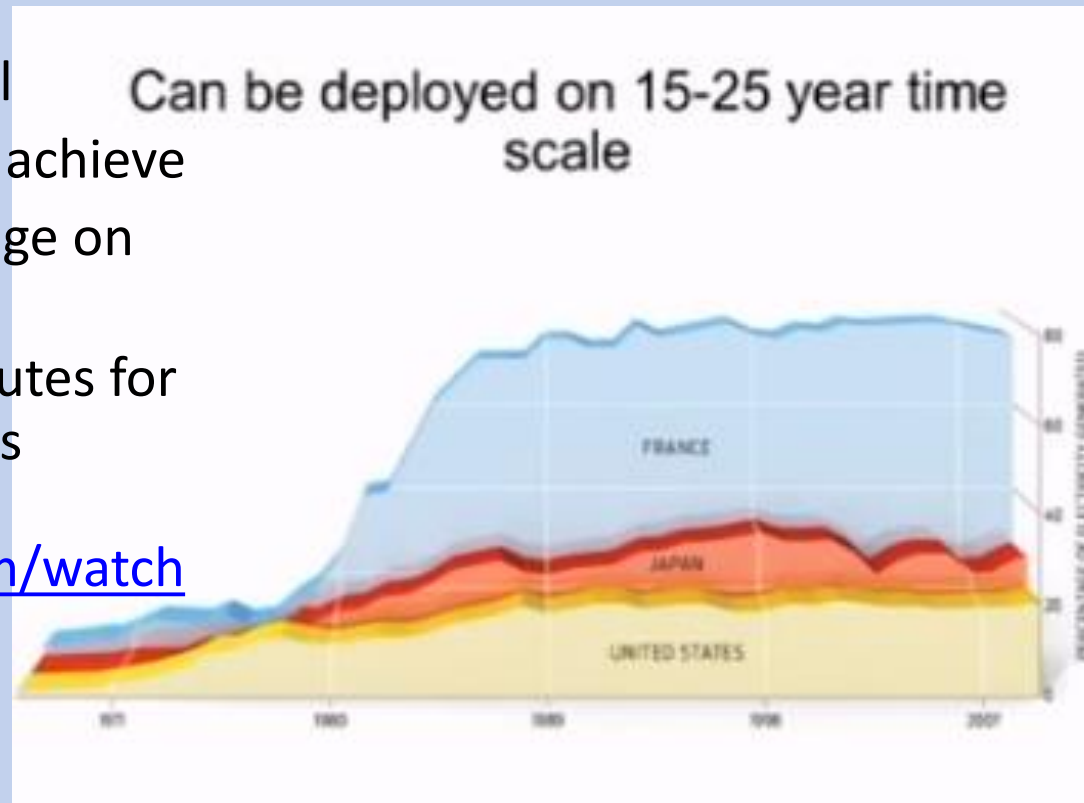
<http://denverclimatestudygroup.com/wp-content/uploads/2015/04/OSHER-10.14.15.pdf>

Colorado changes in renewable energy

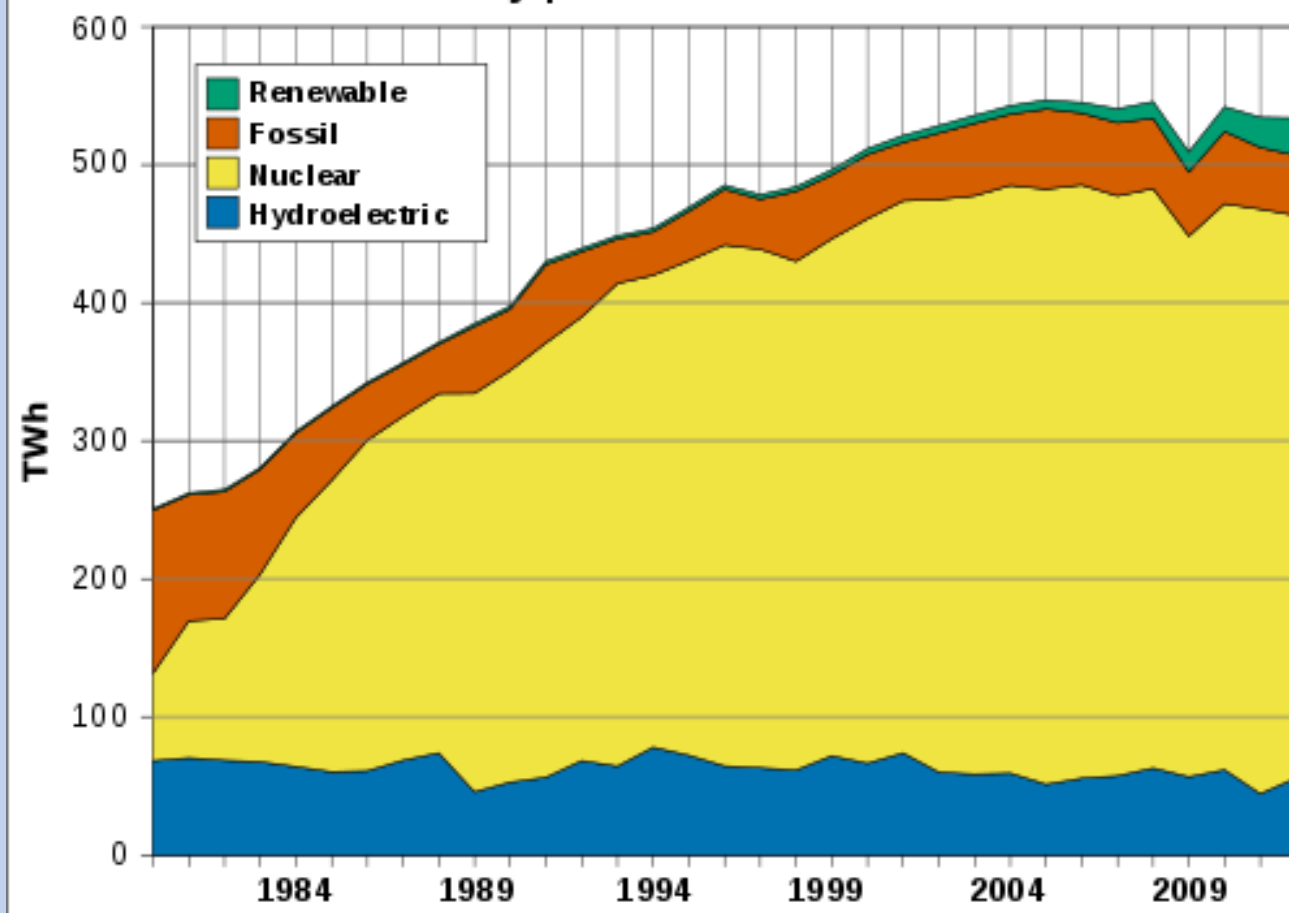
Other non-carbon sourced energy to consider?

- Non Carbon based: Nuclear
 - Fission: Very Controversial
 - Fusion: clean / difficult to achieve
 - Need national policy change on reprocessing
 - See Kerry video at 56 minutes for discussion and conclusions thereafter:

<https://www.youtube.com/watch?v=7so8GRCWA1k>



Electricity production in France



However – POTENTIAL big game changers in Energy and Carbon Dioxide Removal

1. Energy – from fusion
2. Mitigation in the form of carbon dioxide removal (CDR), agricultural changes and biofuels

1. Energy – from fusion

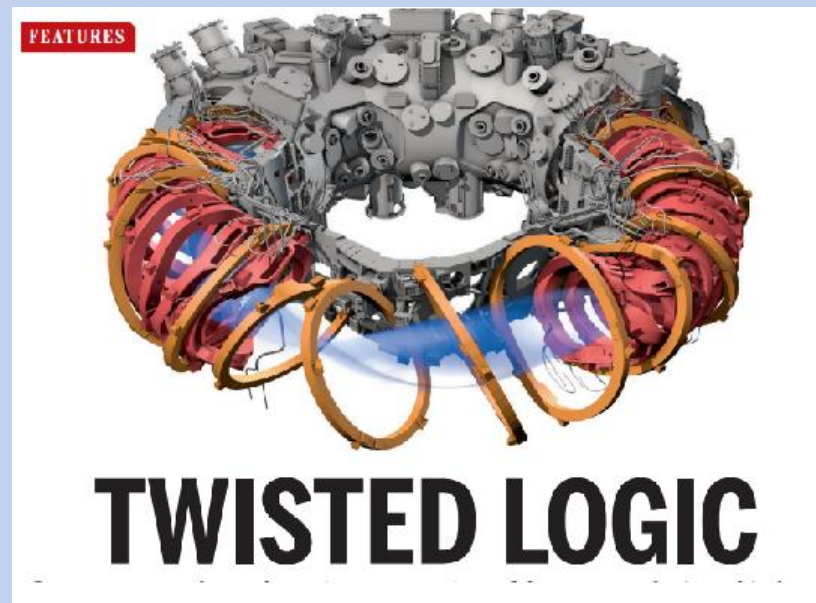
Lockheed Martin Compact Fusion breakthrough?

- <http://www.lockheedmartin.com/us/products/compact-fusion.html>
- <http://aviationweek.com/blog/high-hopes-can-compact-fusion-unlock-new-power-space-and-air-transport>
- <http://aviationweek.com/fusion-podcast>



1. More on Fusion:

Fusion article in Science: Twisted Logic [Science-2015-Clery-369-7](#)



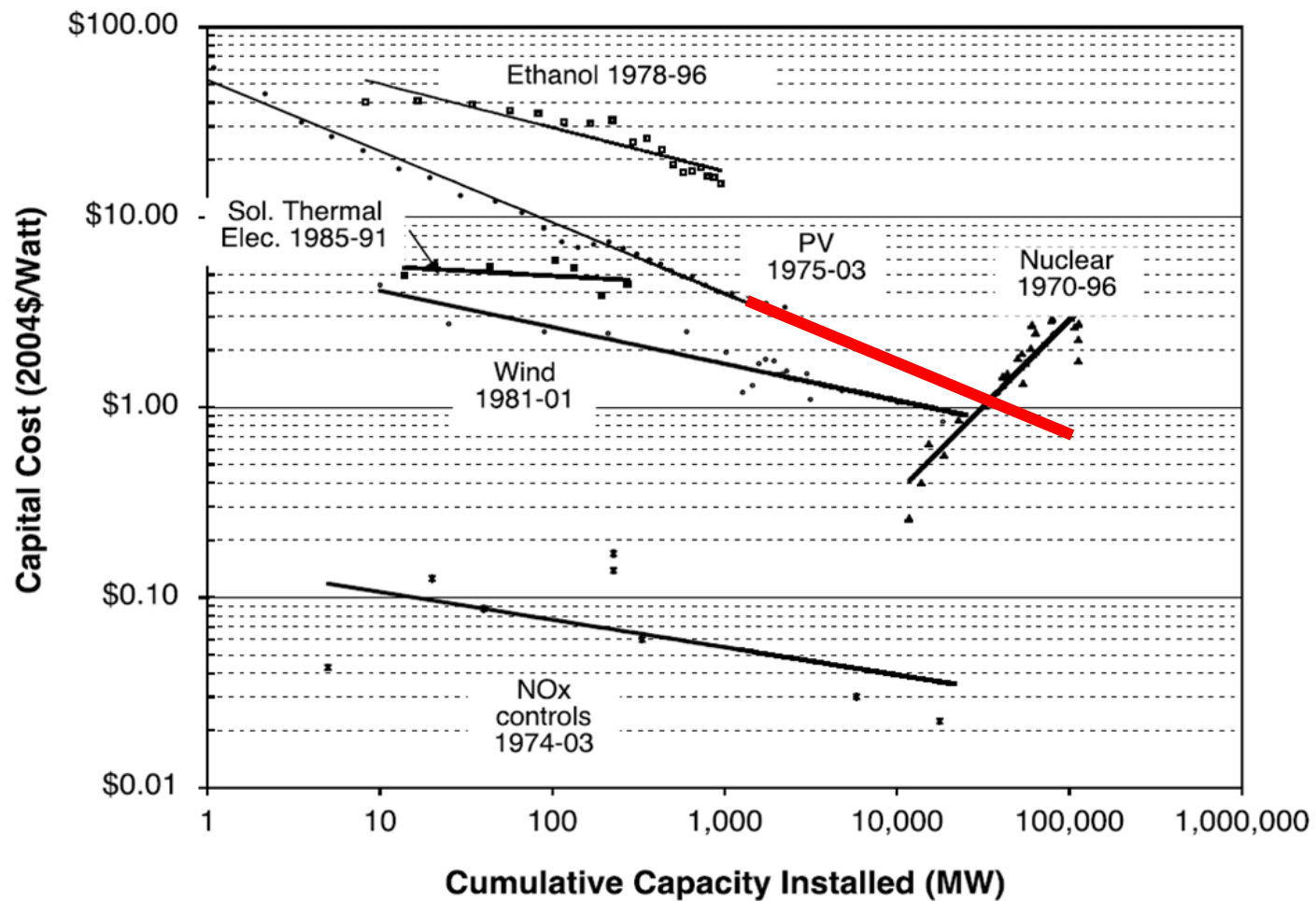
Used fuel has only exhausted part of the potential energy in the uranium pellets after five years in a reactor. Some countries, like France, reprocess and recycle nuclear fuel, extracting elements still capable of generating energy for use in new fuel. The U.S. currently does not, but several advanced reactor designs in development would be able to run on used fuel, actually using up waste and reducing the problem.

Nuclear energy could get us to the cleaner future that proponents of green energy want—without wrecking the global economy.

Will we ever get there?

- **Fusion reactors: Not what they're cracked up to be**
 - <http://thebulletin.org/fusion-reactors-not-what-they%E2%80%99re-cracked-be10699>
 - State not able to replicate Sun
 - State Tritium cannot be fully replenished
 - Huge parasitic power consumption
 - Some forms (deuterium-tritium) do have radiation damage and waste
 - Etc.

BUT
WE MAY NOT NEED IT?



<https://carbonremoval.files.wordpress.com/2014/12/energy-learning-curves.png>

014/12/energy-learning-curves.png

Storage options

- https://en.wikipedia.org/wiki/Energy_storage
- [2Methods](#)
 - [2.1Outline](#)
 - [2.2Mechanical storage](#)
 - [2.3Thermal storage](#)
 - [2.4Electrochemical](#)
 - [2.5Other chemical](#)
 - [2.6Electrical methods](#)
 - [2.7Interseasonal thermal storage](#)
 -

BACKUP OR GRID

- Balanced power is necessary: not too much, not too little
- SOLUTION – EITHER
 - Backup:
 - Battery,
 - Compressed Air,
 - Re-pumped Hydro,
 - H₂ (this can be 2-way for excess power or needed power)
 - Rubber Bands, etc.
 - Grid

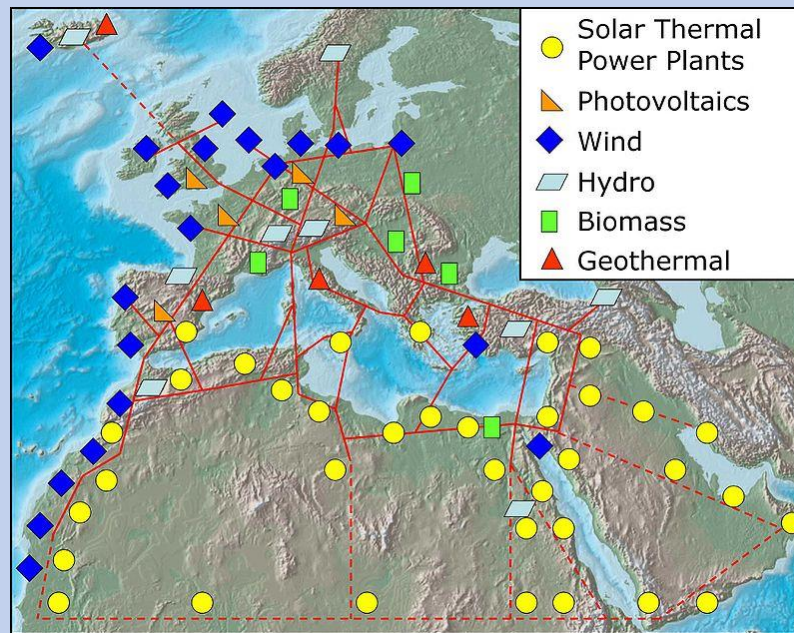
Grid: Big or Small?

- A case for small?
- <http://www.wbur.org/bostonomix/2017/04/19/microgrid-joint-base-cape-cod>

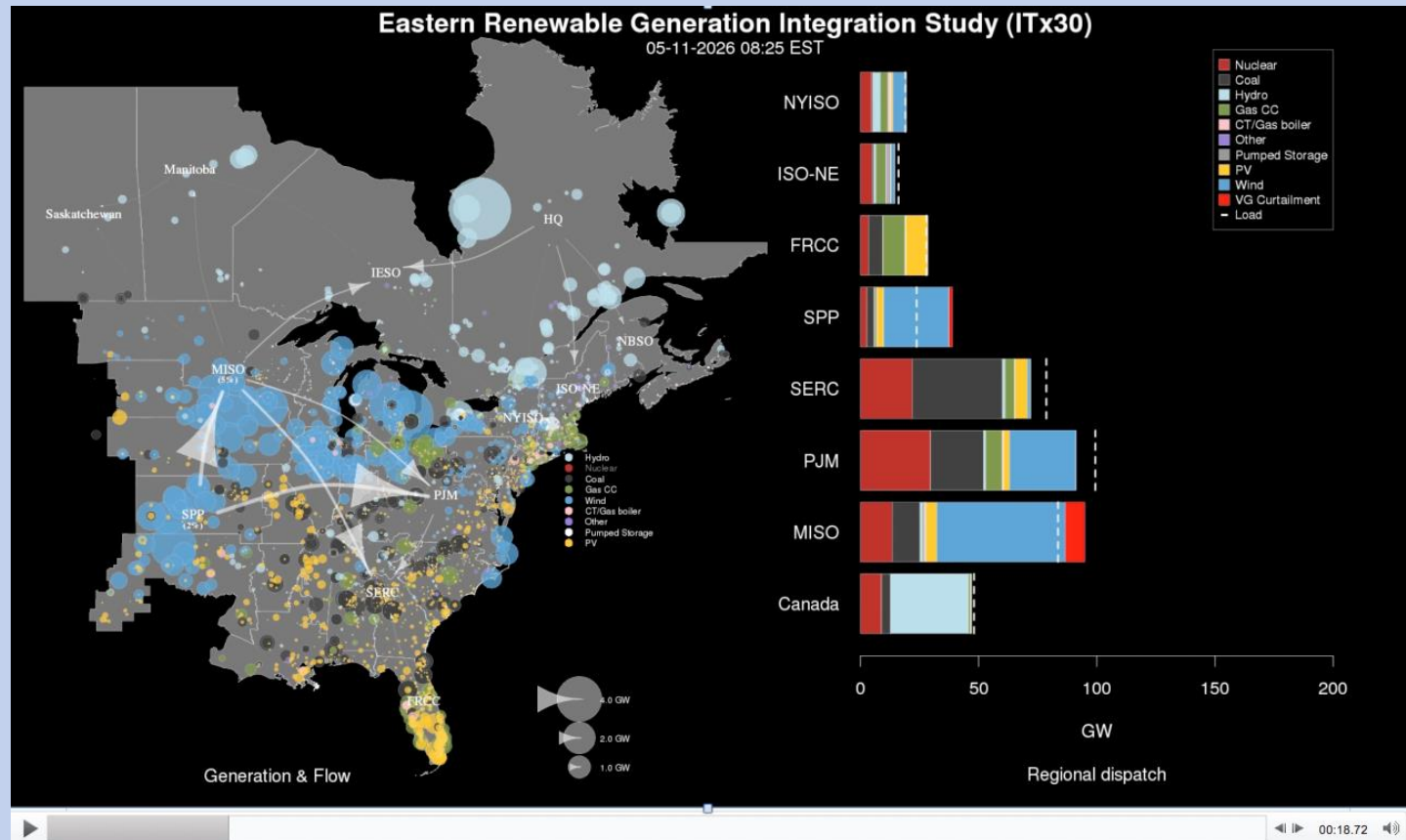
Grid: Big or Small?

- Case for super-grid:

https://en.wikipedia.org/wiki/Super_grid



Click on next slide for simulation



Click on slide for ERGIS

Visualization



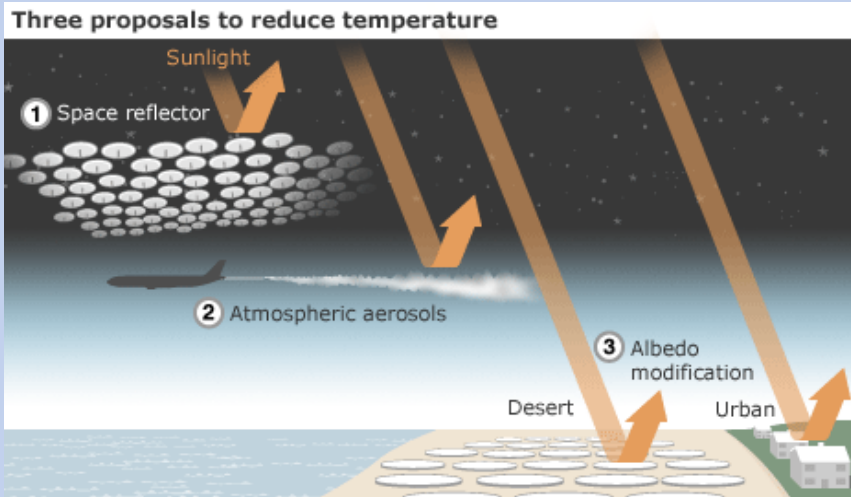
EASTERN RENEWABLE GENERATION INTEGRATION STUDY

GENERATION, REGIONAL FLOWS, & DISPATCH
ITx30

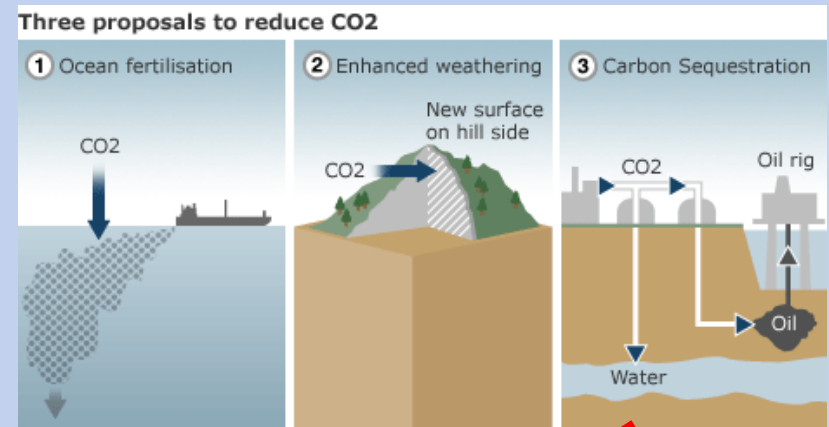
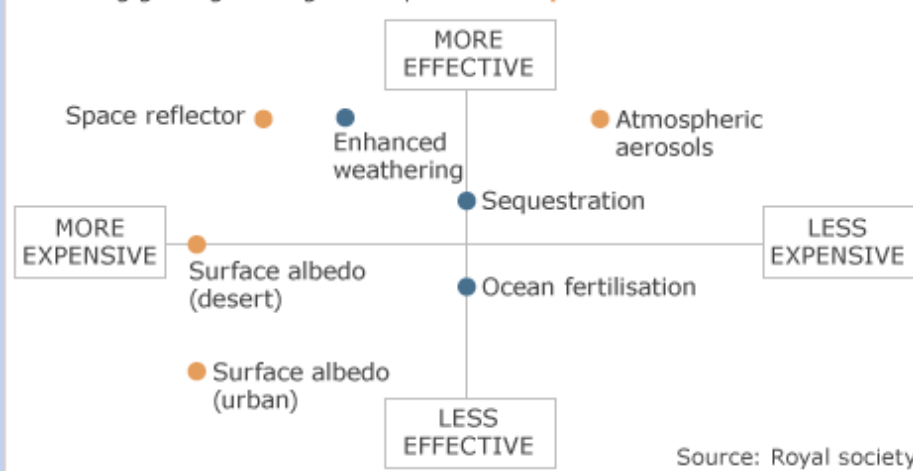
MAY 11 - MAY 13, 2026
HIGH VARIABLE GENERATION

Geoengineering

Solar Radiation Management vs. Carbon dioxide Removal (SRM VS. CDR)



Which is the best way to control climate change
Evaluating geoengineering techniques for **temperature** and **carbon**



Biochar & Beccs

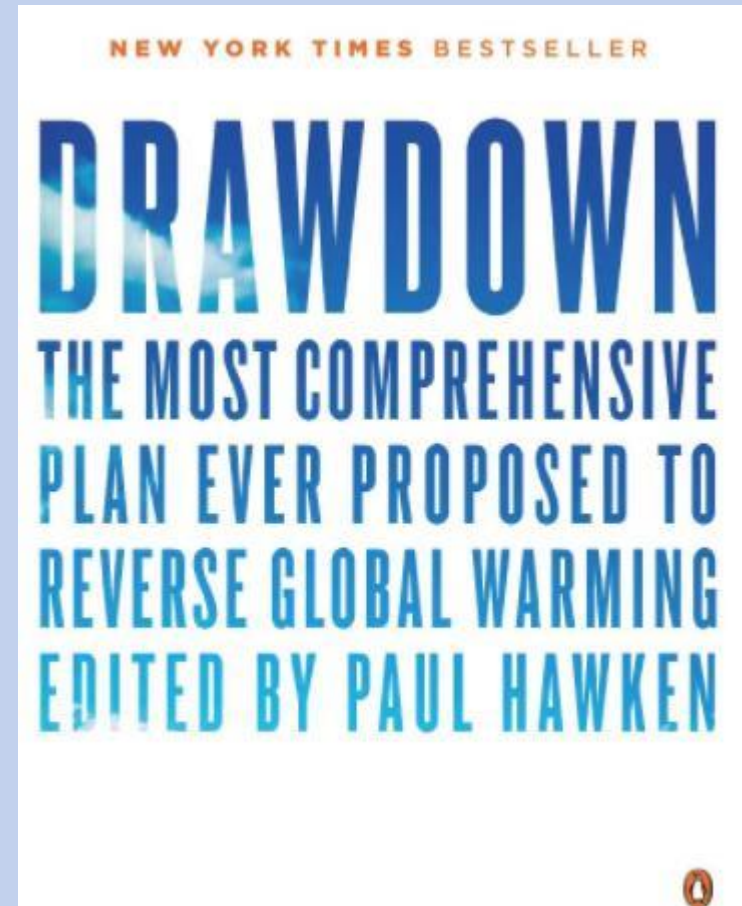
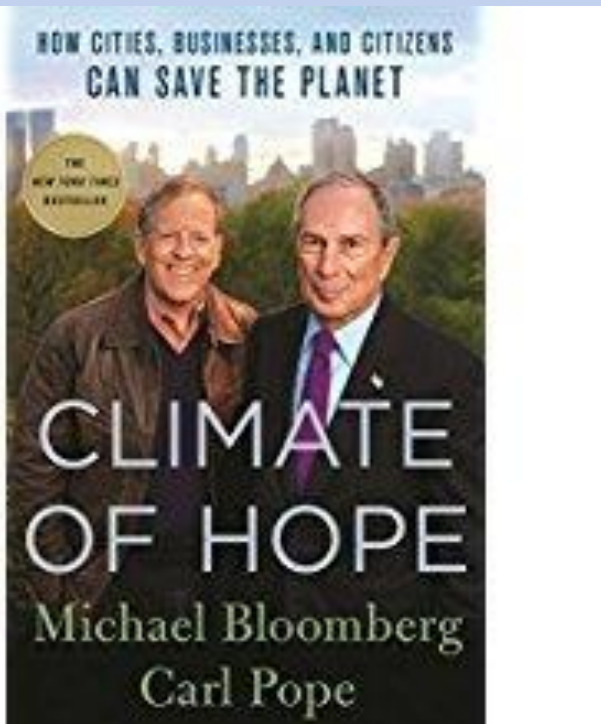
- <https://en.wikipedia.org/wiki/Biochar>
- https://en.wikipedia.org/wiki/Bio-energy_with_carbon_capture_and_storage

Royal Society

Additional

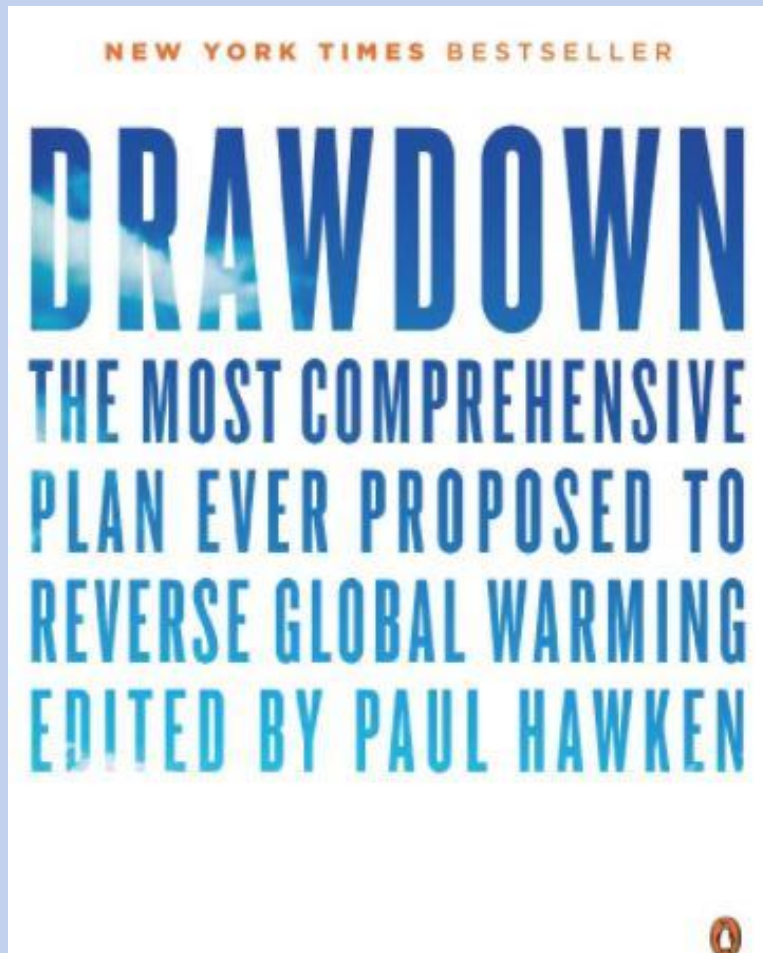
- **SRM – Solar Radiation Management**
 - Cloud Brightening to increase Earth's Albedo (reflectivity) also investigated
- **CDR – Carbon Dioxide Removal (carbon negativity)**
 - Ocean fertilization with Iron to create algal blooms that sink to the sea floor:
 - https://en.wikipedia.org/wiki/Ocean_fertilization
 - Enhanced weathering: taking unstable mantle minerals, particularly Olivine to lock up Carbon
https://en.wikipedia.org/wiki/Enhanced_weathering
 - Carbon Sequestration often ignores the potential of Biochar
 - Carbon Sequestration synonymous with Carbon Negativity

- READ:
Climate of Hope – Solutions
Drawdown – and associated web
pages



Drawdown

<http://www.drawdown.org/solutions-summary-by-rank>



- Drawdown video: 60 minutes with Paul Hawken: <https://youtu.be/4XrFnK1RrLE>

Summary of Solutions by Overall Rank

- <http://www.drawdown.org/solutions-summary-by-rank>

Rank	Solution	Sector	TOTAL ATMOSPHERIC CO ₂ -EQ REDUCTION (GT)	NET COST (BILLIONS US \$)	SAVINGS (BILLIONS US \$)
1	Refrigerant Management	Materials	89.74	N/A	\$-902.77
2	Wind Turbines (Onshore)	Electricity Generation	84.60	\$1,225.37	\$7,425.00
3	Reduced Food Waste	Food	70.53	N/A	N/A
4	Plant-Rich Diet	Food	66.11	N/A	N/A
5	Tropical Forests	Land Use	61.23	N/A	N/A
6	Educating Girls	Women and Girls	59.60	N/A	N/A
7	Family Planning	Women and Girls	59.60	N/A	N/A
8	Solar Farms	Electricity Generation	36.90	\$-80.60	\$5,023.84
9	Silvopasture	Food	31.19	\$41.59	\$699.37
10	Rooftop Solar	Electricity Generation	24.60	\$453.14	\$3,457.63
11	Regenerative Agriculture	Food	23.15	\$57.22	\$1,928.10
12	Temperate Forests	Land Use	22.61	N/A	N/A
13	Peatlands	Land Use	21.57	N/A	N/A
14	Tropical Staple Trees	Food	20.19	\$120.07	\$626.97
15	Afforestation	Land Use	18.06	\$29.44	\$392.33
16	Conservation Agriculture	Food	17.35	\$37.53	\$2,119.07
17	Tree Intercropping	Food	17.20	\$146.99	\$22.10
18	Geothermal	Electricity Generation	16.60	\$-155.48	\$1,024.34
19	Managed Grazing	Food	16.34	\$50.48	\$735.27
20	Nuclear	Electricity Generation	16.09	\$0.88	\$1,713.40

Summary of Solutions by Overall Rank

- <http://www.drawdown.org/solutions-summary-by-rank>

21	Clean Cookstoves	Food	15.81	\$72.16	\$166.28
22	Wind Turbines (Offshore)	Electricity Generation	14.10	\$572.40	\$274.57
23	Farmland Restoration	Food	14.08	\$72.24	\$1,342.47
24	Improved Rice Cultivation	Food	11.34	N/A	\$519.06
25	Concentrated Solar	Electricity Generation	10.90	\$1,319.70	\$413.85
26	Electric Vehicles	Transport	10.80	\$14,148.00	\$9,726.40
27	District Heating	Buildings and Cities	9.38	\$457.10	\$3,543.50
28	Multistrata Agroforestry	Food	9.28	\$26.76	\$709.75
29	Wave and Tidal	Electricity Generation	9.20	\$411.84	\$-1,004.70
30	Methane Digesters (Large)	Electricity Generation	8.40	\$201.41	\$148.83
31	Insulation	Buildings and Cities	8.27	\$3,655.92	\$2,513.33
32	Ships	Transport	7.87	\$915.93	\$424.38
33	LED Lighting (Household)	Buildings and Cities	7.81	\$323.52	\$1,729.54
34	Biomass	Electricity Generation	7.50	\$402.31	\$519.35
35	Bamboo	Land Use	7.22	\$23.79	\$264.80
36	Alternative Cement	Materials	6.69	\$-273.90	N/A
37	Mass Transit	Transport	6.57	N/A	\$2,379.73
38	Forest Protection	Land Use	6.20	N/A	N/A
39	Indigenous Peoples' Land Management	Land Use	6.19	N/A	N/A
40	Trucks	Transport	6.18	\$543.54	\$2,781.63

Summary of Solutions by Overall Rank

- <http://www.drawdown.org/solutions-summary-by-rank>

41	Solar Water	Electricity Generation	6.08	\$2.99	\$773.65
42	Heat Pumps	Buildings and Cities	5.20	\$118.71	\$1,546.66
43	Airplanes	Transport	5.05	\$662.42	\$3,187.80
44	LED Lighting (Commercial)	Buildings and Cities	5.04	\$-205.05	\$1,089.63
45	Building Automation	Buildings and Cities	4.62	\$68.12	\$880.55
46	Water Saving - Home	Materials	4.61	\$72.44	\$1,800.12
47	Bioplastic	Materials	4.30	\$19.15	N/A
48	In-Stream Hydro	Electricity Generation	4.00	\$202.53	\$568.36
49	Cars	Transport	4.00	\$-598.69	\$1,761.72
50	Cogeneration	Electricity Generation	3.97	\$279.25	\$566.93
51	Perennial Biomass	Land Use	3.33	\$77.94	\$541.89
52	Coastal Wetlands	Land Use	3.19	N/A	N/A
53	System of Rice Intensification	Food	3.13	N/A	\$677.83
54	Walkable Cities	Buildings and Cities	2.92	N/A	\$3,278.24
55	Household Recycling	Materials	2.77	\$366.92	\$71.13
56	Industrial Recycling	Materials	2.77	\$366.92	\$71.13
57	Smart Thermostats	Buildings and Cities	2.62	\$74.16	\$640.10
58	Landfill Methane	Buildings and Cities	2.50	\$-1.82	\$67.57
59	Bike Infrastructure	Buildings and Cities	2.31	\$-2,026.97	\$400.47
60	Composting	Food	2.28	\$-63.72	\$-60.82

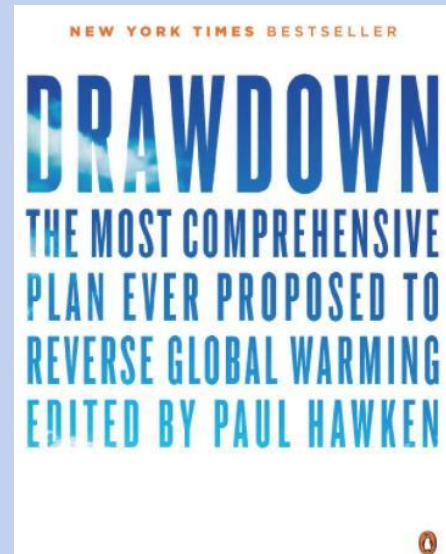
Summary of Solutions by Overall Rank

- <http://www.drawdown.org/solutions-summary-by-rank>

61	Smart Glass	Buildings and Cities	2.19	\$932.30	\$325.10
62	Women Smallholders	Women and Girls	2.06	N/A	\$87.60
63	Telepresence	Transport	1.99	\$127.72	\$1,310.59
64	Methane Digesters (Small)	Electricity Generation	1.90	\$15.50	\$13.90
65	Nutrient Management	Food	1.81	N/A	\$102.32
66	High-speed Rail	Transport	1.52	\$1,038.42	\$368.10
67	Farmland Irrigation	Food	1.33	\$216.16	\$429.67
68	Waste-to-Energy	Electricity Generation	1.10	\$36.00	\$19.82
69	Electric Bikes	Transport	0.96	\$106.75	\$226.07
70	Recycled Paper	Materials	0.90	\$573.48	N/A
71	Water Distribution	Buildings and Cities	0.87	\$137.37	\$903.11
72	Biochar	Food	0.81	N/A	N/A
73	Green Roofs	Buildings and Cities	0.77	\$1,393.29	\$988.46
74	Trains	Transport	0.52	\$808.64	\$313.86
75	Ridesharing	Transport	0.32	N/A	\$185.56
76	Micro Wind	Electricity Generation	0.20	\$36.12	\$19.90
77	Energy Storage (Distributed)	Electricity Generation	N/A	N/A	N/A
77	Energy Storage (Utilities)	Electricity Generation	N/A	N/A	N/A
77	Grid Flexibility	Electricity Generation	N/A	N/A	N/A
78	Microgrids	Electricity Generation	N/A	N/A	N/A
79	Net Zero Buildings	Buildings and Cities	N/A	N/A	N/A
80	Retrofitting	Buildings and Cities	N/A	N/A	N/A
			1050.99	\$29,636.40	\$73,874.44

Colorado Renewable Energy Society – YouTube of selected talks:

- Drawdown CRES YouTube video: Drawdown: Ways out of the Climate Crisis. Paul Hawken, Chip Comins: <https://youtu.be/4XrFnK1RrLE>
- Other Drawdown links:
 - <http://www.drawdown.org/>
 - <http://www.drawdown.org/solutions>
 - <https://www.facebook.com/projectdrawdown>
- <http://www.drawdown.org/solutions-summary-by-rank>



OLLI Courses to Consider

- Phil Nelson – Extreme Weather
- Alec Tsoucatos – Steady state economics – when more is not enough
- Great Decision – Peter Lohaus & Jeff Pederson