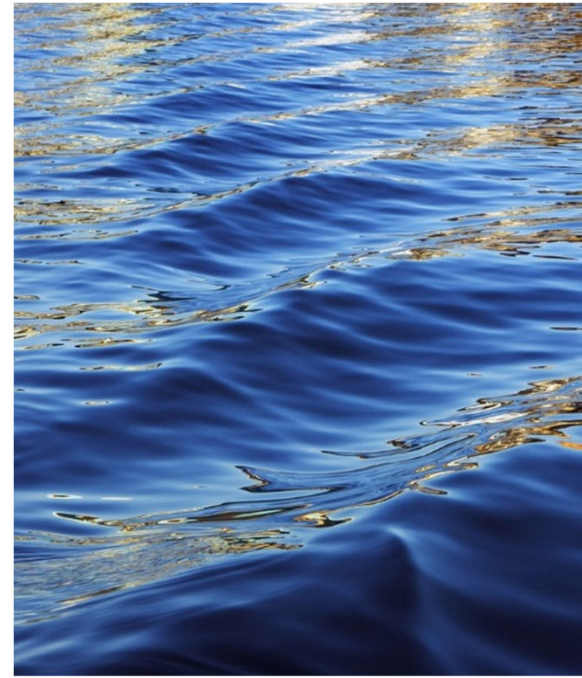




# Invention and Innovation in Biosolids

Bill Toffey, Effluential Synergies LLC  
May 11, 2023  
2023 VWEA Education Seminar:  
Advancements and Challenges in Biosolids



# The Climate: How Are We Doing?



**Our Final Warning: Six Degrees of Climate Emergency**  
by Mark Lynas, Richard Burnip, et al.

★★★★☆ - 225

Audible Audiobook

1 Credit

Available instantly

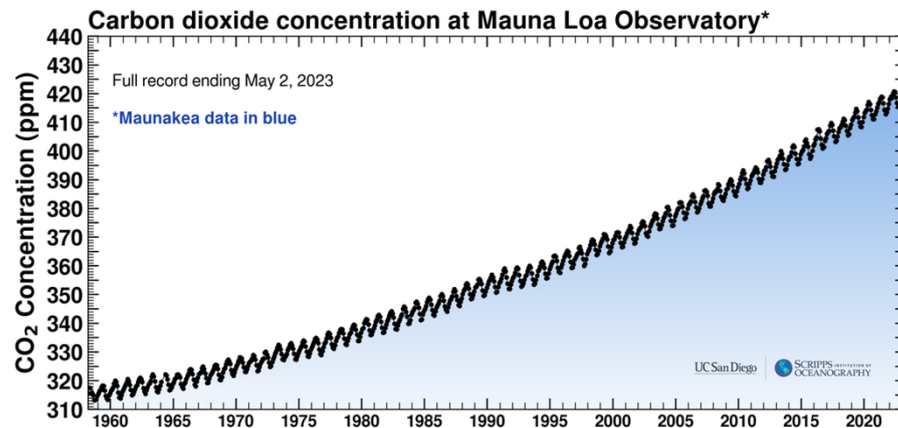
Kindle

\$17<sup>99</sup>

## CO<sub>2</sub> In the Atmosphere

Listen on YouTube to: [Dave Borlace](#)

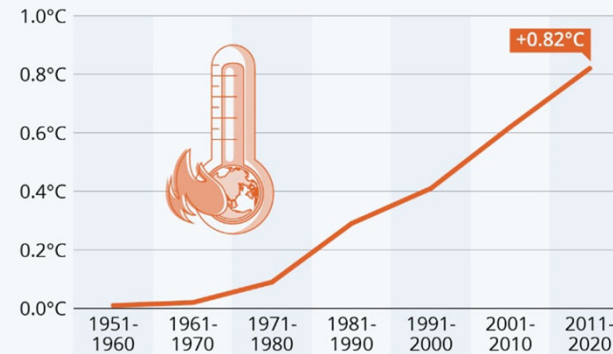
- [Latest UN report on Climate Change. How we doin'?](#)



## Global Surface Temperatures

### Each Decade Hotter Than the Last

Temperature changes each decade relative to the 20<sup>th</sup> century average (in degrees Celsius)



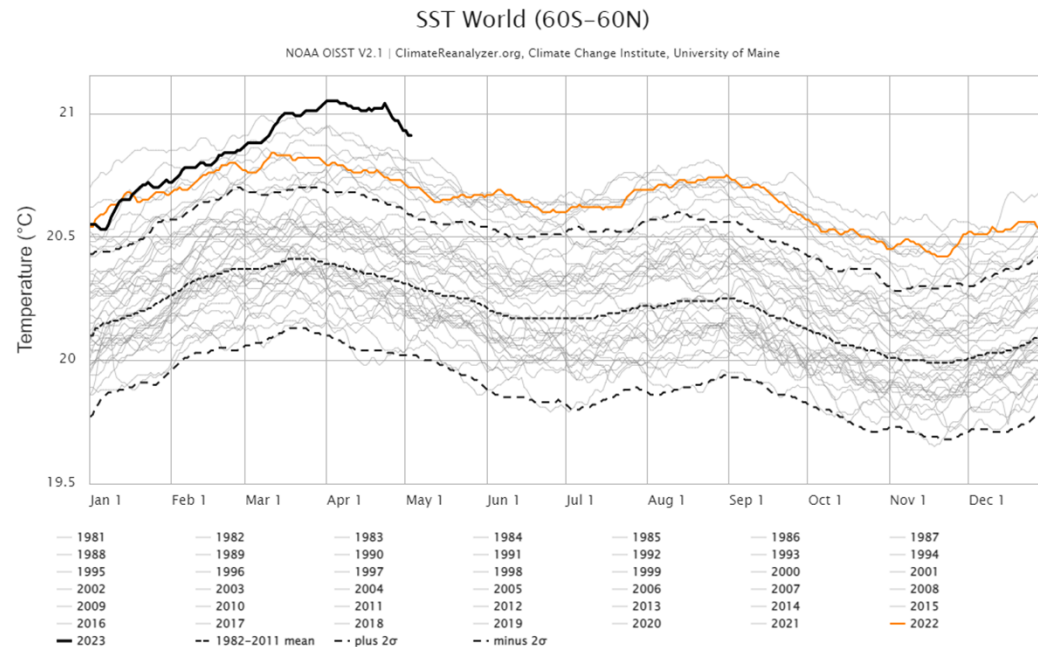
Source: NOAA



statista

# “This one could be a Monster”

A huge El Nino, adding a lot of additional atmospheric heating, pushing the jet streams over the US that can create floods in SE US and CA, droughts in parts of Africa and SE Asia.



# Carbon Dioxide Removal: An Immense Investment

- Massive new National investments in carbon dioxide removal are in the future
- [Facing brutal climate math, US bets billions on direct air capture](#)
  - "This industry is fragile right now, but all the arrows are lined up in the right direction.
  - Across a range of technical processes, it can cost more than \$1,000 to capture and lock away a ton of planet-warming carbon dioxide, yet the U.S. government has targeted a \$100 a ton price tag.
  - Carbon Capture told Reuters it expects to hit \$250 a ton by 2030 and \$150 a ton within a decade."
- IMAGINE: If biosolids management systems were compensated \$1000 per Ton CO<sub>2</sub>e
- IMAGINE: If municipal wastewater facilities provided meaningful resources for adaptation to climate change and for building resilience to increased risks of heat, drought and storms.
- IMAGINE: If you, too, were a "Decarb Bro?"
  - [Do You Even Decarbonize, Bro?](#) "We are against doomerism," "The environmental movement has been traditionally seen as altruistic," said Kyri Baker, an assistant professor of engineering at the University of Colorado and a self-described decarb bro. "It was about giving away stuff and making sacrifices." The decarb bro flips those associations on their heads, rejecting pure doom and putting faith in business innovation and government spending to fight climate change
- IMAGINE: If you had the insight to forecast the innovative technologies you need to respond to the urgent challenges of climate change

7 minute read · April 18, 2023 3:45 PM EDT · Last updated 15 days ago  
**Facing brutal climate math, US bets billions on direct air capture**

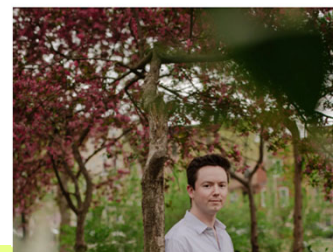
By Susanna Twizale · Valerie Volcovici · Simon Jessop · and Peter Henderson ·



## *Do You Even Decarbonize, Bro?*

'Decarb bros' think the best way to combat climate change is to ditch the gloom of earlier environmentalism and focus on what new technology can do.

Give this article · Share · Bookmark



# Responding to Climate Change with Determined Innovation

Listen to the advice of:  
[Vaclav Smil](#):



Fellow of the Royal Society of Canada (Science Academy) and recipient of American Association for the Advancement of Science Award for Public Understanding of Science and Technology. Author of [How the World Really Works: The Science Behind How We Got Here and Where We're Going](#)

- [Newest Book: Invention and Innovation: A Brief History of Hype and Failure](#)
- He urged doing first things first, “satisfying water and food requirements... does not depend on any new spectacular inventions, but rather on determined innovation, ...of “desirable basics” doing away with micronutrient deficiency. ...(But) we will have to keep reckoning with repeated, and major, failures resulting from ... biases and irrational attachments to certain quests.”
- He urged “determined innovation” over “spectacular invention” to avoid hype and reduce failures.

# Responding to Climate Change without Stupid Mistakes



Listen to the advice of:  
[Sabine Hossenfelder](#)



Collective Stupidity -- How Can We Avoid It?

443K views • 1 month ago

 Sabine Hossenfelder

Correction to what I say at 11:53 -- I was referring to Milgram's famous experiments in which

CC



Intro | Emergent behaviour | Collective intelligence | Collective stupidity | What c

Hossenfelder has a PhD in physics, and her current work is mostly in the foundation of physics. She has written over 80 research papers on topics ranging from quantum gravity to particle physics, cosmology, astrophysics, statistical mechanics, and quantum foundations. She is also the presenter of the podcast: [Science without the Gobbledygook](#)

A recent podcast was [Collective Stupidity -- How Can We Avoid It?](#)

- In dealing with a complicated decision, first issue brought up may not be the most important. Invite people to share opinions and knowledge, but also have them step back and think, looking for them to choose inputs wisely and reminding them about possibility of egocentric bias. Be careful around obviously confident people, as they may amplify errors if they are allowed to step out first and dominate a group.



## Why I Worry About Stupidity and Hype

21 years attempting to manage odors and compost inventories at a municipally-owned, open-air, aerated static pile compost facility at "gateway" to Philadelphia from the airport, designed to process compost 24-7. 300,000 wet tons annually, having been funded with a 85% federal grants, designed by a world class engineering consultancy

*Wat. Sci. Tech.* Vol. 22, No. 12, pp. 107-116, 1990.  
Printed in Great Britain. All rights reserved.

### **LARGE-SCALE SEWAGE SLUDGE COMPOSTING: A CASE FOR MAINTAINING A DIVERSIFIED PROGRAM**

William E. Toffey

*Sludge Utilization Manager, Philadelphia Water Department,  
1101 Market Street, Philadelphia, PA 19107, USA*

# Choosing a “First Things First” Approach for Biosolids Technologies for Responding to Climate Change

## Eight things the world must do to avoid the worst of climate change

- Reduce methane
- stop deforestation
- restore degraded land
- change agriculture and way we eat
- install solar and wind
- energy efficiency
- stop burning coal
- 8<sup>th</sup>! **Put climate at the heart of all decision-making**
  - Does carbon footprint still matter?
  - Is energy self-sufficiency and efficiency the key?
  - Resiliency in face of increasing risks of storms and flooding is a central concern
  - Nutrient recovery is a key to future climate actions: carbon, nitrogen and phosphorus
  - Soil regeneration addresses multiple community risks from climate change

THE GOAL: How can we deploy technologies that put climate at the heart of our work, but make no stupid decisions and avoid hype and failure?

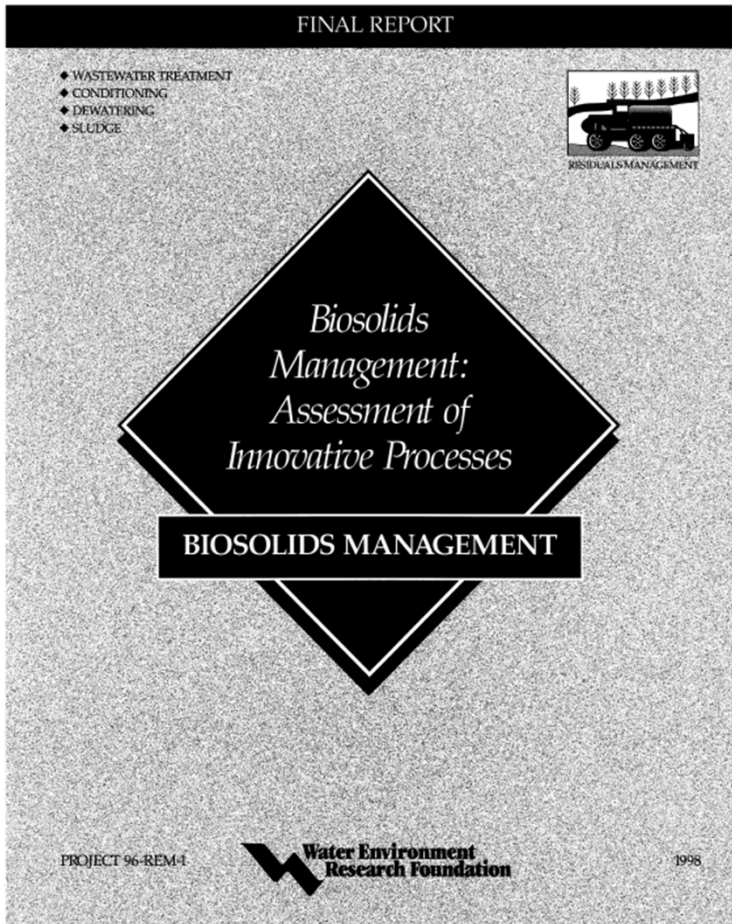
### Explainer

## Eight things the world must do to avoid the worst of climate change

Latest IPCC report highlights key measures countries must take to avoid climate catastrophe







## HOW TO EVALUATE BIOSOLIDS TECHNOLOGIES? 25 Years Ago WERF Showed the Way: Assessment of Innovative Processes

### 110 Technologies reviewed:

- ♦ Embryonic: They have been tested at a laboratory or bench scale only.
- ♦ Innovative: They have been tested at a demonstration scale or have some degree of initial use.
- ♦ Established: They have been applied at several full-scale operations.

# “Spectacular Invention” versus “Determined Innovation”

- Spectacular Invention?

- Sludge to Oil
- eBeam Irradiation
- Carver Greenfield
- Shockwave Plasma Process
- Minergy / Light Weight Aggregate

## EnerTech energy plant in Rialto closes

- eBeam irradiation will **de-stabilize** sludge solids

### The Carver-Greenfield Process:

Sustained Shockwave Plasma (SSP) Destruction of Sewage Sludge – A Rapid Oxidation Process 🛒

North Shore Sanitary District (NSSD) selected Minergy's GlassPack® system as the technology of choice for sustainable biosolids management at a Sludge Recycling Facility in Zion, Ill., U.S.A. NSSD's Sludge Recycling

- Determined Innovation?

- Multiple phase digestion processes (*TPAD, Dual Phase, Three Phase*)
- Multiple kinds of dewatering presses (*Screw Press, Rotary Press, Belt Press*)
- Different kinds of enclosed composting (*Windrow, Static Pile, Agitated Bed, Tunnel*)
- Biosolids dryers of many kinds (*Rotary, Paddle, Belt, Drum, Disc, Thin Film, Biodryer*)

# WERF Technologies 1998 and Today

## What Worked

- Digestion and Other Pathogen Treatment:
  - Temperature Phased Anaerobic Digestion
  - Two Stage Digestion
  - Aerobic Digestion
  - Autothermophilic Aerobic Digestion
  - Alkaline Stabilization
  - Bioset Process (sort of)
  - High Chlorine Oxidation (sort of)
- Dewatering:
  - Rotary Press
  - Screw Presses
  - Belt Press
  - Vertical Press
  - Centrifuges
- Drying:
  - Direct Dryers
  - Indirect Dryers
  - Drying Beds
  - Infrared Dryer (Sort of)
  - Flash Dryer (Sort of)
  - Thin Film Dryer (Sort of)

## What Didn't Catch On

- Digestion and Other Pathogen Treatment
- High Pressure Anaerobic Digestion
  - Pasteurization
  - Active Sludge Pasteurization
  - Advanced Alkaline Stabilization
  - Carver-Greenfield
  - Wet Air Oxidation
- Dewatering::
- Chamber Presses
  - Electroacoustic Dewatering
  - Electroosmotic Dewatering
  - Membrane Press
  - Vacuum Filtration
- Drying:
- Kinetic Dryer
  - Microwave Dryer
  - Filter Press with Drying (J-VAP)
  - Mechanical Freeze/Thaw
  - Fluidized Bed Dryer
  - Auger-assisted Drying Bed
  - DHV Drying
  - Quick Dry Beds (Deskin)

# FATE OF “EMBRYONIC” TECHNOLOGIES 1998

## Embryonic 1998, Established 2023

- Thermal Hydrolysis

## Embryonic 1998, Only Still Innovative in 2023

- Electrodewatering
- Supercritical Water Oxidation
- Sludge pyrolyzer
- Sludge gasification

## Embryonic 1998, Gone in 2023?

- Pulse Power
- Sirex Pulse Power
- Preheating
- KADY Process
- Acoustical cavitation
- Enzyme conditioning
- Microwave conditioning
- Chemical conditioning
- Centridry

# Non-oxidative Thermal Conversion Projects

## WERF 1998

- Sludge to Oil Processes (Energsludge, STORS, EnerTech)
- Gasification
- Cogasification (with coal)
- Electric Arc Gasification
- Gasification of Char from Pyrolysis
- Deep-shaft Wet Air Oxidation
- Microwave Gasification
- Sludge Pyrolyzer
- Supercritical Water Oxidation
- EcoTechnology
- Vertad

## 2023 Projects

- CHAR Technologies
- Aries Clean Energy
- BioForceTech Corporation
- EarthCare, LLC
- EcoRemedy
- SoMax HTC
- OxyPower HTC
- Biowaste Pyrolysis Solutions
- KORE Infrastructure
- Genifuel Corporation
- Heartland Technology
- 374Water
- Saratoga Biochar Solutions

# INTRODUCED AFTER 1998

- Thermochemical Hydrolysis - Lystek and Pondus
- New Dryers – Solar Dryers and Belt Dryer
- New Presses – Bucher Press
- Phosphorus Extraction/Recovery -
  - Ostara/NuReSys/CNPAirprex (2023)



# Lessons Learned from 25 Years of Invention and Innovation

## Big Picture: How Are We Doin'?

- Much space for innovation of fundamental technologies
- Solids reduction central to many technologies
- Efficient energy and resource use a lesser factor
- Thermal processing still awaiting a breakthrough
- After Part 503, innovation leaps, but then lags without keen regulatory or economic drivers
- Consumer response not assessed

## What We Need Most in Time of Climate Change

- Water, nutrient and carbon recycling
- Products of value to our communities
- Operational Improvements and automation in light of workforce issues
- Resilience, reliability, flexibility, energy efficiency to deal with risks imposed by extreme weather conditions

# Put Climate at the Center of Biosolids Management

- Look to the long haul – say 30 years out -- and don't use past as guide as stunning changes are in store for all parts of world

## Sea Level Rise Impacts on Wastewater Treatment Systems Along the U.S. Coasts

Michelle A. Hummel<sup>1</sup> , Matthew S. Berry<sup>2</sup> , and Mark T. Stacey<sup>1</sup> 

- Put PFAS in its place.

- Learn from long history of concerns for “heavy metals,” dioxin, PCBs, PBDEs
- Consider evolving understanding of “Source Apportionment”
- Forecast source control over the next 25 years
- Await the results of influent and biosolids sampling leading to deploy of new risk assessment

Bloom Soil used for tree cultivation

- Reflect on the potential for Smil's “hype and failure” and Hossenfelder's “collective stupidity”
- Respond to the opportunity to deploy biosolids in service of community resilience in face of climate change.

### Source apportionment of serum PFASs in two highly exposed communities

Dylan J. Wallis <sup>a,\*</sup>, Kelsey E. Barton <sup>b,1</sup>, Detlef R.U. Knappe <sup>c,f</sup>, Nadine Kotlarz <sup>c,f</sup>,  
Carrie A. McDonough <sup>e</sup>, Christopher P. Higgins <sup>d</sup>, Jane A. Hoppin <sup>a,f</sup>, John L. Adgate <sup>b</sup>

<sup>a</sup> Department of Biological Sciences, North Carolina State University, Raleigh, NC, USA

<sup>b</sup> Department of Environmental and Occupational Health, Colorado School of Public Health, University of Colorado, Anschutz Medical Campus, Aurora, CO, USA

<sup>c</sup> Department of Civil, Environmental, and Environmental Engineering, North Carolina State University, Raleigh, NC 27695-7000, USA





# Adapting to Climate Challenges

## Upgrade Biosolids Infrastructure for Resilience

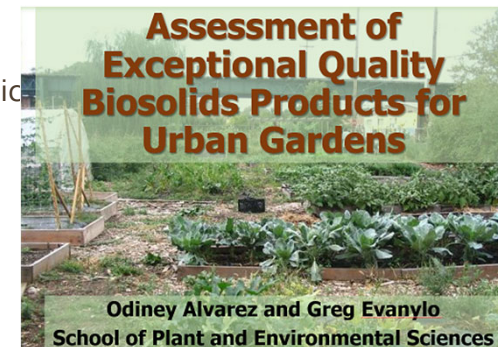
- Carbon Footprint and GHG at this stage is distraction and facetious, because no historical precedent for pace of change and increased risk.
- Goals include Energy Autarky, Reliable and Repairable Equipment, Flood protection, Heat adaptation.

## Further Develop High Performance Digestion and Conditioning

- Microbial Hydrolysis Process with *Caldicellulosiruptor bescii* (*C. bescii*), a hyper-thermophilic bacterium *Cellulosdisruptor besci*, to increase volatile solids reduction
- Post anaerobic digestion with aerobic treatment to improve dewaterability and odor quali
- Solids conditioning for effective dewatering (e.g., P removal, aerobic treatment and CO2 seems promising)

## Use Climate-Smart Biosolids Technologies

- Avoid the Spectacular Invention and embrace Determined Innovation with the goal to strengthen technologies of proven performance in making products, dependably and efficiently, such as digestion and composting, expand automation for reduced workplace risks.



# Embraceable Technologies for Climate Resilience

## Contribute Biosolids to Build Community Resilience

- Use biosolids products, rich in carbon, nitrogen and phosphorus, for local soils
- Install green infrastructure for mitigating storm runoff
- Develop soil blends suited for urban reforestation to address heat islands
- Provide biosolids products for urban agriculture and heat tolerant landscapes

## Increase Nutrient and Carbon Recovery

- P Extraction as struvite for marketable fertilizer should be expanded
- Select new technologies for greater ammonia and organic C capture

## Composting for Products Suitable for Urban Markets

- Enclosed ASP and Enclosed Agitated Tunnel has long track record of operational success
- Accommodates other organic wastes from the community
- Odor control is effective for siting in urban areas
- Market Development has been strong wherever compost has been produced
- Composting of TH and high performance digested biosolids produces supreme products

