Net-zero emissions food systems

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Extended Introductions

1. Who are you? (What do you prefer to be called?)

2. Where are you based / What are you working on (briefly)?

3. What meal reminds you of home? (Whatever that means to you!)
Imagine a world in which energy systems and industry have all been decarbonized...the remaining emissions (25-30% of current) come from food systems, whose drivers and dynamics are fundamentally different.
Net-zero emissions energy systems

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BACKGROUND: Net emissions of CO₂ by human activities—including not only energy services and industrial production but also land use and agriculture—must approach zero in order to stabilize global mean temperature. Energy services such as light-duty transportation, heating, cooling, and lighting may be relatively straightforward to decarbonize by electrifying and generating electricity from variable renewable energy sources (such as wind and solar) and dispatchable (“on-demand”) nonrenewable sources (including nuclear power and fossil fuels with carbon capture and storage). However, other energy services essential to modern civilization entail emissions that are likely to be more difficult to fully eliminate. These difficult-to-decarbonize energy services include aviation, long-distance transport, and shipping; production of cement and steel; structural materials; and essential energy services (2016)

Corrected 29 June 2018. See full text.

RESEARCH

ENERGY

Net-zero emissions energy systems

Search, development, demonstration, and deployment. It may take decades to research, develop, and deploy these new technologies.

ADVANCES: A successful transition to a future net-zero emissions energy system is likely to depend on vast amounts of inexpensive, emissions-free electricity; mechanisms to quickly and cheaply balance large and uncertain time-varying differences between demand and electricity generation; electrified substitutes for most fuel-using devices; alternative materials and manufacturing processes for structural materials; and carbon-neutral fuels for the parts of the economy that are not easily electrified. Recycling and removal of carbon from the atmosphere (carbon management) is also likely to be an important activity of any net-zero emissions energy system. The specific technologies that will be favored in future marketplaces are largely uncertain, but only a finite number of technology choices exist today for each functional role. To take appropriate actions in the near term, it is imperative to clearly identify desired end points. To achieve a robust, reliable, and affordable net-zero emissions energy system later this century, efforts to research, develop, demonstrate, and deploy those candidate technologies must start now.

OUTLOOK: Combinations of known technologies could eliminate emissions related to all essential energy services and processes, but substantial increases in costs are an immediate barrier to avoiding emissions in each category. In some cases, innovation and deployment can be expected to reduce costs and create new options. More rapid changes may depend on coordinating operations across energy and industry sectors, which could help boost utilization rates of capital-intensive assets, but this will require overcoming institutional and organizational challenges in order to create.

ON OUR WEBSITE

Read the full article at http://dx.doi.org/10.1126/science.aao7533

B. Demand for structural materials
C. Demand for aviation, long-distance transport, and shipping
D. Ammonia plant
H. Direct solar fuels
C₂H₅O₂
I. Biomass gas/liquids
J. Direct air capture
K. Hydrogen/pumped storage
L. Electrolysis
M. Natural gas/biomass/syngas w/ capture
N. Nuclear
O. Solar
P. Hydrogen/synthetic gas
Q. Other centralized storage (e.g., thermal, batteries)
R. Compressed air energy storage

NH₃

Davis et al., Science, 2018

G. Cement and steel w/ capture
E. Geologic storage
F. Synthetic gas/liquids
What emissions are we talking about?

**Land-use change:**
5 Gt CO2 in 2017, [9%] of human GHG emissions

**Land management:**
7 Gt CO2e in 2017, [13%] of human GHG emissions

**Energy for food** (on-farm, processing, transport, etc.):
5 Gt CO2 in 2017, [8%] of human GHG emissions

**End of life/landfill:**
2 Gt CO2e in 2017, [3%] of human GHG emissions

DeAngelo et al., *unpublished*
Models suggest land will be net-negative to help offset difficult energy and industry sources

DeAngelo et al., Nature Comm, 2021
Meanwhile, land-use emissions are >0.5 tCO$_2$e everywhere

Hong et al., *Nature*, 2021
Taxonomy of options?

- These roughly map to the thematic bins for our workshop sessions.
- Each session will have a few short talks as overview, but focus is on the group discussion.
Deforestation / Keeping C in the Ground - [Jen]

Land needs and assumptions. What might land use look like in a food secure and climate-stable world? (What happens to carbon and water cycles as earth warms?)

Dynamics deforestation and land use change. Regional focus in key forests.

Freezing food’s footprint. What works? What doesn’t? What coordinated efforts (and science) are needed?
Food Demand - [Roz]

**Drivers:** How do changes in population, income, prices, and urbanization alter the demand for different food groups (grains and starches, fats and oils, protein)?

**Levers:** What market or policy levers exist to shift demand toward low-emission foods, and what are the implications for food security and nutrition?

**A New Frontier:** How scalable is the adoption of alternative fats and meats in the next few decades?
Behavior - [Julianne]

Drivers. What are the primary drivers of food consumption choices/tastes?

Levers and nudges. What behavioral levers have worked to change food consumption choices?

Targeted action. What dietary categories and/or consumer demographics seem most promising for implementing behavioral levers?
Yield gains. What’s possible and how?

Reducing crop emissions. Genetic engineering, plant breeding, optimizing inputs.

Suppression and removals. Livestock management, soil amendments, agricultural carbon removal, circular nitrogen.
What are our collective objectives?

1. Build community of creative, ambitious people who want to solve this issue.

2. Frame the problem together (review paper) and identify new short-run projects / collaborations to fill important knowledge gaps.

1. Articulate bigger gaps / longer-run issues, and start seeding teams to work on those.
Group Documents

1. Agenda & Participant List
2. Repository of Presentations
3. Active Discussion Notes
4. Reference List
5. Paper / Project List
6. Big Ideas List