The End of Fossil Fuels

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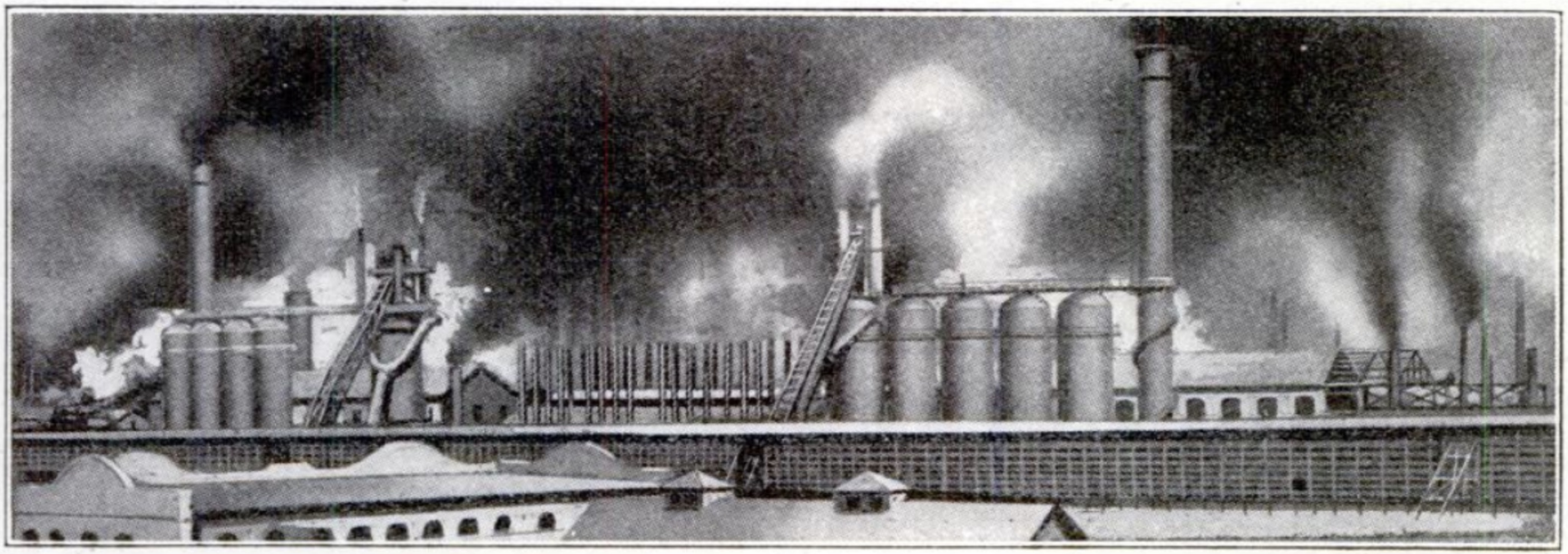
Big Idea

Save the planet for future generations though preventing the emission of further greenhouse gases, in particular carbon dioxide

Popular Mechanics 1912, pages 339-342



The furnaces of the world are now burning about 2,000,000,000 tons of coal a year. When this is burned, uniting with oxygen, it adds about 7,000,000,000 tons of carbon dioxide to the atmosphere yearly. This tends to make the air a more effective blanket for the earth and to raise its temperature. The effect may be considerable in a few centuries.

Big Idea

Save the planet for future generations though preventing the emission of further greenhouse gases, in particular carbon dioxide

- This project would enable the U.S. goal of achieving net-zero GHG emissions by 2050.
- See the White House report https://www.whitehouse.gov/wp-content/uploads/2021/10/US-Long-Term-Strategy.pdf
- The U.S. Department of Energy has the goal of decarbonizing energy production by 2050. See https://www.energy.gov/eere/doe-industrial-decarbonization-roadmap

Reasoning and Justification

- We have overstepped the planetary boundaries and treated the planet without regard for the consequences.
- Scientists have long ago raised the alarm but failed to motivate decision makers to prepare for action. It is time for science to speak up and push for a moon-shot program of decarbonization.

Goal Areas

- Accelerate clean energy innovations
- Increase climate change resilience
- Promote sustainable practices

Broader Impacts

- Dramatic reduction in carbon emissions
- Significant improvements in quality of life, health, and environment.
- Creation of green jobs
- Independence on oil and gas
- Increased geopolitical stability
- Localized energy production ("power to the people")
- Reduced transportation costs
- Local jobs, local resilience

Scientific Challenges

- Reduce energy consumption
- Increase energy efficiency
- Electrify what can be electrified
- Develop renewables (biofuels, hydrogen, methanol, etc.) for what cannot be electrified
- Manage the transition to a fossil-free system

Requirements

This is an ambitious goal that requires progress on many levels. Needed in particular are:

- Multidisciplinary teams: Scientists, Engineers, Social Scientists, Industry.
- Coordinated support from multiple funding agencies and, within NSF, multiple divisions.
- Timeline:
  - 5 years to start up, identify topics, recruit team members, and begin implementation
  - 10 years until first significant results are providing accelerated progress towards a net-zero carbon economy
  - 25 years to complete implementation of a net-zero vision.

Methodology

- Various scales of planning
  - Project, tactical, operational, strategic
- Variety of stakeholders and users
- Different sources of uncertainty & risk
- Integrate different tools and methods

Why NSF, DMS?

- Mathematical models, data analytics, network science, machine learning and high performance computing have a key role to play in this work.
- A recent advance is the incorporation of observational data and high resolution simulations for subsystems in Earth System Models to improve climate projections, e.g., Geophysical Research Letters, Schneider et al, 2017.
- Similar approaches would be needed for:
  - making green energy producing chemical processes more efficient;
  - improving the energy storage capabilities of batteries and fuel cells;
  - the discovery of new materials to enable energy production and conversions;
  - the incorporation of large numbers of renewable energy generators into the electrical grid;
  - designing green buildings to reduce energy consumption;
  - Etc., etc.

Conclusion

- Successful sustainable and renewable enterprises require an efficient, appropriate raw material supply
- Improvements and efficiency gains in productions and logistics are critical
- Integrated, multi-scale models and tools are needed for complex multi-facility environments
- Developing specialized models and tools for industry can help de-risk investment in the clean energy.
- NSF has the intellectual standing to propose a science-based approach to decarbonization and can do its part by supporting the basic research needed to accelerate a national effort to eliminate the need for fossil fuels.

Thank you

Mathematics is the language with which GOD has written the Universe.

Galileo

Any Questions?

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