

ME 2101: Principles of Thermodynamics I

Dr. Chris Damm

Energy and the Environment

Access to clean, affordable and reliable energy has been a cornerstone of the world's increasing prosperity and economic growth since the beginning of the industrial revolution.

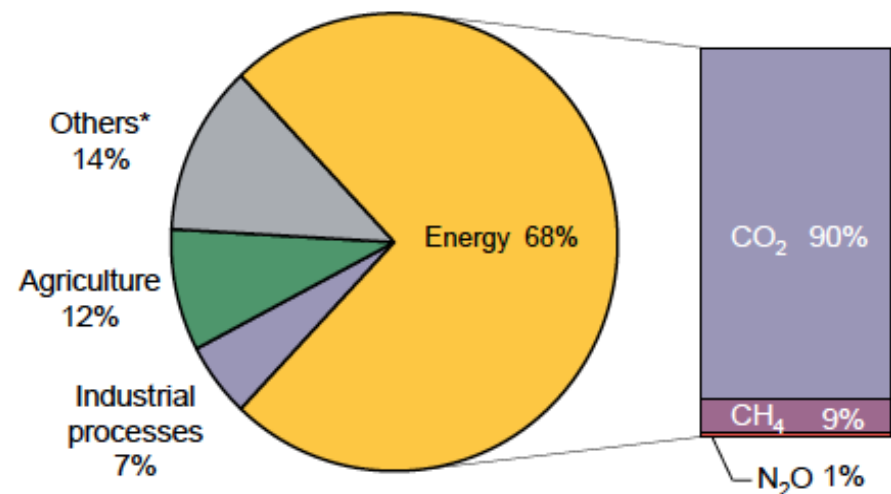
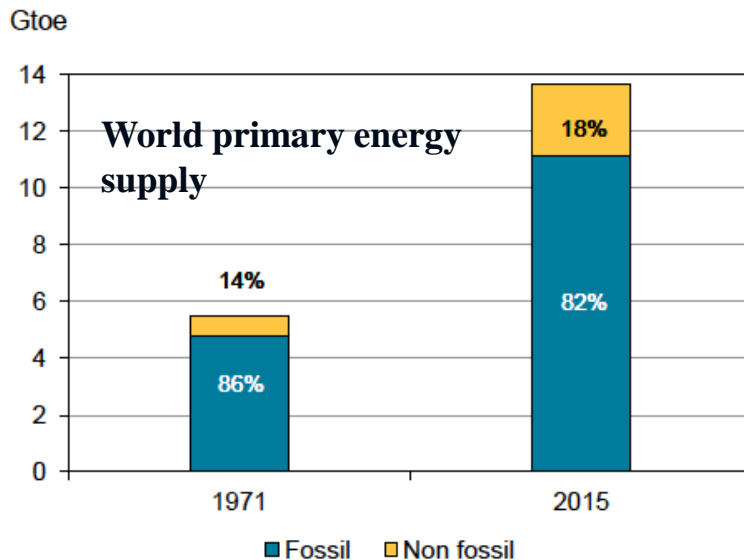
- S. Chu, A. Majumdar

Few sectors affect the prosperity of every sphere of economic and social life or exert as much direct influence on general technological progress than energy. Concerns surrounding cost, reliability, security, and the environment, have brought the development of a clean and diverse portfolio of energy supplies to the forefront of the national conversation.

– T.C. Lieuwen

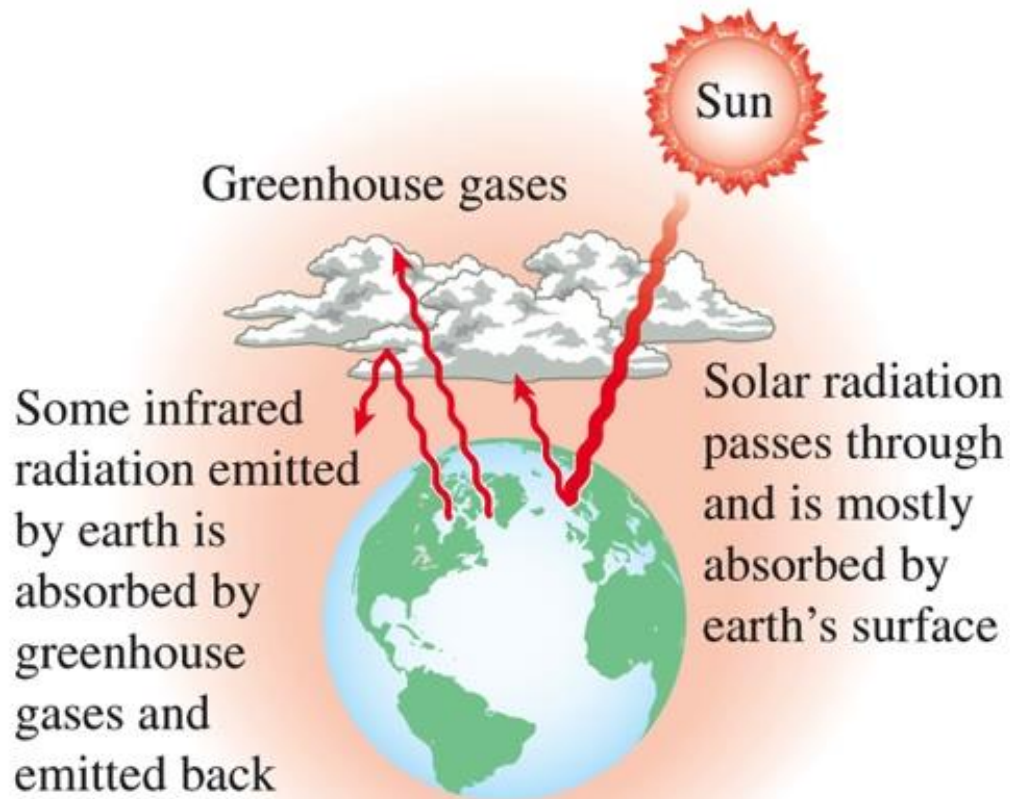
What is driving the push for alternative energy technologies?

- Chemical energy conversion by combustion to useful work/heat is a significant energy source (>80% in U.S.)
- Traditional energy/fuel resources are finite
- The U.S. has become too dependent on foreign energy resources
- CO₂ emissions are troublesome



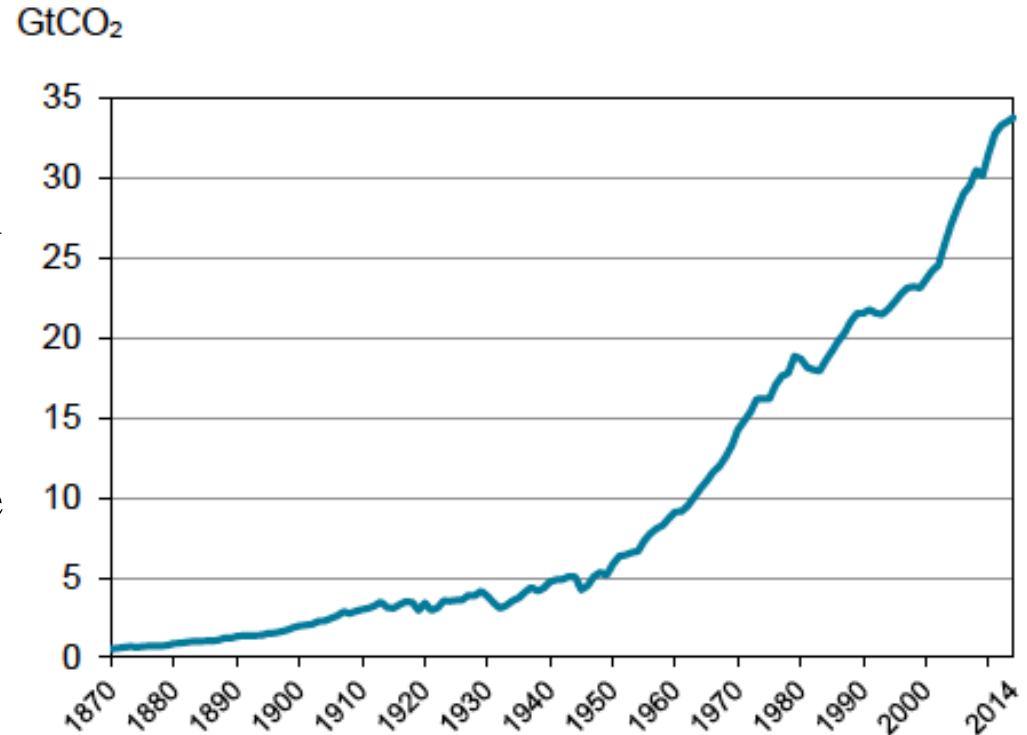
Greenhouse Effect

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Experts agree that human-caused global climate change is a serious problem

- Our National Academy of Science has studied the science of climate change and found that it is a serious problem
- National Academy of Engineering has identified the necessary shift to make solar energy more economical as one of the “Grand Challenges of Engineering”
- Carbon dioxide emissions are now being regulated around the world.



Understanding CO₂ Emission Trends

■ Largest emitters (2015):

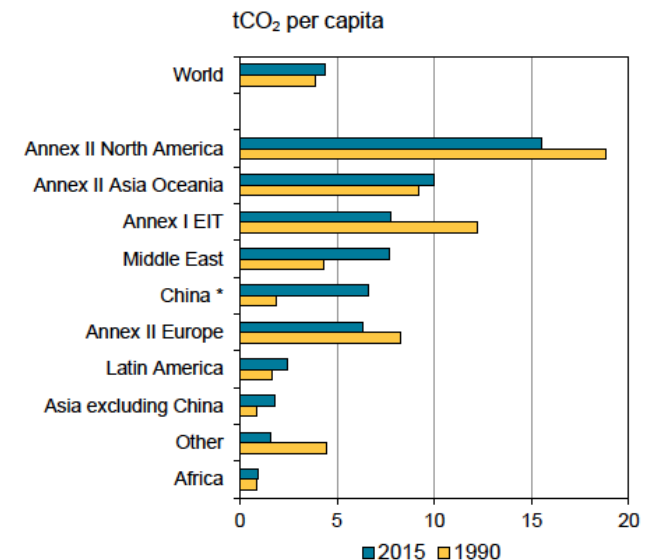
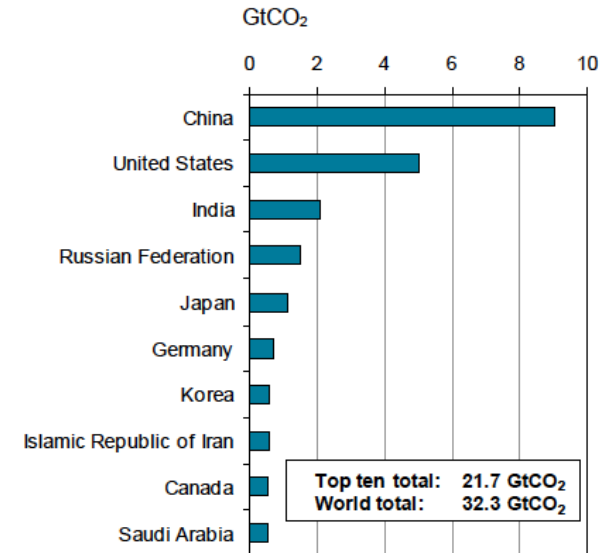
- China: 9.0 Gigatonnes (up 251% since 1990)
- US: 5.3 Gigatonnes (up 9% from 1990)

■ Per capita emissions

- China: 5.9 tCO₂/person (up 199% from 1990)
- US: 16.9 tCO₂/person (down 13%)
- UK: 7.1 tCO₂/person (down 26%)
- Nepal: 0.1 tCO₂/person (up 188%)

■ Emissions per GDP

- China: 1.9 kg/US\$ (down 56% from 1990)
- US: 0.40 kg/US\$ (down 35% from 1990)
- UK: 0.19 kg/US\$ (down 49% from 1990)
- Sweden: 0.11 kg/US\$ (down 46% from 1990)



The Role of Industry

- World Business Council for Sustainable Development
 - 200 leading companies
 - Combined revenues = \$8.5 Trillion
 - Includes: Alcoa, Caterpillar, Coca-Cola, ConocoPhillips, Ford, Dow Chemical, GE, GM, IBM, *Johnson Controls*, S.C. Johnson & Son
- U.S. Climate Action Partnership
 - Alcoa, Dow, Shell, GE, etc. partner with the National Resources Defense Council (NRDC) and others to lobby lawmakers for federal carbon regulation.

Triple Bottom Line → financial, social, and environmental

Other Emissions

Products of incomplete combustion

- **Soot** → carbon particles
 - Reduced visibility
 - Soiling of environment
 - Respiratory diseases
- **Carbon Monoxide** → incomplete conversion to CO_2
 - Reduce oxygen carrying capacity of blood cells → asphyxiation
- **Unburned hydrocarbons (UHC)**
 - Toxic (carcinogenic)

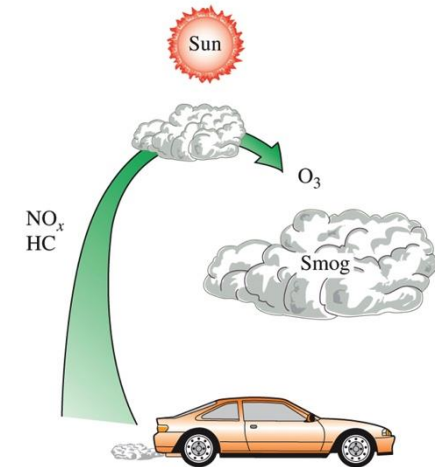
NO_x (NO/NO_2) → high temperature pollutant

- When combined with UHC's and sunlight → ground level ozone (O_3) → **SMOG**
- Form nitric acids in the atmosphere → Acid Rain
- Damage to plant life

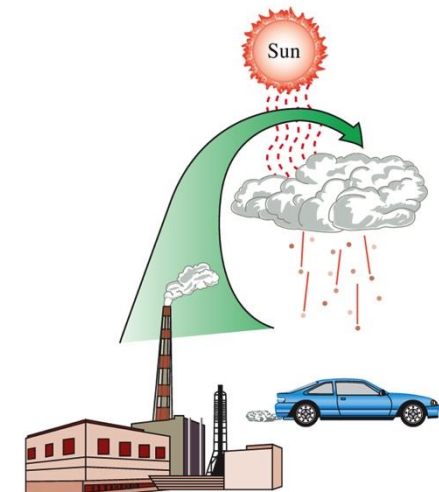
Oxides of Sulphur (SO_2/SO_3)

- Primarily formed in coal-fired power plants
- Arise from sulphur present in the fuel
- Corrosive and lead to formation of sulphuric acid in atmosphere → Acid Rain

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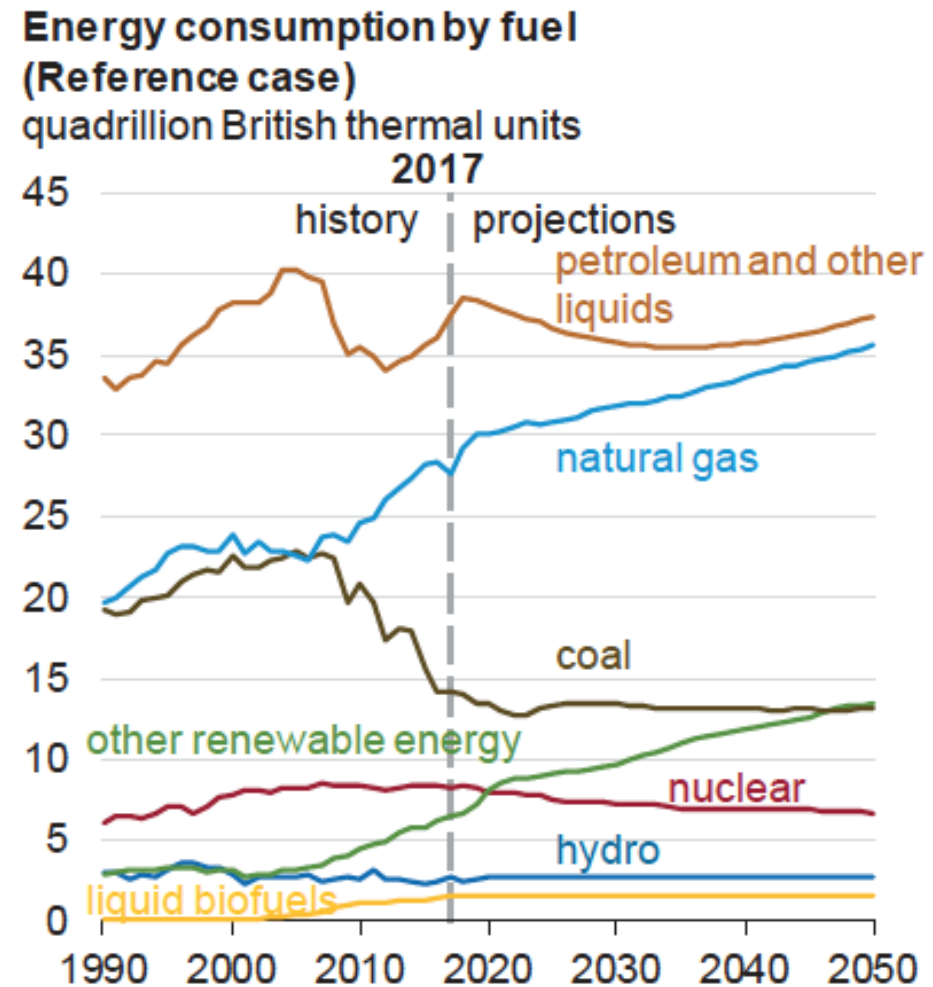


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What can engineers do to help solve these problems?

- Improve efficiency of energy generation and energy use (e.g. automobiles)
- Develop alternative energy systems



Acknowledgement

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