# The Evolution of the Economy and the Sustainability Challenge

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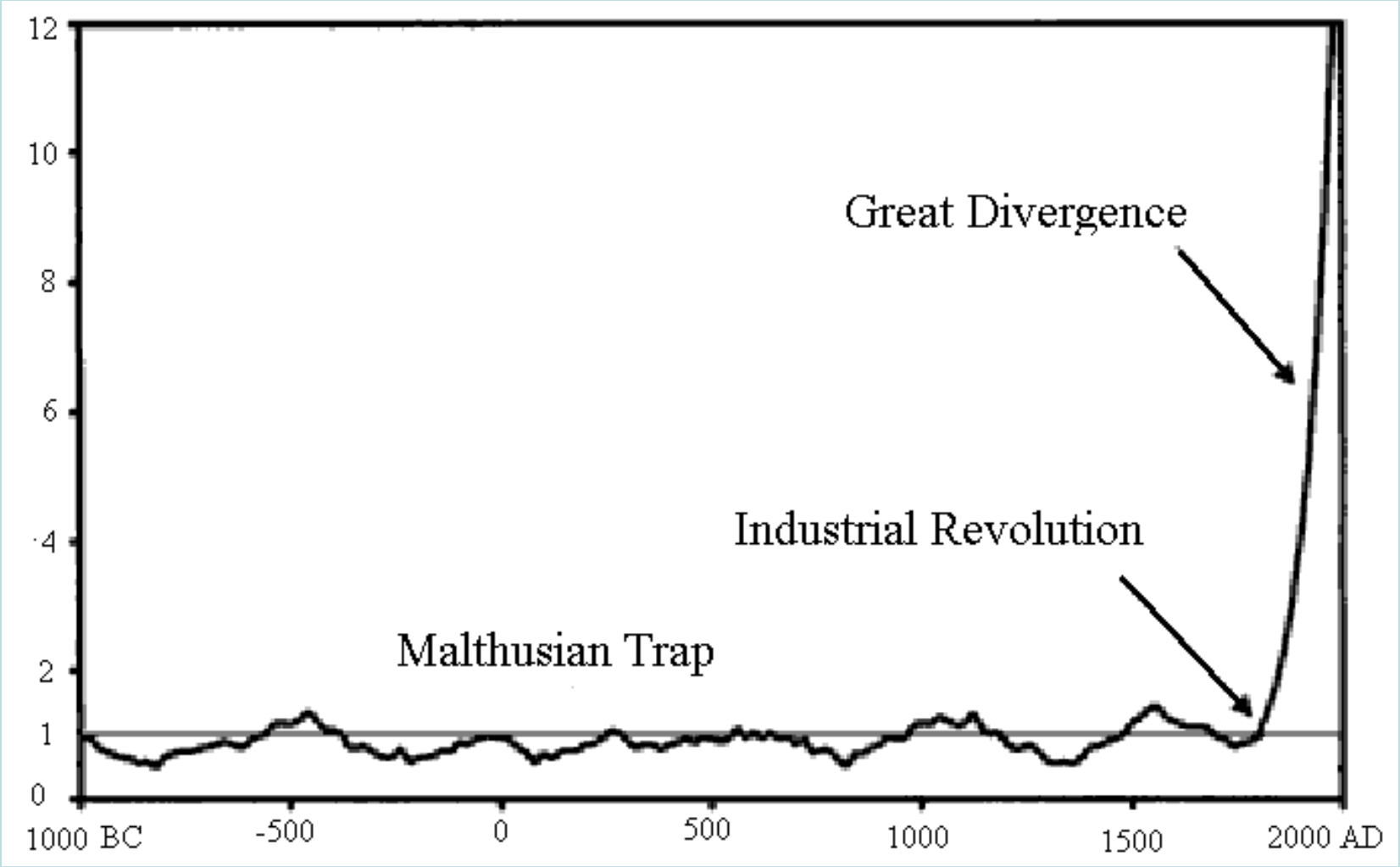
Focus on Sustainability: Design and Logistics face to face

# Stagnate Incomes Prior to 1800

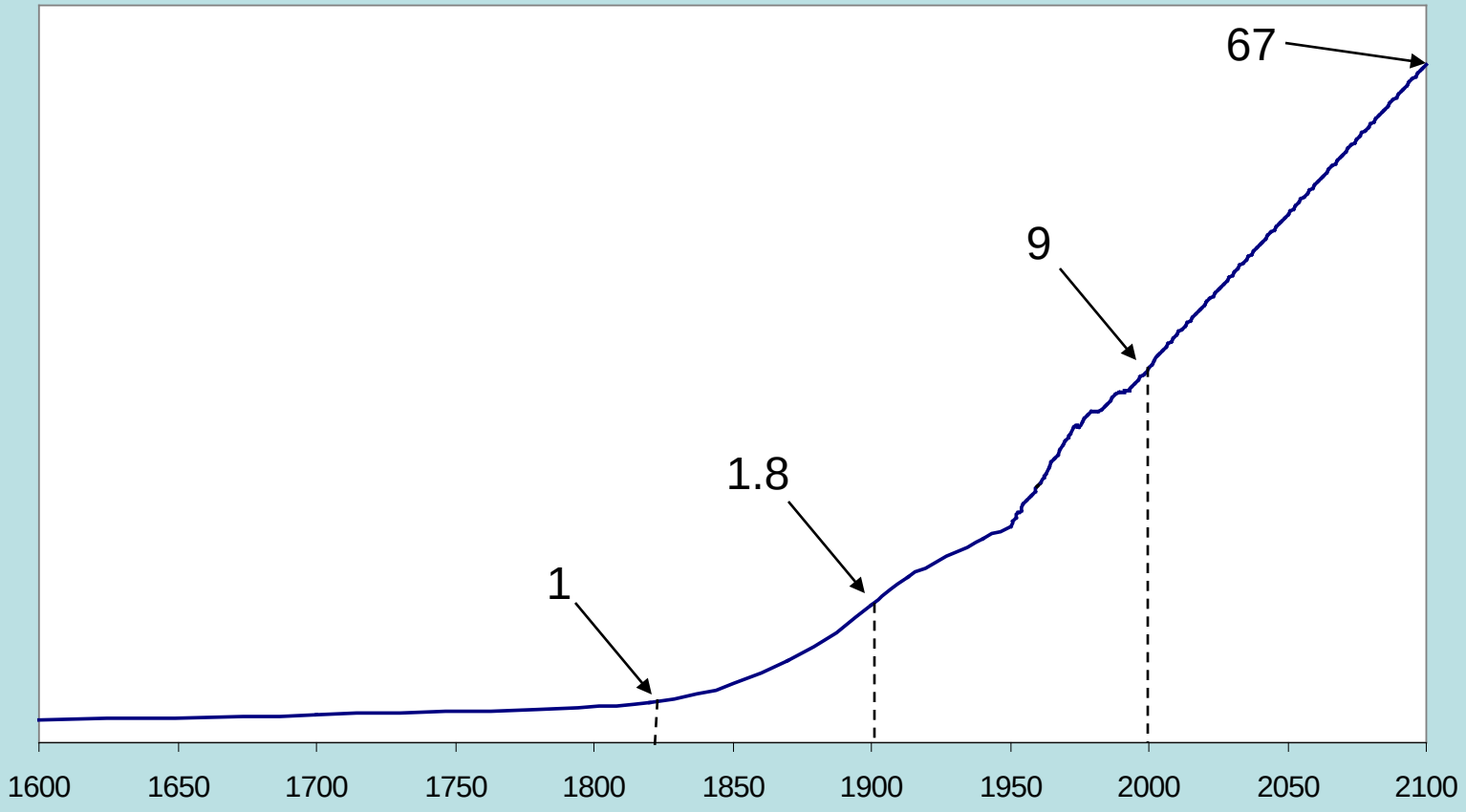
## Growing Income After 1800

## Starting in the West

# Income per Person, 1000 BC to Present (1800 = 1)



# Projected Income per Person (1800 = 1)



**Will population size**

**limit growth in living standards?**

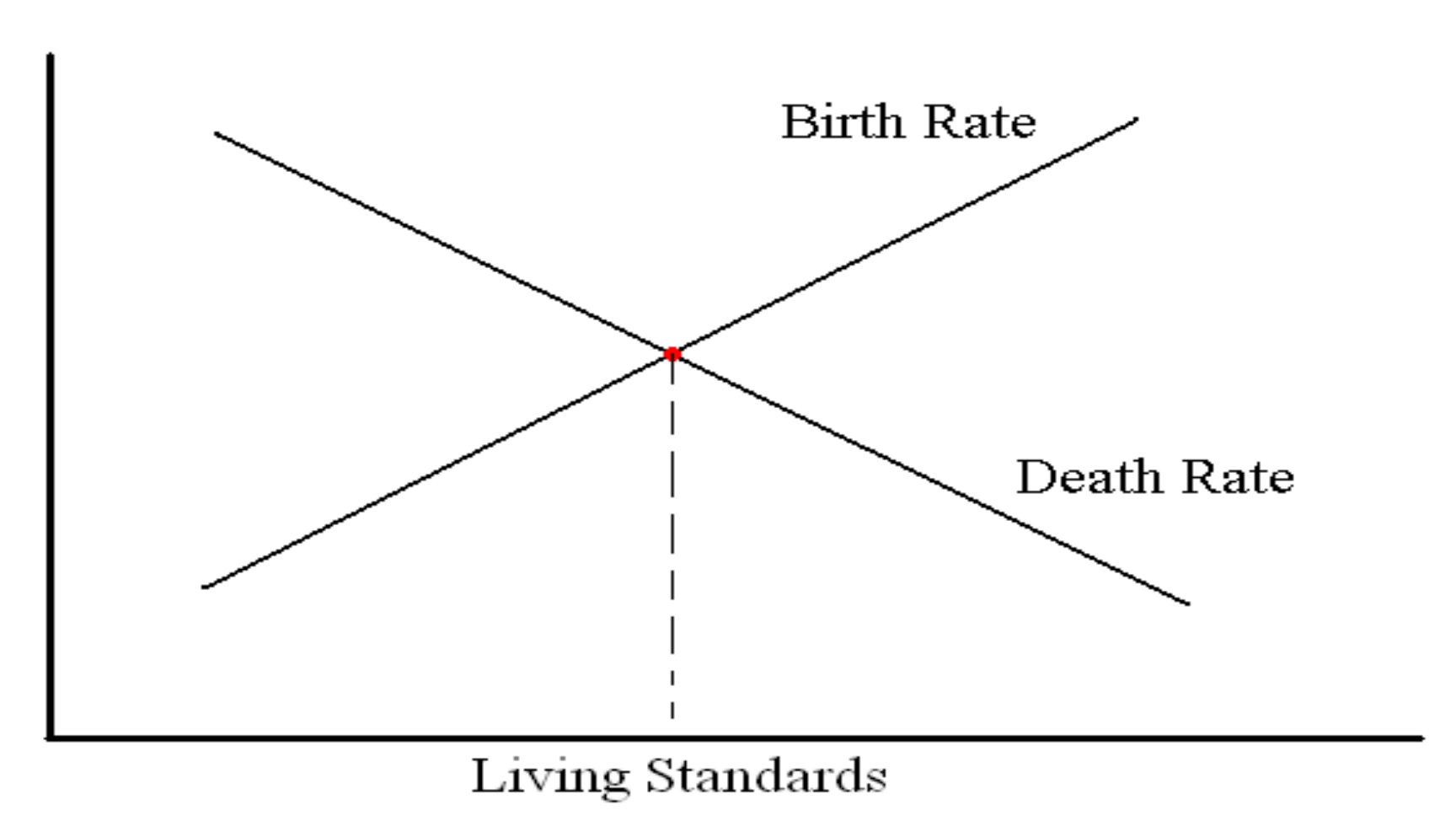
# World Population (Millions)

| Year | Population |
|---|---|
| 1000 BC | 50 |
| 500 BC | 100 |
| 500 | 200 |
| 1600 | 500 |
| 1800 | 1000 |
| 1930 | 2000 |
| 1975 | 4000 |
| 2008 | 6700 |

# Sustainable Population

- Up to 1800 it was the point at which death rates equal birth rates
- Birth rates increased with living standards and death rates fell with living standard
- This led to a sustainable population that increased only slowly over time with better crops and domestic animals

# Sustainable Living Standards

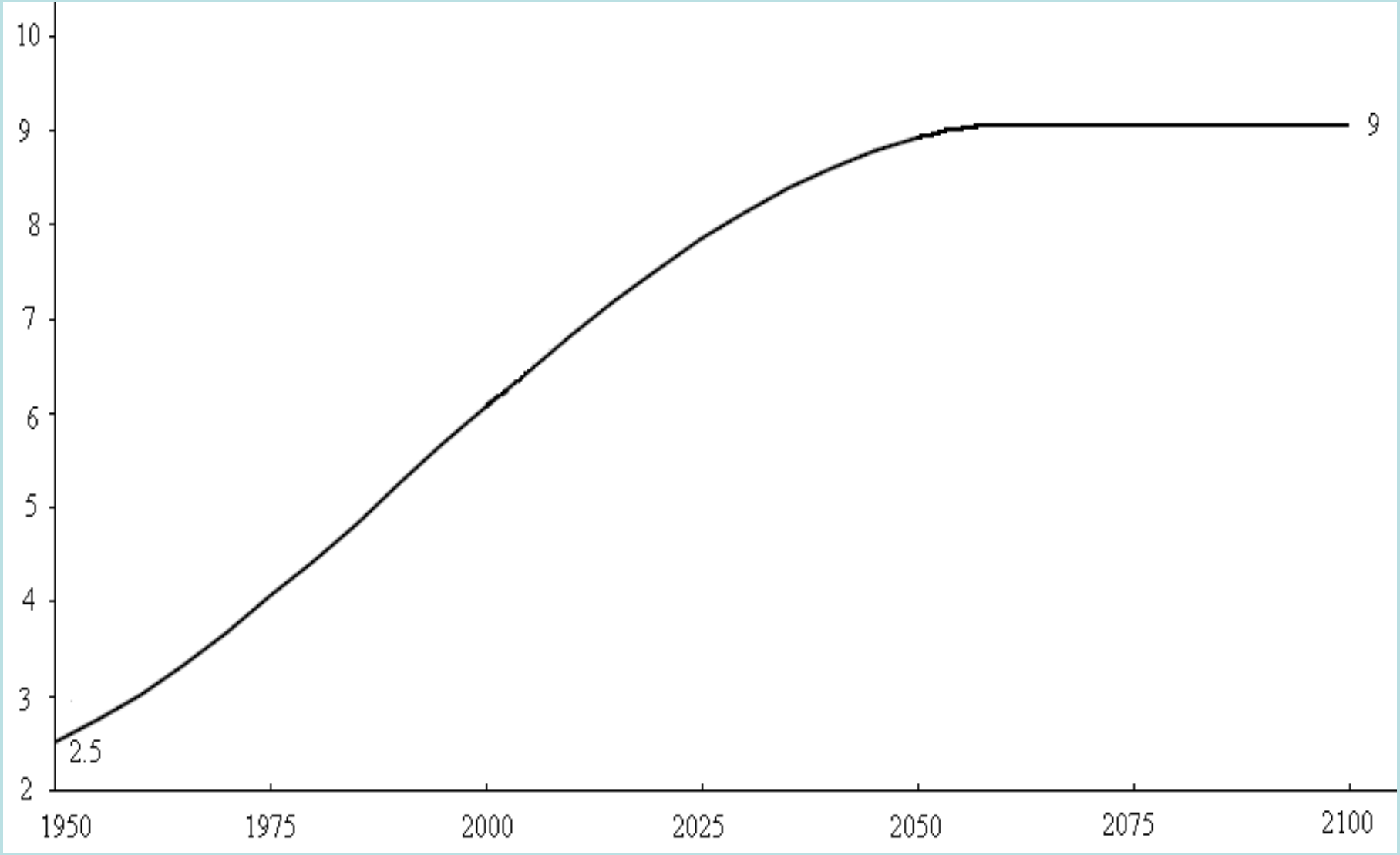


# People are Controlling Population

- UN forecast is that population will stabilize

- This talk is based on this assumption

# UN Population Projection (billions)



# Slowing Growing Population

- Two early important inventions
  - Fire
  - Needle to produce clothing
- Inventions important because they permitted homo sapiens to live in nearly every part of the world
- This gave rise to a larger population
- Humans were hunter gatherers
- Relatively recently became farmers and herders

# Theory: Sustainable Population Size

- For all specie, ***sustainable population*** is one at which death rate equal birth rate
- Birth rates determined by food per individual organism (person), which decreases with population size
- Death rates determined by food per person, ***and other factors***
  - Disease
  - Predators

# Living Standards before 1800

- More or less constant across time and regions
- Higher at some times because of disease
  - Black plague in England and Western Europe
- Some people controlled population through infanticide
  - For example Polynesia was a healthy and rich place before Europeans arrived.
  - Polynesians ate well and worked little. HOW?
    - Infanticide controlled population
    - Now we have better ways to control population

# Will There be Adequate Food?

- Assume population will stabilize at 9 billion by 2050, about one-third more than current level of 6.7 billion
- Technology advances will do the job
  - Genetic engineering speeds up the evolution of crops
  - No one dreamed that India could feed itself in 1965. Ten years later it was.
  - Green revolution did it
  - There will be a green revolution specialized to Africa
  - New crops will use less insecticide and fertilizer

# Will there Be Enough Useable Energy

- No shortage of energy from the sun
  - A half hour of solar energy falling on the earth exceeds the total amount of energy people use in a year
- Problem is using a bigger part of solar energy than we currently do

# We Can and Will Economize on the Use of Energy

# Information Technology Key

- Just beginning to exploit this great innovation
- The last great innovation was electricity
- Energy used per unit of light produced (lumen) fell by a factor of 10,000 (Nordhaus)
  - Animal fat (before 1800), then whale oil, then coal oil, then incandescent light bulb, then compact fluorescence bulb

# Before 19th Century Relied on Currently Arriving Solar Energy

- Land was a crucial input
  - Food to feed people and animal to produce mechanical energy
  - Trees to produce kinetic (heat) energy
- Then we relied increasingly on stored solar energy
  - Coil, oil, and natural gas
- Steam engine and then internal combustion engine
  - Converted these to mechanical energy

# Economize on Use of Energy

- Technological innovations as occurred in lighting
- Less used to make fertilizer – genetically modifies plants that fix nitrogen in the soil and produce their own insecticide
- Jet engines much more efficient and quieter
- Smart houses controlled electronically

# As Humans Get Richer, They Choose Cleaner Air and Cleaner Water

- They are luxury goods and as we get richer we buy more of them
- Local externalities are not a problem. If the externality is a bad (air pollution) as we get richer we choose to buy more (cleaner air).
  - I say buy because the cleaner air is paid for by higher prices for the products that generate the pollution
- A dramatic example of an economic innovation that made clean air cheaper was the market mechanism used to reduce $SO_2$ dramatically.

# CO2 Problem?

- This is a global, not local problem
- Clear that there is a lot of propaganda and therefore it is difficult to assess consequences
- Some possibilities
  - Store the C02  when coal is burned
  - Reflect high energy ultraviolet light with large white disks in the ocean
- CO2 is sinking in the ocean at a steady rate
- Use to be a lot more CO2 in the atmosphere
  - 7 times as much 200 million years ago when the mean earth temperature was 3 degrees higher

# Nuclear Energy: The Interim solution

- Predict countries will follow the French and rely on nuclear power
- No CO2 except associated with building the plants

Problem: Storage of waste

- People like the reactors being built nearby in France
- They don't like having the waste stored deep in the ground near them
- Even though it is safe

- At some point things will change
- Necessary to bribe the local people with some payment

- Public opinion can change quickly
- Let’s look at off shore oil drilling

# Offshore Oil Drilling

- Gasoline  $1.30 / liter led to the U.S. ban on offshore drilling to be eliminate fast
- Now oil is down to $ 0.50 / liter

# There a Big stock of Natural Gas

- Natural gas produces much less $CO_2$ per unit of energy produced than coal and oil as it is $CH_4$.
  - There are two molecules of $H_2O$ for every molecule of $CO_2$ when it is burned

# What Will Be Consumed?

- Luxury goods such as Italian designer cloths
- More meals at fine restaurants in the USA
- Good Italian wine
- Italian tourism services
  - Who has a richer history?
  - Who has as much beautiful art?

**These luxury goods are not energy intensive**

# Electronics

- Cars that drive themselves
  - Don’t have to worry about drinking and driving
  - Much safer

# Medical Services

- Will be more cosmetic surgery
- Replacement of joints that wear out
  - Hips
  - Knees
- Productivity of this sector will increase
  - People are living longer
  - And having fewer years with morbidity (Nobel Laureate Fogel)
- Not energy intensive sector

# Old-Age Care

- The old can stay in their home longer
- Have electronic device to notify someone that they need help
  - This saves on expensive institutionalized care
  - Permits people to stay in their homes longer

# Solar Energy

- The earth receives more *energy* from the *sun* in just one-half hour than the world uses in a whole year.
- Think in terms of 50 years before renewable solar costs are down to alternatives
  - It will happen
- Develop way to store electric energy produced to handle peak load problem  (coils at near absolute zero have zero resistance)

# Europeans Tax Payers are Helping Africans by Subsidizing Food Production

- Means cheaper food for the Sub-Saharan Africans and that is good for these people.
- Farmers there will move to the cities. This will foster economic development.
- The U.S. and Europe should not pay famers not to produce.
- Europe should not destroy food.
- The U.S. should drop its ethanol program

***Bottom line is that there will be no shortage of food.***

# Fishing

- Most of us love fresh fish
- Has been some over fishing
- Has been recovery of some fisheries
- Innovations has permitted better property rights system to be set up and maximal sustainable yields obtained
- Better technology including better property rights systems will lead to the recovery of more fisheries

# Making the World a ***Better*** Place for Humans

- Draining the swamps in Northern Illinois was a great things for humans.
- It was a yellow fever and malaria infested area. Unfit for humans
- It became some of the most fertile productive farm land in the world
- It became a fit place for humans to live
- Getting rid of the small pox virus was a good thing for humans

# Summary

- No shortage of food
- Sustainable renewable energy is becoming a better alternative and in 50 years will dominate
- In the advanced industrial countries, growth will be in the parts of the service sector that are not energy intensive
- The IT revolution has just begun and will permit economizing on the use of energy and lead to wonderful new products

**To Conclude**

**Don’t Underestimate Humans**

**They are so creative**