Smart Buildings / Smart People
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Toronto

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BEG

Building Engineering Group

University of Waterloo

Technology is the answer.

But what is the question?

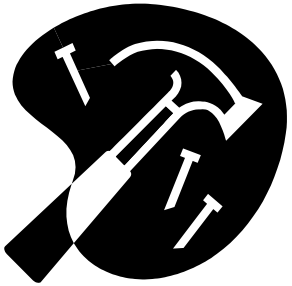
Amory Lovins

This presentation

- **Buildings**
  - **Context**
  - **Importance**
- **Role of Technology**
  - **Smart ideas**
  - **Good design**

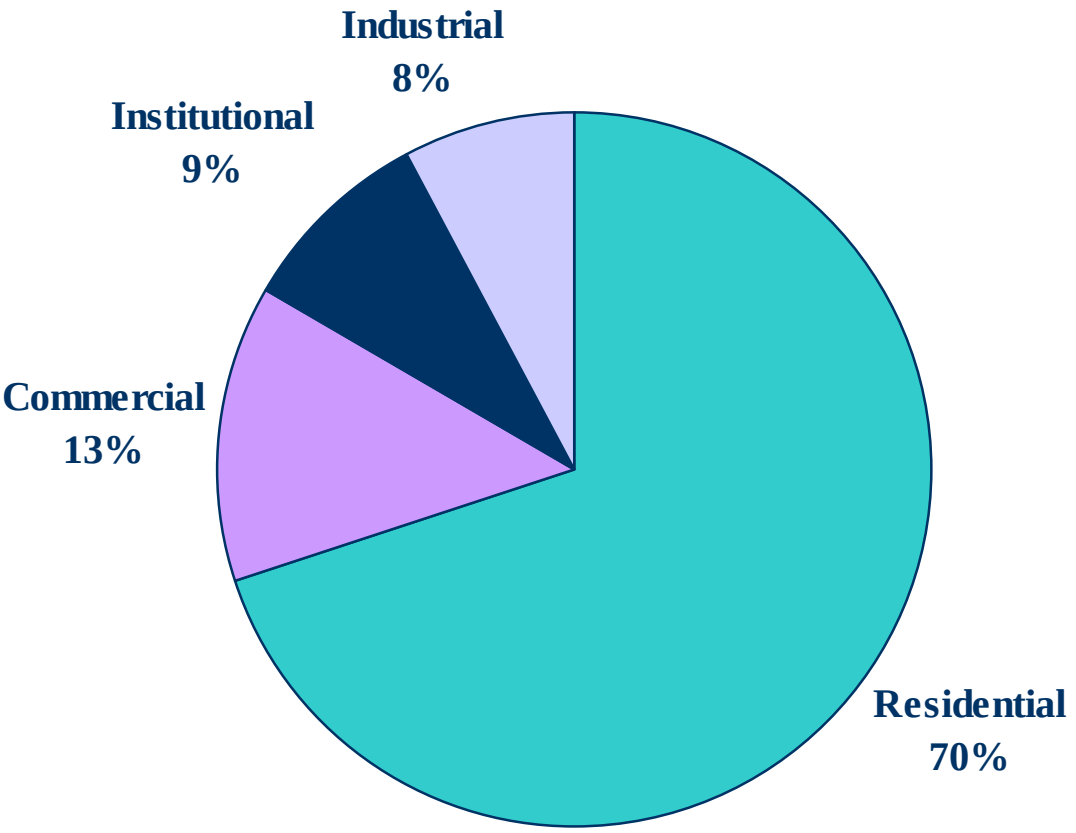
Components of the Built Environment

- **Buildings and the parts thereof**
- **Service infrastructure/utilities, etc.**
- **Distribution/transportation/traffic handling systems**
- Occupants/users/owners
- ***Providing and maintaining the built environment is the largest single industry on the planet***



Buildings as Capital Investment

- **$55 Billion** spent on Building Construction in Canada (1997)
- **8.7% of Can. GDP**
- **Need homes for billions of people in developing world**
- **Global expenditure: US$ 3 500 000 000 000/yr**



The impact of buildings on Health & Productivity

- Typical North Americans spend 90% of their lives ***indoors***
- Building related illnesses account for $60 to $400 Billion of lost productivity in the US
- Studies are now showing even suburban sprawl has health impacts

Problems with the Built Environment

- Environmental damage
- Buildings don’t work well
- Buildings cost too much
- Sometimes they even hurt us

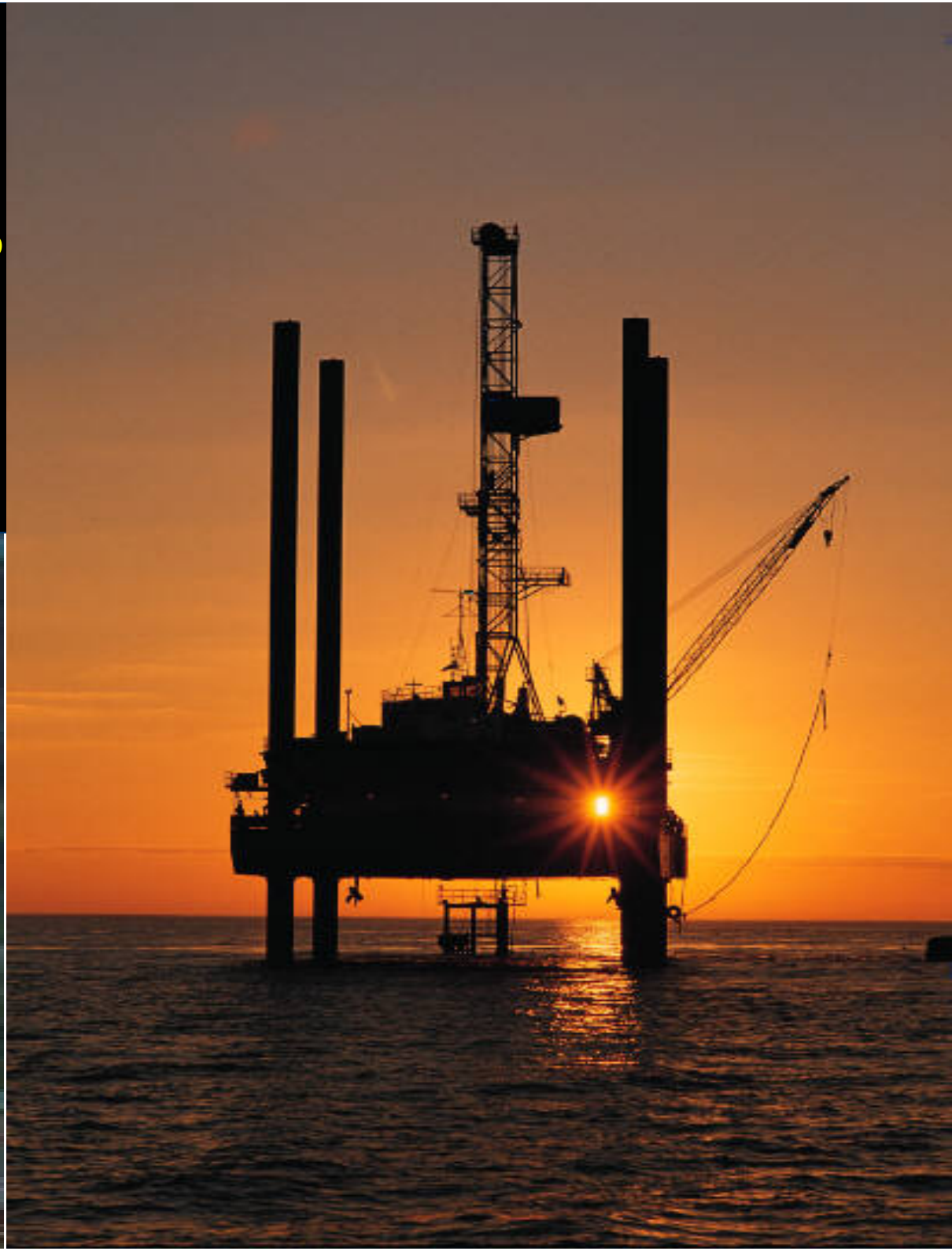
- Can technology help?

Buildings

- Buildings also part of the environment
- They consume resources
  - materials and energy
  - Cost a lot of money
- Pollute, displace, destroy (provide) habitats
- A “durable good”
  - Running shoe (1 yr), car (10 yr), bldg (100yr?)
- Hence - more careful long-term design
  - i.e. societal involvement is justified

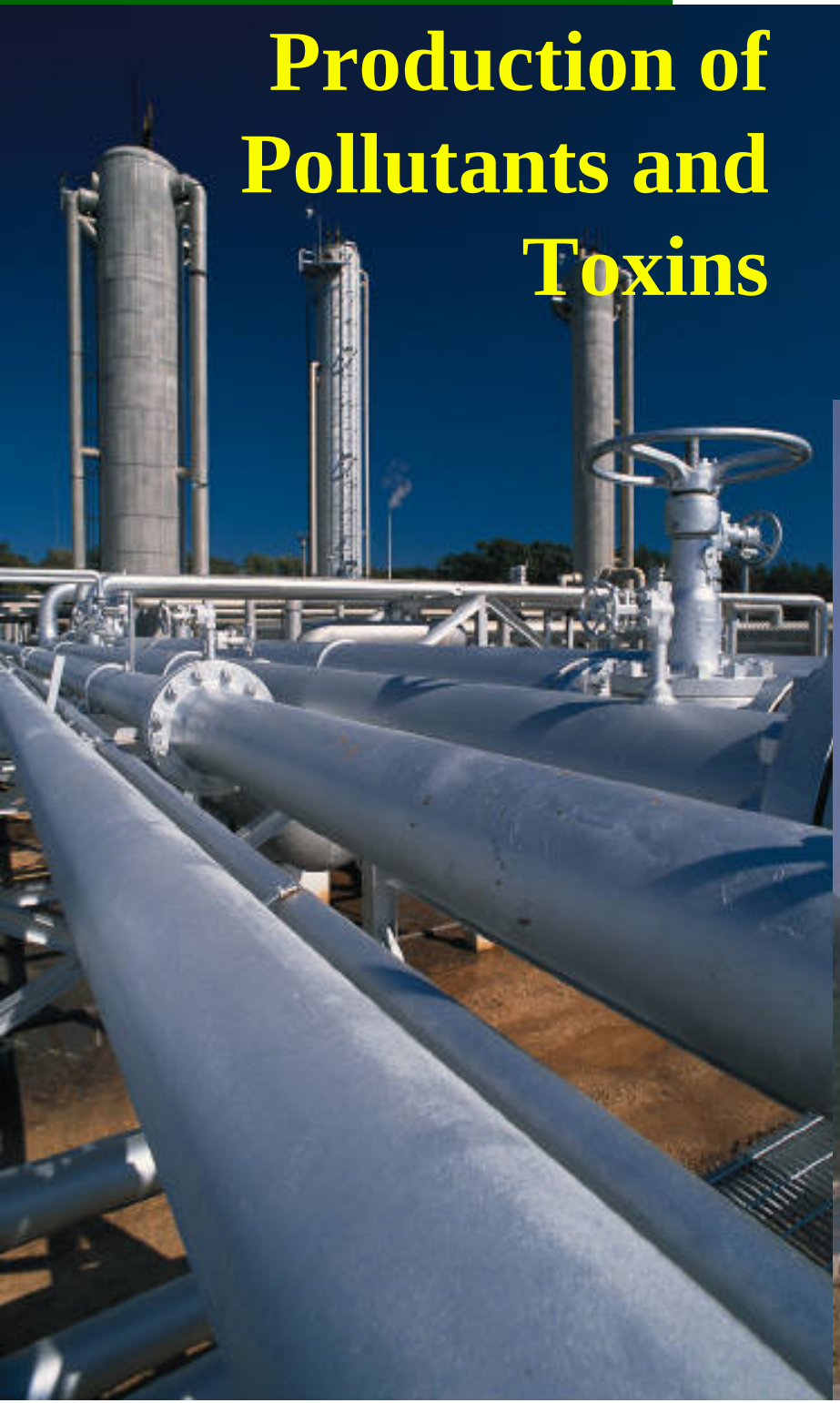
Resource Depletion & Pollution

- Buildings consume 35-50% of world energy in production and use
- about 40% in Canada



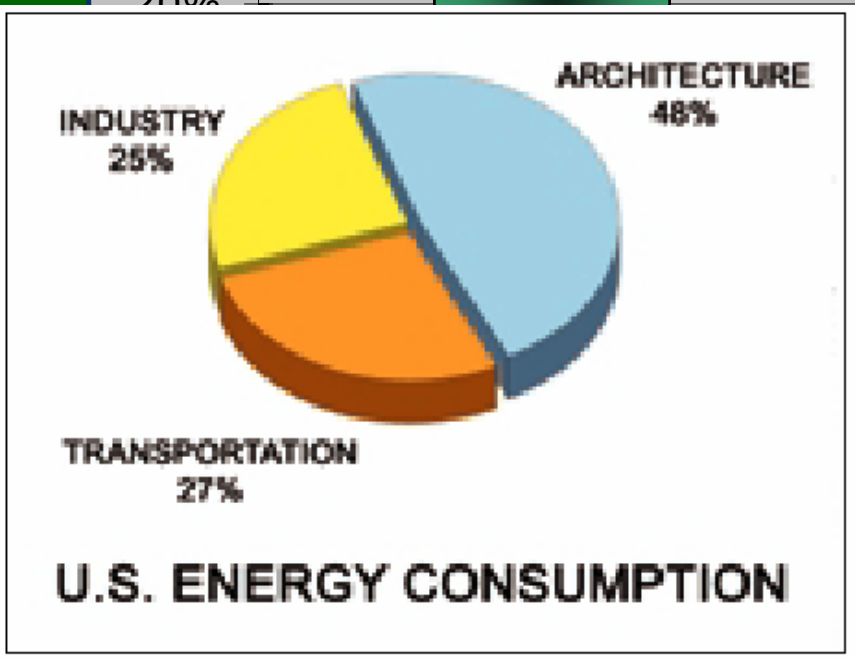
Production of Pollutants and Toxins

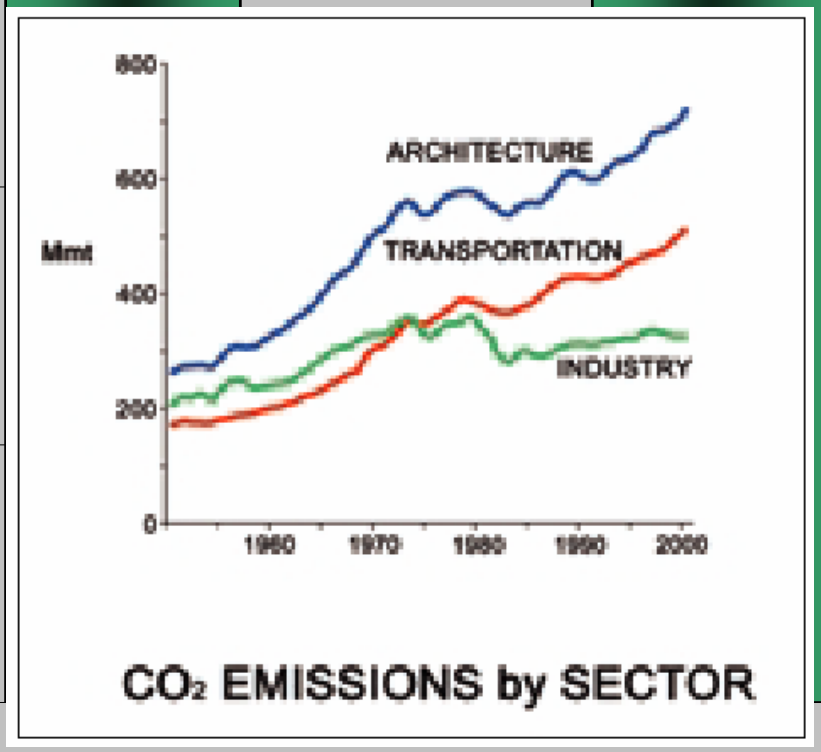
- Landfill waste
- Energy pollution
- Toxic materials



- Buildings consume 40+% of all harvested or mined resources

Building Operational Energy vs Other Sectors





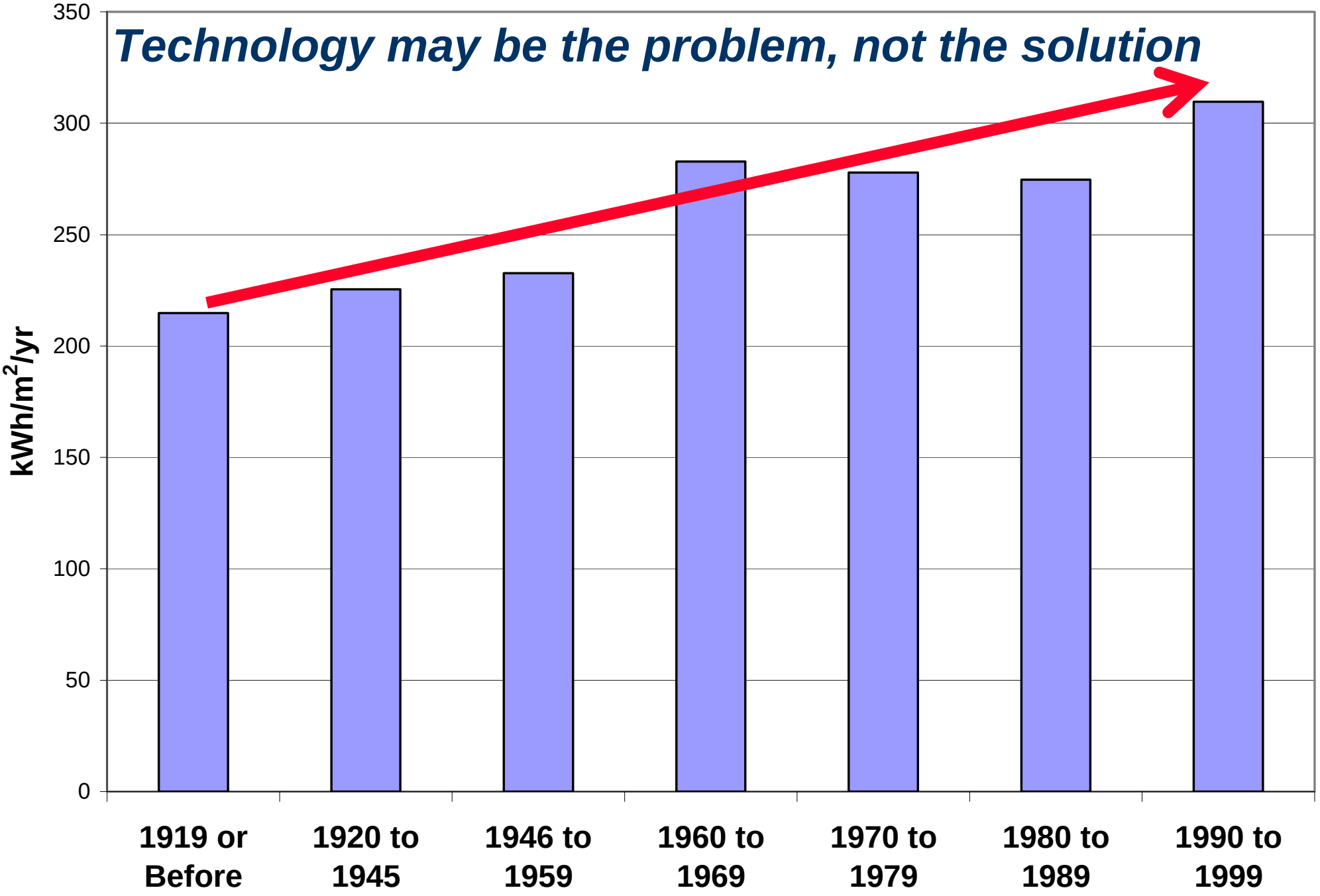
40%

30%

Industry

Transport

US Commercial Building Energy Use



Ecological Damage

Urban Planning-

- Solar heating
- Rainwater run off
- Need to drive
- Transit cant work

Buildings and their connections (roads) displace and destroy habitat

Buildings, Energy, Pollution

- Buildings consume *68%* of all electricity
- Operation of US buildings
  - Purchased energy costs $265 Billion in US
  - 560 million tons of CO_2 per year
  - 36% of US total and 9% of global CO_2 production
  - 49% of US total SO_2

Energy & Efficiency

- People want services not energy
  - Warm house, not gas
  - Light, not electricity
- Hence, efficiency allow us to have our cake and east it
- Energy reductions after ’73 / ’79
- California brownouts(2001)
  - 14% cut in 6 months simply by citizen action

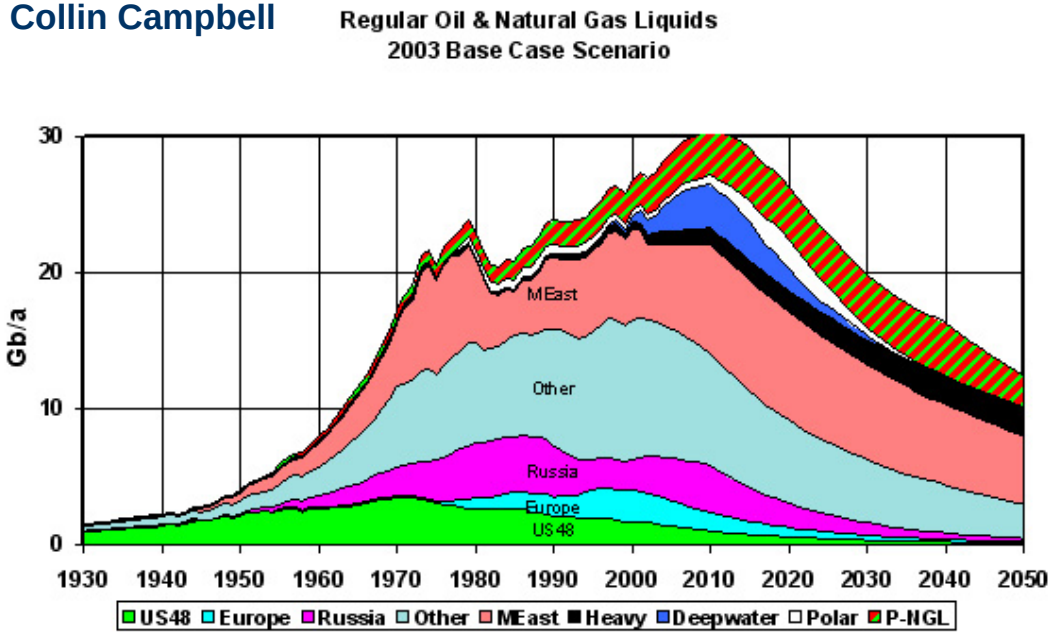
The Zero-sum Myth

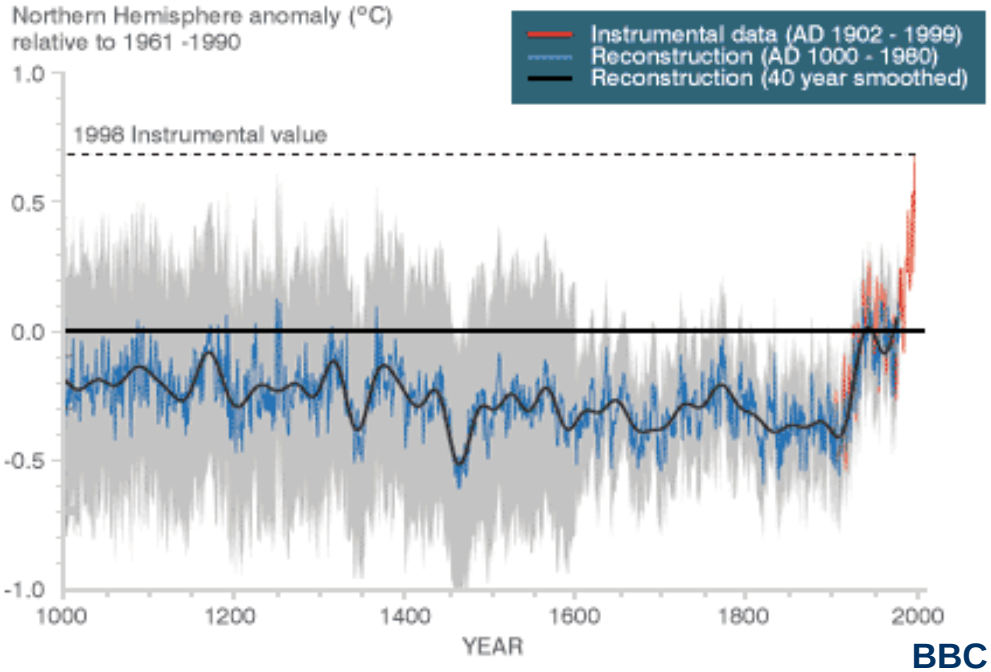
- Myth: "*It is not economical to save energy and reduce pollution*"
- Fact: Median threshold for EE decisions
  - 1.9 yr payback / 71% after-tax ROI (Dept of Energy)
- Pollution inspection & control = expensive
- Saving energy is not expensive
  - Can often be CHEAPER!
  - e.g. Dupont, Lockheed
  - Building Science Corp (www.buildingscience.com)

Renewable Energy

- *Cheap* oil and gas is almost gone
- Huge new energy services required for developing world
- We cant burn more

Collin Campbell





BBC

How to do it

- We already know how!
  - E.g. Compact fluorescents (1/5)
  - E.g. Highly insulating windows (1/3)
  - E.g. Better enclosure insulation / airtightness (1/2)
  - E.g. Efficient HVAC and office equipment (1/2)
- Future
  - Superwindows
  - Renewable / bio-materials
  - Building systems that allow recycling

Fans

- Most use dampers to control airflow
  - Close to valve to control flow
- Modern systems control speed of fan
- Controls respond to needs

Lights

- Compact Fluorescents
  - Use 1/5 as much energy, last 10 times as long
- LED Exit Lights
  - Last 15 yrs, use 2 Watts ($1/yr operating)
- Incandescent lights
  - Last 2 years, use 40 Watts ($20/yr + replace)
  - Replacement costs $15-30 each time
- LED lights cost $10 more than old style

So… what is the answer?

- **Technology is necessary, but not sufficient**

Design & Technology

- **What problem do you wish to solve?**

$4000

www.smarthome.com

Fridge Energy consumption

1973 –1800 kWh/yr

2003 - 500 kWh/yr

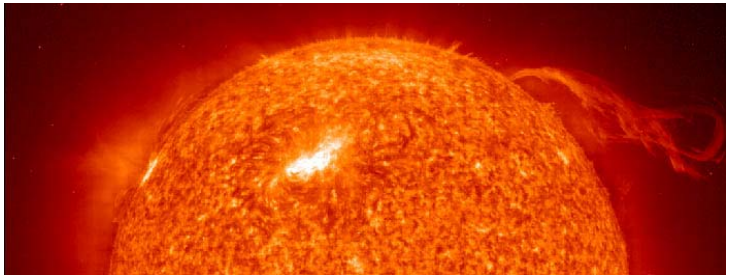
Best available – Sun Frost – uses 200 kWh/yr
(but costs $3000! so is not economical)

Solutions

- Design new building systems
  - Requires simulation
  - Requires teamwork for implementation
- Energy Efficiency
  - Cheapest form of energy
  - Stop wasting
  - Upgrade building stock, change city planning
- Improved renewable energy
  - Integrated power networks to share

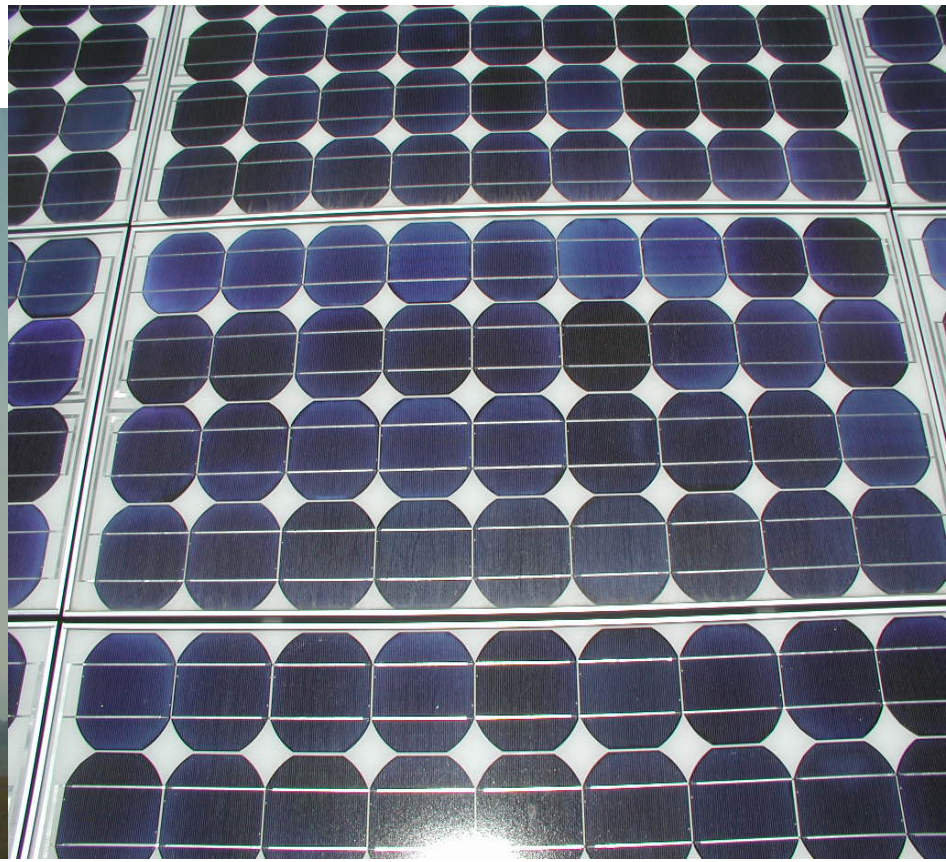
How to do it

- System integration
  - "Professional specialization" disease
  - Sub-system optimization
  - Non-optimal whole system design
- Real benefits come as a system, not individual
  - Airtight, shade and solar windows save AC costs, fans, and ducts
  - Better insulation can mean no furnace
  - Reduced power req't = alternative energy economical

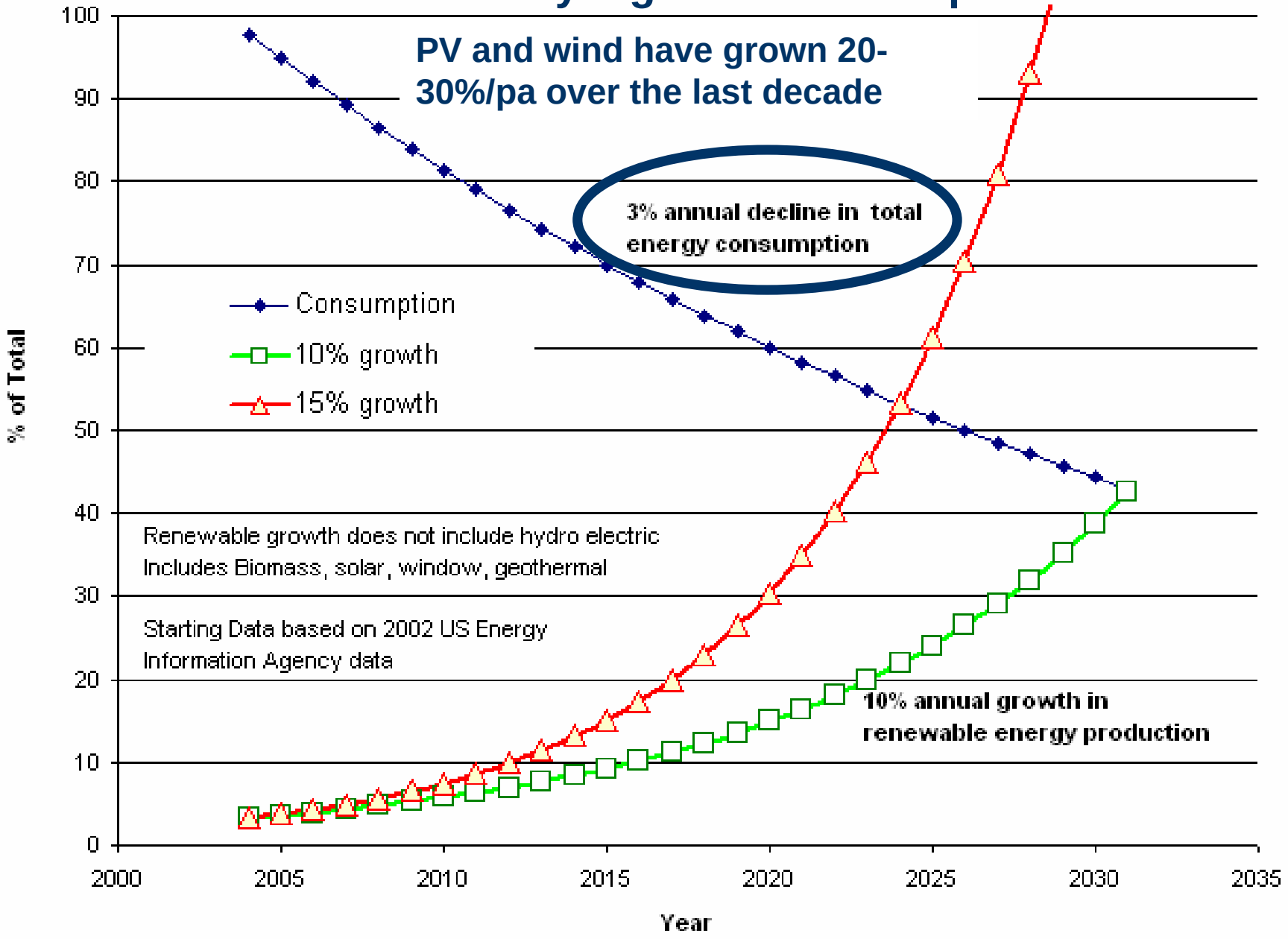


Renewable Energy Growth

- PV and Wind growing fast (>20% annual)
- Europe aiming for >20% electricity by RE



Slow increase in efficiency + growth in RE = powerful combo



Prediction based on Straube 2004

The Hydrogen Economy Myth

- **Hydrogen is not a source of energy**
  - **Where is it to come from? Natural gas? Nuclear?**
  - **Electrolysis from renewables is wasting renewables**
- **Electricity ->hydrogen ->fuel cell-> electricity**
  = cycle efficiency of 33% (50%+ in 25 years)
- **Biofuels may be better: Methane? Ethanol?**
  - **Waterloo Landfill Power**
  - **Algae generation of bio-diesel**
- **Hydrogen is difficult to store and handle**
  - **It may be worth it, my be best method**
- **We must consider alternatives!**

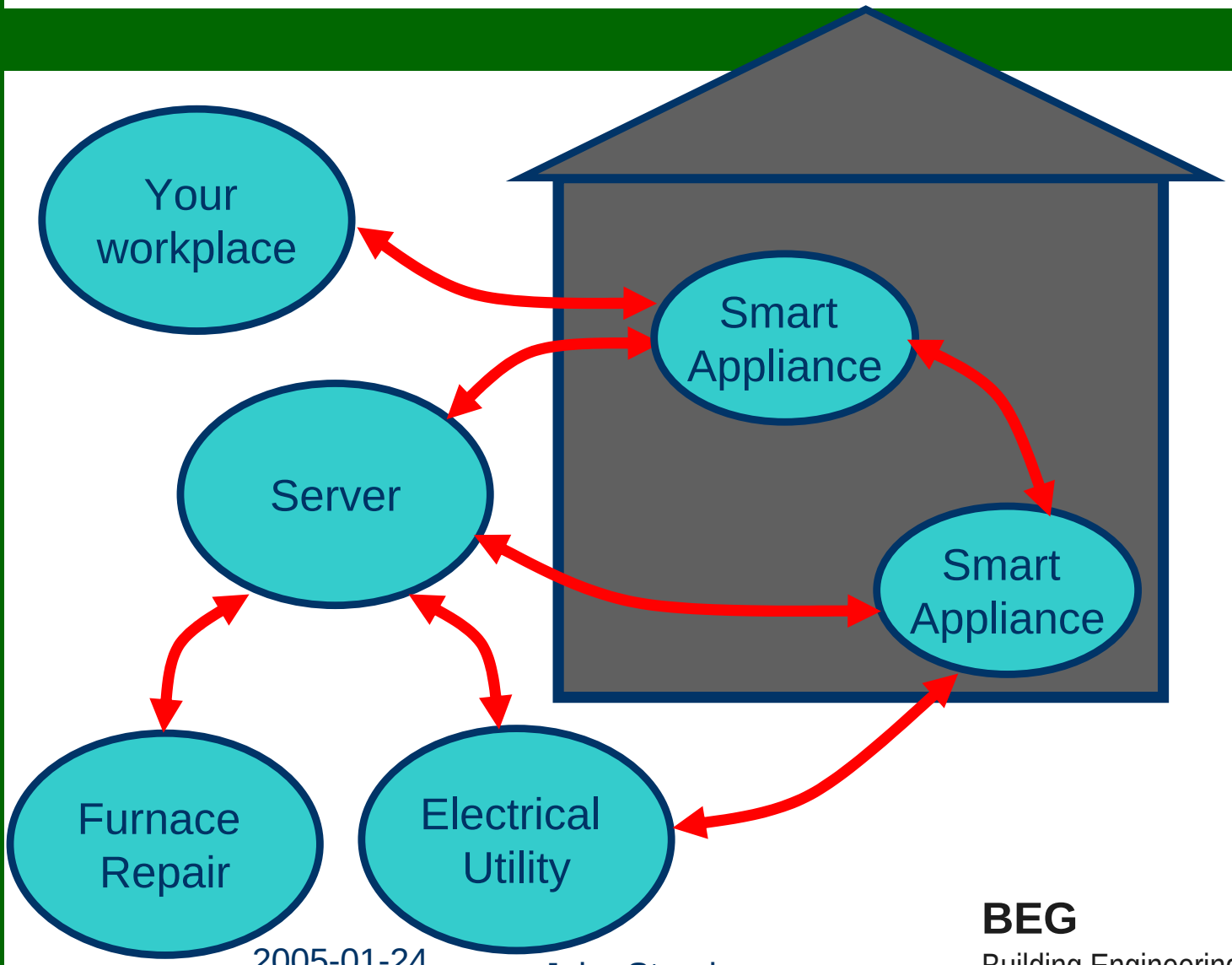
Storage and Generation

- Distributed energy production
  - Power to become like internet
  - User and consumers are the same
  - Utility is an arbiter, deal maker
- Storage will become incredibly important
  - Local storage / central storage
  - Low loss technologies
  - Billion dollar prize
  - Maybe Hydrogen

“Smart Buildings”

- Embedded electronics
- Communication between building components
- Communication between building components and the world

“Smart” Building



Bio materials

- Plastics from plants
  - Dupont-Pioneer and Dow-Cargill
- Fuel from plants
  - Bio diesel, bio gas
- Renewable materials
- Tunable properties

Green on the Grand
Enermodal Engineering

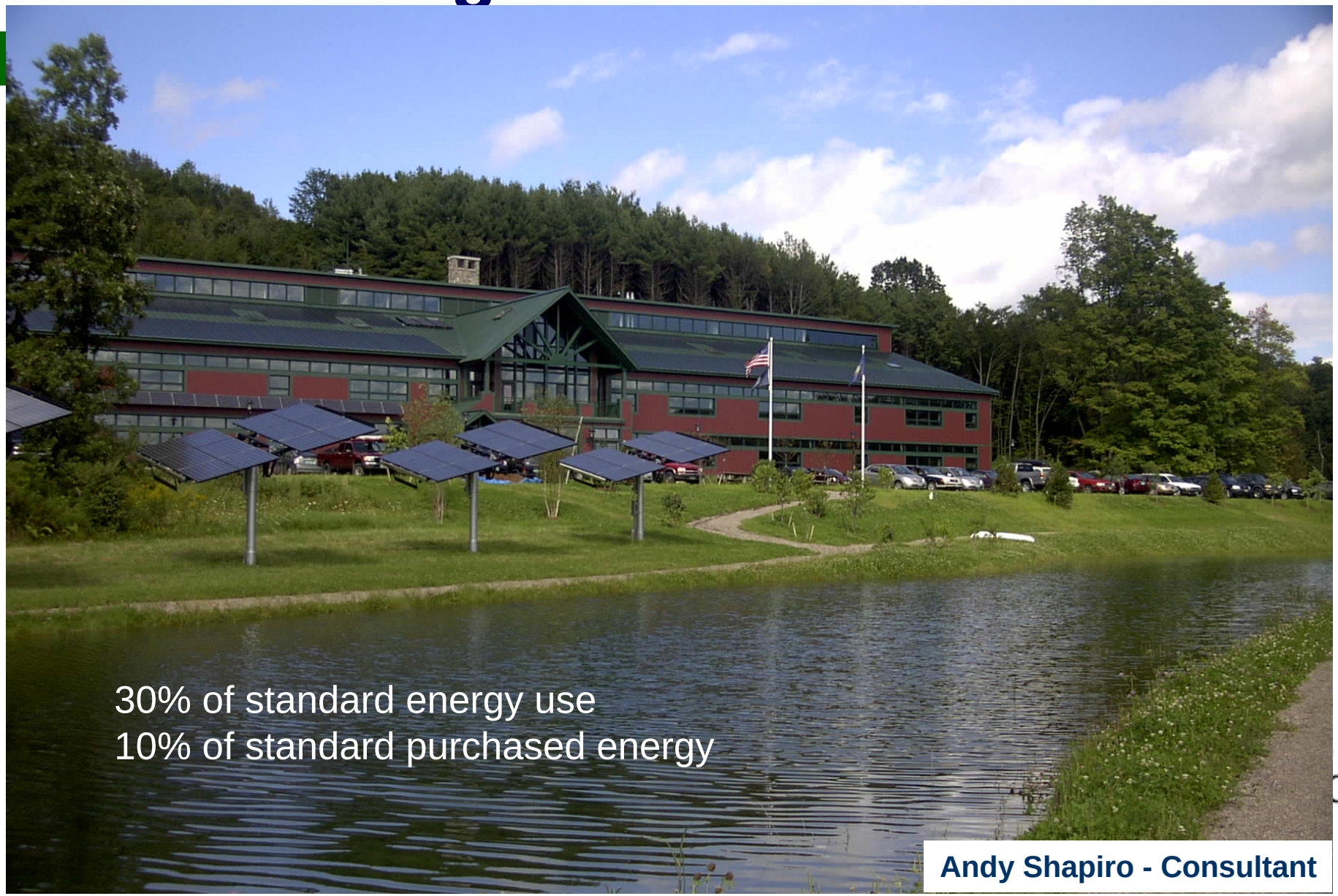
- much lower energy consumption
- much lower resource consumption
- better air quality
- lower first cost

Waterloo Apt

- Less cost than average, about 1/3 energy

University of Waterloo

NRG Building Vermont



Andy Shapiro - Consultant

Real Goods .com

Arkin-Tilt Architects

Rocky Mountain Institute (RMI.org)

- Less than median cost

Purchases 99% less heating

- 90% less electricity

Ridge Winery

- Strawbale-earth plaster
- Low-energy

Conclusion

- **Buildings**
  - **Are very important**
  - **Consume resources & damage the environment**
  - **can be much better**
- **We need better design**
  - **Technology is a tool**
  - **Must understand, apply and invent technology**
  - **Remember the big picture**
  - **Solve problems that are worthwhile**