ELEC3202: Green electronics
Introduction

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The world’s population is growing

- 7 billion people on Earth today
- 1 in 8 people who have ever lived are alive today
- 10.1 billion expected by 2100
Population growth will continue

POPULATION OF THE EARTH

Number of people living worldwide since 1700 in billions

- 1804: 1 bln
- 1927: 2 bln
- 1960: 3 bln
- 1974: 4 bln
- 1999: 6 bln
- 2012: 7 bln
- 2024: 8 bln
- 2048: 9 bln

Source: United Nations World Population Prospects, Deutsche Stiftung Weltbevölkerung
For further information please visit: www.knowledge.allianz.com
Energy use correlates with quality of life?

From Stephen G. Benka
“The Energy Challenge”
Traditional electricity production

- Coal, oil and natural gas are burnt to produce heat.
- Heat is used to turn water into steam which is used to drive a turbine to generate electricity.
- Problems:
  - Fossil fuels are finite resources
  - Burning produces CO\textsubscript{2} \rightarrow greenhouse gas \rightarrow Climate change
Fossil fuels are finite resources

- Fossil fuel production cannot continue to keep up with demand forever.
- A peak in production will be reached due to a combination of geological and economical reasons.
- As conventional supplies run out, more expensive, unconventional supplies will be exploited, e.g. fracking.
- Expensive energy will limit economic growth.
- We need to develop viable alternative energy sources to take over from increasingly expensive fossil fuels.

Literature fossil fuel peak year estimates.

<table>
<thead>
<tr>
<th>Fossil fuel type</th>
<th>Number of estimates</th>
<th>Peak year estimates</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Average year</td>
</tr>
<tr>
<td>Conventional oil</td>
<td>28</td>
<td>2016</td>
</tr>
<tr>
<td>Conventional plus unconventional oil</td>
<td>17</td>
<td>2022</td>
</tr>
<tr>
<td>Gas</td>
<td>9</td>
<td>2022</td>
</tr>
<tr>
<td>Coal</td>
<td>7</td>
<td>2049</td>
</tr>
<tr>
<td>All fossil fuels</td>
<td>7</td>
<td>2028</td>
</tr>
</tbody>
</table>

Legget and Ball, Energy Policy 41 (2012) 610-617
Burning fossil fuels releases CO$_2$

CO$_2$ concentration data from ice cores and air sampling

From Intergovernmental Panel on Climate Change (IPCC), 2007
Global Warming Impact

Temperature

CO2

Energy
Our climate is changing...

(a) Global average temperature

(b) Global average sea level

(c) Northern Hemisphere snow cover

IPCC, 2007
The great energy challenge

• We need to develop viable, large scale alternative energy sources to take over from increasingly expensive fossil fuels.

• These need to be free of carbon emissions to limit climate change.

• Reduce waste of currently available resources

• Example to follow!
Lighting the World
Energy Usage: lighting facts

- Global lighting power consumption (2005) 2,650 TWh,
- 19% total global electricity consumption used for lighting.
  - greenhouse gas emissions of 1900 megatonnes (Mt) of CO2/year.

- Equivalent to:
  - 70% of global emissions from cars
  - 3 X emissions from global aircraft.

- Many developing countries produce light using oil lamps.
  - Accounts for:
    - 1% of global lighting energy consumption,
    - 20% of lighting CO2 emissions.
    - 3% of world’s oil supply, (> oil output of Kuwait)

- Incandescent bulbs have a typical efficiency of 5% and efficacy of 15 lm/W (efficacy is corrected for human colour perception)
- Fluorescent tubes have efficacy of 60–100 lm/W and efficiency typically 25%
Lighting technology evolution
Lighting Europe
LED technology evolution

- LED performance: +20 x Decade
- Price per light: -0.1 x Decade

**Lm/Package**
- +20x/Decade

**Cost/Lumen**
- -10x/Decade

Efficiency Driven

Package Driven

Illumination Tipping Point

- 120 – 150 lumen/W
- 100 – 150 lumen/$
LED technology evolution
LED market size by application

Packaged LED Revenue - Split by Application

Increase of penetration rate of LEDs

Decrease of aftermarket volume (replacement) due to higher lifetime of LEDs
Luminaire cost structure

LED is only one contributor but represents the single largest opportunity for cost reduction:
Alternative energy sources

Photovoltaics (PV):
Semiconductor devices that generate electrical power by absorbing photons