

**GEO 3370, SPRING 2005**  
**LECTURE MATERIAL ON HISTORY OF ENERGY USE**  
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**Note:** *There will be no class on Tue. Jan. 25. For Thursday Jan. 27, please read & be prepared to discuss the chapters from Perlin, A Forest Journey.*

*Below is some general background and historical material on energy & power use. You do not need to know the technical definitions of each of the energy & power units below, but you should familiar with the units and know (a) which are units of energy and which are units of power; (b) that these units can be numerically converted into each other & approximately what the conversions are.*

**UNITS OF ENERGY & POWER**

ENERGY MEASUREMENT: calories, joules, BTU, kwh

- (1) **Calorie** (kilocalories) / *heat measure*
  - » *Energy to raise temp of 1 cm<sup>3</sup> water 1° C.*  
*(kcal = 1000 calories; Mcal=1 million cal)*
  - » *Human adults need ≈2000-2700 kcal/day (8-11 MJ)*
- (2) **Joule** (megajoules) / *work measure*
  - » *Work when force of 1 newton acts over 1 m*
  - » *≈4.2 joules = 1 cal.*
- (3) **British thermal unit** (BTUs)
  - » *BTU≈1055 joules (≈250 calories)*
- (4) **Kilowatt-hour** (kwh)
  - » *1000 watts for one hour*
  - » *1 kilowatt-hour (kWh) = 860 kcal = 3600 kJ = 3412 Btu*

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**POWER = rate of energy flow (energy/time)**  
*(often, ability to move things)*

**Units of power:** *Horsepower, Watts*

- **Watt** = 1 joule/sec.
- **Horsepower** ≈ 750 watts (originally defined as power of large work horse pulling 180 lbs @ 3 ft/sec)
  - *Human power:* ≈ 70 - 100 watts (≈0.1 horsepower)
  - *Small car:* ≈ 100 Hp (75 KW) • *Toaster:* 1 KW

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## INDUSTRIES, ENERGY, & POWER SOURCES BEFORE THE INDUSTRIAL REVOLUTION

- (1) **Main Heat Energy Sources & Uses**
- » **Wood & charcoal** (& other biomass) – used both for domestic heating & cooking and industrial production
  - **Domestic heating & cooking**
    - » *Large preindustrial city in cold climate needed wood (or biomass) from area 100x its size for sustainable fuel supply*
  - **Industrial production**, using heat energy (*see below*)
- (2) **Energy densities (energy per unit weight)**
- » **Charcoal** (partially burned wood [moisture removed]) has highest **energy density** of biomass fuels
 

• Green wood, peat, grasses	5-10 MJ/kg
• Dry wood, crop residues	12-15 MJ/kg
• Charcoal	28-32 MJ/kg
  - » Higher energy density means **less weight** (fuel) **must be moved** for given **energy output**
- (3) **Industries using heat energy**
- **Iron & other metals** (*tools, weapons, art...*)
  - Brickmaking
  - Ceramics
  - Glassware
  - Plaster, etc.
  - » *Charcoal main fuel for metal smelting in much of Europe before Industrial Revolution*
  - » *Each ton of iron required 10 acres (4 ha) forest*
  - » *10,000 tons iron/yr (typical early 18th c prod. per country) used 400 sq km forest per yr*
- (4) **Other Uses of Wood**
- House Construction
  - Wagons
  - Shipbuilding
  - Carbon for iron
  - » ***Deforestation in Europe (& N. Amer.)***
- (5) **Sources of Power**
- Power = rate of energy flow (energy / time)*  
*(often can be thought of as the ability to move things)*
- Human labor
  - Animals (horses, etc)
  - Wind (sails, windmills, etc)
  - Water (mills, etc.)
  - » ***No conversion of heat energy to power before the Industrial Revolution***

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## RESOURCE SCARCITIES & THE INDUSTRIAL REVOLUTION

(based on Wilkinson, "The English Industrial Revolution")

### In Britain & elsewhere, land was the basis for

- **Food & feed production** (humans & livestock)
- **Industry** (heat from wood; carbon for iron)
- **Cooking, lighting** (wood; tallow for candles [from sheep])  
{Whale oil as substitute for tallow}
- **Construction** (lumber; bricks)
- **Land transport** (horses; wood for wagons)
- **Sea transport** (wood for ships)
- **Clothing** (wool & exports; leather; cotton)
- **Chemicals** (alkali from wood ash for soap, etc.)
- **Investment** (land as wealth & for prestige)

### Demand for all of these was intensified by:

- (1) Growth in British economic production & trade through 16<sup>th</sup> & 17<sup>th</sup> c  
Britain transformed from underdeveloped to "rapidly developing" nation
- (2) **Rapid population growth**, from mid-18<sup>th</sup> c.  
1750-1850: 180% growth (7.4 mil to 20.8 mil)

### Interlinked scarcities & responses led to **Industrial Revolution** (& "positive feedbacks")

#### (1) **FOOD & FEED NEEDS**

- » Need to feed **people & livestock** (horses, cattle, sheep, etc.) – met mainly by expanding agricultural land
- » **Expansion of agricultural land** led to greater scarcities of other land-based resources
- » Britain became net wheat **importer** in 1760s (Debates over "Corn Laws" & free trade)
- **"Second Agricultural Revolution"**
  - » **Innovations** in soil & water management, agronomy, crop varieties, livestock breeding
  - » Large increases in **yields & output** – helped relieve some land pressure

#### (2) **WOOD & FUEL SCARCITY**

- » Timber scarcity by 17<sup>th</sup> c due to incr'd use of wood for **fuel, construction, ships**, etc
- » **Fuelwood prices** increased **twice as fast** as general price level thru 16<sup>th</sup> c & 17<sup>th</sup> c
- » Scarcities met partly with **imports of timber & high energy products** (esp. iron)

(To be continued in class...)