Renewable Energy In Agriculture

Paul Harris

Energy in Our Lives

Consider life without energy as we accept it today!

Energy in Our Lives

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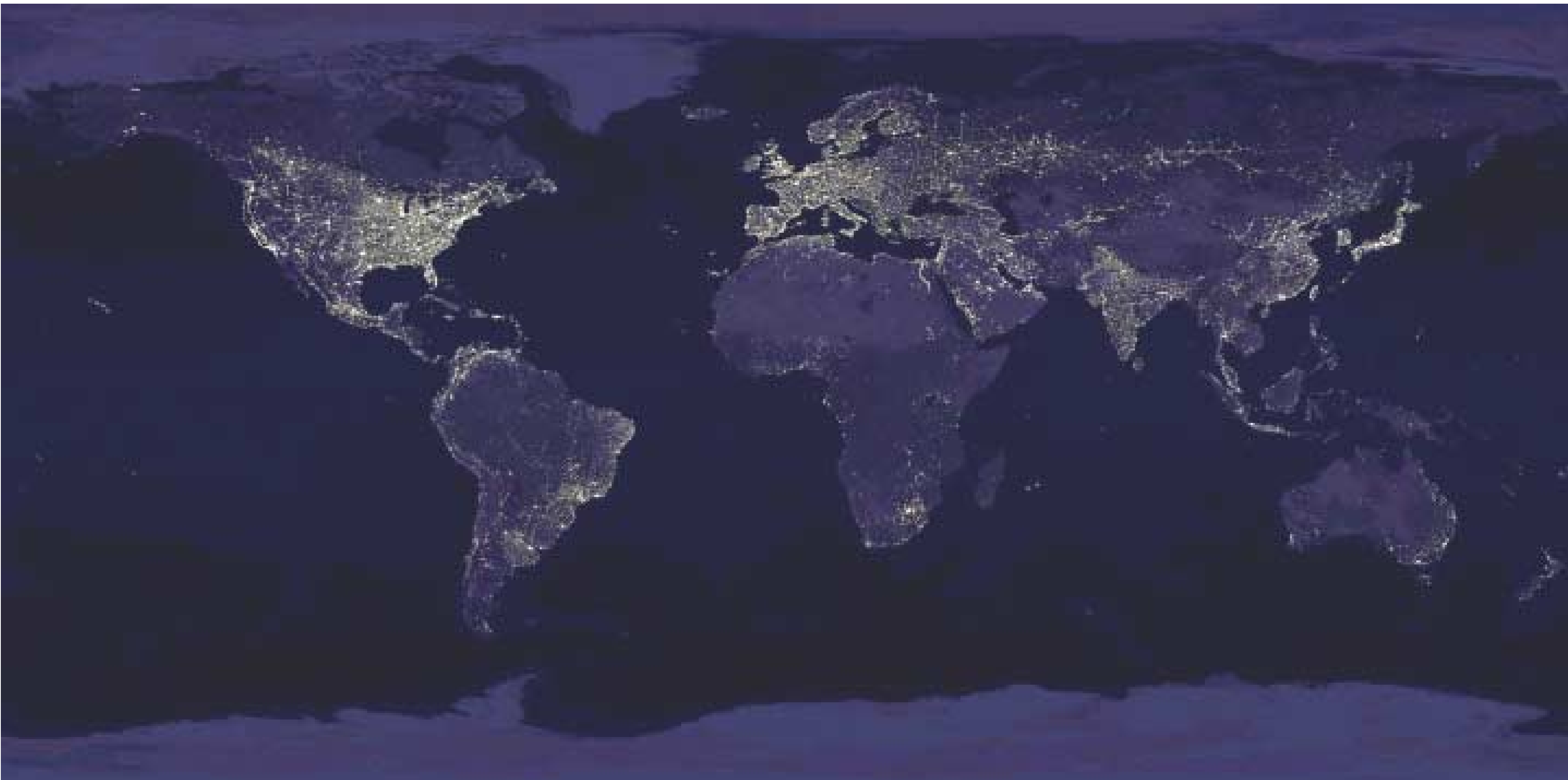
- Buildings.
- Lights.
- Air Conditioning.
- Paper.
- Transport.
- Clothing.
- Etc. Etc. Etc. Etc. Etc. Etc. Etc. Etc. Etc. Etc.

World Energy Distribution



National Ecological Footprints

Data from WWF "LIVING PLANET REPORT 2002" (1999 data unless otherwise specified)

Country	%Popln	%Nat TEF	%Crop	%Grazing	%Energy
United States of America	4.70%	20.16%	13.71%	13.46%	24.58%
China	21.34%	14.52%	14.70%	17.18%	12.95%
India	16.65%	5.67%	9.18%	0.00%	4.40%
Russian Federation	2.45%	4.87%	5.26%	3.29%	5.44%
Japan	2.13%	4.48%	1.97%	1.14%	5.69%
Brazil	2.82%	2.97%	3.56%	13.88%	1.46%
Germany	1.38%	2.86%	1.84%	1.11%	3.73%
United Kingdom	1.00%	2.36%	1.34%	2.95%	2.92%
France	0.99%	2.30%	1.91%	1.68%	2.65%
Canada	0.51%	2.00%	2.20%	1.42%	2.13%
Australia	0.32%	1.06%	1.02%	1.76%	1.21%
United Arab Emirates	0.04%	0.20%	0.10%	0.07%	0.30%
Congo	0.05%	0.02%	0.02%	0.01%	0.01%
Gabon	0.02%	0.02%	0.03%	0.01%	0.01%
Namibia	0.03%	0.02%	0.04%	0.06%	0.01%
Liberia	0.05%	0.02%	0.02%	0.00%	0.01%
Sierra Leone	0.07%	0.02%	0.03%	0.02%	0.01%
Botswana	0.03%	0.02%	0.02%	0.09%	0.00%
Mauritius	0.02%	0.01%	0.02%	0.02%	0.01%
Lesotho	0.03%	0.01%	0.02%	0.05%	0.00%
Gambia, The	0.02%	0.01%	0.02%	0.01%	0.00%
Guinea-Bissau	0.02%	0.01%	0.01%	0.01%	0.00%

To Conclusions

The Future of Fossil Energy

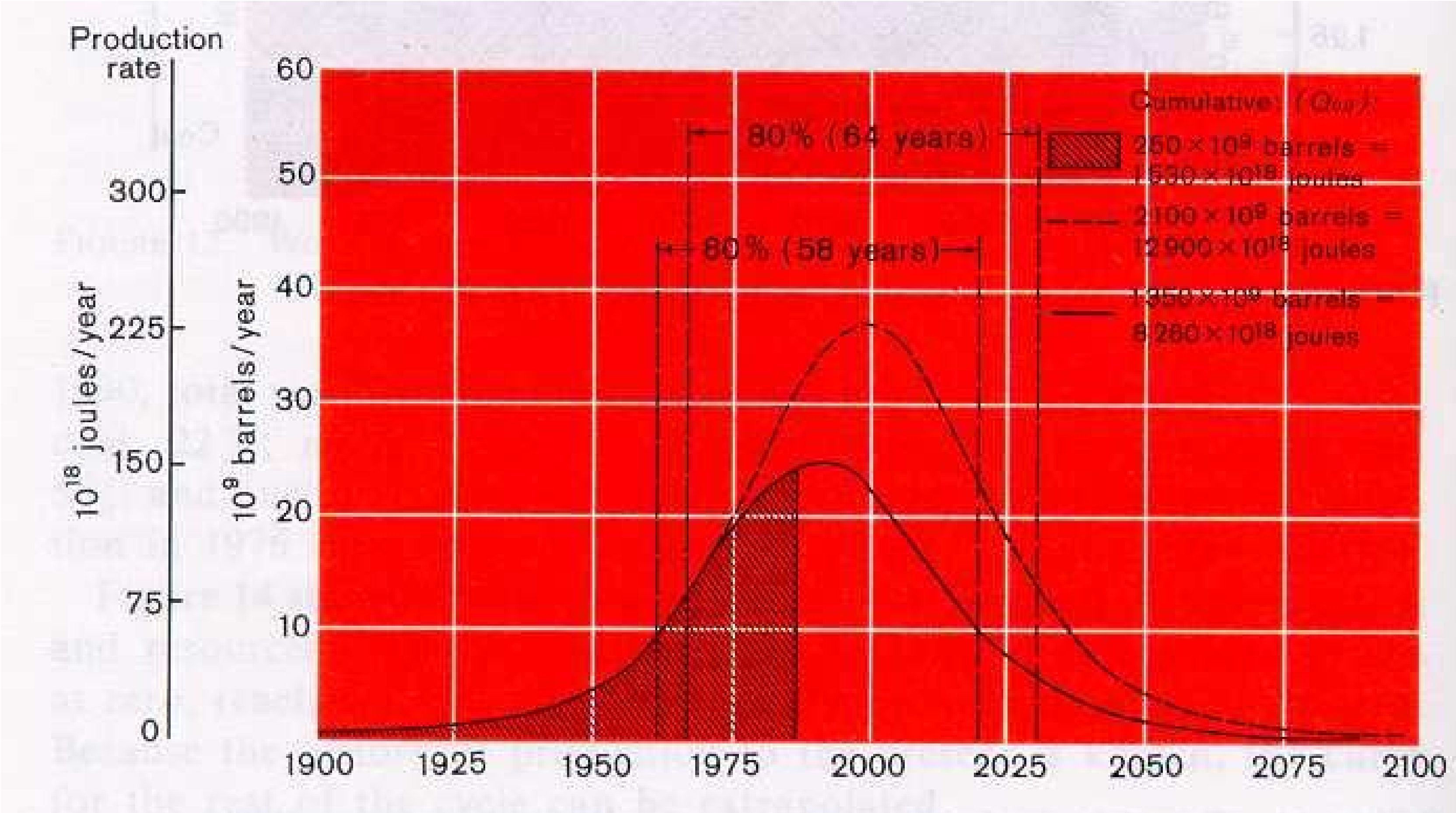


FIGURE 15. Complete cycle of world crude petroleum production (120).

From "Energy for World Agriculture", FAO Agriculture Series No. 7, 1979

It appears that oil "production" (extraction) may have peaked

Consider Changes in Agricultural Energy Use.

- Early Agriculture
- Agriculture ~200 years ago.
- The steam age.
- Internal combustion engines.
- Chemicals.
- Future outlook.

1790

- **3,900,000 Americans**
- **90% in agriculture (3,510,000 people)**
- **50- 60** man hrs/ A for wheat

From Splinter, W.E. SEAg 2002 Conference

1890

- **6,000,000 Americans**
- **45% in agriculture (2,700,000 people)**
- **8- 10** man hrs/ A for wheat

From Splinter, W.E. SEAg 2002 Conference

1980

- **225,000,000 Americans**
- **3% in Agriculture (6,750,000 people)**
- **0.5** man hrs/ A for wheat

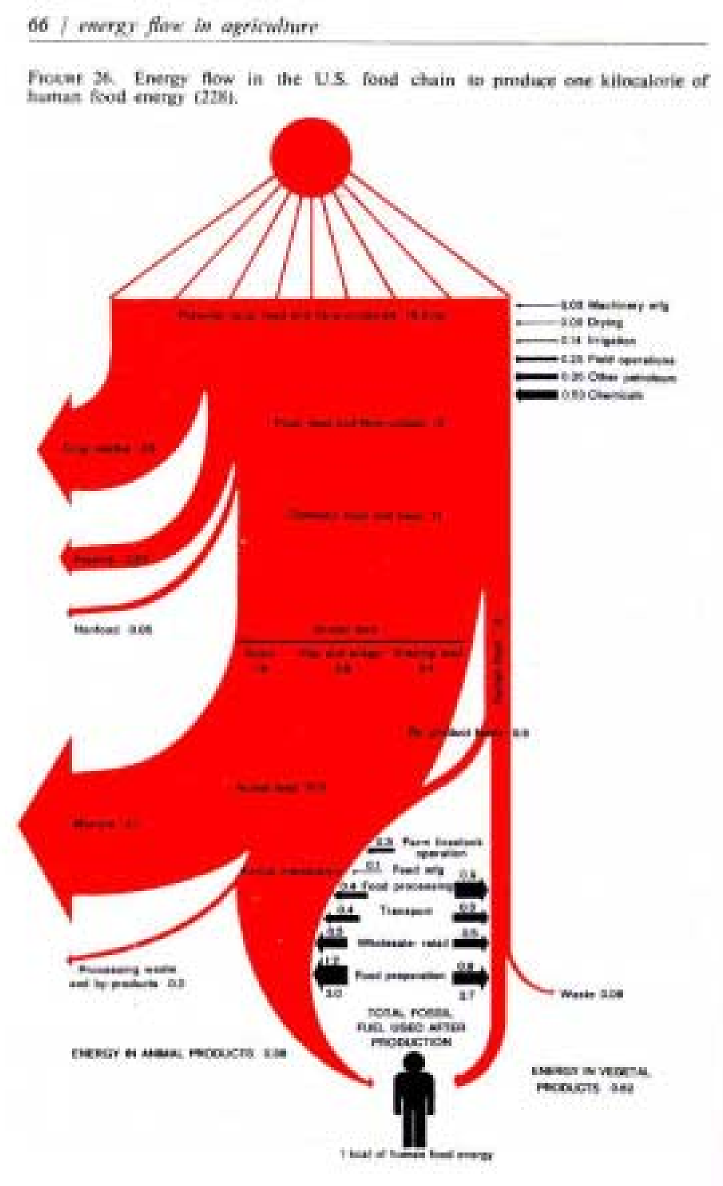
From Splinter, W.E. SEAg 2002 Conference

One Day's Work

man/hoe	horse/plow	tractor/plow
0.04 Ha	0.7 Ha	24 Ha
5 BigMacs	20 BigMacs	4164 BigMacs
2,700 cal	11,600 cal	2,334,600 cal
$26.88	$38.40	$93.60
$672 /Ha	$55 /Ha	$4 /Ha
1.1 people	2.2 people	33.3 people
2450 cal/hd	5270 cal/hd	70410 cal/hd
67500 cal/Ha	16600 cal/Ha	97300 cal/Ha

From Splinter, W.E. SEAg 2002 Conference

Energy in Agriculture

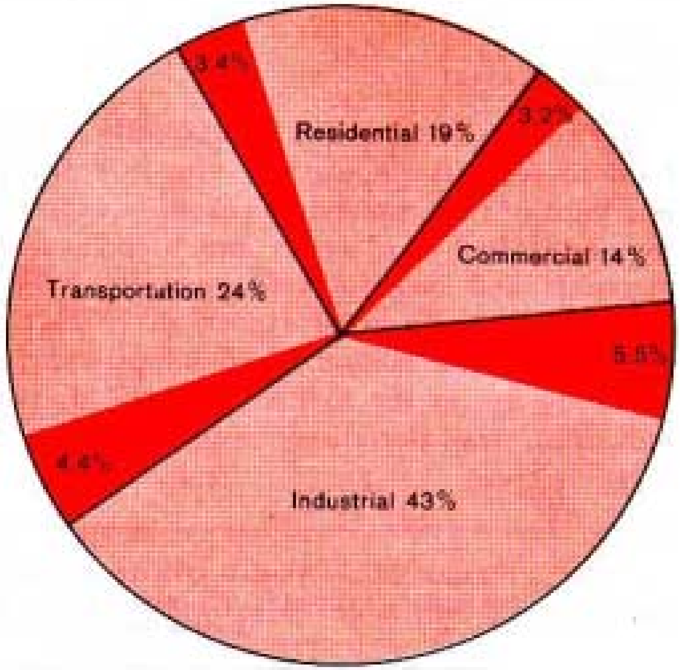


From "Energy for World Agriculture", FAO Agriculture Series No. 7, 1979

Note: A person needs 3000 kcal per day, which will take 2.3 kW to produce.

Agriculture Energy Use

FIGURE 24
Major categories of energy use and consumption (shaded area) in the U.S. food system (1).



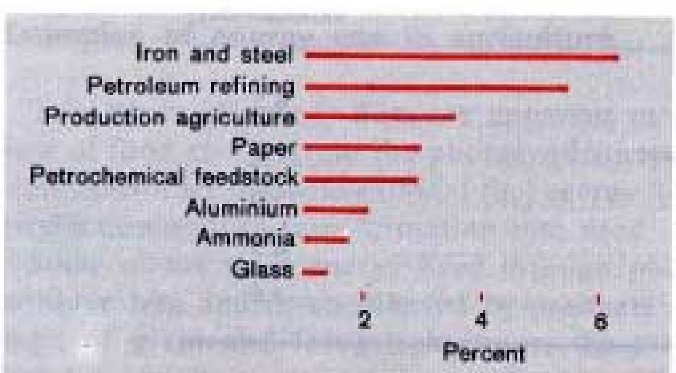


FIGURE 25
Percent of total U.S. energy consumption by industry (113).

From "Energy for World Agriculture", FAO Agriculture Series No. 7, 1979

To Conclusions

Energy for Different Foods

TABLE 19. – ENERGY SUBSIDY FOR VARIOUS FOOD CROPS

Kilocalories of energy subsidy per kilocalorie of food output	*Type of production*
0.02-0.05	Rice production in Indonesia, China and Burma with hand labour supplemented by minimal draught power.
0.05–0.1	Rice production in Thailand. Large-scale cultivation of directly consumed potatoes.
0.1-0.2	Hunting and gathering. Intensive rice production in Europe.
0.2-0.5	Extensive maize cultivation. Intensive potato cultivation. Intensive soybean cultivation.
0.5–0.9	Intensive maize cultivation. Family egg production. Extensive beef production.
About 1	Dairy farming on grassland. Coastal fishing.
2–5	Beef production on grassland. Industrialized egg production.
5–10	Powdered fish proteins.
10–20	Fishing. Livestock raising on feedlots.

SOURCE: (227)

From "Energy for World Agriculture", FAO Agriculture Series No. 7, 1979

Energy for Inputs

- Phosphate Fertiliser – 14 MJ/kg P
- Nitrogen Fertiliser - 80 MJ/kg N
- Potassium Fertiliser – 9 MJ/kg K
- Diuron – 270 MJ/kg ai
- Atrazine – 190 MJ/kg ai
- Trifluralin – 150 MJ/kg ai
- Paraquat – 460 MJ/kg ai
- MCPA – 130 MJ/kg ai

cf. coal 25 MJ/kg or diesel 32 MJ/l

From “Energy for World Agriculture”, FAO Agriculture Series No. 7, 1979

Sources of Renewable Energy.

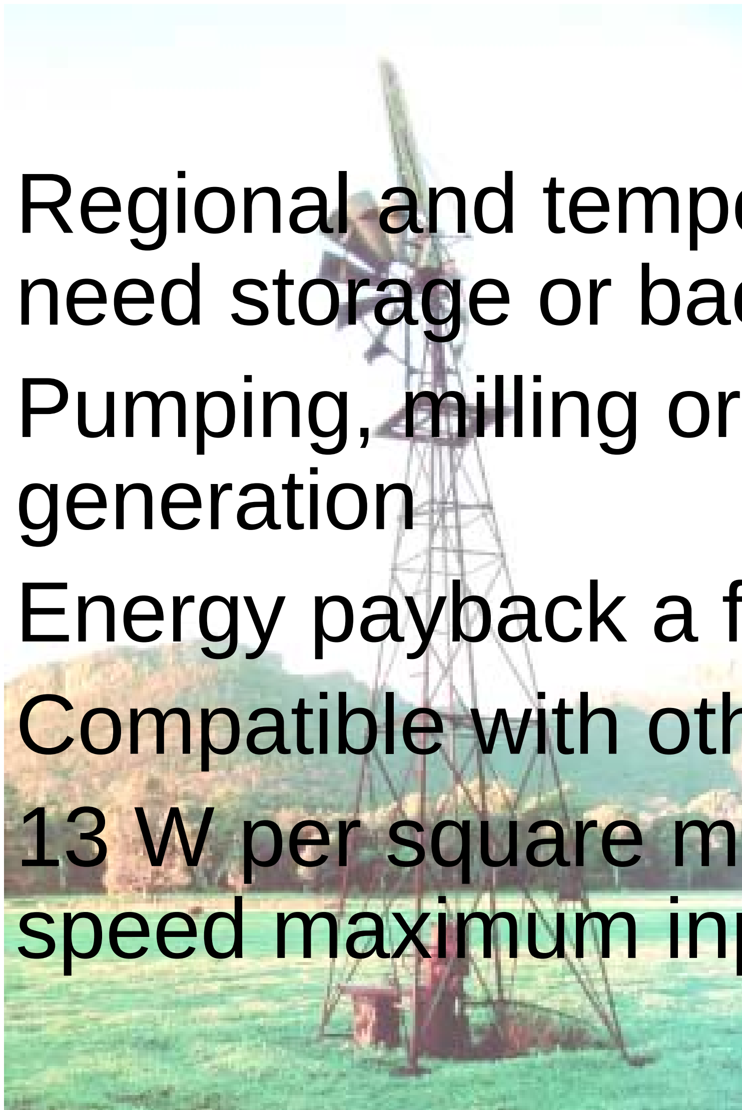
Advantages and disadvantages of sources and the equipment required will be discussed.

- Solar
- Wind
- Hydro
- Tidal/Wave
- Biomass
- Biogas
- Biodiesel
- Muscle
- Hydrogen
- Geothermal?

Solar

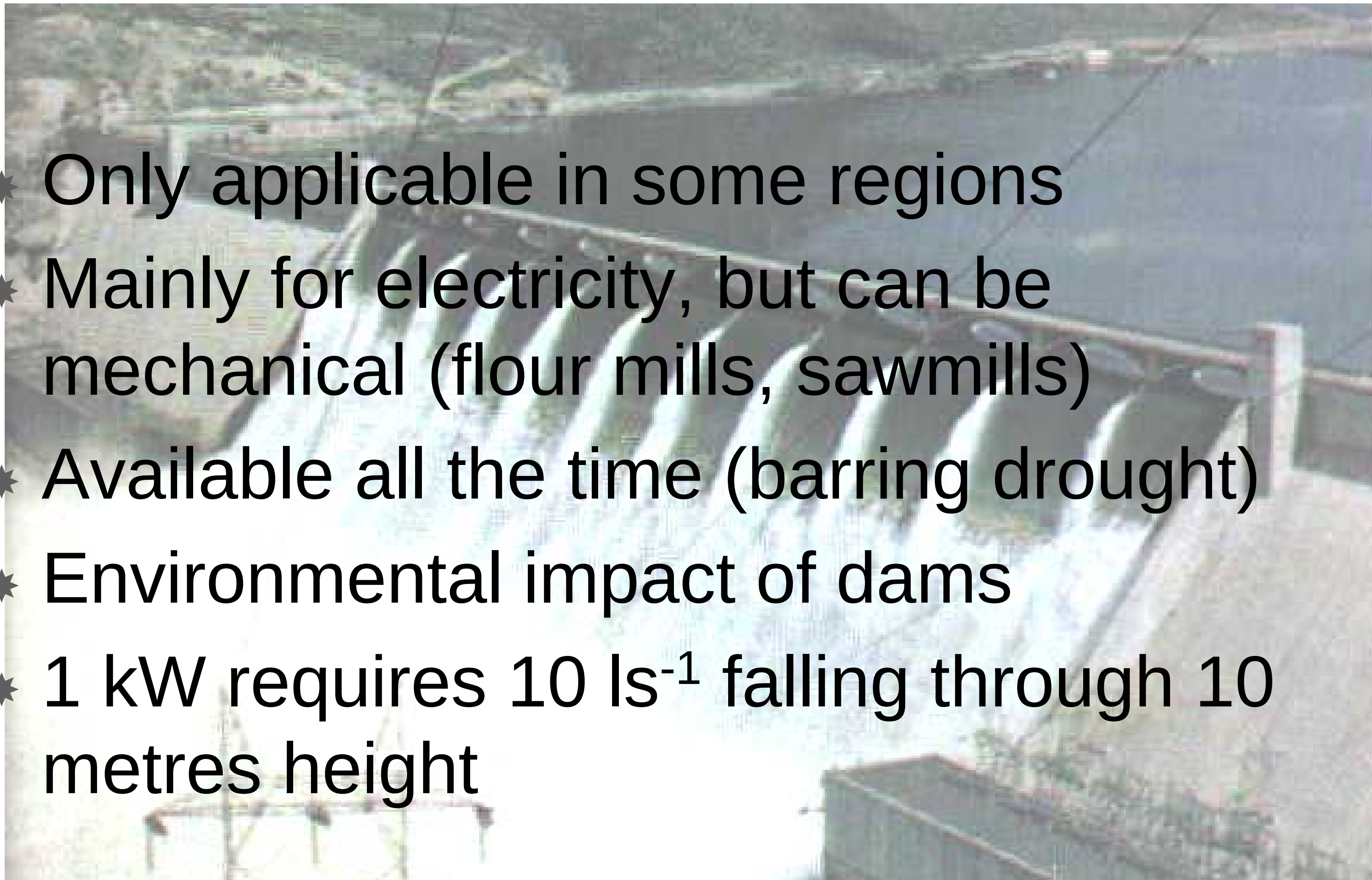
- Original source of all energy (except geothermal and nuclear)
- Generate heat and/or electricity
- Influenced by time of day, cloud and season – need storage/backup
- Photovoltaics have ~ 5 year energy payback but nasty industrial processes
- 1 kW per square metre maximum incoming energy
- Alignment of collector is also a factor

Wind



- Regional and temporal variability – need storage or backup
- Pumping, milling or electricity generation
- Energy payback a few months
- Compatible with other land uses
- 13 W per square metre at 10 kph wind speed maximum input energy

Hydro



- Only applicable in some regions
- Mainly for electricity, but can be mechanical (flour mills, sawmills)
- Available all the time (barring drought)
- Environmental impact of dams
- 1 kW requires 10 ls^{-1} falling through 10 metres height

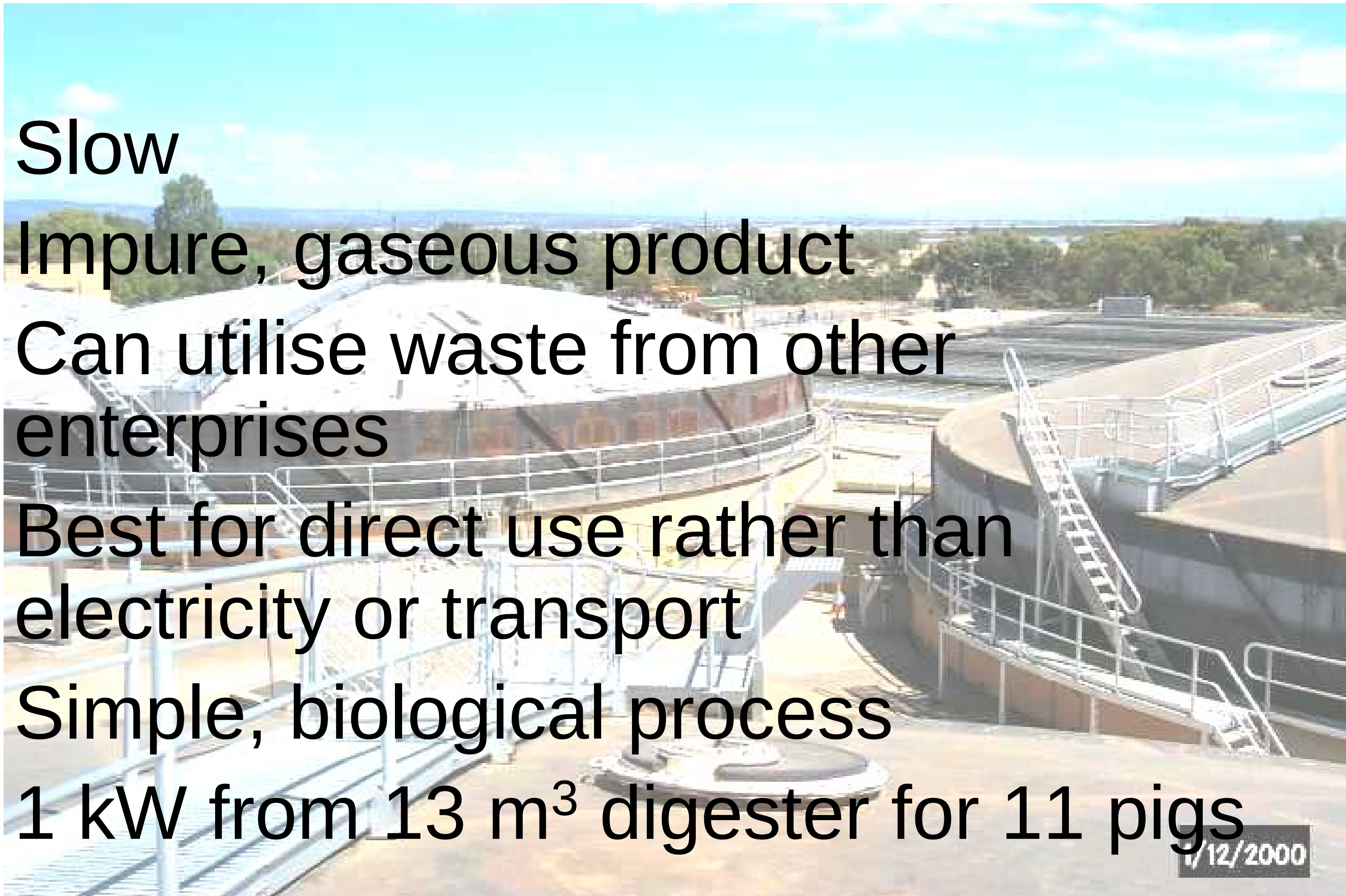
Tidal/Wave

- Restricted to some coastal regions
- Low level energy
- Exposed, environmentally sensitive locations
- 1 kW developed from 100 ls^{-1} of water at 1 m head

Biomass

- Cropped or waste material
- Water content
- Various processes/products
- Usually high temperature process producing ash
- 1 kg wood is equivalent to approximately 0.5 litre of diesel

Biogas



- Slow
- Impure, gaseous product
- Can utilise waste from other enterprises
- Best for direct use rather than electricity or transport
- Simple, biological process
- 1 kW from 13 m^3 digester for 11 pigs

Biodiesel

- Area for production
- Processing required
- Direct replacement for fossil fuel

Muscle

- Limited power
- Tires quickly
- 75 W for a fit person
- Horse 750 W

Hydrogen

- High technology
- Each transformation of energy loses efficiency
- Fuel cell or IC engine use
- Source of hydrogen?

Geothermal

- Only in volcanic areas
- Limited Life – long term effect

Applications

- Value Adding
  - a cost becomes an income
  - waste becomes

etsaw

- Distributed Systems
  - reduced transport
  - ownership
  - reliability
- Systems Approach

Conclusions

- There is no quick fix solution - we will need to use every tool at our disposal, quickly
- Energy consumption will have to decrease from current levels
- Agriculture is a small part of the energy scene, but adopting efficient and renewable practices will help maintain production and viability while extending existing reserves
- Consider “triple bottom line” – environmental, social and economic aspects

Some Thoughts/Observations

- We have tunnel vision/reductionist thinking
- We have a remarkable tendency to make things as complicated as possible
- The harder you push any system the more unstable it becomes and the more management it requires

  (Harris' Law)

World Views

The commonly held worldview is an old one from the frontier. It comes from the rear-view mirror, reflecting times when the world was big and people were few.

The emerging worldview, held as yet by a minority of citizens, is grounded in the reality of the present: a time when the world is small and people are many.

Alan Durning

http://www.cooperativeindividualism.org/durning_worldwatch_essay.html