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Global decline in oil and natural resources; implications for the scope and content of papers for publication in LRRD

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Abstract

The scope and aims of "Livestock Research for Rural Development" relate specifically to the issues raised in this editorial. We see it as a challenge and an obligation to promote farming systems that will contribute to reducing the dependency on supplies of fossil fuel, grain and water.

Availability of primary resources and environmental, ecological, social and political issues are having, or will have, enormous effects on rural development in the near future. There is strong evidence that world oil production has peaked and that rural development will be massively handicapped by expensive energy in the future. The global peak in production of high-quality fossil fuels is already causing shock waves through the world economy and reshaping geopolitics. Barely recognised by politicians, scientists or the public, this event will precipitate a cascade of environmental, economic, political and cultural changes for which society is totally unprepared. While these changes will be seen as a threat, global energy peak has the potential to quickly eclipse climate change as the driving force for sustainable development

The problem appears to be so acute that it will be impossible for the emerging nations to develop along the same lines as those that led to the present wealth of the industrialized nations. This statement alone suggests that a “non fossil fuel dependent development” will be necessary in the future. The general viewpoint is that future society will be organized in a very different way, the emphasis being on small, localized and decentralized systems. In this context, the integrated utilization of biomass for both food and energy production, particularly in the yet to develop countries, is an option that can be generalized immediately. By decentralizing the production of electricity and using fibrous biomass as the feed stock for gasification, the new paradigm could be "migration from the towns to the countryside". Rural areas would thus revert to their original role, and become the source of energy, food and employment. Dual purpose crops and cropping systems will have a comparative advantage, and provide a more productive and sustainable alternative to maize and soya bean. This new paradigm will in turn impact on future strategies for research and education.

We see this as the major challenge now, for agricultural scientists and educationalists. We believe we have an obligation to promote farming systems, in all countries, that will contribute to reducing the dependency on supplies of fossil fuel, grain and water. At the same time this will contribute materially to a reversal of the damage to the environment that oil-based technology has caused.

Key words: Biomass, decline in oil, energy, alcohol, grain, water, farming systems

Introduction

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Our dependence on oil

In 1952 Sir Charles Galton Darwin wrote:

> "The fifth revolution will come when we have spent the stores of coal and oil that have been accumulating in the earth during hundreds of millions of years... It is to be hoped that before then other sources of energy will have been developed... Whether a convenient substitute for the present fuels is found or not, there can be no doubt that there will have to be a great change in ways of life. This change may justly be called a revolution, but it differs from all the preceding ones in that there is no likelihood of its leading to increases of population, but even perhaps to the reverse."

In 1956, geophysicist Marion King Hubbert--then working at the Shell research lab in Houston observed that oil fields follow a pattern in which output climbs slowly after discovery, and rises rapidly once the well is mapped when easy to get oil is being obtained under pressure. The pattern slows and finally peaks which coincides with exhaustion of 50% of the reserves. From then on the changes in production reverse, such that the well's production over its life time is a graph that looks like a bell curve. Following peak production, the cost of extraction of oil increases substantially. From this pattern of US oil use Hubbert predicted that US oil production would reach its highest level in the early 1970s. Though roundly criticized by oil experts and economists, Hubbert's prediction came true in 1971 (Deffeyes 2003). Campbell (1997) and Campbell and Laherrère (1998) applied the same model to global oil wells and found from the same logic that estimated that world oil would peak probably in 2005. New information indicates that world oil production may have peaked in the year 2000 (Deffeyes 2003).

A conference (Oil-based Technology and Economy - Prospects for the Future), jointly organized by The Danish Board of Technology and The Society of Danish Engineers, was held in Copenhagen, Denmark, in December 2003 (www.ida.dk/oilconference)

The conclusions of the conference were:

- That the world economy has become completely dependent on supplies of fossil fuel and on liquid oil in particular
- That the decline in oil supplies is inevitable and could begin as early as 2010 (Figure 1) or at the latest by 2030-35 (EIA 2000)
- The tendencies in demand and supply depict a world economy becoming technologically more and more dependent on conventional oil until, suddenly, a steep decline in the supply of oil sets in.
- No economically competitive alternatives to conventional oil are sufficiently advanced for them to be put in place to avoid the global economic recession that will be caused by such a decline.
- It appears that the shift from growth to decline in the production of cheap conventional oil entails a host of environmental, economic, political and technological problems to be solved within a short period of time.
- Just to wait and see which solutions may turn up is to wait to see the uncertain outcome of a hazardous experiment.

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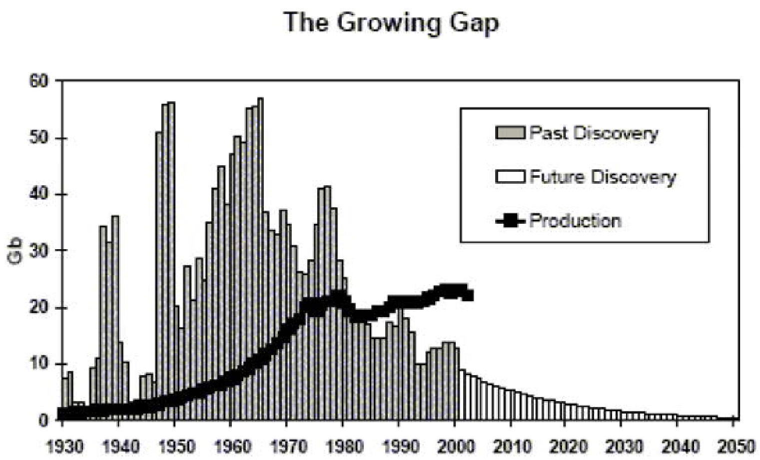

Figure 1: Past and future discoveries of oil and production (from Campbell 2003)

The role of agriculture in the presentations and discussions in the conference received little attention except for the following comments:

> <<Nevertheless, farmers around the world could incorporate the production of sufficient amounts of bio-diesel, ethanol, biogas *(and producer gas)* to fuel their tractors, and other machinery in ecologically sustainable farming cycles.
>
> This *is* possible because the residues (straw, *bagasse, stems from forage trees, animal manure) from integrated farming systems, the primary purpose of which is to produce human food or animal feed, can be used as feedstock for fuel (eg: synthesis gas from fibrous crop residues; and biogas from animal manure) (the text in italics is ours: TRP-RAL).*
>
> It would be a most important achievement if the basis of the food chain of all human societies in this manner became independent of petroleum supplies>>.

The view of Matt Simmons (Oil analyst)

More recently (August 4, 2004), F Jay Schempf (*Petroleum News Contributing Writer)* published an interview with Mr Matt Simmons, Oil Analyst and Founder and President of a Company with 30 years experience of investment banking completing 500 oil and gas banking projects [$US58 billion]. Excerpts from the interview are presented below, because we believe everyone - and not least the readers of LRRD -- should be aware of the reality underlying the debate about oil:

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"Matt Simmons hopes he is wrong.

But if he's right in his belief that Saudi Arabia's giant oil fields might already have peaked [Comment added: *which produce about 25% of the world's output of oil (Piddick 2004)]* and could start into rapid decline in as few as three years, somebody better have a "Plan B" ready or there's no way, he says - absolutely no way - to avoid a world energy cataclysm.

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Simmons asked for anybody, including the Saudis themselves, to refute his claim. But so far, in his view, nobody's stepped up. He acknowledges, however, that the Saudis recently have been more forthcoming about their ability to supply all the extra oil the world will require from Saudi fields. But still, it appears that nobody is willing to counter his specific charges.

There's no Act 2

Normally, Simmons said "Saudi fields would be subject to the same decline curves as those experienced by any of the world's oil fields, once reservoir pressure begins to dwindle. The difference is, he said, Saudi Aramco doubled up to catch up, almost from the start, by keeping reservoirs pressures - and individual well flow rates - as high as possible, seemingly for as long as possible."

In simple terms, says Simmons, the Saudis have produced their fields under simultaneous primary and secondary recovery, having instituted huge water-flooding programs relatively soon after completing field development.

"All of these fields are old," he pointed out, "but Saudi Aramco has managed them in a 'gold standard' fashion by instituting careful and rigorous water injection to maintain very high reservoir pressures. They're effectively sweeping the reservoirs until the easily recoverable oil is gone. In so doing, they have defied the standard decline curves. With water injection, they've maintained reservoir pressures above the bubble point. The trouble is, once they finally finish the sweep, they've done both primary and secondary depletion. There isn't any Act 2." [Comment added *This means that the classical bell curve will be distorted with a more rapid decline in oil reserves once peak production has passed.]*

New technology won't do it

He added that Saudi Aramco senior managers also believe "with some passion" that the technological tools they are now employing would contain the rise of water in existing fields. Such tools, he noted, include horizontal and extended-reach wells and multi-lateral well completions, among others.

"My worry is that too many other oil companies around the world also believed these same tools would allow them to steadily grow their production from a reduced amount of wells drilled," he said. "Instead, it turned out that virtually every key oil producer using these same tools sadly ended up seeing their production growth peter out."

While the tools did extract more oil per well, he explained, they also accelerated the recovery of economical oil. In turn, this created decline rates never seen before in existing production.

Calls for mandatory oil reserves transparency

But regardless of who's right or who's wrong, Simmons said, the solution to determining whether Saudi fields can meet ever-climbing demand is a simple one: Adopt a far higher standard of petroleum data transparency and begin reporting timely field-by-field production statistics, supported by the average number of producing wells in each field, and have it verified by a reliable third party.

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Without such information and without it being handed over quickly, the world could be in for a huge surprise, said Simmons. In his opinion, great crises come out of ignoring great problems, and the sooner the world is aware of a problem, the sooner a solution - "Plan B" - can be reached. He said that with greater oil supply transparency, the current oil price probably would not gyrate the way it has in the past. "The increased knowledge of what's really going on in the energy business versus the perception of what we thought was going on will help people understand that we need to get used to high energy prices and that $40 per barrel oil is not dangerous," said Simmons.

What's dangerous, he said, is $40 per barrel oil being too cheap.

Difference can't be filled from elsewhere

But the outlook is still extremely grave, he said.

"If I'm correct about my concerns, Saudi Arabia is now producing more than they should to sustain their oil output," he deadpanned. "The harder you pull a field in its production, the faster you bring on the end of its reservoir pressure. So, I could argue that for the well-being of the world, Saudi Arabia probably ought to back off and start producing 3 to 4 million bpd so that their oil might last another 30 to 50 years. However, they may already have peaked in their ability to grow oil production, and if that's so, the world has peaked, as well."

Could the difference be made up from other world oil-producing areas? Again, Simmons is dubious. Not from West Africa, he said. Not from Russia, either. And currently, alternative fuels won't do it, either. Not natural gas, the available global supply statistics on which are even murkier than those for oil. Not hydrogen fuels, since they require a basic energy feedstock. Not even nuclear power, which he said would take decades to add, with scarcely a clue as to how much uranium remains throughout the world.

"There isn't any case you could make, by any stretch of the imagination, based on anything we know, that you could go elsewhere to make up the difference," said Simmons. "This could become the biggest energy issue the world has ever faced."

Among all the ramifications of a worldwide energy shortage, Simmons said, the geopolitical implications are perhaps the most severe, particularly since the United States imports 25 percent of Saudi Arabia's total oil exports, which average about 6 million bpd.

"I have oftentimes said that I would not want to be part of any energy delegation charged with the responsibility of having to tell the leaders of either India, or particularly of China, that their exciting emergence into prosperity is over because we have no spare energy to fuel their great dreams."

Meanwhile, Matt Simmons is waiting - and hoping - for someone to prove him wrong.

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In summary

On the supply side, the future looks bleak as is evident from the comments by Simmons. While on the demand side, the statistics indicate an exponential increase (Figure 2), fuelled mainly by demand from China, India and the USA. The present situation is explicitly summarized by Richard H. Sibson (Box 2).

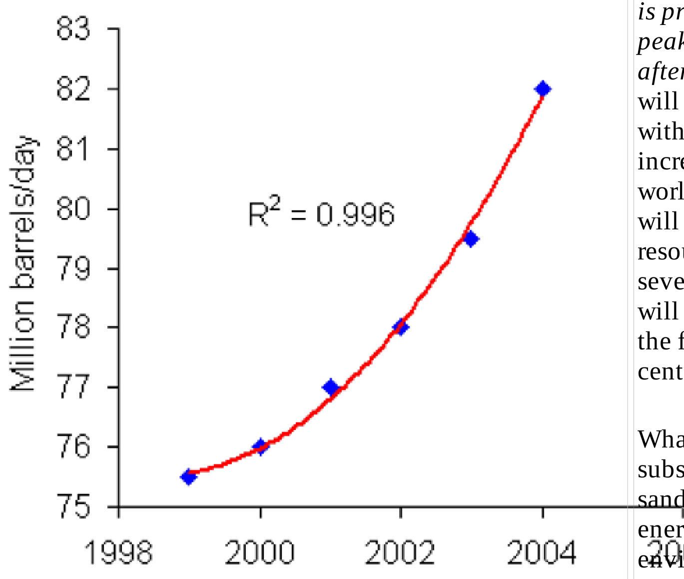

Figure 2: Demand curve for oil is exponential (IEA 2004)

Box 2:
Put simply, across the Earth, we are currently burning more than 4 barrels of oil for every new barrel discovered while demand continues to rise. Independent analysts estimate that we have produced nearly 50% of the total global resource of recoverable conventional oil. *The global 'Hubbert Peak' for conventional oil production is predicted to occur in 2005±5 years, with the peak in gas production following shortly afterwards.* Beyond the global peak, oil price will escalate steeply as demand exceeds supply with the Gulf States no longer able to meet the increasing shortfall throughout the rest of the world. Competition for a dwindling oil supply will become increasingly fierce. The world resource of conventional oil, accumulated over several hundred million years of geological time, will effectively be dissipated only 200 years after the first oil wells were drilled in the mid 19th century.

What alternatives exist? There are very substantial reserves of non-conventional oil (tar sands, oil shale, etc.), but extraction will be energy intensive, expensive, slow, and very environmentally unfriendly! Renewable energy sources (hydro, solar, wind, geothermal) along with coal and nuclear power may substitute for oil-gas in electricity and heat generation, but NO known substitutes for long-distance travel and transportation can supplant the oil infrastructure over a short time-frame. Hydrogen-powered fuel cells are being looked at as a clean energy source for short-haul transport, but generation of hydrogen is itself energy intensive. Because of its reliance on cheap long-haul transportation, global trade at its present level seems unsustainable beyond peak oil. Massive disruption to the global economy seems likely by 2010-2015.

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Alcohol

One consequence of the rising price of oil and the acceptance that the decline in supply is inevitable, is the increasing interest in fuel alcohol, partly as an oxidant to reduce emissions from vehicle exhausts, but also as a replacement for gasoline (Figure 3). Alcohol is produced by the fermentation of sugar usually derived from maize or sugar cane which is produced at considerable cost of fossil fuels. As pointed out by Pimentel (2001), alcohol production from maize, on a volume to volume basis, uses as much energy from oil as it produces in alcohol. The proponents of fuel alcohol production justify the industry on the basis of the reduced air pollution in cities and the profit from sale of the byproducts (see Shapouri et al 1995).]. This does not take into account the costs of transporting alcohol to major cities nor does it consider the high costs in soil erosion inherent in grain production and the depletion of resources such as water or the down stream effects of pollution caused by run-off of nutrients from grain production. For example, in the latter caseno costs are directed at US grain producers for the resultant 21,000 square mile "Dead Zone" in the Gulf of Mexico due to eutrophication and largely attributable to fertilizer run-off via the Mississippi basin from grain lands; nor does it factor in the loss of land mass in the same area attributable to the low fresh water flows and sediment in the Mississippi river with the huge off-take of water for irrigation. When these costs are better targeted then the cost of grain has to increase substantially. Alcohol production will undoubtedly provide alternative markets for grain and we will see much set-aside land being used for this purpose. At the present time it is estimated that 12% of the maize production in the United States will be diverted from animal and human feed to alcohol production. This will surely "dry up world surplus grain and throw into doubt the world's chances of avoiding mass starvation if natural or man made food shortages occur in the developing nations particularly Africa. Many countries are now actively encouraging the development of fuel ethanol industries (see Berg 200).

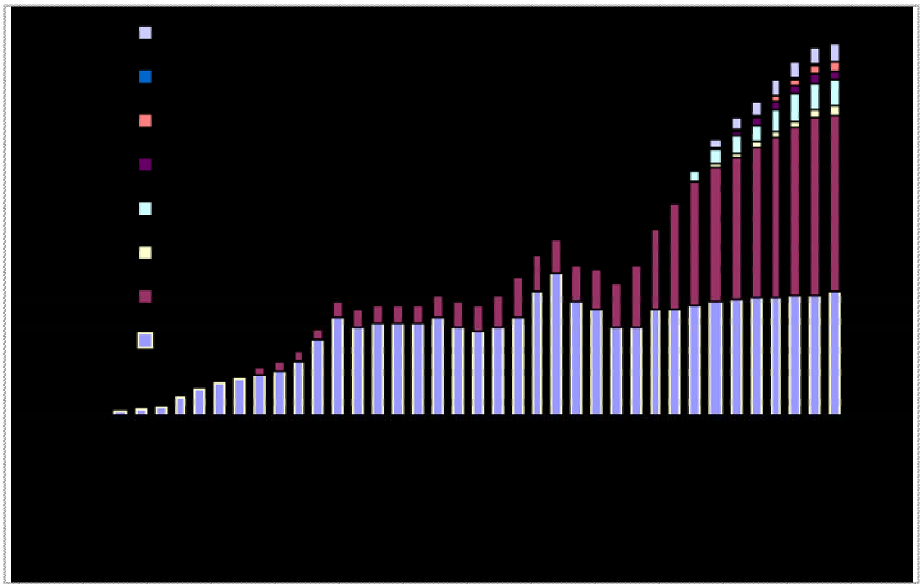

Figure 3: Global tendencies in production of alcohol (Berg 2001)

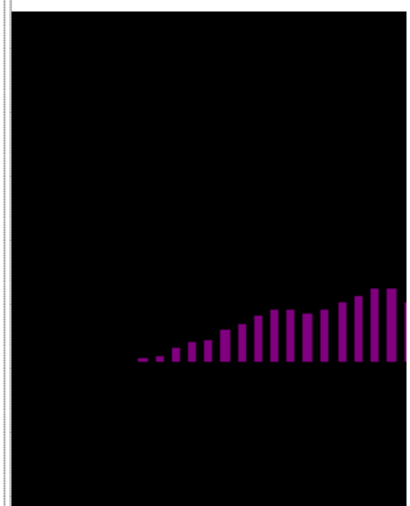

Figure 4: Past and future trends for USA (Pearce Lyons an

It therefore appears inevitable that inexpensive grain will become scarce in a world where large numbers of resource-poor people already suffer under-nutrition and mal nutrition. However, the alcohol industry is going to develop world wide, competing for feedstock with food and feed and removing surplus grain from the market and ensuring that the world price will be high and availability for feeding animals will be low. The insanity of any scheme to produce alcohol as the major transportation fuel is well illustrated by the calculations of Pimmentel and his colleagues, which showed that with highly optimistic assumptions about the costs of alcohol production from grain, to fuel one car for 12 months would need 4.4 ha of good crop land planted to maize whereas, in comparison, only 0.6 ha of crop land is currently used to feed an American citizen. Thus more then 7 times more crop land is required to fuel one automobile then is required to feed one person. If all cars in the USA were fueled by ethanol this would require a greater amount of cropland then the size of the USA.

Apart from the economic and environmental implications, of producing alcohol, there is the direct competition with food and feed supplies. both, it is apparent that many countries, and especially the USA are pursuing the alcohol option. Estimates in the USA are that by 2010 some 50 million tonnes of grain will be converted to alcohol (Figure 4) – this is close to the present exportable grain surplus (about 60 million tonnes) from that country. The related problem is that, as is the case with oil, world demand exceeds the supply (Figure 5), with the result that world stocks have steadily declined over the past few years (Figure 6).

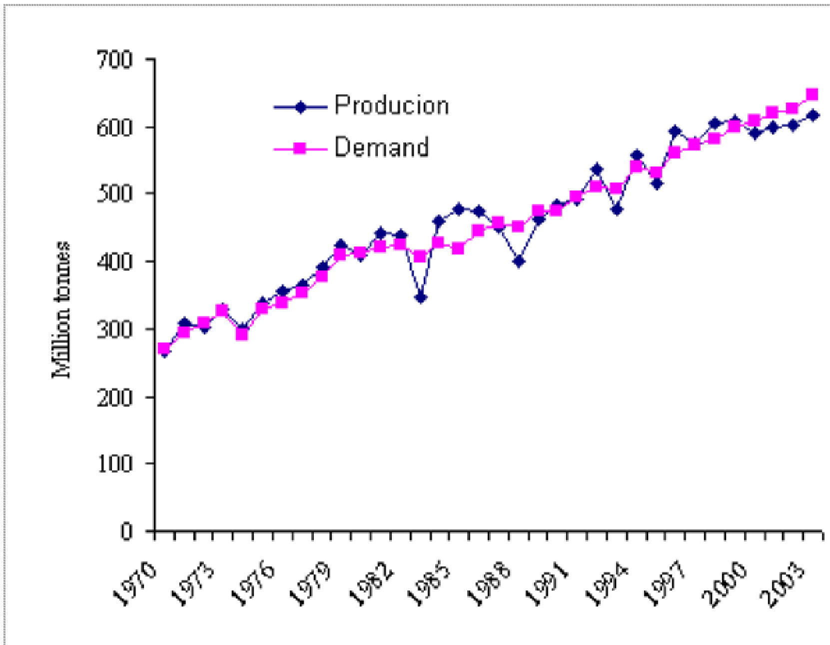

Figure 5: World production and demand for maize (Rameker 2004)

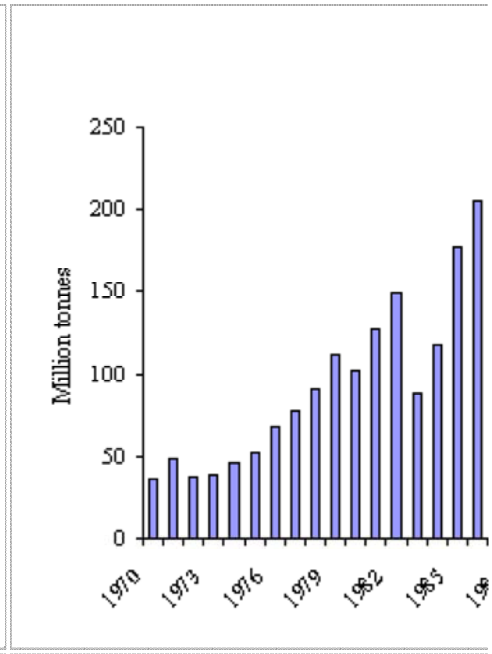

Figure 6: Trends in world stocks of maize (

The same trend is seen for China, the country whose high rate of economic growth is fueling the demand for grain as well as for oil (Figure 7). But demand over the past 4 years has increasingly exceeded production with the result that the shortfall has had to be made up from the reserve stocks. In 2005, it is expected that China will be a net importer of maize (Rameker 2004).

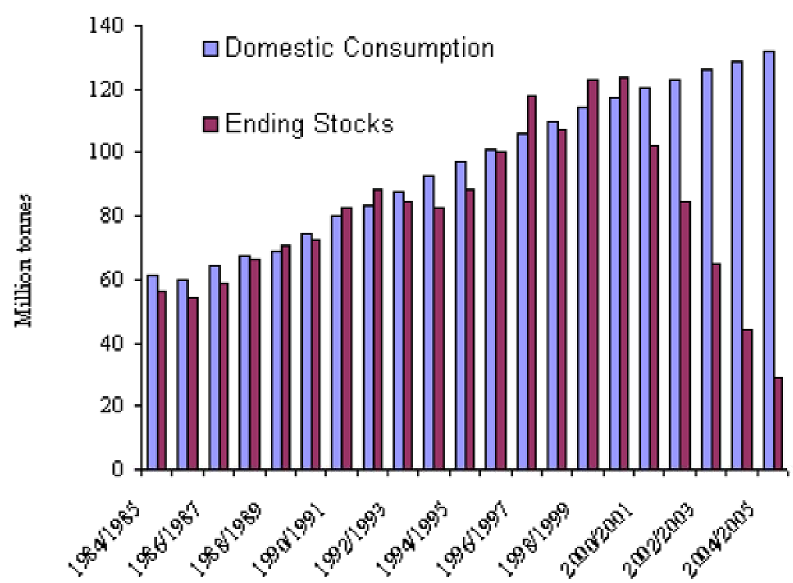

Figure 7: Trends in consumption and stocks of maize in China (Rameker 2004)

Thus the future for feed grains, and the picture for soy beans is similar (Rameker 2004), is likely to mirror that for oil, with a steadily increasing gap between supply and demand, and therefore increasing prices. The repercussions on the intensive animal feed industries are likely to be dramatic and contrary to the optimistic predictions of Delgado et al (1999, 2002).

Water

Water is another declining resource according to the conclusions of the "Stockholm conference on Water" (Swedish International Water Institute - SIWI) August 15 to 19, 2004):

Anders Berntell, Siwi's executive director, told BBC News Online: "The basic problem is that food is the main global consumer of water, with irrigation taking 70% or more of all the water we use, apart from huge volumes of rainwater. The bottom line is that we've got to do something to reduce the amount of water we devote to growing food today".

> A kilogram of grain-fed beef needs at least 15 cubic metres of water
> A kilo of lamb from a sheep fed on grass needs 10 cubic metres.
> A kilo of cereals needs from 0.4 to 3 cubic metres

To some extent irrigation is self limiting with a resultant loss of cultivatable land as when over-pumped, aquifers drop their water levels and the energy to lift the water increases to the point when it is no longer economical to irrigate and land returns to rain-fed agriculture. This loss of irrigation capacity will increase as oil prices rise in the future. Another consequence when ground water levels fall is that irrigation water may be contaminated by heavy metals such as arsenic that is released from rocks when these are exposed to oxygen as is occurring in Bangladesh and parts of China and India. Dams to provide both hydroelectricity and irrigation water often lead to degradation of down stream river and also estuarine-ecology, forcing governments to renew river flows as part of the catchment management. Australia has recently committed to renewing the flow in the Murray River to 21% of its original flow over the next decade. A further area of concern for land use is that clearing of forests and replacement with shallow rooted crops or grasslands is leading to a rise in water tables, increased evaporation and accumulation of salts at the surface which is massively reducing fertile land areas.

Global warming

Global warming is predicted to lead to temperature increases of between 2 and 5 ºC by the year 2050, if fossil fuels continue to be used at the present rates. Thus even if the oil were available, to continue to use it at present rates will lead to massive alterations in climate with irreversible changes in major ecosystems. The disappearance of 10% of the glaciers in Europe in 2003 is one of many warnings of the inevitable outcome of rising global air temperatures. Increasing sea levels will undoubtedly inundate many agriculturally rich delta areas throughout the world either permanently or through the action of periodic storms. This is likely to seriously limit food production and at the same time displacing people: with subsequent increased urbanization; as many as 5 million people live within 3 meters of sea level. Global warming also has the capacity to alter sea currents particularly those that move warm water from the tropics to northern areas . Disruption of such currents has in the past given rise to minor ice ages and would effect much of the Northern hemisphere.

The consequences

The consequences of increasing prices of oil and its derivatives will be felt most in the fields of transport (aerial, terrestrial and maritime) and agriculture, for which the major inputs (fertilizers, other chemicals, machinery and fuel), are derived from petroleum. Urban and suburban lifestyles will be seriously compromised by increasing costs of transport and food; industrial output will suffer a fall in demand which will lead to laying-off of workers to reduce costs (Box 3).

> Box 3:
> One leading American social critic, James Howard Kunstler, sees serious political and cultural turmoil up ahead as the way of life Americans have built over the last 60 years begins to break down. With decreasing access to cheap oil, Kunstler sees the fundamentals of industrial agriculture, manufacturing and retail trade changing significantly. "We're going to be forced to grow more of our food locally and return to a kind of agriculture that really hasn't been practiced here in a long time. Likewise, Kunstler foresees "the demise of Wal-Mart style, big box, national chains." Companies whose profit margins depend on "merchandise made by factories 12,000 miles away" simply won't function in a world of $100-plus barrels of oil. "We're going to have to seriously reorganize our whole system of retail trade and economy."

What is our future?

The general viewpoint is that future society will be organized in a very different way, the emphasis being on small, localized and decentralized systems (Box 4). Some of the developing countries that have maintained large rural populations may be in the best position to weather the increase in oil costs.

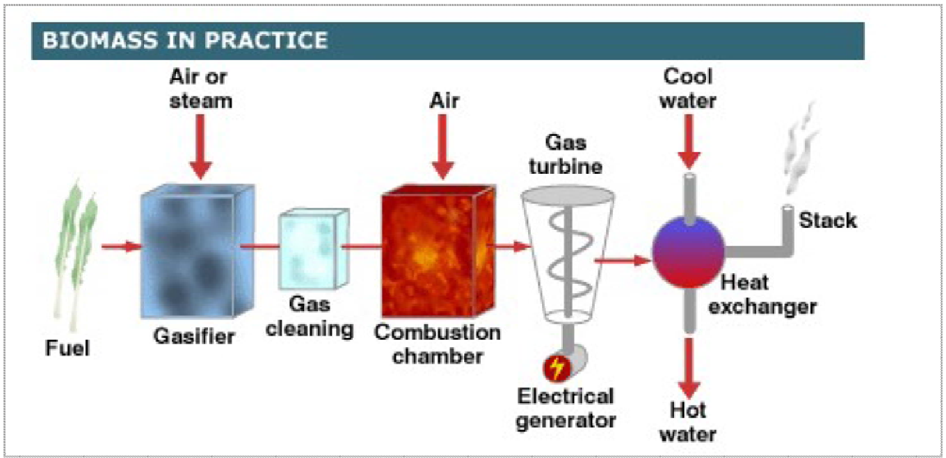

Figure 8: Industrial model of cogeneration: electricity and heat by gasification of biomass

Figure 9: Small scale gasifier-engi in India (Source: ANKUR 2003)

Agriculture and therefore food production is likely to have to have some priority for scarce fuel resources; it is therefore a paradox that what appears to be the most interesting alternative has received only minimal attention, namely the integrated utilization of biomass for both food and energy production, particularly in the yet to develop countries. The concept is that the fibrous component of plants (usually contributing some 50% of the biomass) is converted to a combustible gas (approximately 20% hydrogen and 20% carbon monoxide), by gasification (figure 8), while the non-fibrous components (soluble carbohydrates, protein, minerals and vitamins) provide the food supply for humans and animals. In contrast with the production of alcohol, which is derived finally from soluble sugars, there is no conflict between food and energy needs when the energy is derived from low digestibility fibrous byproducts.

The advantage of the biomass-feed-fuel option is that it can be decentralized, localized and operated on a small scale, hence coinciding with the "new" societal organization required for the "after oil" civilization to be sustainable.

In the industrialized countries energy from biomass is inevitably projected at the industrial level (Figure 8). Fortunately, India with it's rural-based economy has chosen to develop small scale gasification systems (smallest is 4 KW) which match the potential fibrous biomass output from farms in the 1 to 3 ha category (Figure 9). By decentralizing the production of electricity and using fibrous biomass as the feed stock, the new paradigm could be "migration from the towns to the countryside". Rural areas would thus revert to their original role, and become the source of energy, food and employment. In contrast with nuclear, wind or wave energy, the growing and processing of biomass could create the jobs likely to be lost by the decline of oil.

Box 4:
What is in our future? The consensus is the suburbs will surely not survive the end of cheap oil and natural gas. In other words, the massive downscaling of America - voluntary or involuntary - will be the trend of the future. We are in for some profound changes in the 21st century. The imminent collapse of industrial civilization means we'll have to organize human communities in a much different fashion from the completely unsustainable, highly-centralized, earth-destroying, globalized system we have now. There will need to be a move to much smaller, human-scale, localized and decentralized systems that can sustain themselves within their own landbase. Industrial civilization and suburban living relies on cheap sources of energy to continue to grow and expand. That era is coming to an end. One of the most important tasks right now is to prepare for a very different way of life.
Thomas Wheeler 2004.
(thomasdwheeler@comcast.net).

The availability of cheap electricity (the conversion rate in a combined gasifier-motor-generator is of the order of 1.2 kg dry biomass for 1 kwh) in rural areas would create immediate opportunities for use of electric cars and motor cycles as the preferred means of local transport. Batteries could be charged during the night when other uses for electricity are minimal. The joint need for fibre and feed, together with the prospect of escalating prices of grain, creates a scenario for which humid and semi-humid tropical ecosystems are well adapted, and for which appropriate crops and cropping systems already exist.

Sugar cane, cassava, oil palm, legume and non-legume trees and shrubs, are highly productive sources of biomass, providing almost equal proportions of fibre and feed / food (sugar from sugar cane; starch from cassava, oil from oil palm; protein from leaves of trees and shrubs). They are also permanent reservoirs of carbon. Exploiting these crops for energy and food / feed is environmentally benign as there are no net

The price of steak from grain fed ruminants must be measured in terms of oil costs involved in growing the feed, managing and marketing emissions of carbon dioxide, which is continuously recycled by photosynthesis. Erosion is controlled as these are perennial crops and soil fertility is improved through the build up of organic matter in the soil.

the meat. 1 kg of beef requires approximately 1.5 gallons of oil. Or to produce this steer at 600kg live weight will have used 283 gallons of oil (1075 litres). Source National Geographic June, 2004.

LRRD's mission

We do not expect that every article submitted to LRRD should relate specifically to the above issues; but they should at least respond in some way or other to the challenges of developing alternative livestock production systems that have the above goals as their ultimate objective. The status quo as depicted in the photo is certainly not to be encouraged.

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