Peak oil impact: Death of fossil fuelled cities and birth of solar cities of tomorrow

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Cities are energy consumers, not producers. They exist as they siphon large quantity of surplus energy from their hinterlands. Their energy source has a predominant influence on their configuration. With the fossil fuel era coming to a close within this century, and no viable alternative energy source visible on the horizon, cities as they exist today are unsustainable. Their future depends on whether they can reinvent themselves radically—reduce their energy consumption drastically to come closer to that of their hinterlands, and distribute energy equitably to all their residents. Cuba and transition towns in North nations have already begun to go down this road.

Introduction

Proposition 1: Our future is in the cities. In 1900, 13% of the world's people lived in cities, today half the global population live in urban areas, and by 2050, the United Nations Population Fund (UNFPA) projects that 70% of the world's population will live in cities.

Proposition 2: Hyderabad and Bengaluru are fast becoming global cities (whatever that means), and will soon become like Brisbane and San Francisco, their sister cities. Both cities are big IT and bio-technology centres. They export software, software personnel and pharmaceuticals to the world.

Do these propositions hold good? They do not. Here is why.

The world's urban population increased from 0.2 billion in 1900 to 3.5 billion today, and is projected to increase to 6.3 billion by 2050. Urban population increase between the years 1900-2012 and 2012-2050 are approximately the same, about 3 billion in each of these periods.

Europe and North America urbanized from 17% to 75% of their population during the Twentieth Century. North nations used surplus energy siphoned off from their rural areas and South nations and using a very large amount of fossil fuels. During this period they also transformed their cities from biomass and animate energized cities to fossil fuel energized cities.

South nations saw a relatively modest urbanization. Urban populations grew from about 7% of their population in 1900 to 40% today. Except in some select cities, the energizing of South nation cities by fossil fuels is far from complete.

Over 80% of urban growth projected to happen between now and 2050 is expected in the South nations of Asia and Africa. Oil production has peaked (peak oil) recently, and peak gas is projected to happen a couple of decades hence. There are no viable alternate energy sources that can replace fossil fuels. We now no longer have the massive energy required for 70% of our 9 billion population in 2050 to live in cities, or to transform Hyderabad and Bengaluru into Brisbane and San Francisco. To appreciate why the above propositions will fail it is necessary to first understand surplus energy because cities have been built using that energy.

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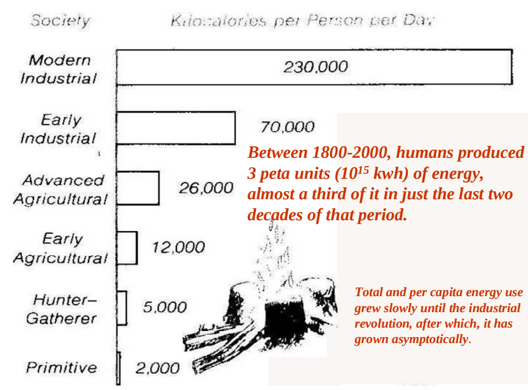
Surplus energy

All living beings are energy seekers, users and converters. Living beings other than humans take only as much as energy from nature as is required for survival and reproduction. Throughout history humans have improved their knowledge of energy extraction and conversion and have drawn increasing amounts of energy from nature, a fraction of which was *surplus energy*.

A hundred thousand years ago, homo sapiens moved out of Africa. For ninety thousand years they hunted and gathered food and when game and wild fruits thinned, they migrated in search of more productive environments. Their wanderings took them to Eurasia first, then to Australia and lastly to the Americas. About 12,000 years BP the colder Younger Dryas period was followed by a warm interglacial one. This was one of the two important prerequisites for hunter gatherers to make a gradual transition to agriculture, the other being the generation of surplus energy.

It is surplus energy that propelled societies from one stage of social development to the next, eg, from hunter-gatherer to primitive agriculture to traditional agriculture, to industrialism. As surplus energy grew, so did society's appetite for it. Had surplus energy entitlements been distributed equitably or owned socially, class society would not have arisen, nor would the energy withdrawals have exceeded earth's capacity to supply it. However, social structures since slavery were fashioned to give inequitable surplus energy entitlements to a priveleged minority.



Surplus energy is the difference between the output and input energy of any activity. For example, input energy for hunting gathering is the energy expended for obtaining food and biomass, which is human energy (energy required for metabolism) plus solar energy required for plant photosynthesis. Output energy is the energy content of the gathered food and biomass. Output energy exceeds input energy because solar energy used in photosynthesis comes free of energy cost, ie, no input energy is required to obtain it.

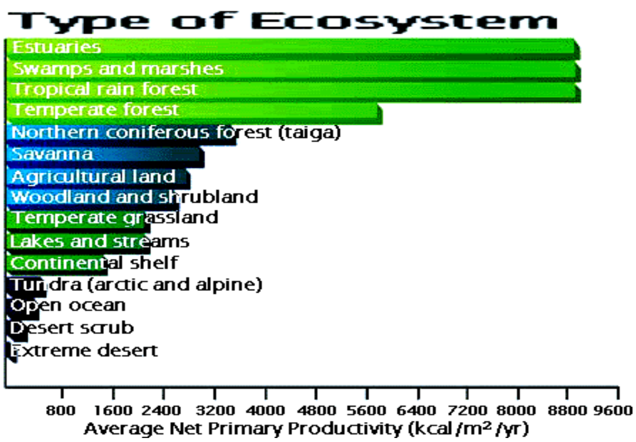
Surplus energy in the form of food and biomass for hunter gatherers was about 10-20 times the amount of energy expended to obtain it. Consequently, they did not have to constantly search for food, and had spare time that was used for leisure and to create knowledge of energy conversion. However, the surplus energy generated by hunter gatherers was inadequate for division of labour to happen.

Primitive agriculture began independently in the Middle East and China (9,000 BP) and the Americas (4,500 BP), soon after certain plants and animals were domesticated there. Founder crops from Mesopotamia and China quickly spread to the Indus Valley and Egypt and local crops there were domesticated as early as 8,000 BP. Surplus energy ranged 20-40 times the input energy. The comfort of this surplus led to rudimentary division of labour, including between genders. Not all persons had to harvest energy in the form of crops and biomass; some could make implements; others could build shelters, etc.

Gradual improved agricultural practices reduced the risk of crop failure, and brought about a shift from primitive to settled agriculture by about 4,000 BP. Surplus energy ranged 20 times the input energy during the Roman period, 40 times during the Middle Ages and 150 times in Early Nineteenth Century.

The Industrial Age saw a radical shift in the energy source. Fossil fuels replaced biomass and solar energies as the primary energy source. Fossil fuels are energy dense (coal—22-32 MJ/kg[3], oil—42-46 MJ/kg, natural gas—50-52 MJ /kg), and are easy to transport and store. Other energy sources do not have the same energy density (water at 100 m head 0.001 MJ/kg) and lack the storage and transportability advantages of fossil fuels. Fossil fuels allow larger energy throughputs to flow through the economy and also generate larger surplus energy. An input of 1 Joule of energy to produce fossil fuels gives an output of 20-80 Joules, the difference between output and input energy being surplus energy.

The first class society, slavery, arose around the time settled agriculture took root and a sufficient amount of surplus energy was generated. Other forms of class societies—feudalism and capitalism, came into existence later. All class societies are based on the appropriation of surplus energy by the upper classes for they claimed that since the investment (as energy input into the economy) was their property, the product (as energy output) also is theirs, which this includes the surplus energy from the sun and fossil fuels that is available free-of-energy cost.



Land, water and the atmosphere indirectly yield energy, the former two because they are hosts to plant life, and the latter because wind motion produces energy. Land is the easiest global common to harvest energy, so it was the first to be privatized. That happened during antiquity. Harvesting energy from water is a little more difficult, hence was privatized more recently. Harvesting energy from air is the most difficult. Privatization of the atmosphere began with the Kyoto protocol by giving carbon dumping wastes to North nations.

The other way to accumulate surplus energy is by forcible occupation of someone else's land or water, as happens in conquest or illegal occupation. In the last three centuries, colonial powers were able to extract and accumulate very large quantities of surplus energy from their colonies by through plantations, taxing agriculture, and extracting and using cheap timber and fossil fuels. The British Empire thrived because it harvested energy from its vast colonies in the old and the new worlds.

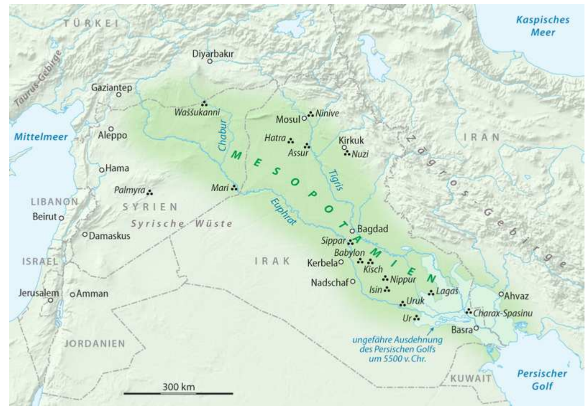
Surplus energy obtained from solar energy and fossil fuels has been created by nature, therefore belongs to it. Human ownership claims over surplus energy is resources is unsustainable.

Energizing cities

Since ancient times, the rise of cities, and their location, structure, functioning and collapse have been deeply influenced by the availability of surplus energy.

[3] Joule (J) and calorie (cal) are measures of energy. 1 cal = 4.2 J. Kcal = Kilo (10^3) cal. MJ/kg is Mega (10^6) Joules per kilogram

Cities in ancient times: Ur, Kish and Uruk were some of the first cities that came into existence in ancient times (7,000 years BP) in the world's first civilization in Mesopotamia. Mohenjo-Daro, Harappa, and Dholavira were built in the Indus Valley 4,500 years BP. Mohenjo-Daro had a population of 50,000 people. The Nile Valley cities of Thebes and Memphis were established soon after in 3,500-2,500 years BP. Ancient America too saw the rise of cities in Meso America and the Andes around 5,000 BP. Around 2,700 BP, Rome and Alexandria had a population of a million each. Most of these cities were located either in river valleys or on sea coasts



Cities of Mesopotamia

Why were the first cities not built earlier? Human-edible phytomass in the wild is low in density, and that prevented hunter gatherers from generating sufficient surplus energy to support division of labour. Moreover, hunter gatherers were nomadic and followed migratory game, or moved to richer pastures after exhausting older ones. River valley cities had populations of 10,000-50,000 each, and were located in fertile soils along rivers, close to farm lands which generated adequate surplus energy (food and biomass) to support them.

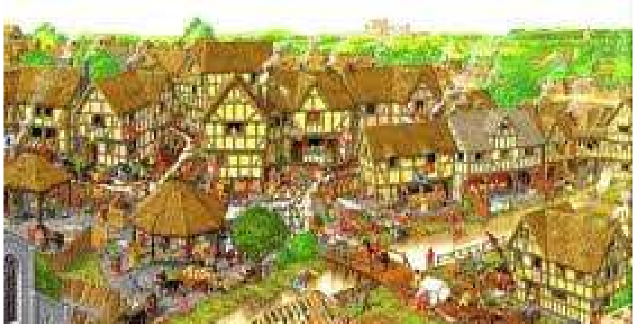
Mohenjo Daro ruins

Ancient cities came into existence only during the Iron Age when charcoal began to be used. They were configured around low density energy sources (animate, biomass, solar) that were available during that period. Streets were wide enough for pedestrians and carts, building materials were stone, mud, wood, thatch and other material that could be obtained and worked upon with small amounts of energy. The buildings themselves were mostly 1-2 stories.

Market in ancient Bianjing

The birth of ancient cities coincided with the development of the first class society, ie, slavery. To maximize their surplus energy accumulation, the upper class (slave lords) minimized input energy costs, in particular transport costs, by bunching artifact production, trade and other functions, eg, religious, administration, knowledge generation and resource sharing as close as possible to one another; hence the development of cities. Moreover, defending cities (considered of high value) against marauders required lower energy investments in smaller boundary walls, moats and standing armies than defending the much larger hinterlands.

Middle Age cities: The primary energy sources in the Middle Ages remained the same as during the ancient period. Additionally, wind and water power, which are secondary energy sources derived from solar and planetary energies, were tapped to power sail ships, wind and water mills. However, the quantities of energy generated with wind and water were small, though not insignificant in terms of their political ramifications. Sail ships facilitated trade between Asia, Africa and Europe. More significantly, sail ships helped Europeans colonize Asia, Africa, Australia and America, and reap the benefit of harvesting surplus energy from colonies.



The Middle Ages saw significant improvements in energy conversion and conveyance technologies. Better iron tools and joints, windlasses, capstans, treadwheels and gearwheels assisted in doing a host of mechanical jobs more efficiently, eg, lifting water and heavy weights. Agriculture, though, continued to remain the primary economic activity.

Since trade with distant places gained importance, cities were built on rivers, seashores, on important overland trade routes, at religious and cultural centres and political seats of power. Venice, Machilipatnam, London, Herat, Angkor Wat, Guangzhou, Reims, Ashikaga, Baghdad, Teotihuacan, Lahore, and Macchu Picchu were cities of this period.

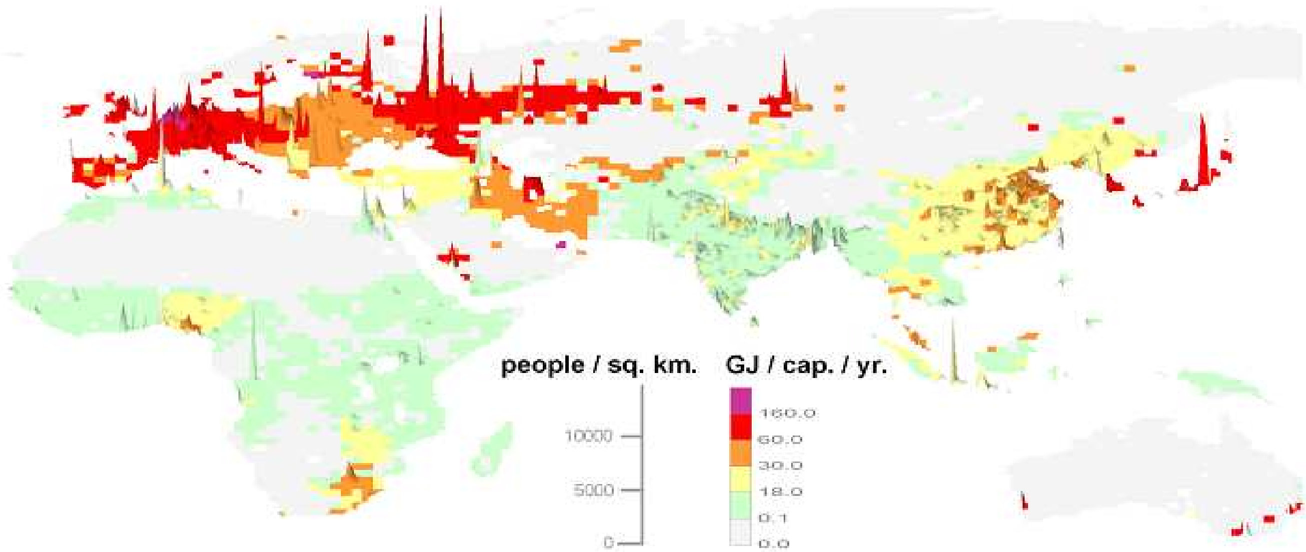
Roads in these cities were still just wide enough for pedestrians, carts and chariots. Buildings were still made of the same materials as earlier, except that better architecture, design (arches, beams) and building materials allowed taller buildings to be constructed, though the height rarely exceeded 5-6 stories. Cities were slightly larger than earlier, and improved roads and carriages allowed for them to be better connected with one another. Cities were invariably walled and moated to ward off enemy armies. The walls now had to be thicker to withstand cannon balls.

Industrial Age cities: Fossil fuels and vastly improved energy conversion and conveyance technologies launched the Industrial Age. European imperialism siphoned off vast quantities of surplus energy from Asia, Africa and the Americas. A part of this energy was used to transform Europe's medieval cities into fossil fuel age cities. Roads were widened for automobile use. Cities expanded laterally eating up farmland; and vertically to dizzying heights as cement concrete had the strength to do that. Massive bridges allowed wide rivers to be crossed easily, and aeroplanes reduced travel time between continents.

There are two types of cities in the Industrial Age. The first type is located largely in Europe, North

A North Industrial Age city

America and Australasia, where the transition from Medieval Age cities is largely complete. Typical examples of North cities are: Berlin, San Francisco, Stockholm, Melbourne and Tokyo. The second type of cities is in the developing countries in Asia, Africa and South America, where the transition is still in progress. Rawalpindi, Bangkok, Tehran, Delhi, Sao Paulo are examples of South cities.



Per capita energy use in Eurasia and Africa

Modern cities have problems of higher crime rates, higher living costs, long commute times, growing traffic and air pollution related health effects, and high cost of utilities. While European and North American countries have been able to solve these problems to an extent, the new cities in the South nations have either been unable to cope with them adequately or have been overwhelmed by them for lack of adequate financial resources (read surplus energy).

Energy analysis of urbanization

Urban areas are net energy and life support system consumers, rural areas are net producers: A major part of the energy production happens in hinterlands, but its consumption happens largely in urban areas. Of the 18 Btoe[4] being consumed by humans today, over 95% is harvested, mined and produced in hinterlands as biomass, fossil fuels, nuclear and renewable energies (wind, water, solar).

This pattern of production and consumption is true not just for energy but also for other natural resources, including the critical life-support systems of land, air, water and bio-diversity. For example, water for Hyderabad city is pumped 200 km from the Krishna River. The carbon dioxide generated in cities is exchanged for oxygen in forests and rural areas. Land required for producing food, fibre and building materials is largely in rural areas. Likewise, biodiversity that is so essential for the very existence of the human species largely exists in forests and rural areas.

[4] Btoe-Billion tons of oil equivalent. 1 Ton of oil equivalent (toe) = 42 Giga (10^9) Joules

Power consumption is significantly higher in cities: Power consumption of today's North cities is in the range 10-100 W/m^2. Current global (urban + rural areas) power consumption is 0.5[5] W/m^2, ie, 20-200 times lower than urban consumption levels. Rural power consumption will be lower than 0.5 W/m^2.

Net energy transfer from rural to urban areas: Surplus energy in agriculture creates division of labour, ie, frees a fraction of working people from producing food. These persons can produce other goods, services and knowledge for society. Since the global outlook is to *maximize gain for a few*, surplus from agriculture flows to such activities that do this most efficiently. Since these activities are located in urban areas, agricultural surplus is transferred primarily to cities.

There are many ways that transfer of agricultural surplus is transferred to cities. Private ownership of agricultural land is the most widely used method for doing this. Since input energy into a farm is claimed to be owned by a person, a claim of ownership is made on the output energy, including surplus energy contained in the products. To maximize gain, surplus energy is invested in an urban area.

A second way of transferring energy is by not paying the full energy cost for goods and services produced in rural areas but consumed in urban areas. In one study, an analysis of the 1,200 MW coal-based power plant in Udupi District. Coal for the plant is imported either from other Orissa or from abroad and 90% of the power produced is sent to Bengaluru. The air pollutants are not removed and therefore cause crop yield loss in a 25 Km radius around the plant. When yield loss was converted into net primary production[6] (NPP) loss, it was found that the loss farmers in a 25 Km suffered a loss equal to 10% of the plant's power[7] generation capacity, ie, 120 MW. By not expending energy to clean up their pollutants, but by dumping them on the environment, the power plant was in effect causing an energy loss to the local farmers, and indirectly causing a gain for the urban area that it was largely servicing.

If the polluter pays principle, which holds for India as well, is followed, this power plant should be located in Cubbon Park in the middle of Bengaluru city. Where is there environmental justice in the farmers of Udupi suffering crop yield losses in order for Bengaluru to benefit?

A 1,000 MW thermal power plant using Indian coal generates 9 MTPA[8] of carbon dioxide per year, requiring 12,000 km^2 of forest area to sequester. Andhra Pradesh (AP) has a coal-based thermal generation capacity of about 8,100 MW, which requires 100,000 km^2 of forest land to sequester its carbon emissions. Fifty seven percent of the power generated in the state (urban population 33%) is consumed by cities, requiring 57,000 km^2 of forest land (90% of the 63,800 km^2 of forests in the state) to sequester the carbon dioxide generated by the power plants.

Hinterlands downstream of cities, particularly in South nations, often get untreated city sewage, which impacts their health, livestock, fish and crops. By not paying effluent cleanup costs or rectifying the downstream impact, cities save energy, which the hinterland pays for either in cleanup costs or degraded environments and health impacts. Hayatnagar, a downstream settlement to Hyderabad suffers because of Hyderabad's environmental dumping.

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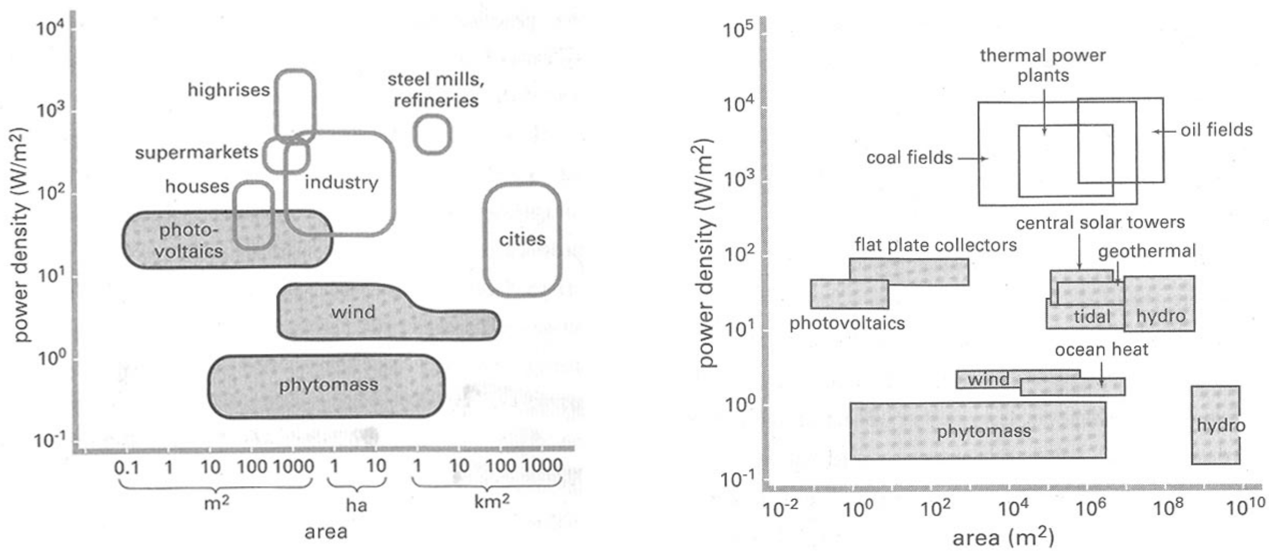
[5] Assumptions: Global energy consumption = 18 GJ/a, of which 1/3rd is from biomass. Global cropped area = 15.3 mill km^2, woodland/grassland = 34.4 mill km^2, urban areas = 0.4 mill km^2, forest land = 39.9 mill km^2, other land (inland water bodies, deserts, polar areas, uninhabited lands) = 44.1 mill km^2. Only the first three land use categories were used for computing the world's power consumption (Source for land use area-FAO).
[6] NPP is mass or energy in biomass and is expressed as Kg/m^2 (if NPP is expressed as mass) or $Kcal/m^2$ (if NPP is expressed as energy)
[7] Power is defined as the energy consumption or generation per unit time. 1 Watt (W) = 1 Joule/second
[8] Million tons per annum

Urban power consumption density is higher than all energy sources except for fossil fuels and nuclear energies: Historically, the power consumption density in cities has been limited by the power density of its energy sources. Global average net primary production (NPP) for all biomass is 0.47 W/m^2, and for crops is 0.4 W/m^2. Power production in rural areas would be a shade lower for crops in the ancient and medieval periods. The power consumption in ancient and medieval cities that were dependent on biomass, animate and solar energies were therefore low. Fossil fuels power production density is of the order of 1-2 kW/m^2, an order of magnitude three times more than that of biomass. Today's North cities therefore have a power consumption density of 10-100 W/m^2. Such power densities can only be supported by energy-dense fossil fuels. The older energy sources cannot support today's North cities. Nor can renewable energy sources support today's cities as power production densities of renewable are significantly lower by an order of magnitude of three when compared with fossil fuels: solar—30-35 W/m^2; geothermal, wind and hydro generation—5-15 W/m^2.



Power production and consumption densities

Cities distribute their energy unevenly: Barring a few odd exceptions, cities, since ancient times, distributed their energy resources unevenly, reflecting a bias in favour of the rich. They got the lion's share of city's energy investments in the form of infrastructure, etc, whereas the poor got the least. The poorer parts of a city were more polluted, dirty and unsafe than the richer parts. Fifty percent of Mumbai's population that lives in slums has to be satisfied with poor transport infrastructure, sanitation, public parks, water and power supply, whereas those that live in downtown rich areas like Malabar Hill are well serviced with broad roads, good sanitation, power and water supply.

Energy cost of cities: Assuming that the average power consumption of North and South cities are 80 and 40 W/m^2, respectively, and the average global farmland NPP is 0.4 W/m^2, North and South cities would require all the biomass energy (leaving nothing for those who live off this land) generated on croplands that are 200 and 100 times the area of these cities.

Metropolitan Hyderabad with an area of 250 km^2 requires all the energy produced on 25,000 km^2 of rural AP land. Since only 33% of Hyderabad's energy consumption is biomass, biomass energy from 8,250 km^2 of rural AP land is required to support Hyderabad. Hyderabad occupies less than 0.1% of AP's land, but requires the biomass energy produced on 4.3% of the state's rural area[9]. Projecting this analysis to all of urban AP, biomass produced on 18% of the state's rural areas will fulfill the biomass energy requirements of the state's cities.

Had all of urban AP been energy consumers like North cities, 36% of AP's rural area would be required to meet the state's urban population's biomass requirement. Since AP urbanization ratio (33.4%) is quite similar India's (31%), the above statement would hold good for India as a whole.

The world's urban areas occupy an area of 400,000 km^2 (<1% of the earth's land mass), but consume 80% (@50 W/m^2) of the world's energy consumption of 18 Btoe per annum. One third of global urban energy consumption is biomass, ie, 5 Btoe/yr. This is the energy contained in all the biomass produced on 16.6 mill km^2 of rural areas, ie, 33% of the world's rural areas. The percent rural land required to provide biomass energy to the world's cities is higher than that required by AP cities is because energy consumption of North cities is significantly higher than that of South cities.

Some simple projections illustrate why further urbanization is unsustainable. If UNFPA's 70% urban population projection in 2050 is valid, of all the biomass on 85% of the world's rural areas would be required to satisfy urban biomass demand in 2050[10]. Where then do rural people and other species get their biomass energy from?

City icons to establish superiority: From the ziggurats the ancient Sumerians built to the Eifel Tower built in the late Nineteenth Century, cities have consistently created icons to create the perception of awe and superiority in hinterland populations so that they could continue to appropriate surplus energy.

Cities epitomize anthropocentric and gain maximization for few: Cities epitomize the two global outlooks that have had a major influence on human history in the last 5,000 years. City dwellers are not generally in touch with nature and this aids in developing an attitude that they are apart from nature. That cities can extract 33% of NPP from rural areas indicates that nature is meant to be used for the enjoyment of humans, particularly city dwellers.

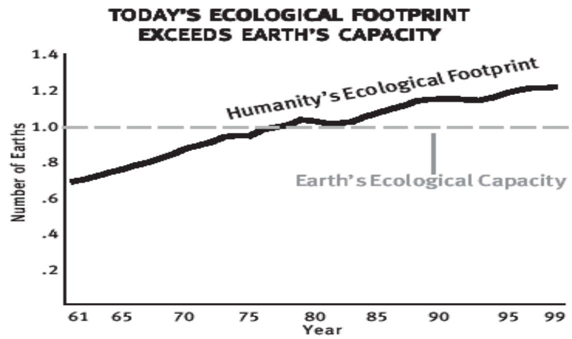
Cities are a good device to maximize surplus energy accumulation in private hands as they minimize energy cost of goods and services, particularly of transport cost, by concentrating various functions in one place. Cities serve the *"Gain maximization for few"* outlook well. And in doing so, they even de-

[9] AP has an area of a little less than 275,000 km^2, 70% of which is rural (farm + pasture + wood lands)
[10] Presuming that energy consumption will increase at the current energy growth rate, ie, 2.25% per annum, and that land under crops, woods and pastures remains the same as today. In 2050, urban areas would require 12.75 Btoe of biomass energy, which is the entire biomass energy produced on 42.33 mill km^2

stroy their natural heritage like they have done to lakes and unique natural rock formations around Hyderabad.

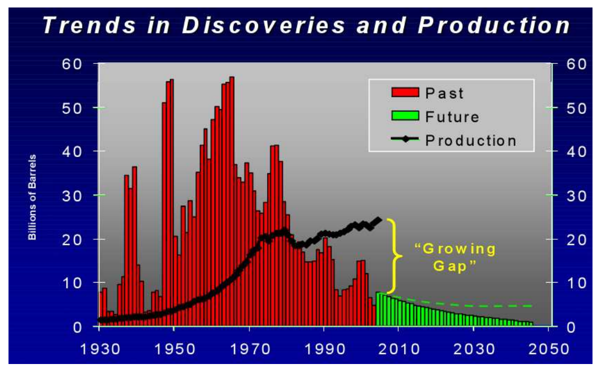
Consequences of energy overdraw and inequity

Humans have overdrawn on the Earth's capacity to deliver energy and natural resources. We now require 1.5 Earths in order to satiate our energy needs. We have dipped into the Earth's natural capital rather than learnt to live off its interest; for instance, rather than using only rainfall for agriculture, we are using increasing amounts of groundwater, thus lowering groundwater levels each year. Rampant environmental degradation (pollution, freshwater depletion, etc) around the world and global warming are manifestations of this.



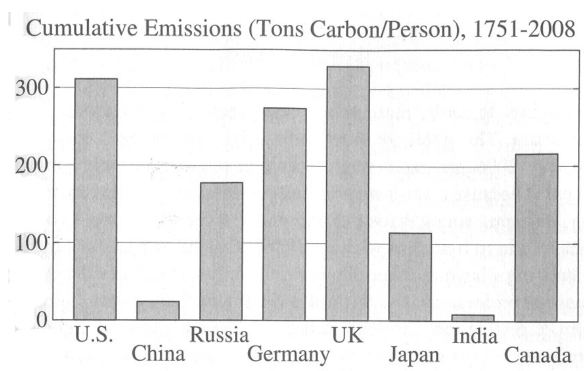
Humanity's consumption and waste production today exceed the Earth's capacity to create new resources and absorb waste. We are currently liquidating natural capital to support current resource use, reducing the Earth's ability to support future life.

Oil is getting over. This phenomenon is known as *peak oil*, ie, global oil production is peaking as new oil finds have been few and far between in the last few decades, and gas will also peak in a couple of decades.



The consequences of the massive fossil fuel use are beginning to be understood only now. Global warming is one of them. Despite a lot of public discussion in the last few years, global warming impacts are yet to be understood properly.

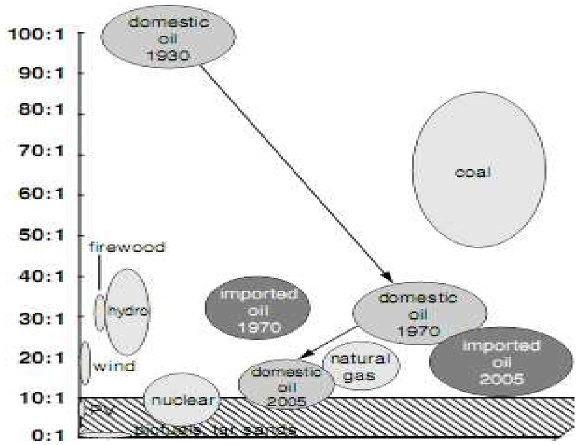
Historically, those responsible for the energy overdraw are Europe, North America, Australasia, Japan, Russia, and the very rich (even though they were small in number) in developing countries. Carbon emissions data since the industrial revolution correlates very well with fossil fuel consumption. Historical carbon emissions (see figure on historical emissions) can be interpreted as being representative of fossil fuel consumption. Europe was able to consume large quantities of energy as they were able to siphon surplus energy from their African and Asian colonies. North America was able to do the same by initially tapping its own vast resources, and subsequently by buying oil cheaply from other countries though unequal exchange.



Cumulative per capita carbon dioxide emissions

A far less understood consequence is civilization collapse. The collapse of many past civilizations—Roman, Mayan, Polynesian—can be traced to energy overdraws. Each of these collapses remained specific to one civilization. Today the world is globalized and tightly integrated. An economic slowdown in one part of the world caused by an energy shortage could very quickly spread to other countries, as happened in 2008. And if the crisis is sufficiently severe, it could lead to a global economic meltdown.

The world has coal reserves to last another 100 years. But, if coal were to replace oil and gas consumption, global warming would happen even faster. For every toe of energy delivered, coal emits twice the CO_2 that oil does, and more than 2.5 times that gas emits.



Neither green nor nuclear energies are capable of replacing fossil fuels. Green energies have a 0.5-2.5 EROEI[11], whereas fossil fuels have a 20-80 EROI. The significantly higher energy density of fossil fuels allows them to yield more energy for every joule of energy invested in producing them. Moreover, the environmental costs (cost of injury to human health, crops, forests, water bodies, etc), of fossil fuels are not paid for, making them very cheap. As for nuclear power plants, there is uranium ore sufficient only to power the current nuclear reactors for another 80 years. Moreover, they have intractable safety and waste disposal problems.

The average per capita annual non-biomass energy consumption is a little over 1.7 toe/yr for the world as a whole; for North America it is 8.1 toe/yr, Western Europe 4 toe/yr, Central Africa 0.3 toe/yr, South America 1.1 toe/yr, South Asia 0.5 toe/yr, and India 0.4 toe/yr. Clearly, it is people in the developed countries that are consuming significantly more than those in the developing countries.

Per capita primary energy consumption (other than biomass)	
Region	***toe/yr***
Central Africa	0.34
Northern Africa	0.69
Southern Africa	1.18
Australia-New Zealand	5.56
Central Asia	3.43
NW Pacific + East Asia	1.28
South Asia	0.49
SE Asia	0.73
Central Europe	1.81
Eastern Europe	3.49
Western Europe	3.86
Caribbean	1.11
Meso America	1.29
South America	1.13
North America	8.08
Arabian Peninsula	3.62
Mashriq	1.23

All human conflict is fundamentally driven by human perception of the potential difference in the access and control of energy between people. This explains class, gender, race, caste, conflicts, as well as conflicts between nations. In the last century, three types of conflicts—interstate, colonial and civil wars were responsible for 100 million deaths.

To avoid civilization collapse due to energy overdraw and conflict due to inequitable distribution of energy, two measures need to be adopted:

- Powering down non-biomass energy consumption to about 40% of its current consumption of 12 Btoe/year, including biomass energy, and in future relying on solar energy for our needs.
- Moving towards energy equity.

If both these steps were implemented today, the per capita energy available would be no more than what was available in the Eighteenth Century.

[11] EROEI is Energy released for energy invested. An EROEI of 20 indicates that one unit of energy is required to explore, mine, refine and deliver 20 units of energy. A negative EROEI, as is the case with some bio-fuels, means that more energy has to go into making and delivering them that the energy they will yield. A low EROEI makes the energy source unattractive.

The opening propositions do not hold good

Let us examine the validity of the two propositions we started with:

- With 70% of the global population becoming urban by 2050, our future is in cities.

To create the necessary urban infrastructure for an additional 2.25 billion people to live in South cities and 0.5 billion people to live in North cities would require an energy investment of 1.23 Btoe/year or about 10% of the total fossil fuels consumed annually today. With oil supply stagnating at around 85 Mb/d since 2005, despite oil price increasing, the energy source for future urbanization to sustain itself is moot.

- Hyderabad will upgrade to be like a North city.

To upgrade Hyderabad to become like a north city requires an energy investment of about 12 Mtoe[12], which would cost approximately Rs 150,000 crores, ie, Rs 1,500 crore/km^2, which is slightly greater than AP Government's 2012-13 budget. Where can Hyderabad find such a heavy investment?

Cities must re-invent themselves

Given the impending energy crisis, cities will not have the necessary surplus energy to sustain themselves. They will not disappear overnight, but will perforce shrink. If such a downsizing is not to be chaotic, it is better to plan it from now. Some of the fundamental issues for cities are:

- Cities should plan their shrink so that they do not to exceed a population of 500,000.
- Cities should distribute energy evenly across all its residents to avoid the risk of conflict between various sections of its residents.
- The difference in the per capita energy consumption of city and rural people should be narrowed significantly.
- Cities must plan to configure themselves on the future energy source, ie, solar energy.
- South cities in will never have the resources (energy and financial) to complete the transition to becoming like North cities. It is best to abandon the attempt to make that transition right away and begin the transition to becoming solar cities.
- Urban environmentalism perforce requires raising issues of environmental injustice that cities have done to their hinterlands, and the need to correct it.

Cities in transition

Several scores of cities and rural communities all over the world are beginning to make local changes to meet the challenge of peak oil. They are known by different names—ecological villages, transition towns, post carbon cities. In India too many urban initiatives are taking place. This story, however, must begin with Cuba where many of the initiatives we are talking about took place about two decades ago.

[12] Assuming that energy cost of the upgrade requires 0.12 Mtoe/km^2 on 100 km^2.

Cuba: "Peak oil" hit Cuba in 1989—in an artificial manner—because there was no oil shortage then. The Soviet Union had begun to collapse and Cuba petroleum imports dried up. US embargo against Cuba did not permit imports from other sources.

Cuba's response is an inspiration to the rest of the world. First, a nation-wide call was given to increase food production by restructuring agriculture. It involved converting from conventional large-scale, high input monoculture systems to smaller scale, organic and semi-organic farming systems. The focus was on using low cost and environmentally safe inputs and relocating production closer to consumption centres to cut transport costs.

A spontaneous decentralized movement to setup urban farms was born. By 1994, more than 8,000 city farms were created in Havana alone. Front lawns of municipal buildings were dug up to grow vegetables. Offices and schools cultivated their own food. Many of the gardeners were retired men. Women played a larger role in agriculture in cities than they did in rural areas. By 1998, an estimated 541,000 tons of food were produced in Havana. Food quality improved as people had access to a greater variety of fresh fruits and vegetables. Some neighbourhoods produced as much as 30% of their food.

The growth of urban agriculture was largely due to the State's initiative. New planning laws placed the highest priority on food production. Licenses were granted to convert unused urban land into farms, and resources were made available to aspiring urban farmers. This helped in converting hundreds of vacant urban spaces into food producing plots. Another successful device was the opening of farmers markets that allowed direct sale of farm produce by farmers to consumers. Deregulation of prices combined with high demand for fresh farm produce in the cities allowed urban farmers to generate two to three times the income of rural farmers.

When oil supply stopped in 1990, transportation in Cuba ground to a near halt. No cars ran; public conveyance collapsed; and the streets were empty. People walked. In the early-1990s, Cuba imported 200,000 Chinese bicycles. Trucks were converted to buses by simply welding steps at the back and adding a skeletal frame of rods and a canopy. The concept was refined into the 'Camellone' (The Camel), Cuba's mass transit bus. Built on a long chassis vehicle, it could accommodate 250 persons. For shorter distances cycles and auto rickshaws were used. In smaller towns, horse drawn or even mule drawn 'cabs' were used. Car-pooling and ride sharing became common. Designated government officials in yellow uniforms were given the right to pull over even government vehicles and seat people in need of transport.

Transition towns: Transition towns are a more recent phenomenon. It is a grassroots network of communities that are working to build resilience in response to peak oil, climate destruction, and economic instability. Transition towns is a brand for environmental and social movements founded (in part) on the principles of permaculture based on Bill Mollison's work titled, *Seminal permaculture—A designers manual* (1988) and David Holmgren's book, *Permaculture: Principles and pathways beyond sustainability* (2003). The techniques in these books were included in a student project overseen by permaculture teacher Rob Hopkins at the Kinsale Further Education College in Ireland. Two of his students, Louise Rooney and Catherine Dunne, set about developing the transition towns concept and took the far-reaching step of presenting it to the Kinsale Town Council, resulting in the historic decision by councilors to adopt the plan to work towards energy independence of the town. The transition towns movement is an example of socioeconomic localization.

The concept was then adapted and expanded in Hopkins' hometown of Totnes. The initiative spread quickly, and as of May 2010, there are over 400 communities recognized as official transition towns in the United Kingdom, Ireland, Canada, Australia, New Zealand, the United States, Italy, and Chile. The term transition towns has morphed into transition initiatives to reflect the range and type of communities involved.

Central to the transition town movement is the idea that a life without oil could in fact be far more enjoyable and fulfilling than the present: "by shifting our mind-set we can actually recognize the coming post-cheap oil era as an opportunity rather than a threat, and design the future low carbon age to be thriving, resilient and abundant-somewhere much better to live than our current alienated consumer culture based on greed, war and the myth of perpetual growth."

An essential aspect of transition in many places is that the outer work of transition needs to be matched by inner transition. That is in order to move down the energy ladder effectively, we need to rebuild our relations with ourselves, with each other and with the "natural" world. That requires focusing on the heart and soul of transition.

A key concept in transition is the idea of a community-versioned, community-designed and community-implemented plan to proactively transition the community away from fossil fuels. The term "community" in this context includes all the key players—local people, local institutions, local agencies and local councils. By 2010, transition initiatives have created a series of local currencies in transition towns including the Totens pound, the Lewes pound, as well as the Brixton pound in London.

Urban India

India has an urban population of over 300 million, greater than the population of USA, or for that matter, greater than any country except China. Urban India lives in 400 urban agglomerates, 35 of the largest ones having a population of over a million each and a total population of 180 million. Three mega cities—Mumbai, Kolkata and Delhi have more than 10 million residents each. Hyderabad and Bengaluru, have more than 5 million each.

It is easier to tackle the problems of the 120 million people who live in the 365 urban agglomerates of less than a million each. On the other hand, many groups and individuals in the mega cities are more aware and have the resources to initiate alternative programmes. And they can help groups and residents in smaller towns. Only in the mega cities has restructuring to suit cheap fossil fuel occurred in a significant way—wide tarred roads, suburbia, etc, though remains incomplete. One third or more of the population of these cities (in Mumbai it is more than half the population) live in slums, poorly serviced by amenities such as proper roads, drinking water and sanitation.

Changes required for a fossil fuel-free society are far easier and cheaper to put into place in India and in other developing countries than in the developed countries. On the other hand public awareness on these issues is low and is not able to effectively influence government policy or even action by local bodies. So the changes that will begin to happen will come as a response to the acute problems that people face. These responses will be in the form of greater use of rain water harvesting, fuel efficient stoves, bicycles, cycle rickshaws, animal drawn vehicles. Solid waste management is probably the only area where city wide policy intervention will be possible.

Roof top rain water harvesting has been widely talked about, but implementation has been slow. It is the most promising area of activity for creation of green jobs and green entrepreneurship. Rain water harvesting need not be limited to rooftops. It involves tree planting in cities, restoring tank and ponds and in general what is called ‘urban water shed management.’

Starting with Magan Chulha, fuel efficient stoves have existed since the 1950s. The problem is that they are initially a bit expensive, and require proper knowledge of their use and maintenance. People with means have alternatives like gas. The long term solution is to increase equality in society, have abundant fuelwood by planting fuel wood trees, have community kitchens and install large reflector-type solar cookers for large kitchens.

The urban garden movement too has caught on with relatively modern and affluent urban people. There are e-groups, training programmes and guide books in most big cities. Poor people, wherever possible do manage to grow whatever is possible.

Bicycles are beginning to make a genuine comeback. Better cycles are now available. On the other hand city planners are still governed by fossil fuel lobby and the convenience of private cars dominates. Indian cities are highly short on pedestrian footpaths and bicycle lanes.

In Vellore in Tamil Nadu a zero waste management programme has been successfully carried out. Several municipalities all over the country are trying it out. This coupled with anti-plastic movement is slowly changing the face of urban India.

Political hurdles

There is lack of awareness and political will in India to transit to fossil fuel free cities. Such a transit requires the making of local decisions and the implementation of local solutions. But local institutions and grassroots democracy are yet weak in India. Indian politics—left, centre and right—since independence has concentrated on capturing central power. These ideas require anarchist inputs—ideas that opposing power in all forms, local direct democracy and local self-management.

Historical roots of town planning in India

Many of the ideas discussed above have roots dating back to a hundred years. In urban planning, as Peter Hall says in 'Cities of Tomorrow', we must begin with Patrick Geddes. Geddes was pioneer in people centric urban and regional planning. 'Town planning is not mere place-planning, nor even work-planning. If it is to be successful it must be folk-planning.' Geddes introduced the 'Diagnostic Survey', 'Conservative Surgery' (as against demolition), planning for health and planning for open spaces and trees. He influenced town planners all over the world. Lewis Mumford and The Regional Planning Association of America and its journal 'The Survey' played an important part in spreading his ideas.

Patrick Geddes was in India between 1915-19 and carried out some 60 town planning exercises. A book, 'Patrick Geddes in India' was reprinted so we have access to most of his ideas.

A quote from Patrick Geddes is an appropriate way to end this article: 'Town planning … should start by the development in youth of a civic consciousness, working up through a knowledge of the immediate locality and city to a larger and most general grasp of their problems. … There is, therefore, a great need of public co-operation; of an ever-increasing body of active citizens who will no longer leave all maters to official authority but work with the municipal representatives.'

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