Sous-titres de *Sans lendemain* (*There is no tomorrow*)

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This is the Earth,
as it looked 90 million years ago.
Geologists call this period the 'Late Cretaceous'.
It was a time of extreme global warming,
When dinosaurs still ruled the planet.
They went about their lives,
secure in their place at the top of the food chain,
oblivious of the changes taking place around them.
The continents were drifting apart,
opening huge rifts in the Earth's crust.
They flooded, becoming seas.
Algae thrived in the extreme heat,
poisoning the water.
They died,
and fell, in their trillions, to the bottom of the rifts.
Rivers washed sediment into the seas,
until the organic remains of the algae were buried.
As the pressure grew, so did the heat,
until a chemical reaction transformed the organics
into hydrocarbon fossil fuels:
Oil and Natural Gas.
A similar process occurred on land,
which produced coal.
It took nature about 5 million years
to create the fossil fuels that the world consumes in 1 year.
The modern way of life
is dependent on this fossilised sunlight,
although a surprising number of people take it for granted.
Since 1860, geologists have discovered over 2 trillion barrels of oil.
Since then, the world has used approximately half.
Before you can pump oil, you have to discover it.
At first it was easy to find, and cheap to extract.
The first great American oilfield was Spindletop, .
discovered in 1900
Many more followed.
Geologists scoured America.
They found enormous deposits of oil, natural gas and coal.
America produced more oil than any other country,
enabling it to become an industrial super-power.
Once an oil well starts producing oil,
it's only a matter of time before it enters a decline.
Individual wells have different production rates.
When many wells are averaged together,
the combined graph looks like a bell curve.
Typically
it takes 40 years after the peak of discovery
for a country to reach its peak of production,
after which it enters a permanent fall.
In the 1950s,
Shell geophysicist M. King Hubbert
predicted that America's oil production would peak in 1970,
40 years after the peak of U.S. oil discovery.
Few believed him.
However, in 1970,
American oil production peaked,
and entered a permanent decline.
Hubbert was vindicated.
From this point on,
America would depend increasingly on imported oil.
This made her vulnerable to supply disruptions,
and contributed to the economic mayhem of the 1973
and 1979 oil shocks.
The 1930s saw the highest rate of oil discoveries in U.S. history.
In spite of advanced technology,
the decline in the discovery of new american oilfields has been relentless.
More recent finds, such as ANWAR,
would at best provide enough oil for 17 months.
Even the new "Jack 2" field in the gulf of Mexico
would only supply a few months of domestic demand.
Though large, neither field comes close to satisfying
America's energy requirements.
Evidence is now mounting
that world oil production is peaking, or is close to it.
Globally, the rate of discovery of new oilfields peaked in the 1960s.
Over 40 years later,
the decline in the discovery of new fields
seems unstoppable.
54 of the 65 major oil producing nations
have already peaked in production.
Many of the others are expected to follow in the near future.
The world will need to bring the equivalent
of a new Saudi Arabia into production
every three years
to make up for declining output in existing oilfields.
In the nineteen sixties,
six barrels of oil were found for every one that was used.
Four decades later,
the world consumes between three and six barrels of oil
for every one that it finds.
Once the peak of world oil production is reached,
demand for oil will outstrip supply,
and the price of gasoline will fluctuate wildly,
affecting far more than the cost of filling a car.
Modern cities are fossil fuel dependent.
Even roads are made from asphalt,
a petroleum product,
as are the roofs of many homes.
Large areas would be uninhabitable
without heating in the winter or air conditioning in the summer.
Suburban sprawl encourages people to drive many miles
to work, school and stores.
Major cities have been zoned with residential
and commercial areas placed far apart,
forcing people to drive.
Suburbia, and many communities
were designed on the assumption of plentiful oil and energy.
Chemicals derived from fossil fuels,
or Petro-chemicals,
are essential in the manufacture of countless products.
The modern system of agriculture
is heavily dependent on fossil fuels,
as are hospitals,
aviation,
water distribution systems,
and the U.S. military,
which alone uses about 140 million barrels of oil a year.
Fossil fuels are also essential for the creation of plastics and polymers,
key ingredients in computers, entertainment devices and clothing.
The global economy currently depends on endless growth,
demanding an increasing supply of cheap energy.
We are so dependant on oil and other fossil fuels,
that even a small disruption in supply
may have far-reaching effects on every aspect of our lives.

ENERGY
Energy is the ability to do work.
The average American today has available the energy equivalent of 150 slaves, working 24 hours a day.
Materials that store this energy for work are called fuels,
Some fuels contain more energy than others.
This is called energy density.
Of these fuels, oil is the most critical.
The world consumes 30 billion barrels a year,
equal to 1 cubic mile of oil,
which contains as much energy
as would be generated from 52 nuclear power plants
working for the next 50 years.
Although oil only generates 1.6% of U.S. electricity,
it powers 96% of all transportation.
In 2008, two thirds of America's oil was imported.
Most was from Canada,
Mexico,
Saudi Arabia,
Venezuela,
Nigeria, Iraq and Angola.
Several factors make oil unique:
it is energy dense.
One barrel of oil contains the energy equivalent
of almost three years of human labour.
It is liquid at room temperature,
easy to transport
and usable in small engines.
To acquire energy, you have to use energy.
The trick is to use smaller amounts to find and extract larger amounts.
This is called EROEI:
Energy Return on Energy Invested.
Conventional oil is a good example.
The easy to extract, high-quality crude was pumped first.
Oilmen spent the energy equivalent of 1 barrel of oil to find and extract 100.
The EROEI of oil was 100.
As the easy to find oil was pumped first,
exploration moved into deep waters,
or distant countries,
using increasing amounts of energy to do so.
Often, the oil we find now is heavy or sour crude,
and is expensive to refine.
The EROEI for oil today is as low as 10.
If you use more energy to get the fuel than is contained in the fuel,
it's not worth the effort to get it.
It is possible to convert one fuel source into another.
Every time you do so,
some of the energy contained in the original fuel is lost.
For instance, there is unconventional oil:
Tar Sands and Shale.
Tar Sands are found mainly in Canada.
Two thirds of the world's shale is in the US.
Both of these fuels can be converted to synthetic crude oil.
However, this requires large amounts of heat and fresh water,
reducing their EROEI,
which varies from five, to as low as one and a half.
Shale is an exceptionally poor fuel,
pound for pound containing about one third the energy
of a box of breakfast cereal.
Coal exists in vast quantities,
and generates almost half of the planet's electricity.
The world uses almost 2 cubic miles of coal a year.
However, Global coal production may peak before 2040.
The claim that America has centuries worth of coal is deceptive,
as it fails to account for growing demand, and decreasing quality.
Much of the high quality anthracite coal is gone,
leaving lower quality coal that is less energy dense.
Production issues arise, as surface coal is depleted,
and miners have to dig deeper and in less accessible areas.
Many use destructive mountaintop removal to reach coal deposits,
causing environmental mayhem.
Natural gas is often found alongside oil and coal.
North American discovery of conventional gas peaked in the 1950s,
and production peaked in the early 70s.
If the discovery graph is moved forward by 23 years,
the possible future of North American conventional natural gas production
is revealed.
Recent breakthroughs have allowed the extraction of unconventional natural gas,
such as shale gas, which might help offset decline in the years ahead.
Unconventional natural gas is controversial,
as it needs high energy prices to be profitable.
Even with Unconventional gas,
there may be a peak in global natural gas production by 2030.
Large uranium reserves for nuclear fission still exist.
To replace the 10 terawatts the world currently generates from fossil fuels,
would require 10,000 nuclear power plants.
At that rate, the known reserves of uranium would last for only 10 to 20 years.
Experiments with plutonium based fast-breeder reactors
in France and Japan
have been expensive failures.
Nuclear fusion faces massive technical obstacles.
Then there are the renewables.
Windpower has a high EROEI, but is intermittent.
Hydro power is reliable,
but most rivers in the developed world are already dammed.
Conventional geothermal power plants
use existing hotspots near the Earth's surface.
They are limited to those areas.
In the experimental EGS system,
two shafts would be drilled 6 miles deep.
Water is pumped down one shaft, to be heated in fissures,
then rise up the other, generating power.
According to a recent MIT report,
this technology might supply 10% of US electricity by 2050.
Wave power is restricted to coastal areas.
The energy density of waves varies from region to region.
Transporting wave-generated electricity inland would be challenging.
Also, the salty ocean environment is corrosive to turbines.
Biofuels are fuels that are grown.
Wood has a low energy density, and grows slowly.
The world uses 3.7 cubic miles of wood a year.
Biodiesel and ethanol
are made from crops grown by petroleum powered agriculture.
The energy profit from these fuels is very low.
Some politicians want to turn corn into ethanol.
Using Ethanol to supply one tenth of projected US oil use in 2020,
would require 3% of America's Land.
To supply one third would require 3 times the area now used to grow food.
To supply all US petroleum consumption in 2020
would take twice as much land as is used to grow food.
Hydrogen has to be extracted from Natural Gas, coal or water,

which uses more energy than we get from the Hydrogen.
This makes a Hydrogen economy unlikely.
All the world's photovoltaic solar panels generate as much electricity
as two coal power plants.
The equivalent of between 1 and 4 tons of coal
are used in the manufacture of a single solar panel.
We'd have to cover as many as 140,000 square miles with panels
to meet current world demand.
As of 2007, there are only about 4 square miles.
Concentrated Solar Power, or Solar Thermal has great potential,
though at the moment there are only a small number of plants operating.
They are also limited to sunny climates,
requiring large amounts of electricity
to be transmitted over long distances.
All of the alternatives to oil depend on oil-powered machinery,
or require materials such as plastics that are produced from oil.
When considering future claims of amazing new fuels or inventions,
ask:
Does the advocate have a working, commercial model of the invention?
What is its energy density?
Can it be stored or easily distributed?
Is it reliable or intermittent?
Can it be scaled to a national level?
Are there hidden engineering challenges?
What is the EROEI?
What are the environmental impacts?
Remember that large numbers can be deceptive.
For example: 1 billion barrels of oil
will satisfy global demand for only 12 days.
A transition from fossil fuels would be a monumental challenge.
As of 2007, coal generates 48.5% of U.S. electricity.
21.6% is from natural gas,
1.6% is from petroleum,
19.4% is from nuclear,
5.8% is from hydro.
Other renewables only generate 2.5%.
Is it possible to replace a system based on fossil fuels
with a patchwork of alternatives?
Major technological advances are needed,
as well as political will and co-operation,
massive investment,
international consensus,
the retrofitting of the $45 trillion global economy,
including transportation,
manufacturing industries,
and agricultural systems,
as well as officials competent to manage the transition.
If all these are achieved,
could the current way of life continue?
Growth
These bacteria live in a bottle.
Their population doubles every minute.
At 11AM there is one bacterium.
At 12 noon the bottle is full.
It is half-full at 11.59
leaving only enough space for one more doubling.
The bacteria see the danger.
They search for new bottles, and find 3.
They assume that their problem is solved.
By 12 noon, the first bottle is full.
By 12.01, the second bottle is full.
By 12.02, all the bottles are full.
This is the problem that we face,
due to the doubling caused by Exponential Growth.
When humanity began to use coal and oil as fuel sources,
it experienced unprecedented growth.
Even low growth rates produce large increases over time.
At a 1% growth rate,
an economy will double in 70 years.
A 2% rate doubles in 35 years.
At a 10% growth rate,
an economy will double in only 7 years.
If an economy grows at the current average of 3%,
it doubles every 23 years.
With each doubling, demand for energy and resources
will exceed all the previous doublings combined.
The financial system is built on the assumption of growth
- which requires an increasing supply of energy to support it.
Banks lend money they don't have,
in effect creating it.
The borrowers use the newly created loan money to grow their businesses,
and pay back the debt,
with an interest payment which requires more growth.
Due to this creation of debt formed money,
most of the world's money represents a debt with interest to be paid.
Without continual new and ever larger generations
of borrowers to produce growth,
and thus pay off these debts,
the world economy will collapse.
Like a Ponzi Scheme,
the system must expand or die.
Partly through this debt system,
the effects of economic growth have been spectacular:
in GDP,
damming of rivers,
water use,
fertiliser consumption,
urban population,
paper consumption,
motor vehicles,
communications
and tourism.
World population has grown to 7 billion,
and is expected to exceed 9 billion by 2050.
On a flat, infinite earth, this would not be a problem.
However, as the Earth is round and finite,
we will eventually face limits to growth.
Economic expansion
has resulted in increases in atmospheric nitrous oxide
and methane,
ozone depletion,
increases in great floods,
damage to ocean ecosystems,
including nitrogen runoff,
loss of rainforest and woodland,
increases in domesticated land,
and species exinctions.
If we place a single grain of rice
on the first square of a chessboard,
double this and place 2 grains on the second,
double again and place 4 on the third,
double again and place 8 on the fourth,
and continue this way,
putting on each square twice the number of grains
than were on the previous one,
by the time we reach the final square,
we need an astronomical number of grains:

9 quintillion,
223 quadrillion,
372 trillion,
36 billion,
854 million,
776 thousand grains:
more grain than the human race
has grown in the last 10,000 years.
Modern economies,
like the grains on the chess board,
doubles every few decades.
On which square of the chessboard are we?
Besides energy,
civilisation demands numerous essential resources:
fresh water,
topsoil,
food,
forests,
and many kinds of minerals and metals.
Growth is limited
by the essential resource in scarcest supply.
A barrel is made of staves,
and like water filling a barrel,
growth can go no further than the lowest stave,
or the most limited essential resource.
Humans currently utilise
40% of all photosynthesis n Earth.
Though it might be possible to use 80%,
we are unlikely to ever use 160%.
FOOD
The global food supply
relies heavily on fossil fuels.
Before WW1,
all agriculture was Organic.
Following the invention of fossil fuel derived fertilisers and pesticides
there were massive improvements in food production,
allowing for increases in human population.
The use of artificial fertilisers
has fed far more people than would have been possible
with organic agriculture alone.
Fossil fuels are needed for farming equipment,
transportation,
refrigeration,
packaging - in plastic,
and cooking.
Modern agriculture uses land to turn fossil fuels into food
- and food into people.
About 7 calories of fossil-fuel energy
are used to produce 1 calorie of food.
In America, food travels approximately 1,500 miles from farm to customer.
Besides fossil fuel decline,
there are several threats to the current system of food production:
Cheap energy,
improved technology
and subsidies have allowed massive fish catches.
Global fish catches peaked in the late nineteen eighties,
forcing fishermen to move into deep waters.
Nitrogen run off by fossil fuel based fertilisers
poisons rivers and seas, creating enormous dead zones.
At this rate,
all fish populations are projected to collapse
by 2048.
Acid rain from cities and industries leeches the soil of vital nutrients,
such as potassium,
calcium,
and magnesium.
Another threat is a lack of water.
Many farms use water pumped from underground aquifers for irrigation.
The aquifers need thousands of years to fill up,
but can be pumped dry in a few decades,
like oil wells.
America's massive Ogallala aquifer has fallen so low
that many farmers have had to return to less productive dry-land farming.
Additionally, The use of irrigation and fertilisers can lead to salinisation:
the accumulation of salt in the soil.
This is a major cause of desertification.
Still another threat is topsoil loss.
200 years ago,
there were 6 feet of topsoil on the American prairies.
Today, through tillage and poor practices,
approximately half is gone.
Irrigation encourages the growth of stem rust fungi like UG-99
- which has the potential to destroy 80% of the world's grain harvest.
According to Norman Borlaug,
father of the Green Revolution,
stem rust "has immense potential for social and human destruction."
The use of biofuels means that less land
will be available for food production.
An area has a finite carrying capacity.
This is the number of animals or people
that can live there indefinitely.
If a species overshoots the carrying capacity of that area,
it will die back until the population returns to its natural limits.
The world has avoided this die-off
by finding new lands to cultivate,
or by increasing production,
which has been possible largely thanks to oil.
To continue growth,
more resources are required than the Earth can provide,
but no new planets are available.
In the face of all these challenges,
global food production must double by 2050
to feed the growing world population.
1 billion people are already malnourished or starving.
There will be challenges in feeding over 9 billion in the years to come,
when world oil and natural gas production will be in decline.
HAPPY ENDING
The global economy grows exponentially,
at about 3% a year,
consuming increasing amounts of non-renewable fuels,
minerals and metals,
as well as renewable resources
like water, forests, soils and fish
faster than they can be replenished.
Even at a growth rate of 1%,
an economy will double in 70 years.
The problem is intensified by other factors:
Globalisation allows people on one continent
to buy goods and food made by those on another.
The lines of supply are long,
placing strains on a limited oil resource.
We now rely on distant countries for basic necessities.
Modern cities are fossil fuel dependent.
Most Banking Systems are based on debt,
forcing people into a spiral of loans and repayments
- producing growth.

What can be done in the face of these problems?
Many believe that the crisis can be prevented
through conservation,
technology,
smart growth,
recycling,
electric cars and hybrids,
substitution,
or voting.
Conservation will save you money,
but it alone won't save the planet.
If some people cut back on oil use,
the reduced demand will drive down the price,
allowing others to buy it for less.
In the same fashion,
a more efficient engine that uses less energy will,
paradoxically, lead to greater energy use.
In the 19th century,
English economist William Stanley Jevons
realised that Better steam engines made coal
a more cost effective fuel source,
which led to the use of more steam engines,
which increased total coal consumption.
Growth of use will consume any energy or resources
saved through conservation.
Many believe that scientists
will solve these problems with new technology.
However, technology is not energy.
Technology can channel energy into work,
but it can't replace it.
It also consumes resources:
for instance;
computers are made with one tenth
of the energy needed to make a car.
More advanced technologies
may make the situation worse,
as many require rare minerals,
which are also approaching limits.
For example,
97% of the world's Rare Earths are produced by China,
most from a single mine in inner Mongolia.
These minerals are used in catalytic converters,
aircraft engines,
high efficiency magnets and hard drives,
hybrid car batteries,
lasers,
portable X-Rays,
shielding for nuclear reactors,
compact discs,
hybrid vehicle motors,
low energy light-bulbs,
fibre optics
and flat-screen displays.
China has begun to consider restricting the export of these minerals,
as demand soars.
So called sustainable growth or smart growth won't help,
as it also uses non renewable metals and minerals
in ever increasing quantities,
including Rare Earths.
Recycling will not solve the problem,
as it requires energy,
and the process is not 100% efficient.
It is only possible to reclaim a fraction of the material being recycled;
a large portion is lost forever as waste.
Electric cars run on electricity.
As most power is generated from fossil fuels,
this is not a solution.
Also, cars of all types consume oil in their production.
Each tire alone requires about 7 gallons of Petroleum.
There are around 800 million cars in the world, as of 2010.
At current growth rates,
this number would reach 2 billion by 2025.
It is unlikely that the planet can support this many vehicles for long,
regardless of their power source.
Many economists believe
that the free market will substitute one energy source
with another through technological innovation.
However, the main substitutes to oil
face their own decline rates.
Substitution also fails to account for the time needed to prepare for a transition.
The U.S. Department of Energy's Hirsch report
estimates that at least 2 decades would be needed to prepare
for the effects of Peak Oil.
The issues of energy shortages,
resource depletion,
topsoil loss,
and pollution are all symptoms of a single, larger problem:
Growth.
As long as our financial system demands endless growth,
reform is unlikely to succeed.
What then, will the future look like?
Optimists believe that growth will continue forever,
without limits.
Pessimists think that we're heading towards a new Stone Age,
or extinction.
The truth may lie between these extremes.
It is possible that society might fall back to a simpler state,
one in which energy use is a lot less.
This would mean a harder life for most.
More manual labour,
more farm work,
and local production of goods, food and services.
What should a person do to prepare for such a possible future?
Expect a decrease in supplies of food and goods from far away places.
Start walking or cycling.
Get used to using less electricity.
Get out of debt.
Try to avoid banks.
Instead of shopping at big box stores,
support local businesses.
Buy food grown locally, at Farmers' Markets.
Instead of a lawn, consider gardening to grow your own food.
Learn how to preserve it.
Consider the use of local currencies
should the larger economy cease to function,
and develop greater self sufficiency.
None of these steps will prevent Collapse,
but they might improve your chances in a low energy future,
one in which we will have to be more self reliant,
as our ancestors once were.