Solarevolution

The Radical Shift to Renewables

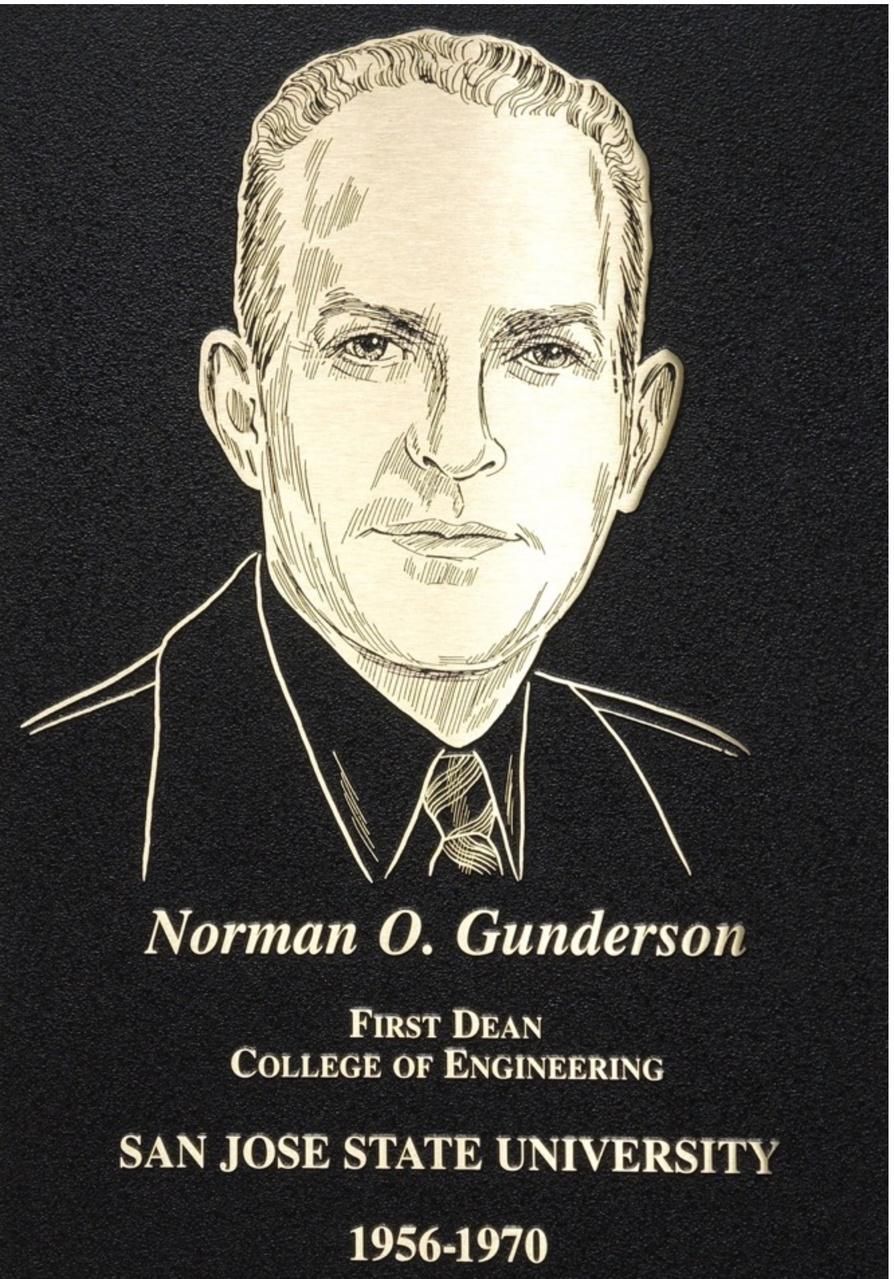
Way more with way less … right now!

Ron Swenson
ME 195 San José State University
May 4th, 2016

International Institute of Sustainable Transportation

www.inist.org

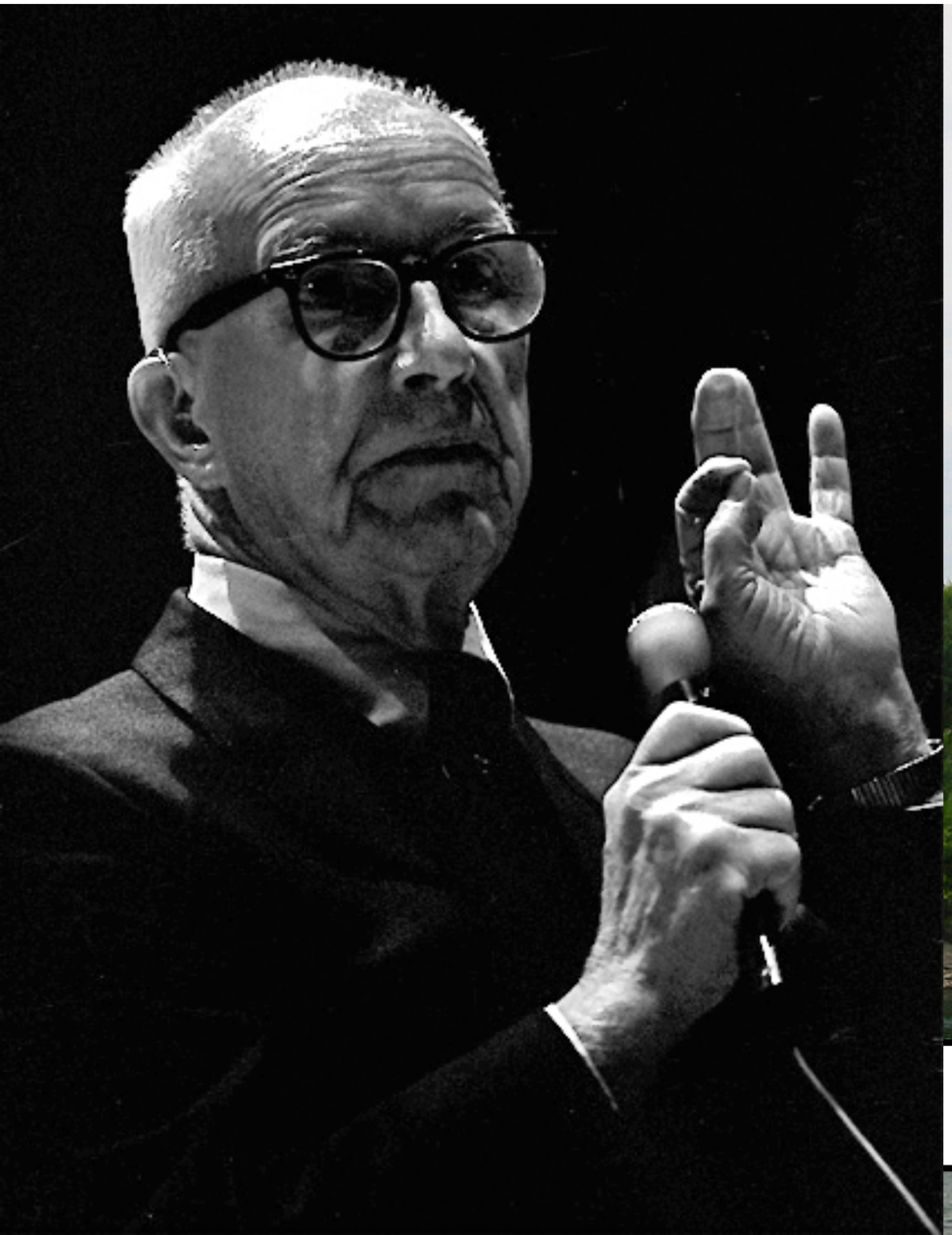
50 years ago I was co-teaching a course in this room



Cybernation and Man
General Engineering

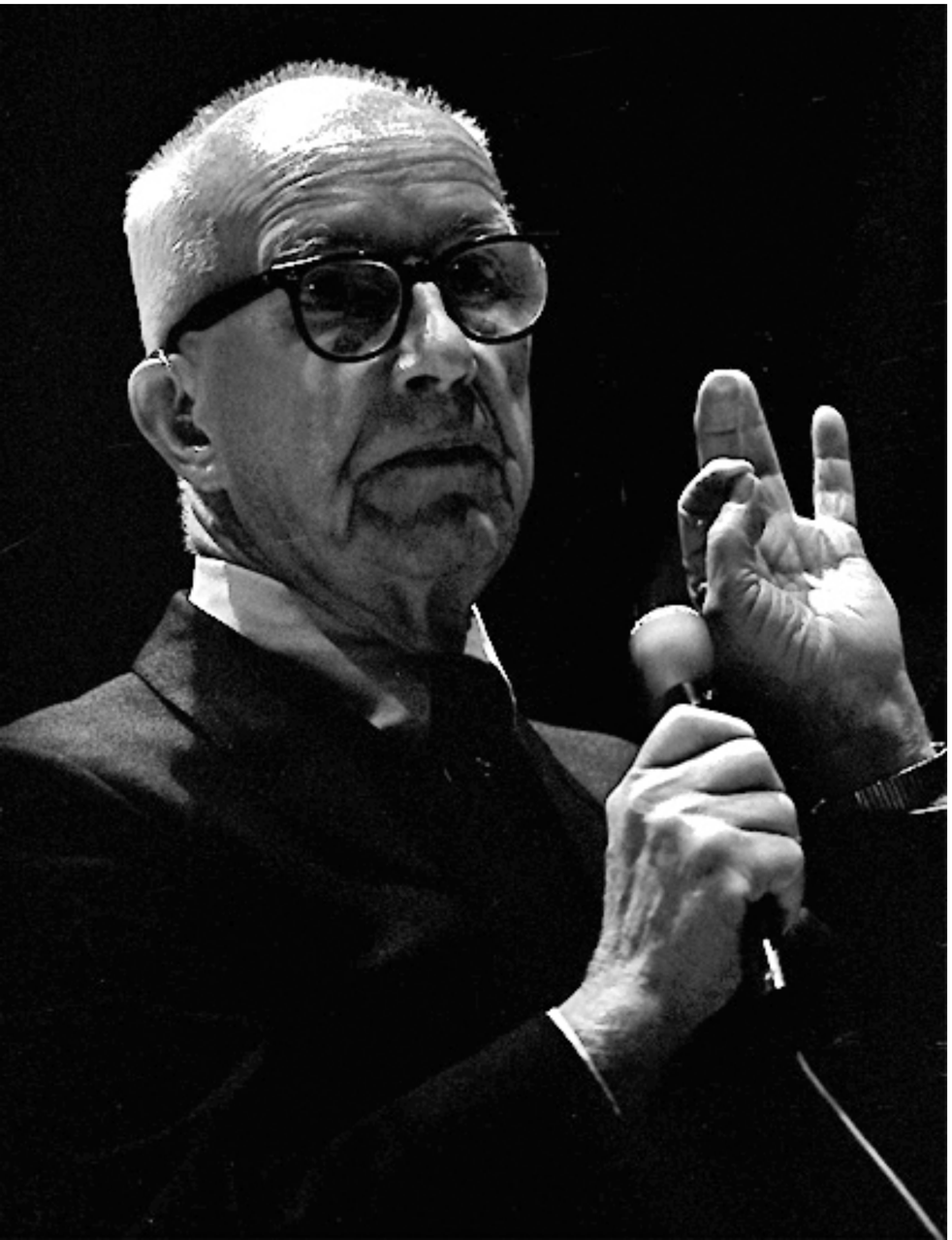
The impact of technology on society

We had a special guest lecturer for 2 months



R Buckminster “Bucky” Fuller

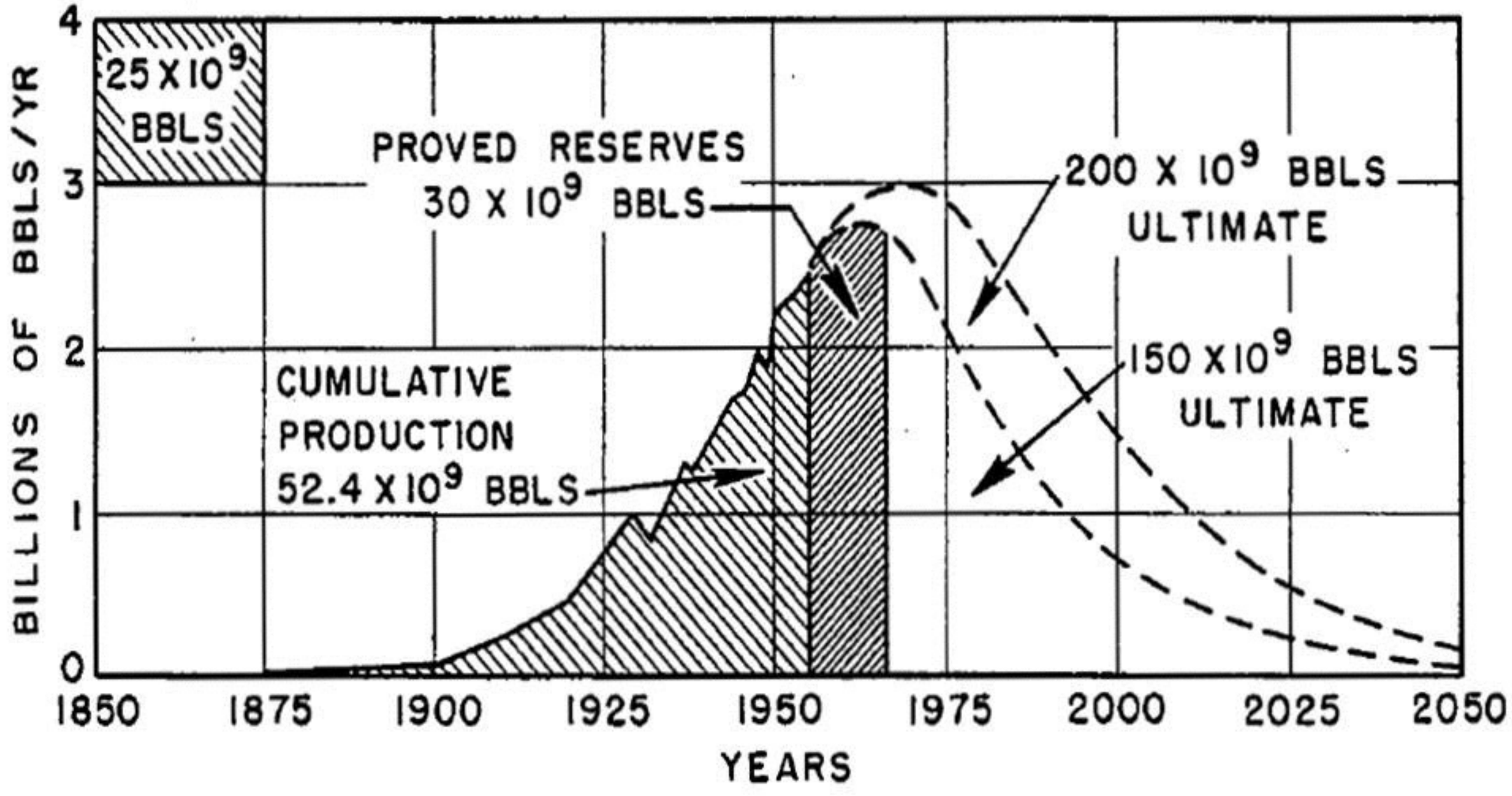
Bucky’s lessons shaped my entire career



- ***We must save our oil for a rainy day***

- ***We can meet the needs of all humanity by doing more with less***

In 1956, Hubbert predicted the limits of oil for the US



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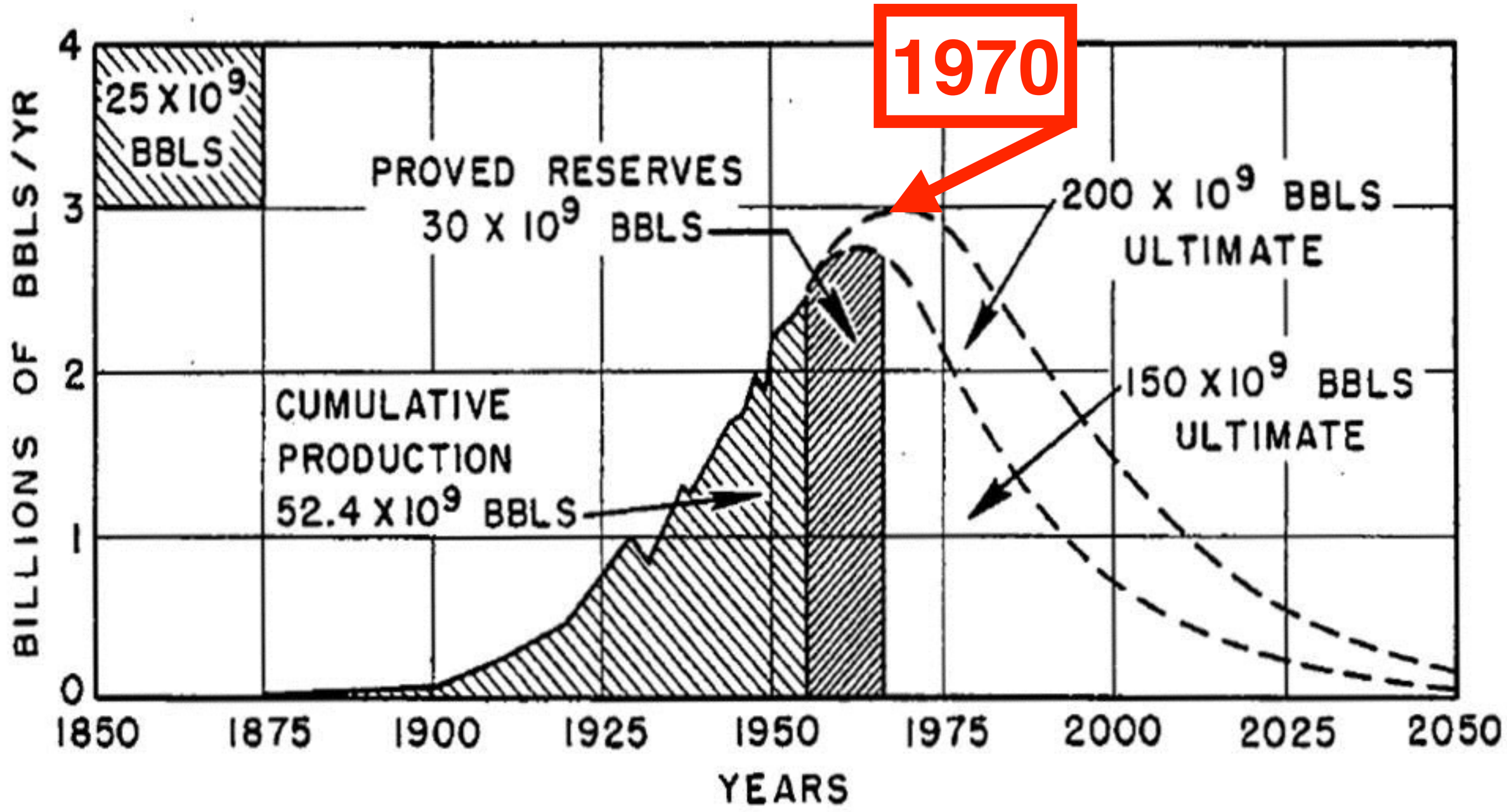

We’ve had many wake-up calls but fossil fuels persist

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1973

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Fuel shortage in Egypt leads to rising tensions; citizens fear possible price hikes, more unrest

Tuesday, 17 January 2012

The streets of Cairo and other cities have been blocked by queues of cars, often snaking around the block, since shortages started becoming apparent on Saturday. (File photo)

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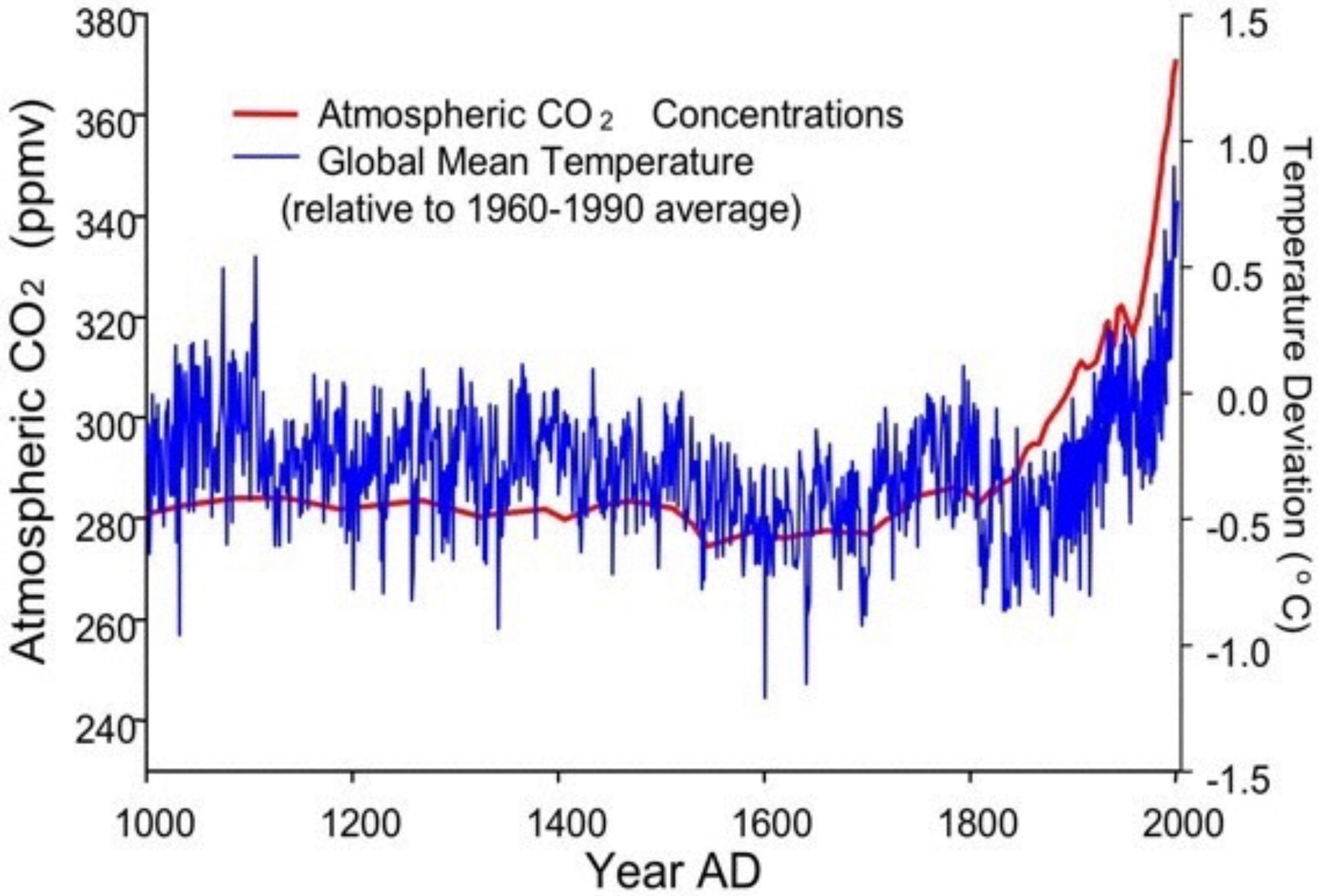
That was *nothing*—Now it's actually getting serious



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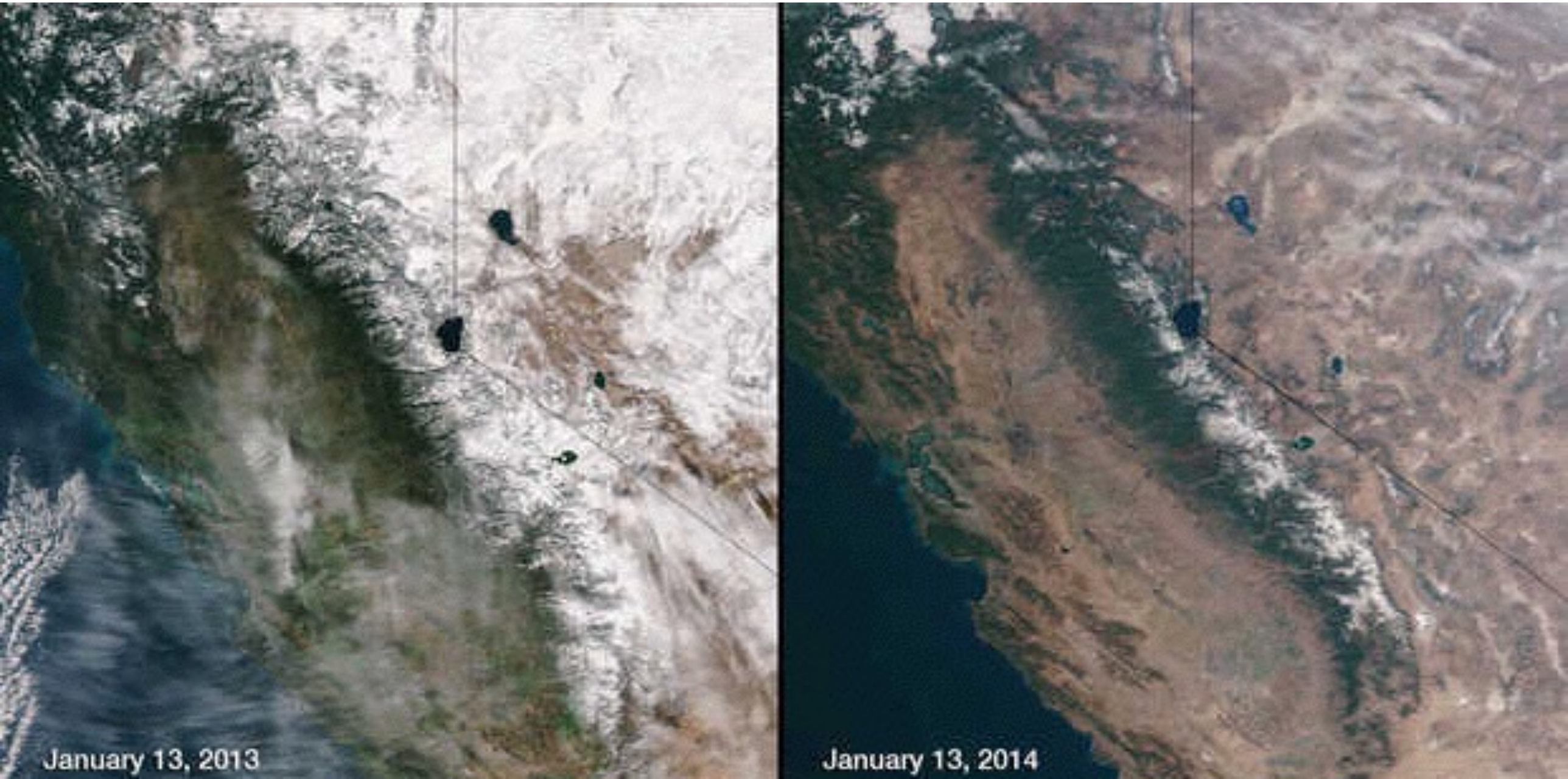
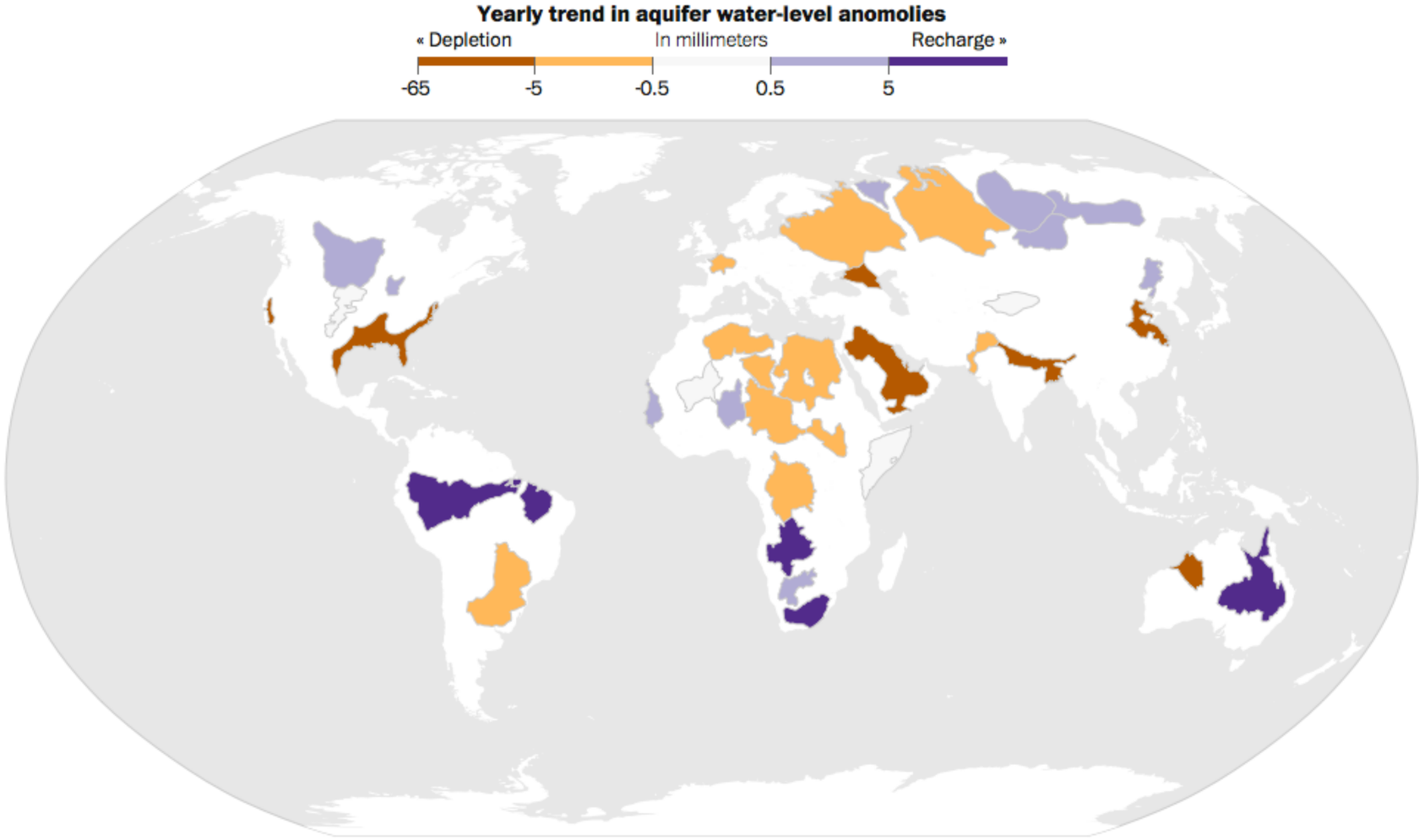


That was *nothing*—Now it's actually getting serious

Satellite system flags stressed aquifers

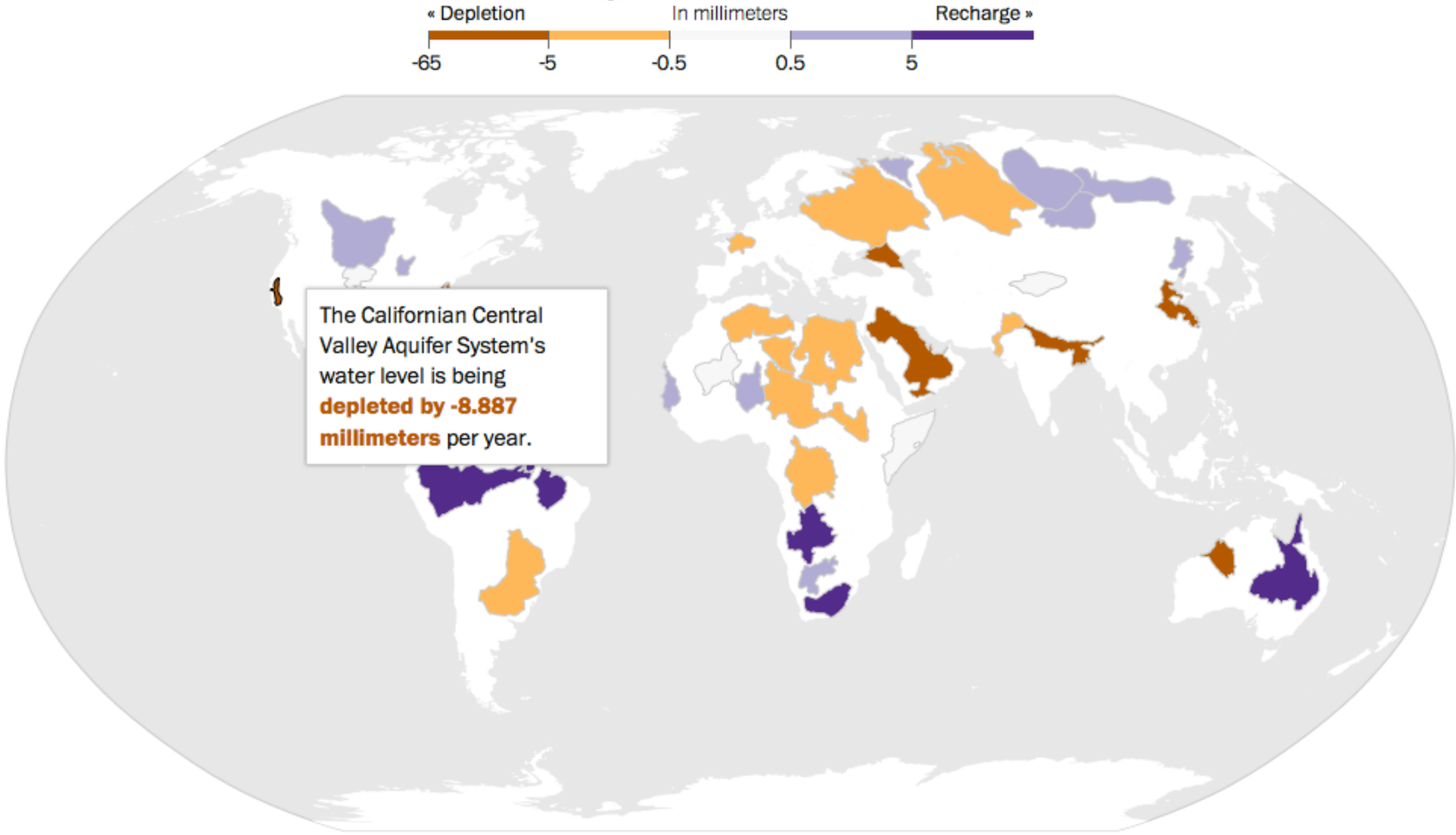
More than half of Earth's 37 largest aquifers are being depleted, according to gravitational data from the GRACE satellite system.



Source: Water Resources Research

That was *nothing*—Now it's actually getting serious

New NASA data show how the world is running out of water



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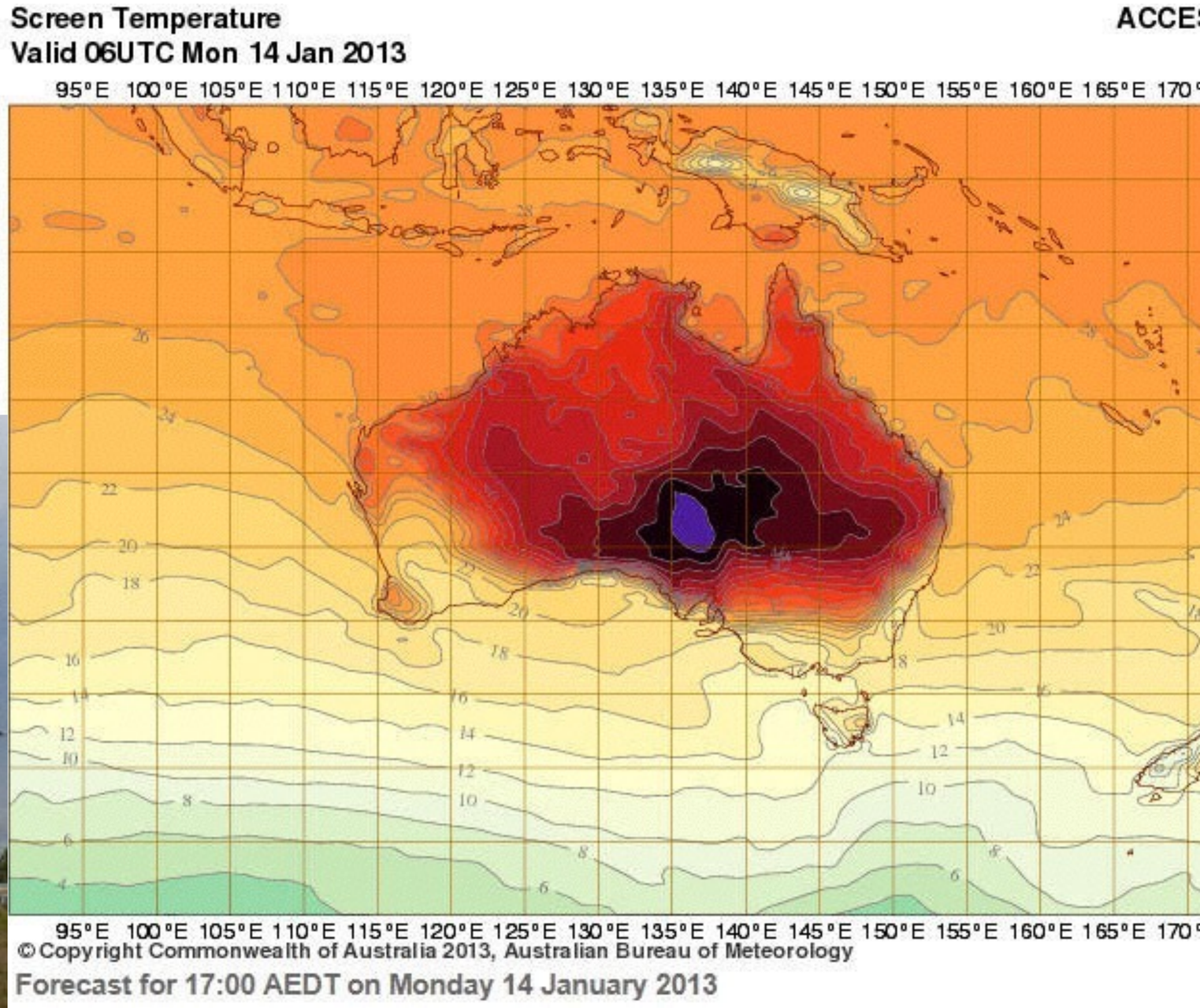
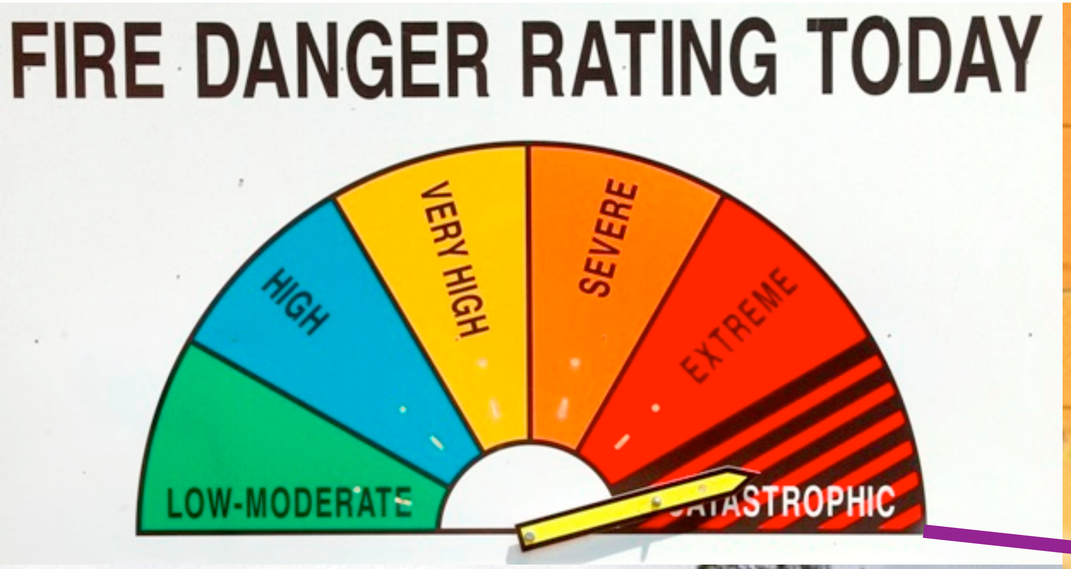
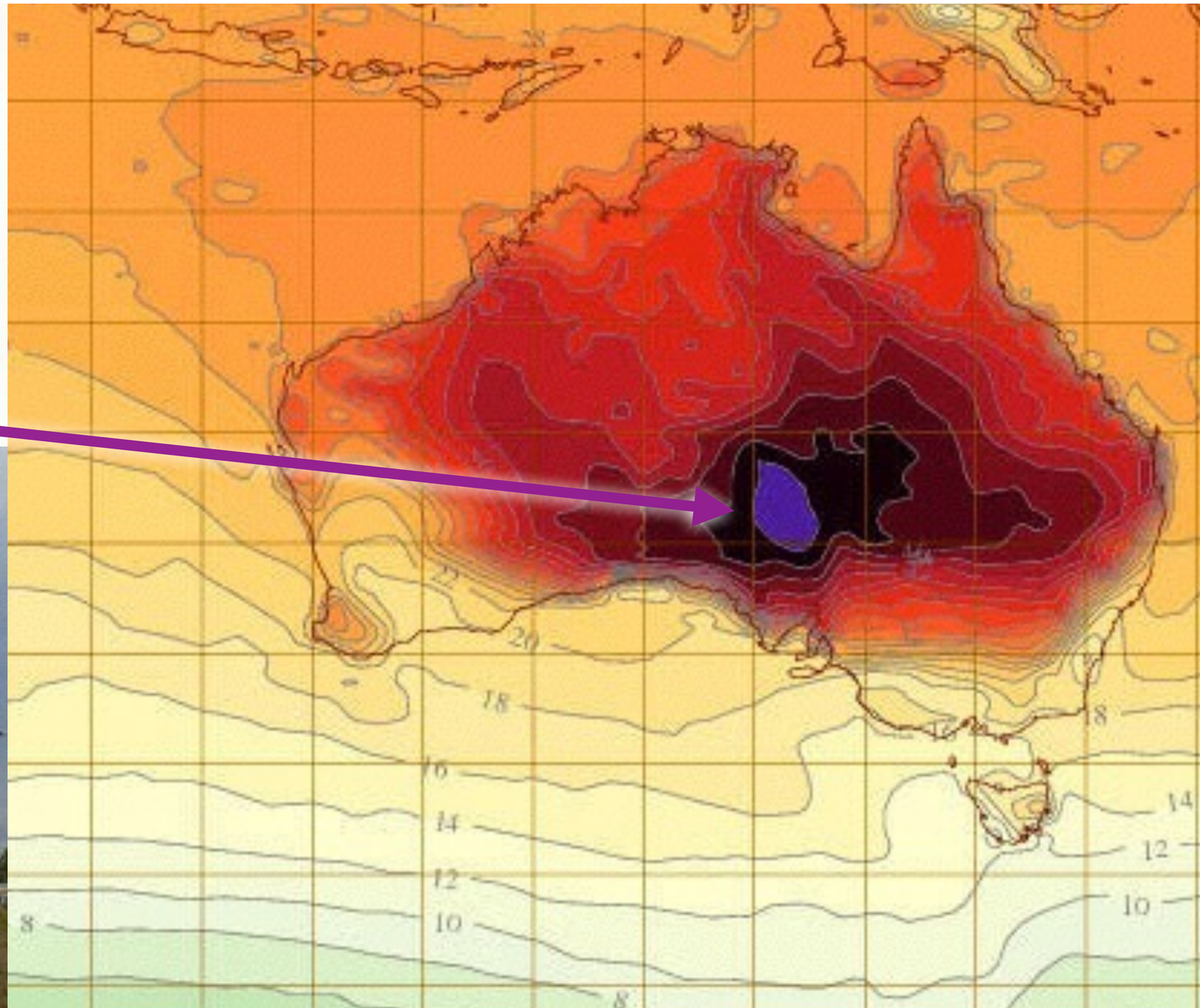
Australia has a new temperature rating:

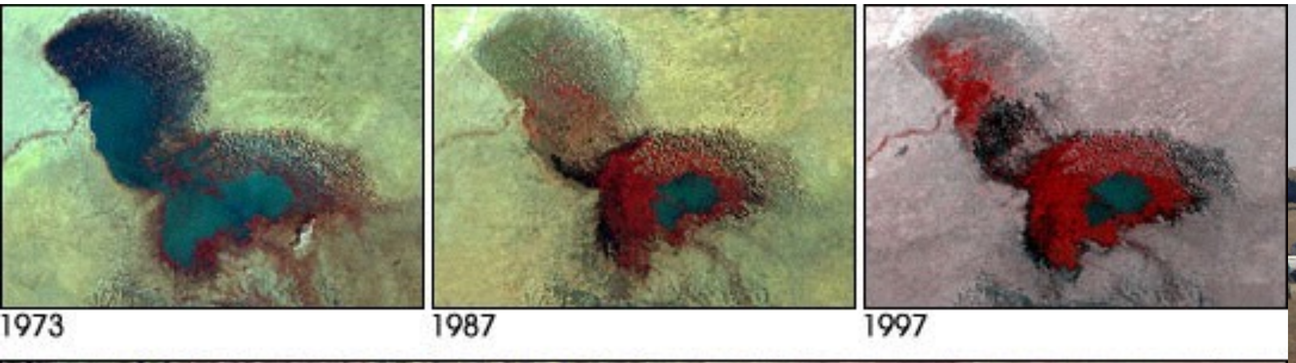


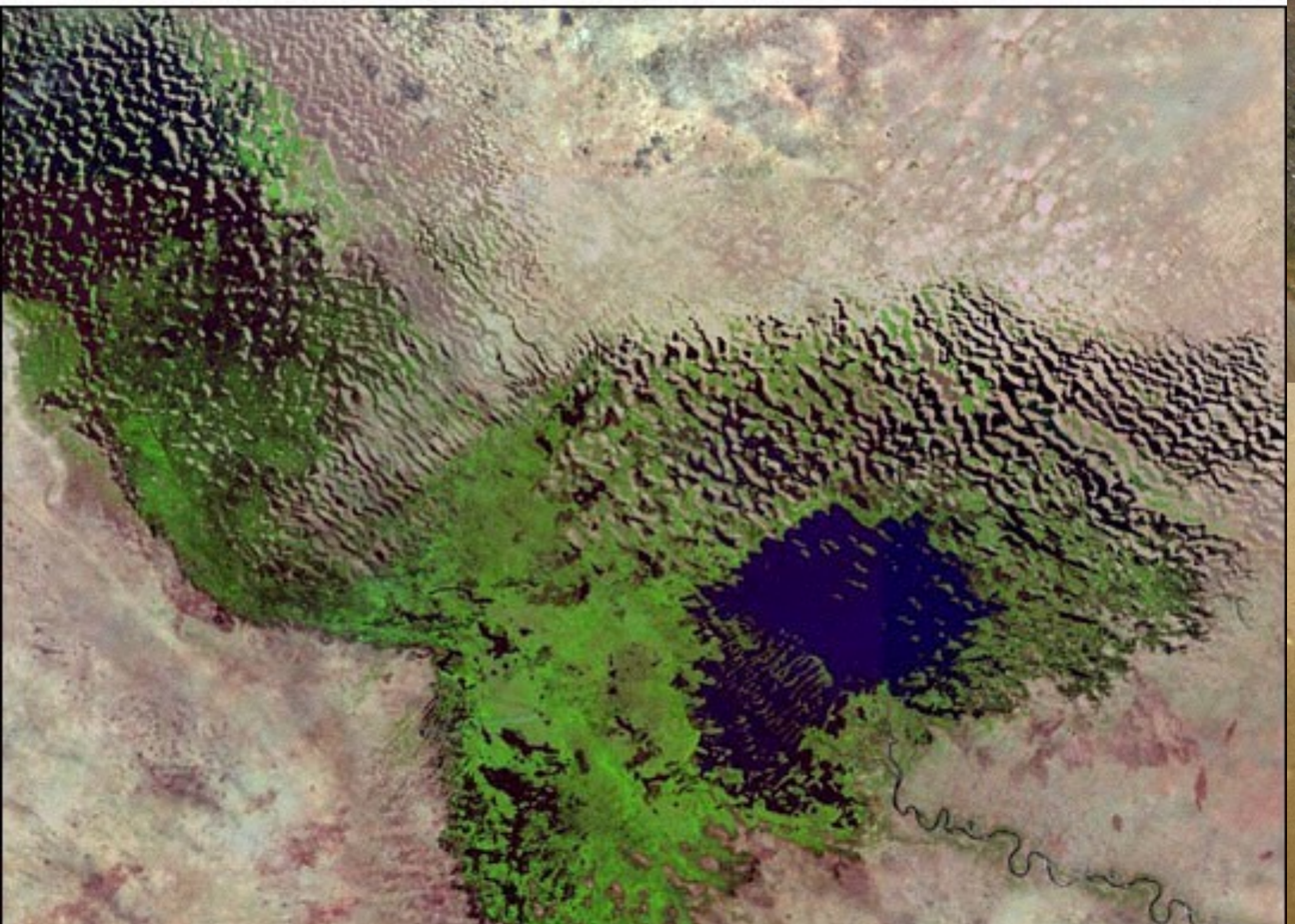
Australia has a new temperature rating: *catastrophic*





And people are suffering in many parts of the world





We must abandon the artifacts of the fossil fuel age

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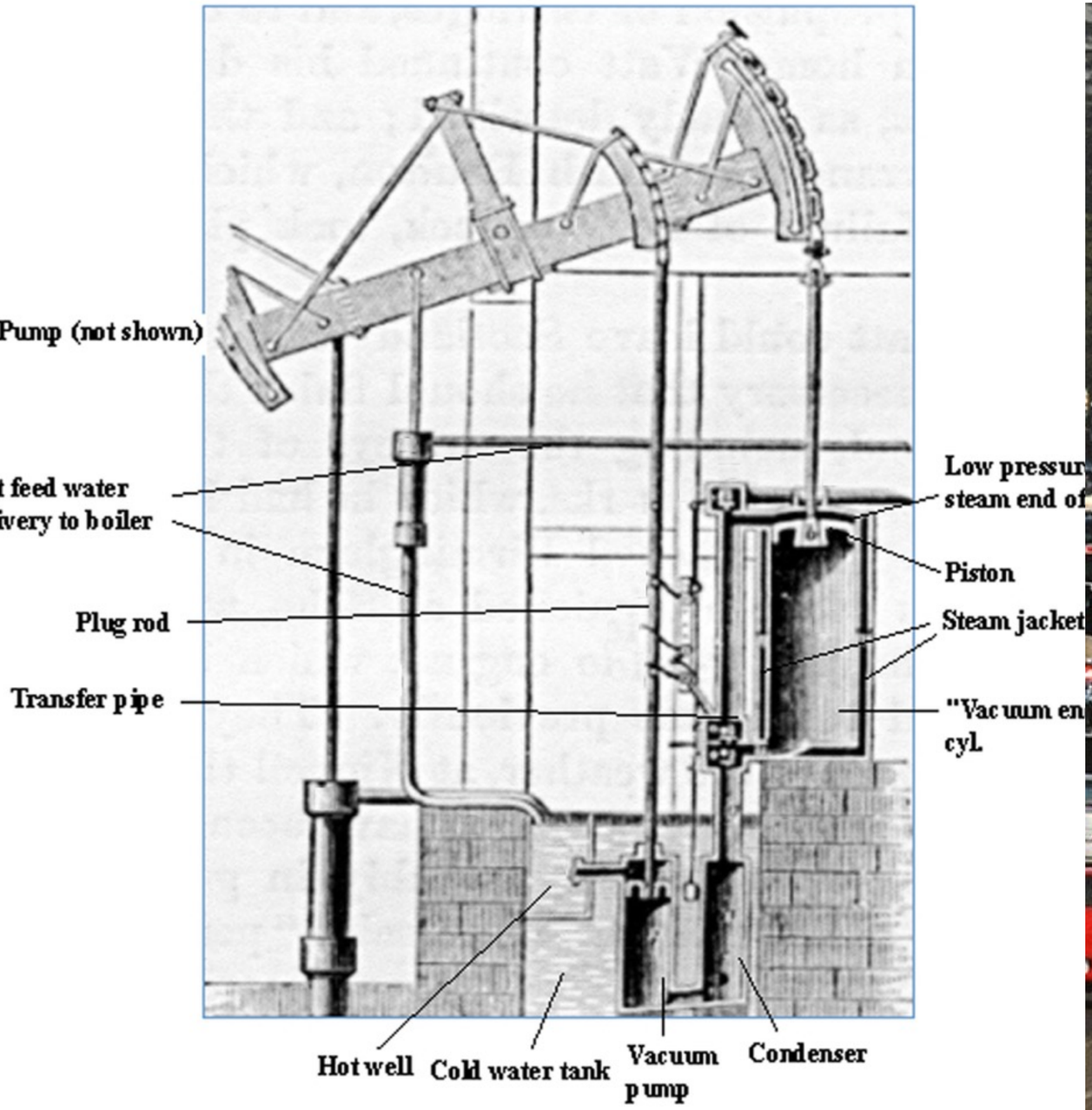

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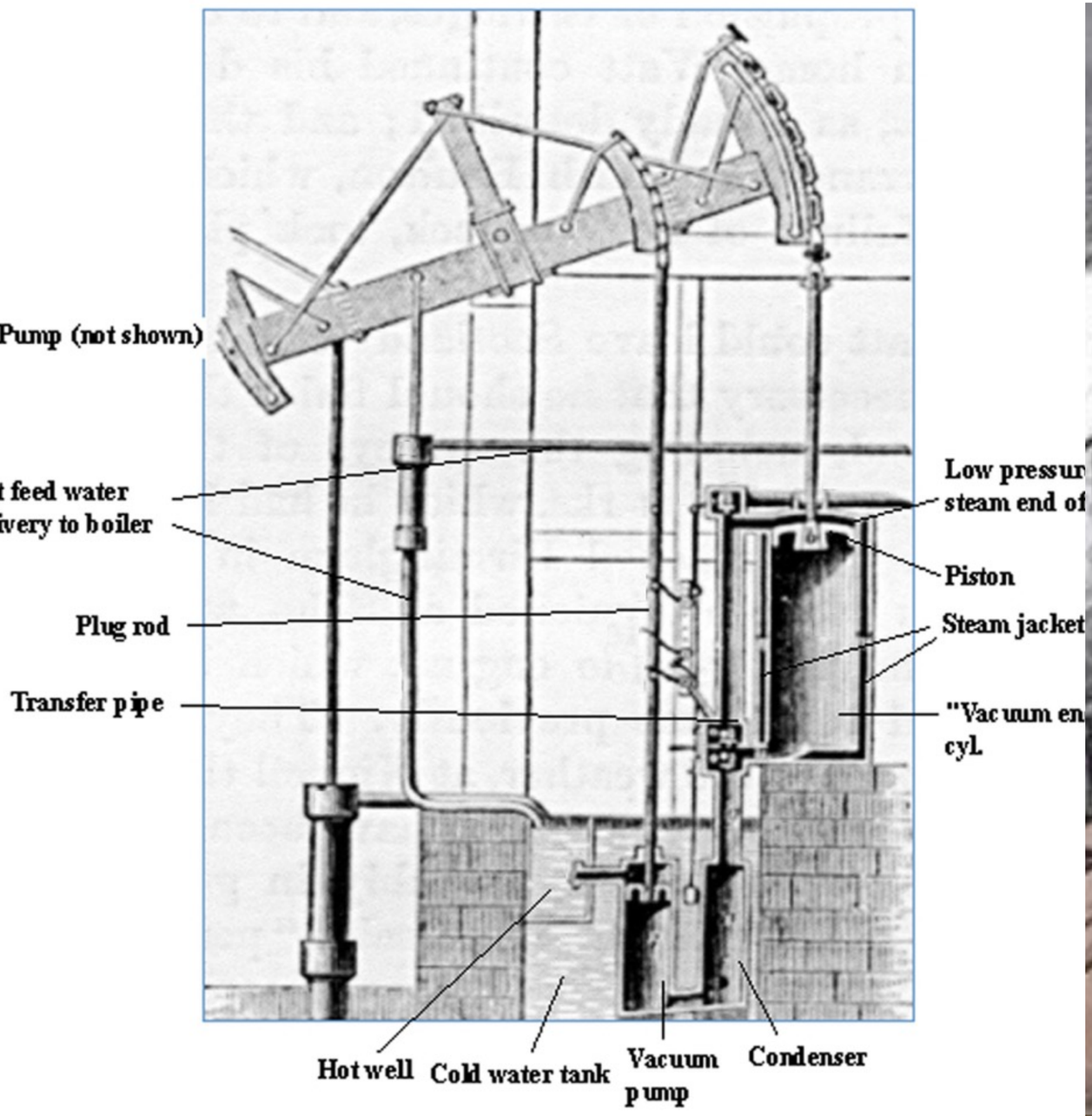
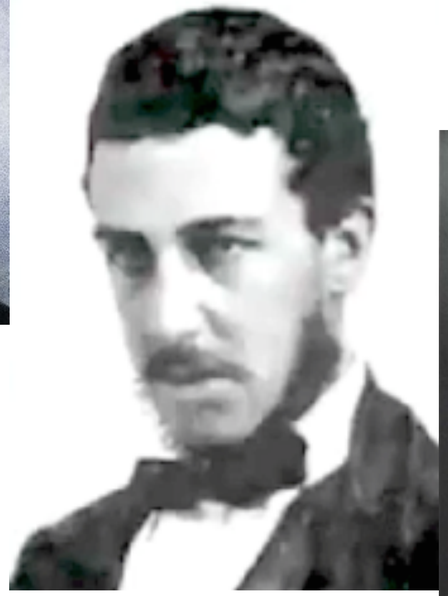


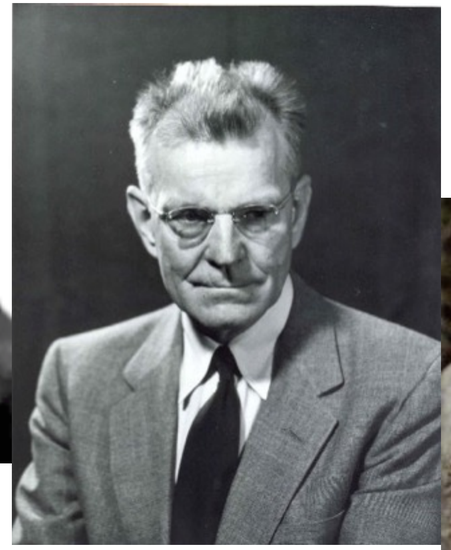
Historic Perspective

There’s been a long debate about humanity’s limits

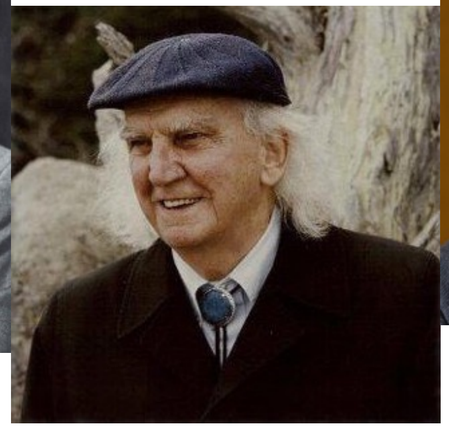
Malthus



Jevons



Hubbert



Boulding

Daly

Fuller

There’s been a long debate about humanity’s limits

Malthus

1766-1834

AN

ESSAY

ON THE

PRINCIPLE OF POPULATION,

AS IT AFFECTS

THE FUTURE IMPROVEMENT OF SOCIETY.

There’s been a long debate about humanity’s limits

Malthus

1766-1834

The power of population is indefinitely greater than the power in the earth to produce subsistence for man.

Population, when unchecked, increases in a geometrical ratio. Subsistence increases only in an arithmetical ratio…

By that law of our nature which makes food necessary to the life of man, the effects of these two unequal powers must be kept equal…

This implies a strong and constantly operating check on population from the difficulty of subsistence.

… Necessity, that imperious all pervading law of nature, restrains [the seeds of life] within the prescribed bounds…. And the race of man cannot, by any efforts of reason, escape from it.

1798

There’s been a long debate about humanity’s limits

Jevons

1800-1880

THE

COAL QUESTION;

AN INQUIRY

CONCERNING THE PROGRESS OF THE NATION,

AND THE

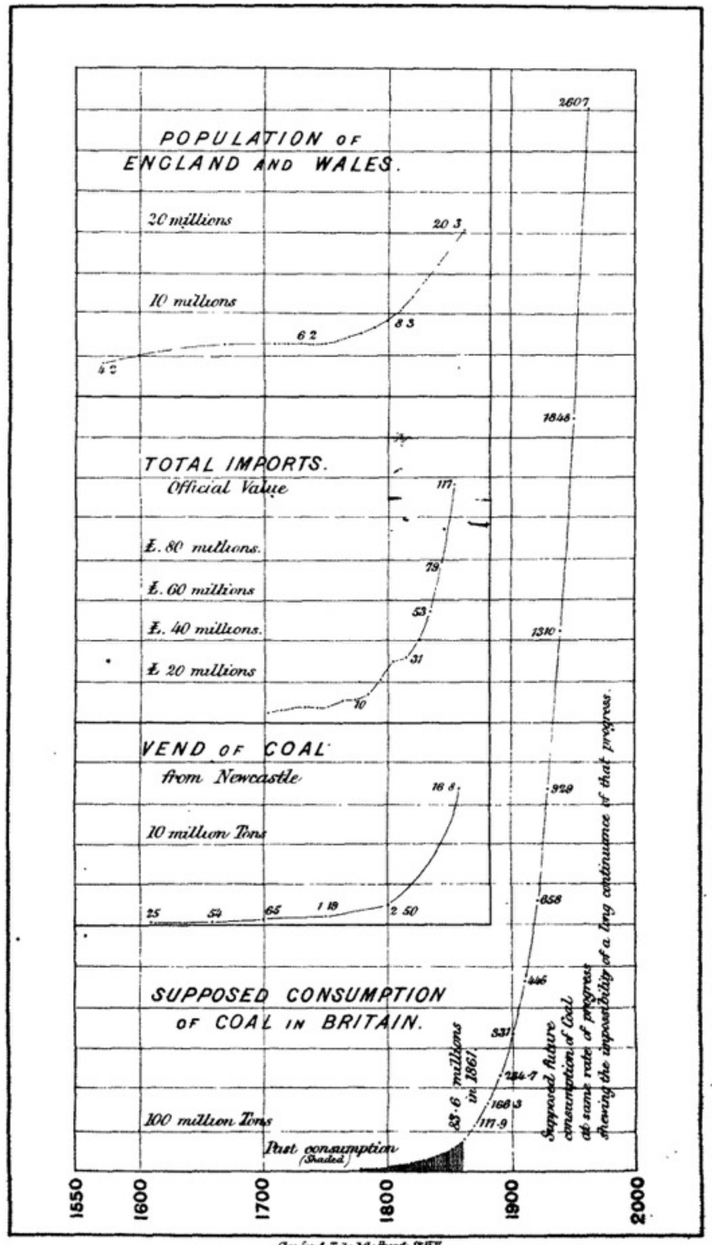
PROBABLE EXHAUSTION OF OUR COAL-MINES.

BY

W. STANLEY JEVONS, M.A.

FELLOW OF UNIVERSITY COLLEGE, LONDON;

COBDEN PROFESSOR OF POLITICAL ECONOMY IN OWENS COLLEGE, MANCHESTER.



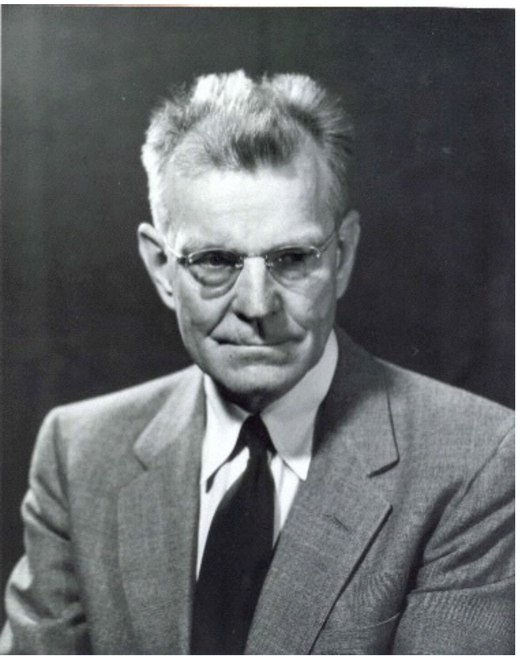
There’s been a long debate about humanity’s limits

Jevons
1800-1880

It is wholly a confusion of ideas to suppose that the economical use of fuel is equivalent to a diminished consumption. The very contrary is the truth … Every improvement of the [steam] engine, when effected, does but accelerate anew the consumption of coal.

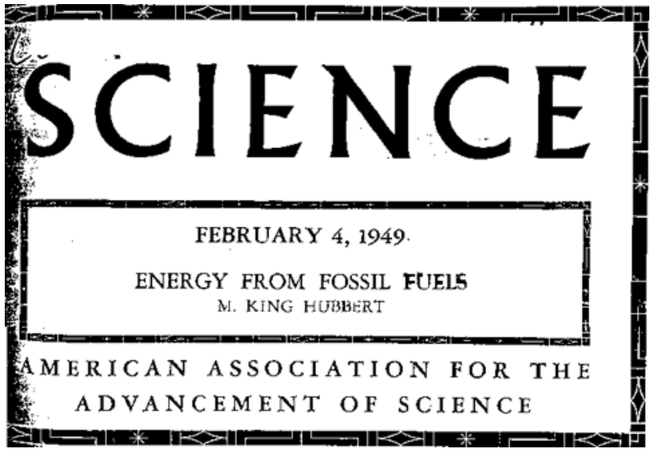
1865

There's been a long debate about humanity's limits



Hubbert

1903-1989



SCIENCE

FEBRUARY 4, 1949

ENERGY FROM FOSSIL FUELS

M. KING HUBBERT

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

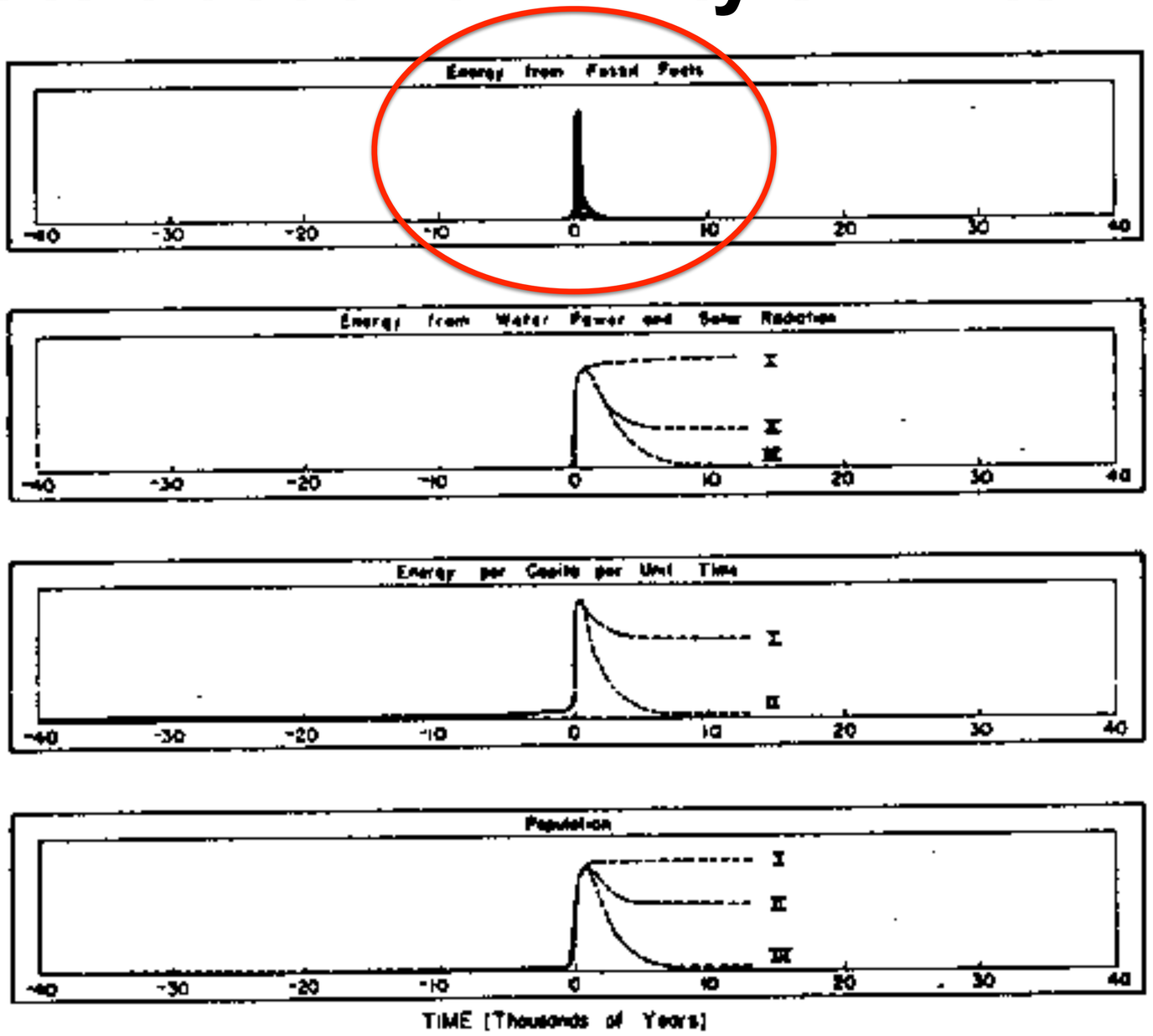
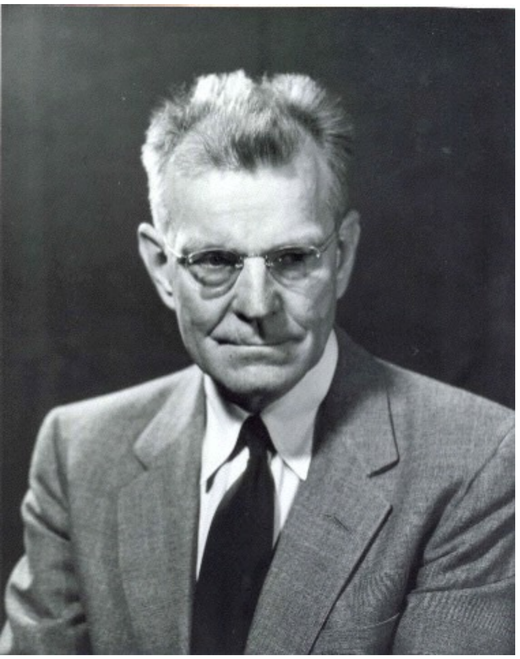


FIG. 8. Human affairs in time perspective.

There's been a long debate about humanity's limits

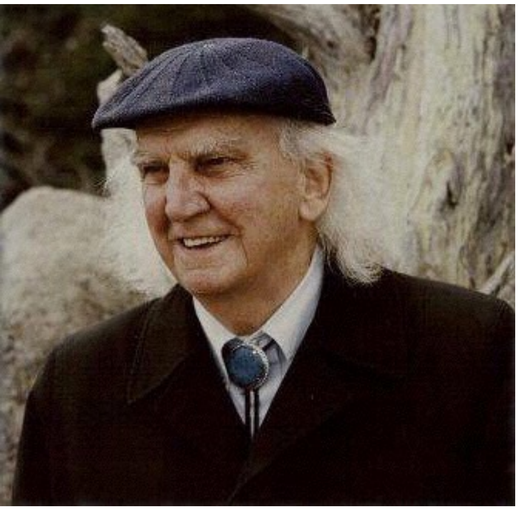


Hubbert
1903-1989

The consumption of energy from fossil fuels is … but a "pip," … thus representing but a moment in the total of human history… It is upon our ability to … evolve a culture … in conformity with the limitations imposed upon us by the basic properties of matter and energy that the future of our civilization largely depends.

1949

There’s been a long debate about humanity’s limits

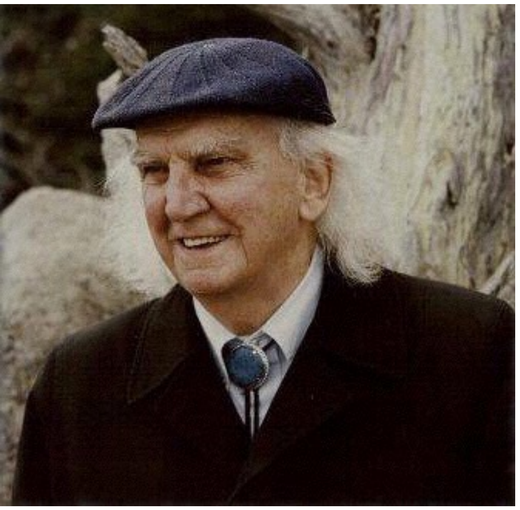


Boulding

1910-1993

Anyone who believes exponential growth can go on forever in a finite world is either a madman or an economist.

There’s been a long debate about humanity’s limits



Boulding

1910-1993

FIRST THEOREM: "THE DISMAL THEOREM"

If the only ultimate check on the growth of population is misery, then the population will grow until it is miserable enough to stop its growth.

SECOND THEOREM: "THE UTTERLY DISMAL THEOREM"

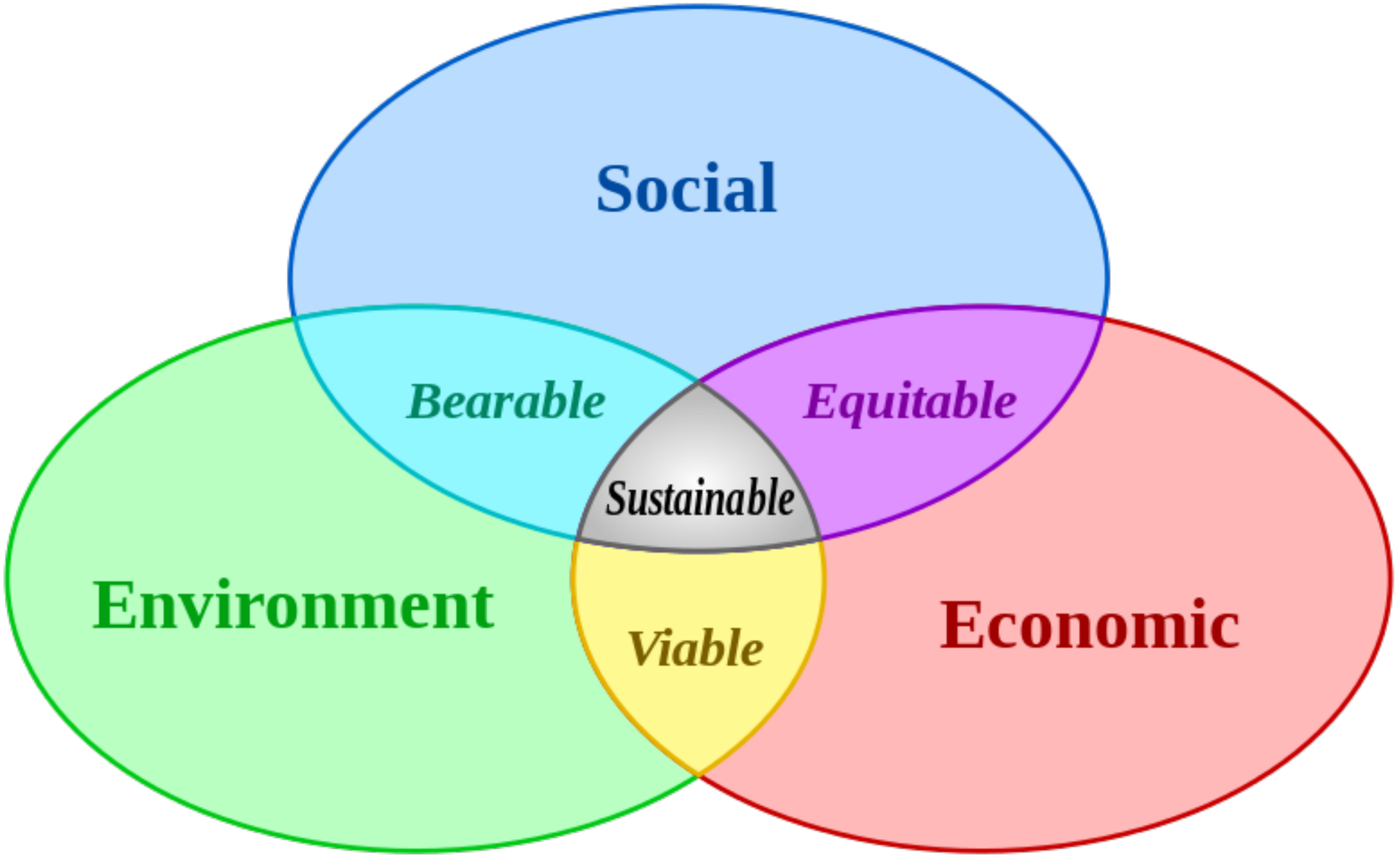
This theorem states that any technical improvement can only relieve misery for a while, for so long as misery is the only check on population, the [technical] improvement will enable population to grow, and will soon enable more people to live in misery than before. The final result of [technical] improvements, therefore, is to increase the equilibrium population which is to increase the sum total of human misery.

THIRD THEOREM: "THE MODERATELY CHEERFUL FORM OF THE DISMAL THEOREM

Fortunately it is not too difficult to restate the Dismal Theorem in a moderately cheerful form, which states that if something else, other than misery and starvation, can be found which will keep a prosperous population in check, the population does not have to grow until it is miserable and starves, and it can be stably prosperous.

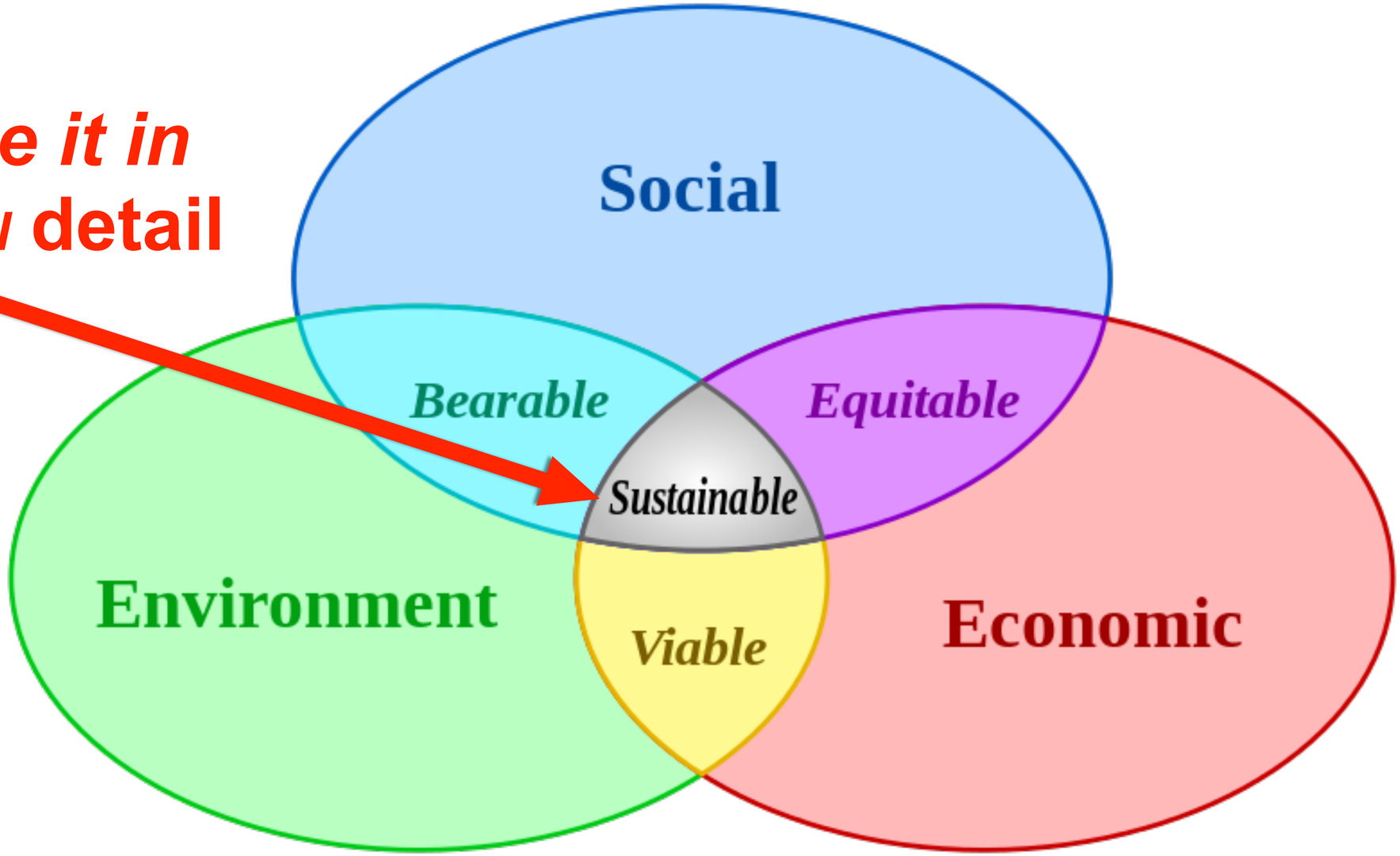
1971

We hear a lot about *sustainability* these days… and it is often represented like this

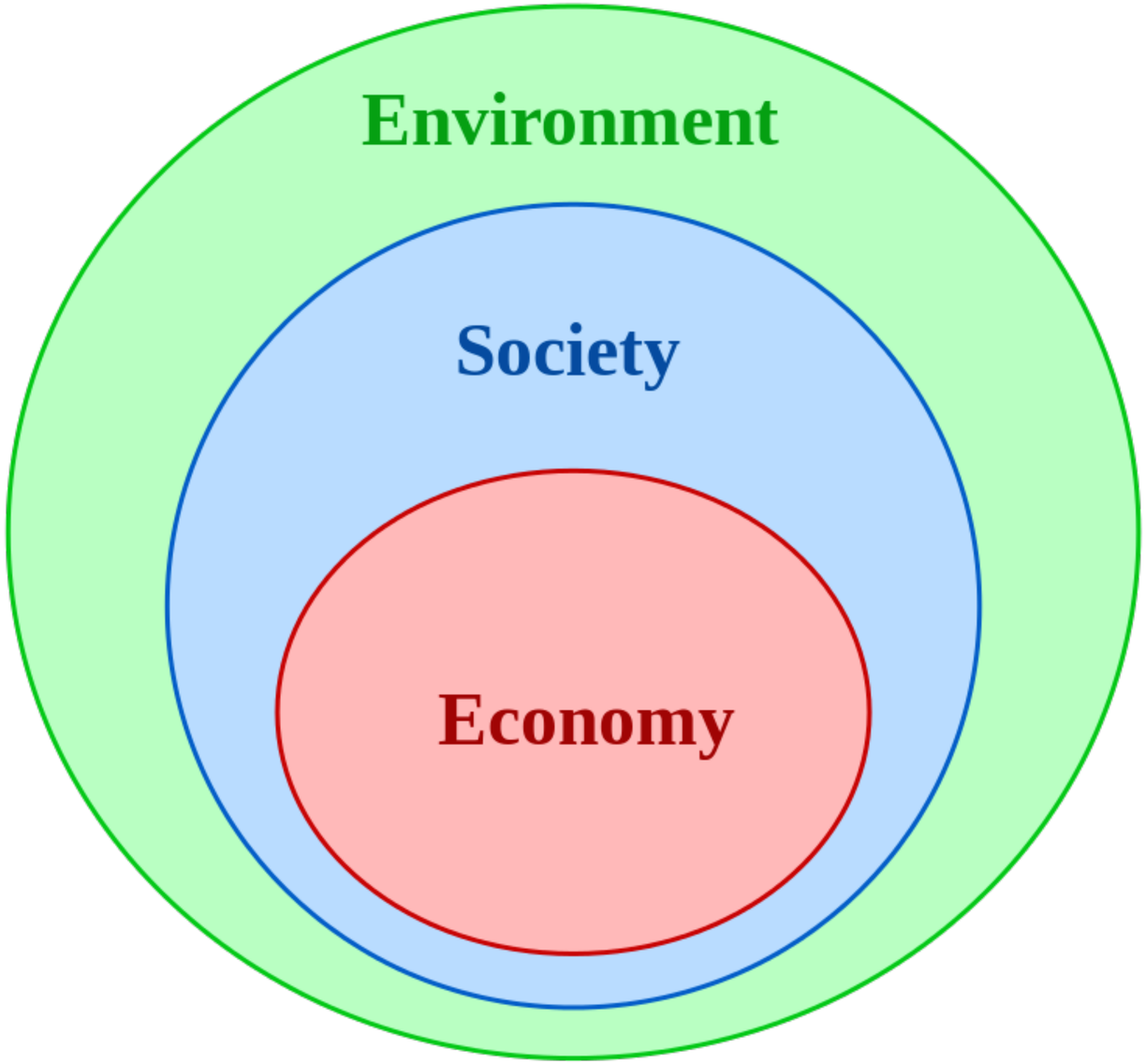


We hear a lot about *sustainability* these days… and it is often represented like this

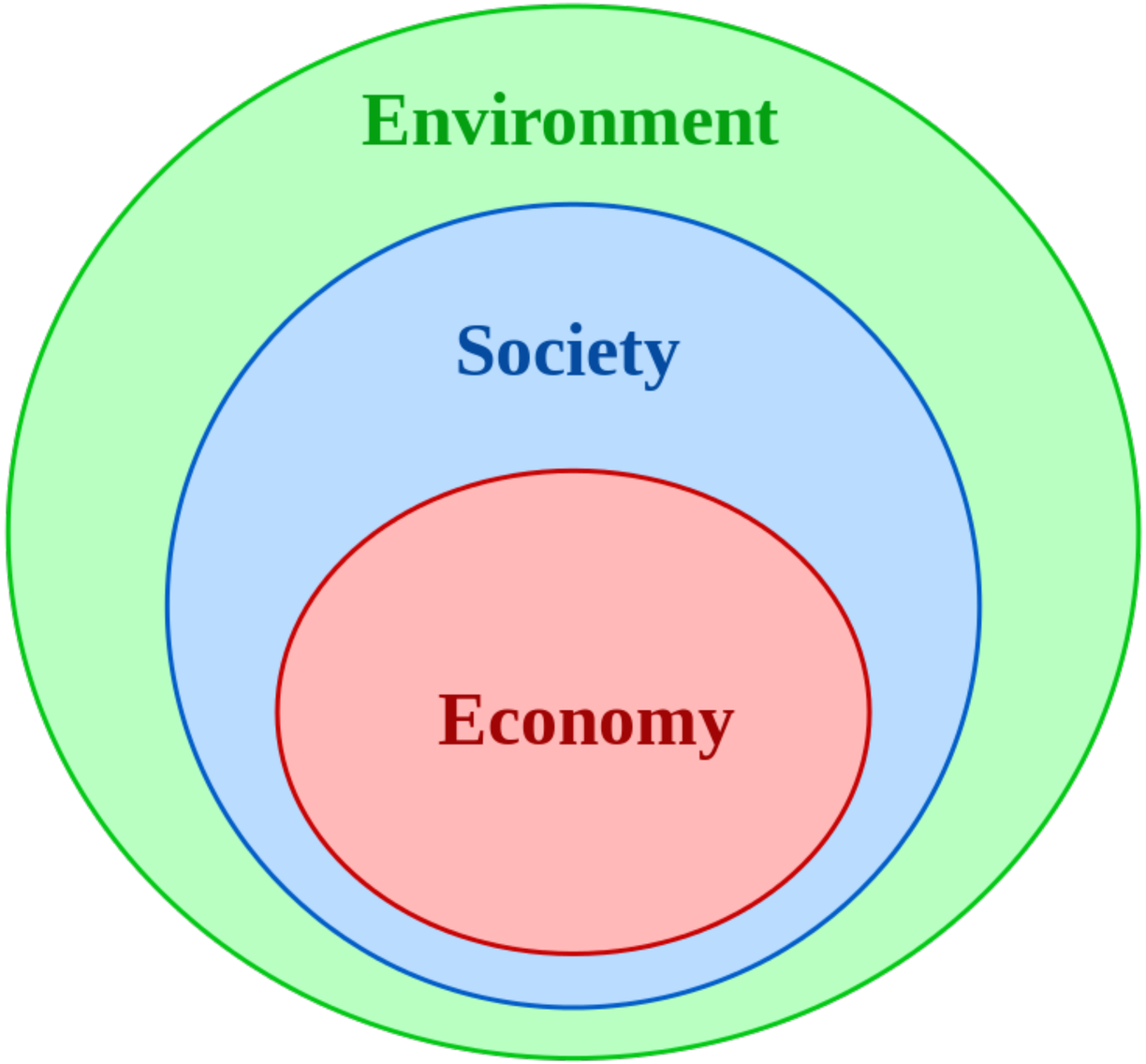
squeeze it in as a small detail



But the economy is a wholly owned subsidiary of the environment



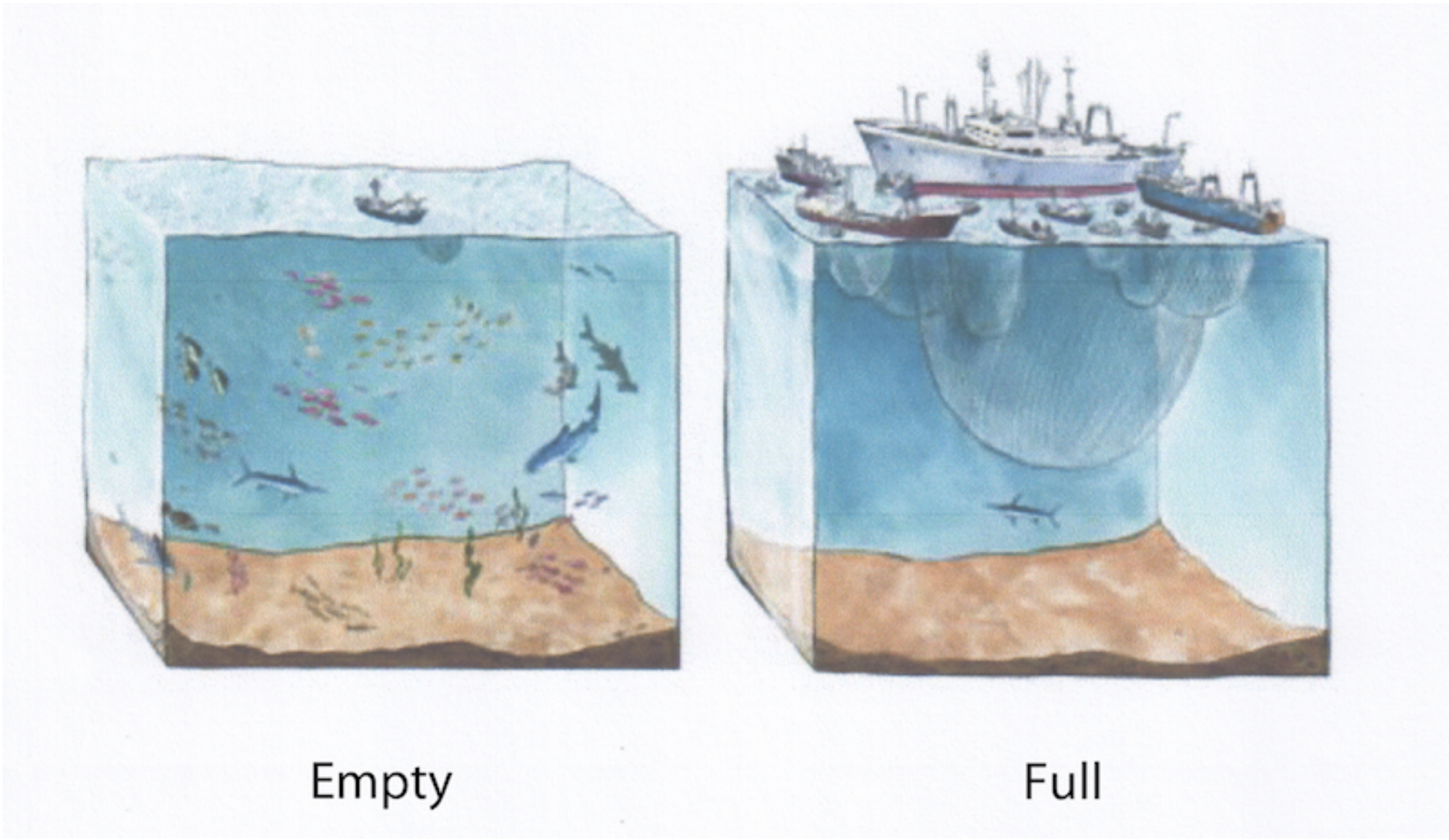
So an economy is *sustainable* only if it consumes energy *slower* than it can be *renewed*.



The debate is resolved by reframing the question

Herman Daly

1938-



The debate is resolved by reframing the question

Herman Daly
1938-

In the past, the fish catch was limited by the number of fishing boats and fishermen.

Now, it is limited by the number of fish and their capacity to reproduce. More fishing boats will not result in more caught fish.

2015

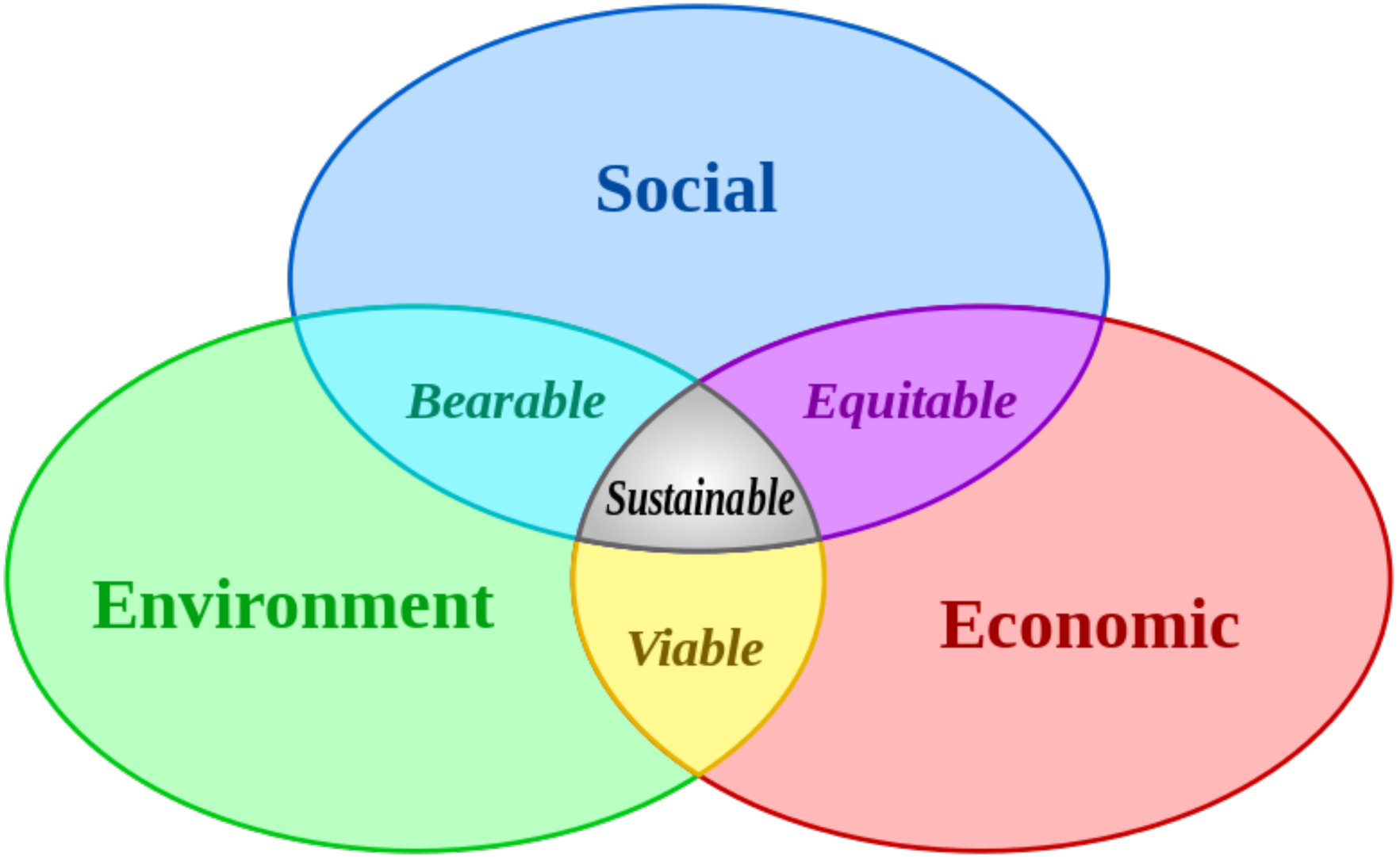
And that brings us back to this room … 50 years ago

Fuller
1895-1983

I seek through comprehensive anticipatory design science and its reductions to physical practices to reform the environment instead of trying to reform humans, being intent thereby to accomplish prototyped capabilities of doing more with less…

<u>Mission</u>: To make the whole world work for 100% of humanity in the shortest possible time through spontaneous cooperation without ecological damage or disadvantage to anyone.

Let’s look at the “triple bottom line” a little closer

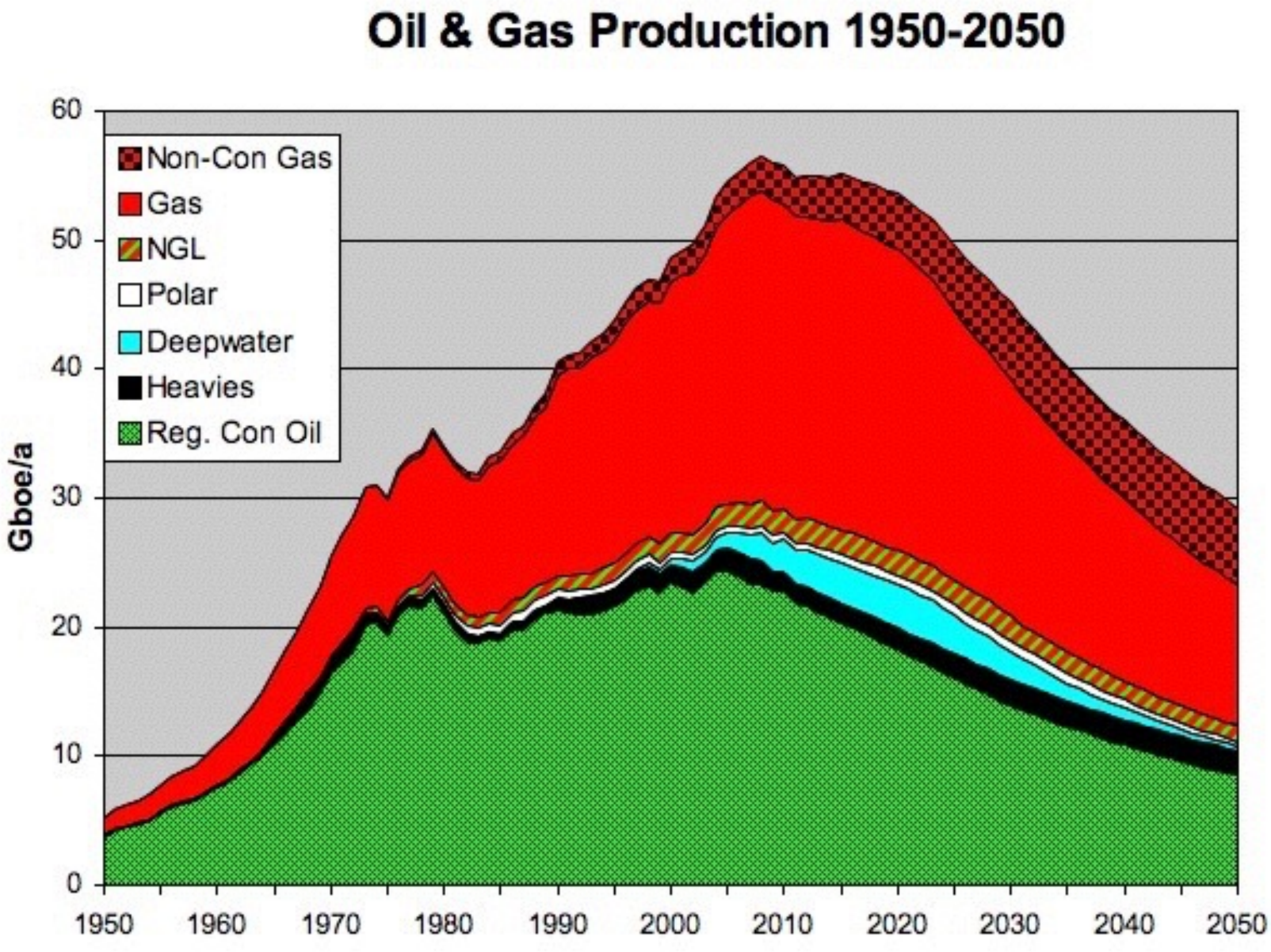


Environment

Social (Equity)

Economics

A society dependent upon finite resources is terminal



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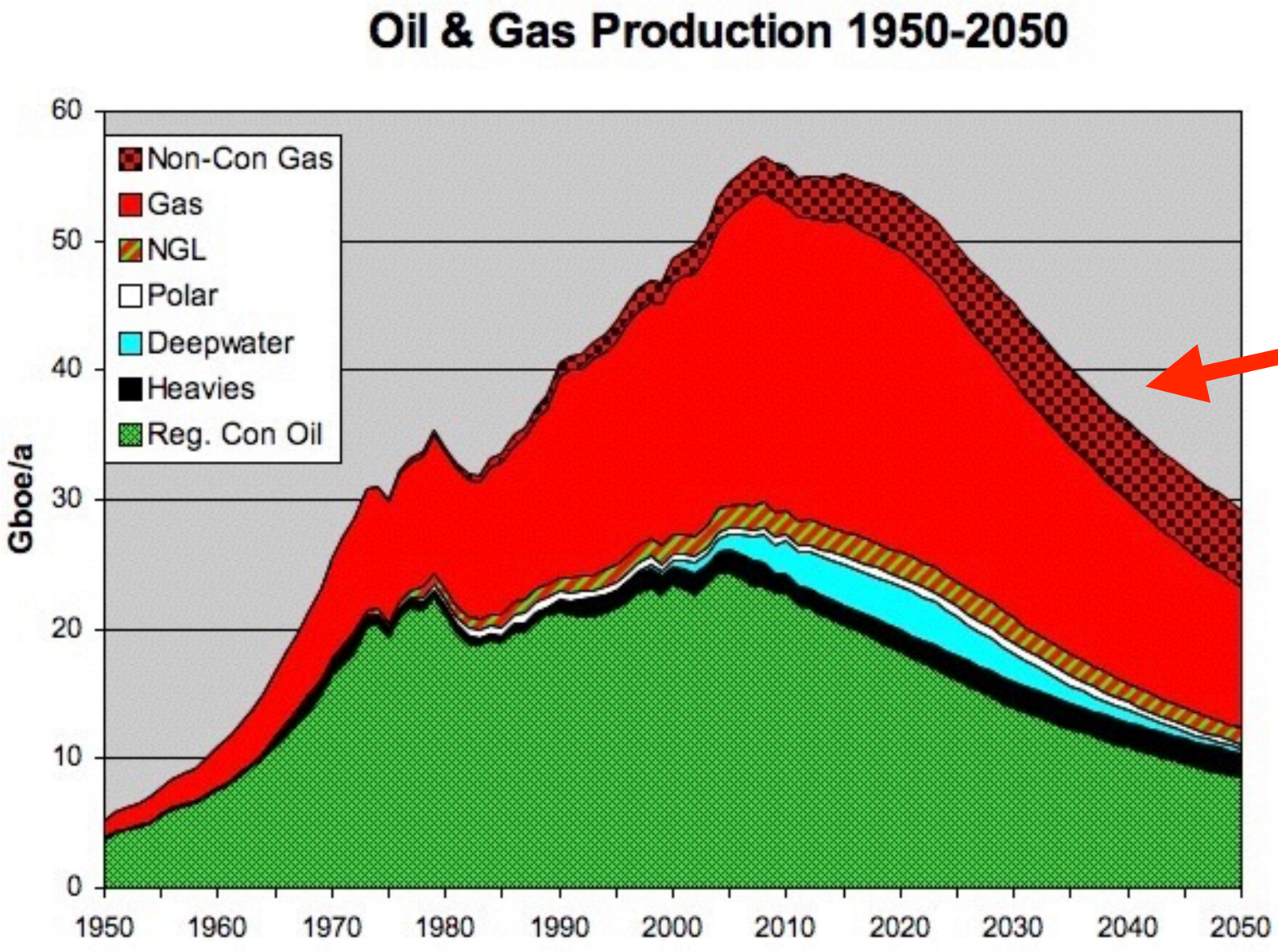
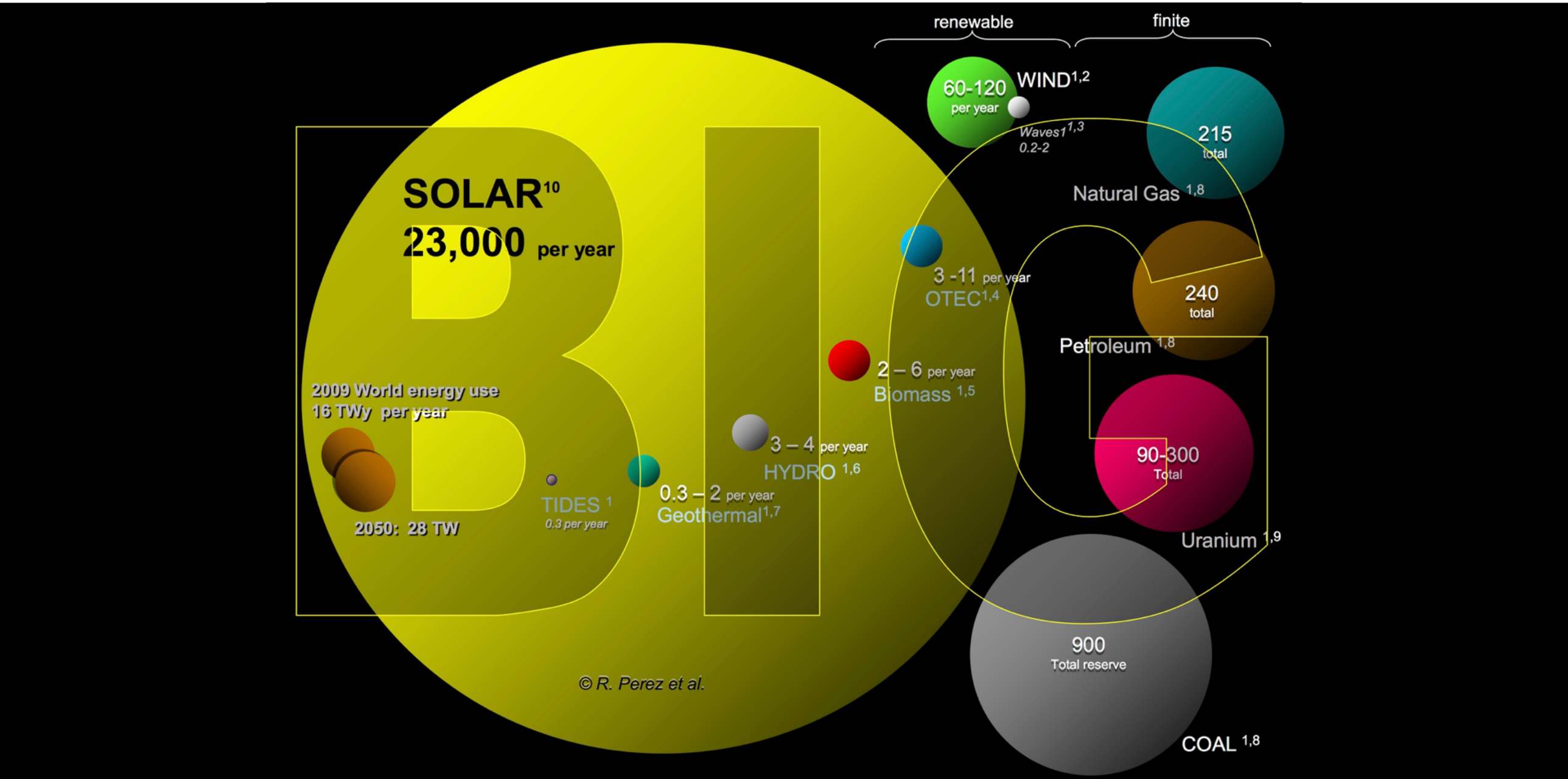


Oil is finite

What do you conclude from that?!

The sun is going to last quite a while

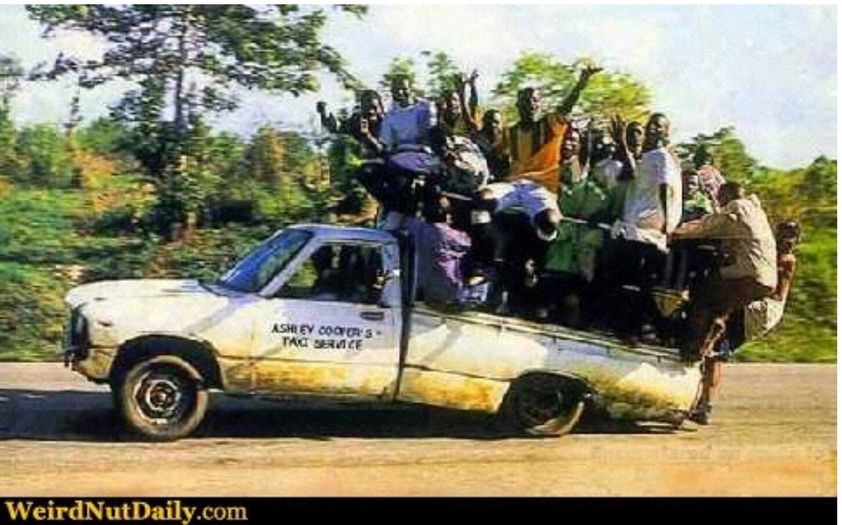


Environment

Equity

Economics

Access to energy services is not equitable



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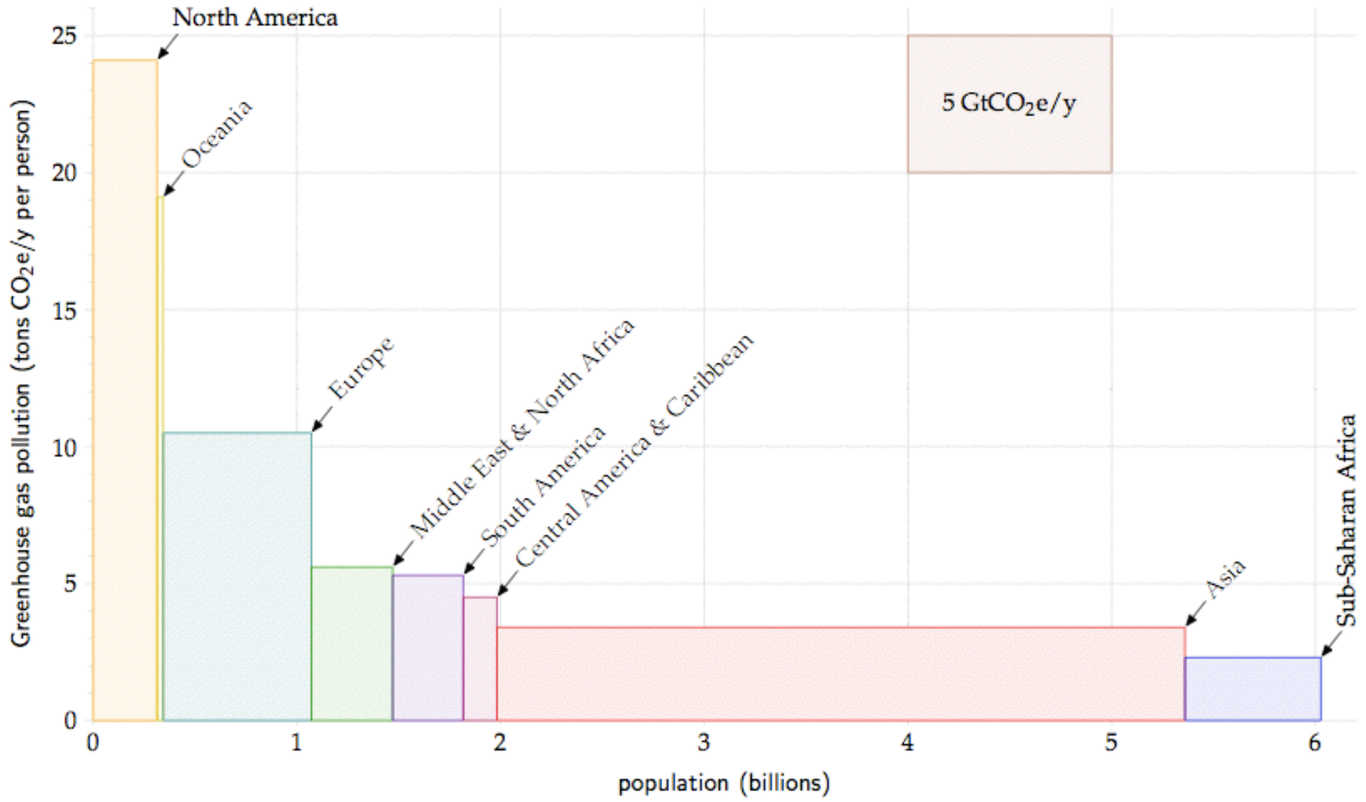
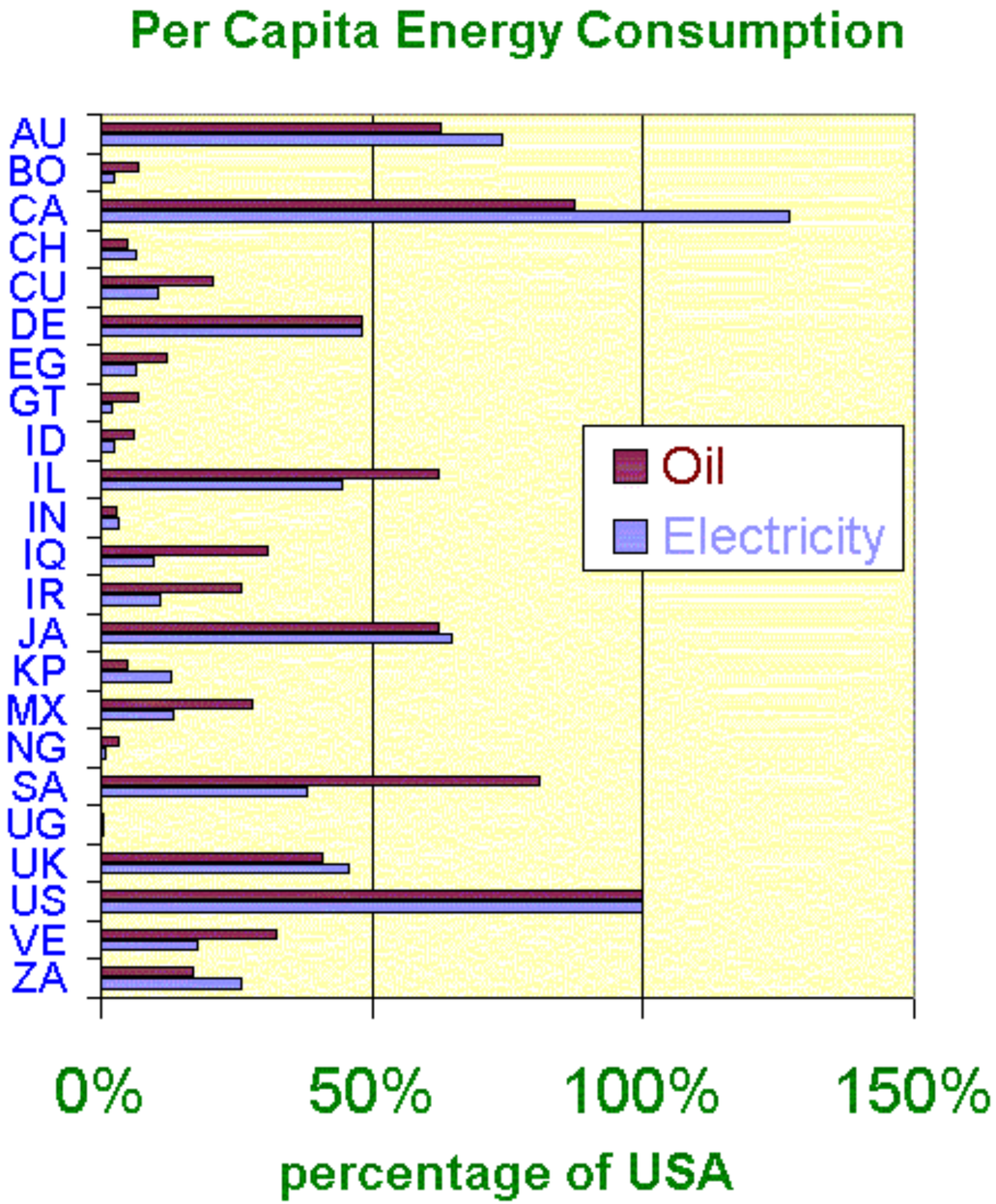




Environment

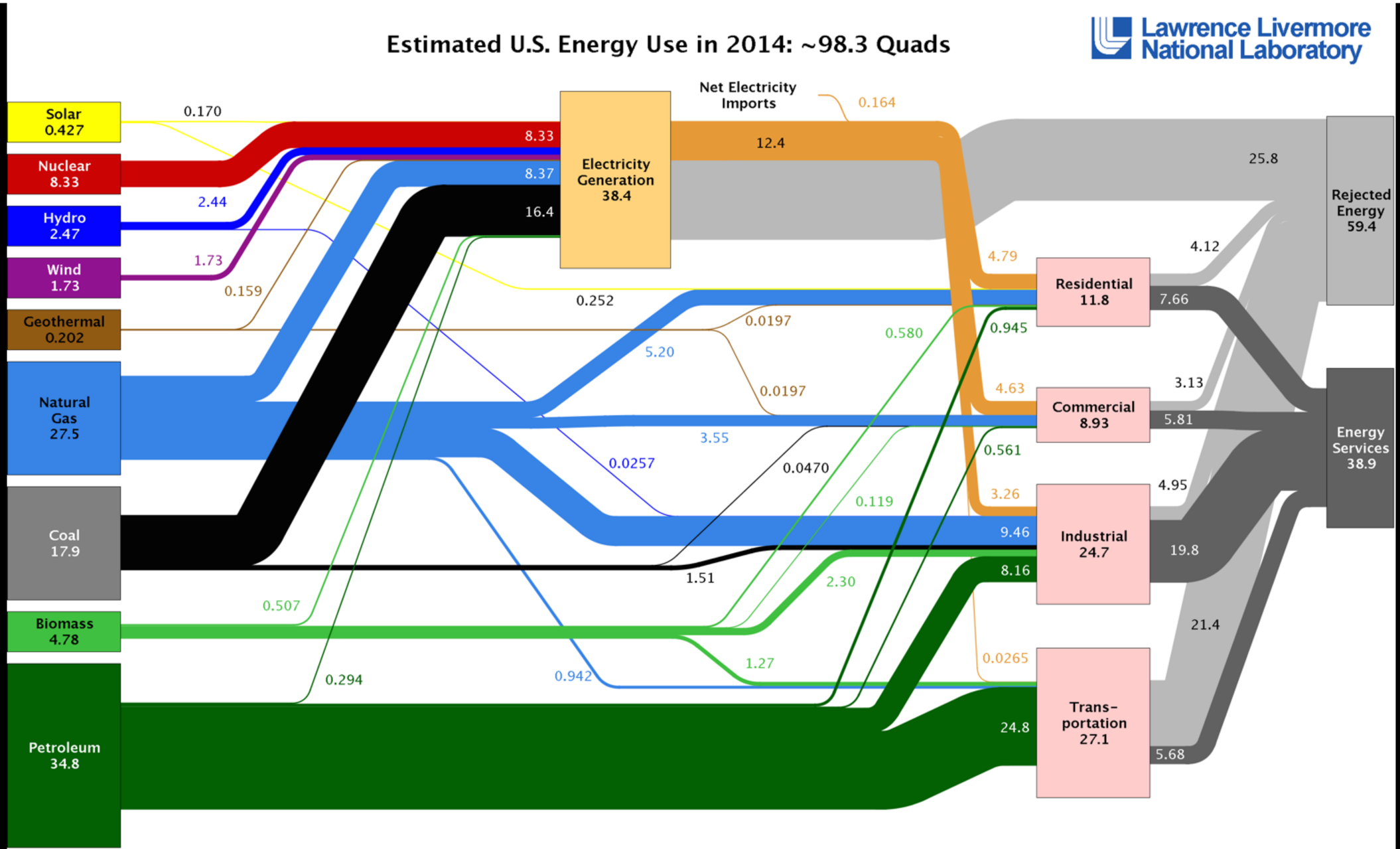
Equity

Economics

Coal plants are energy hogs

Coal plants are energy hogs

You put coal in the boiler & most of it goes up in *smoke*



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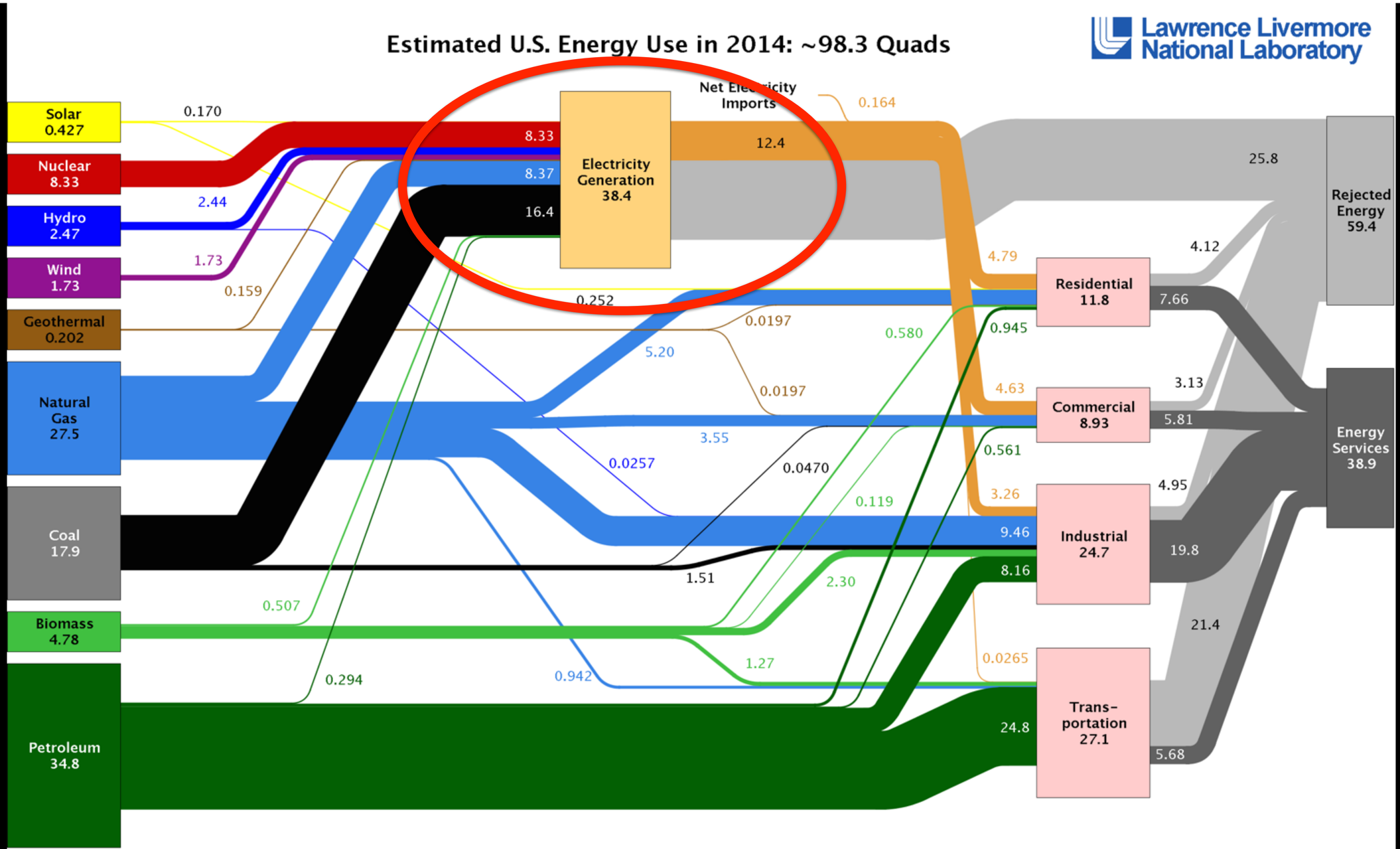

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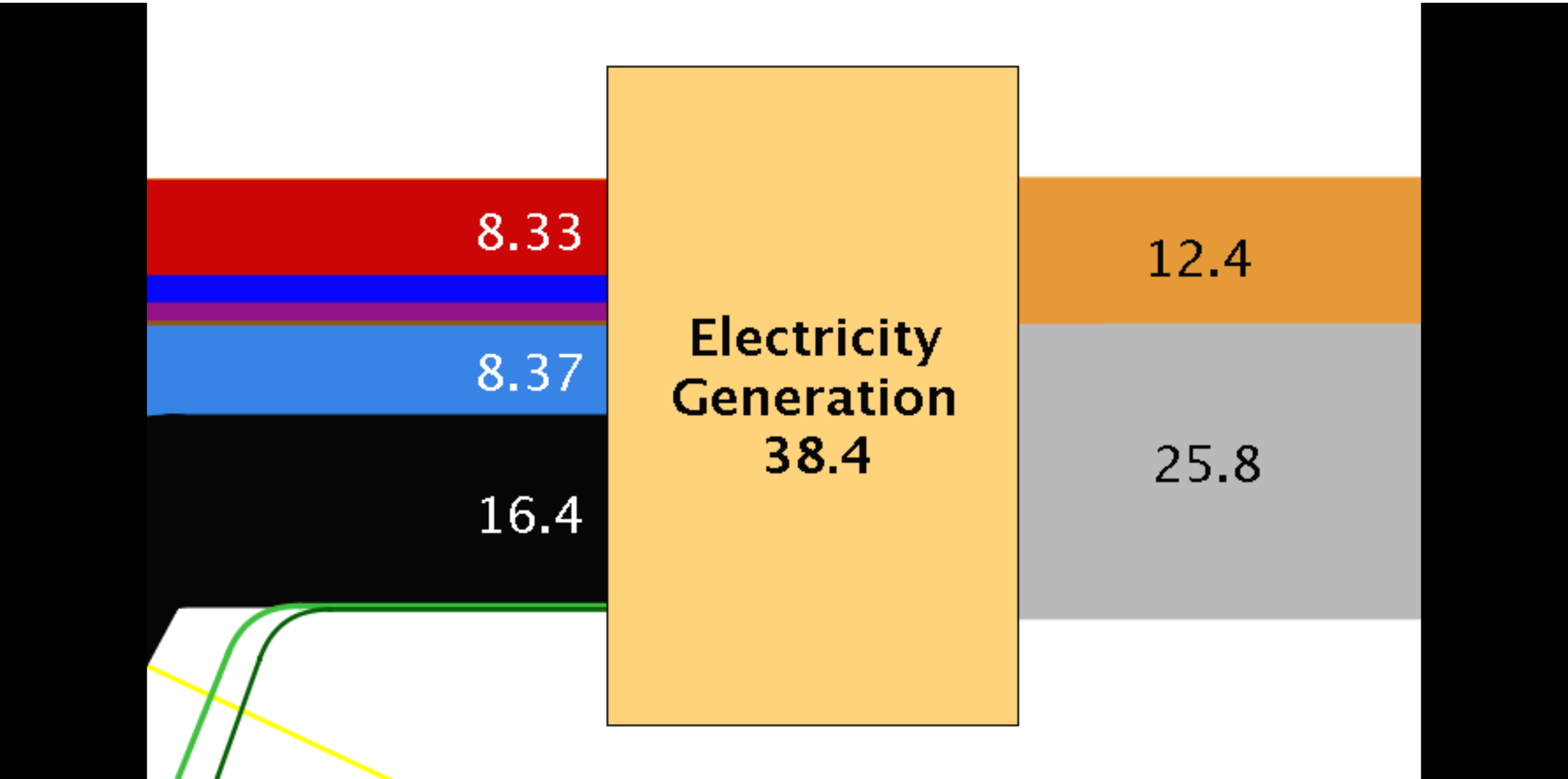

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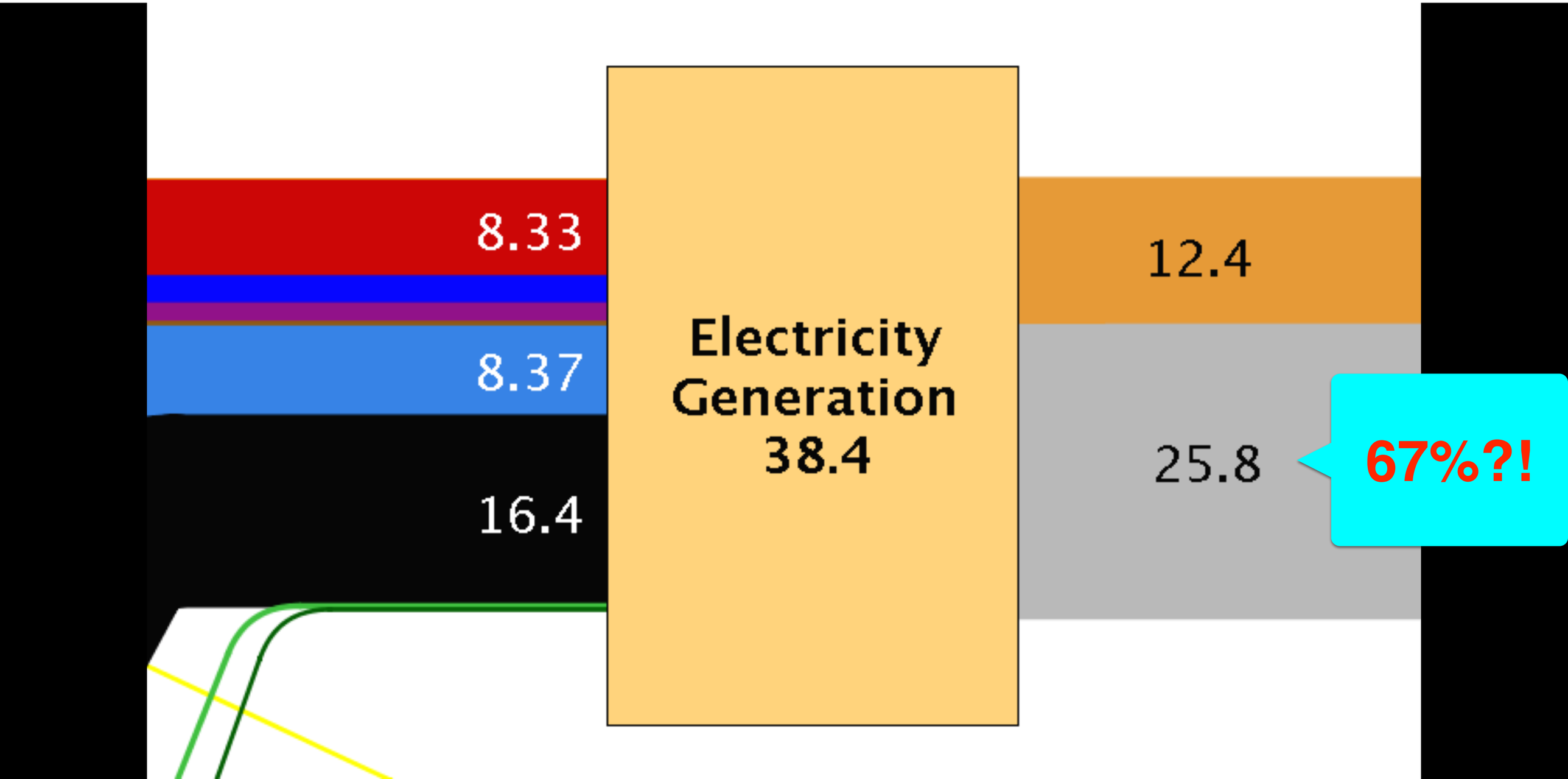
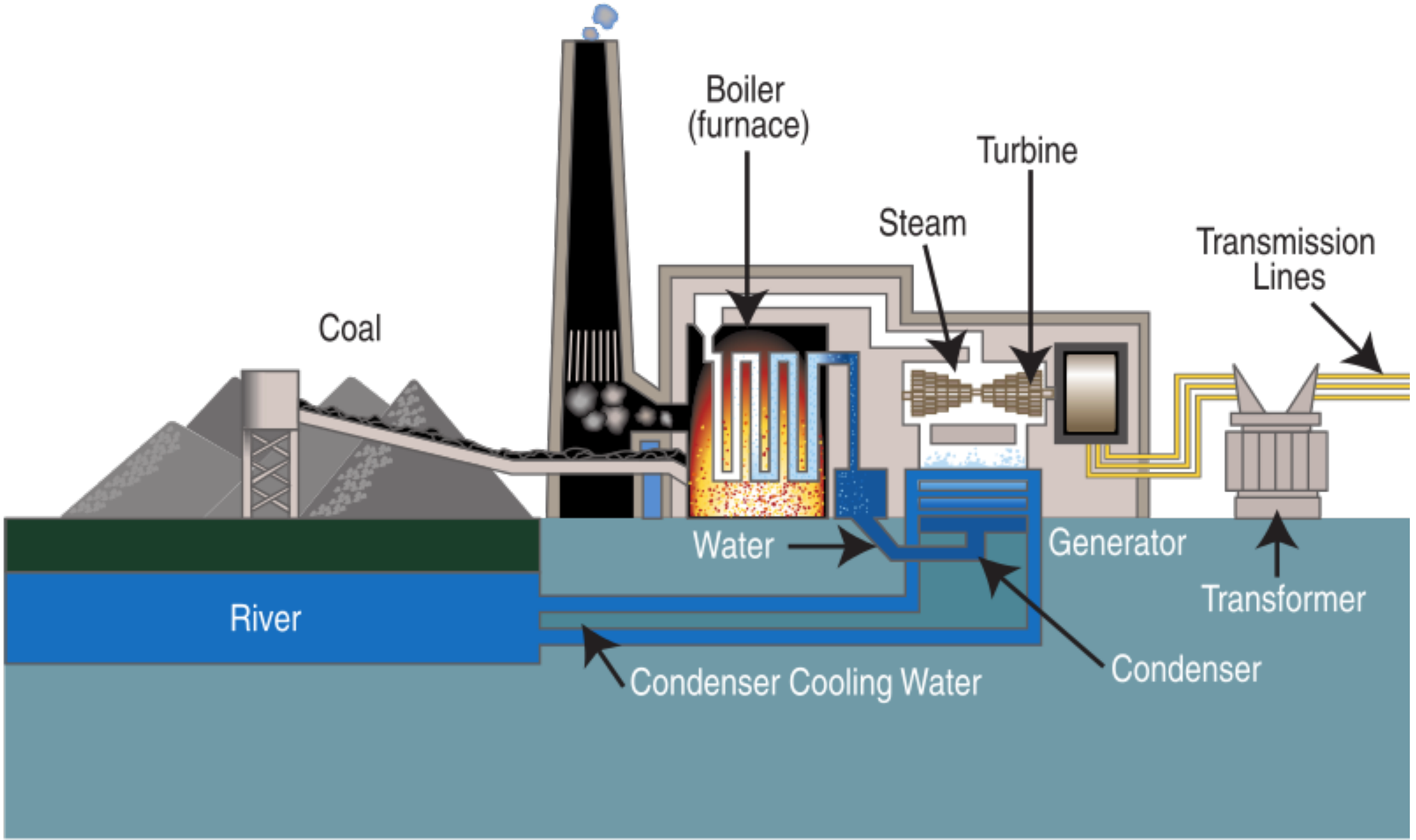


And they really can’t get much better



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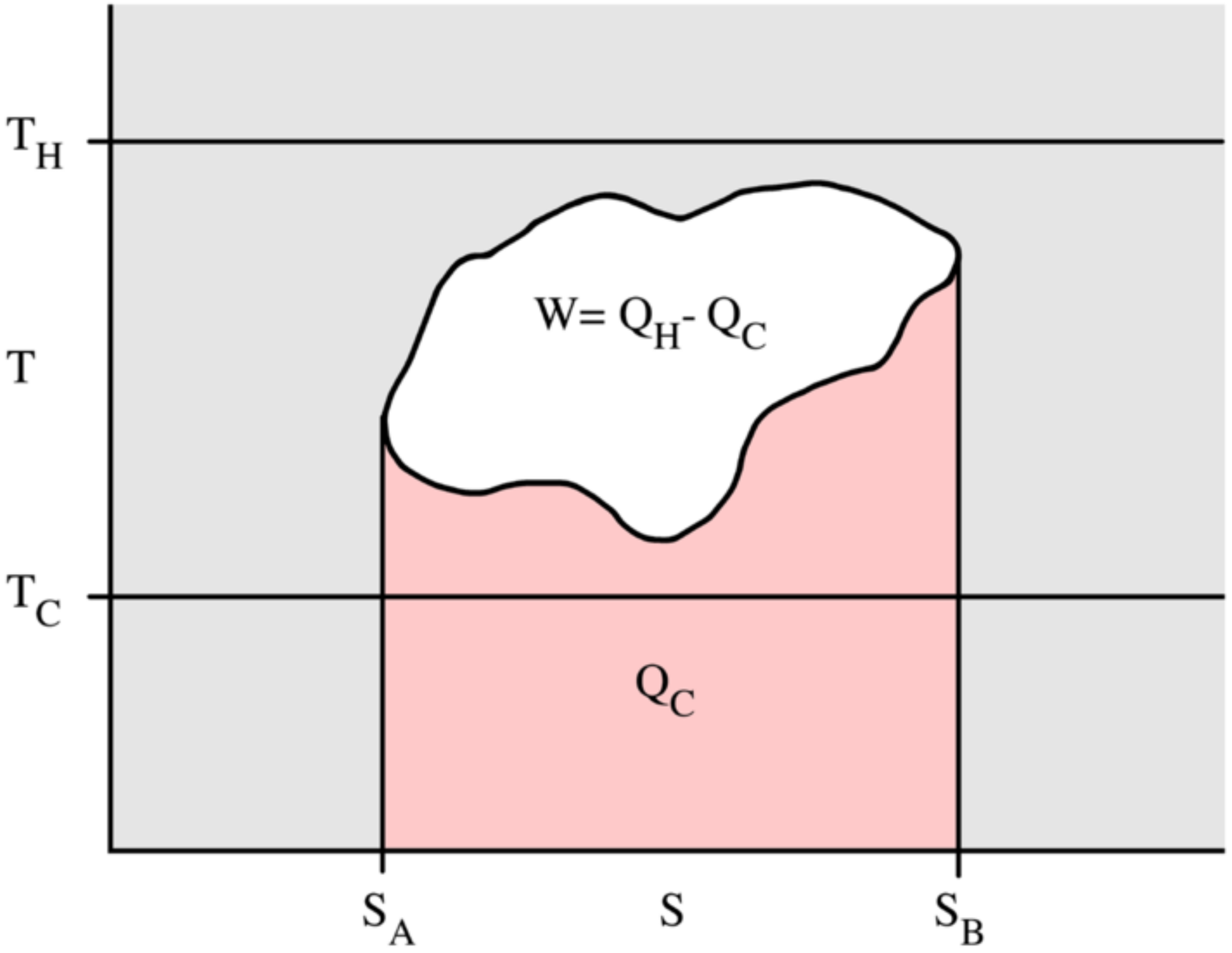

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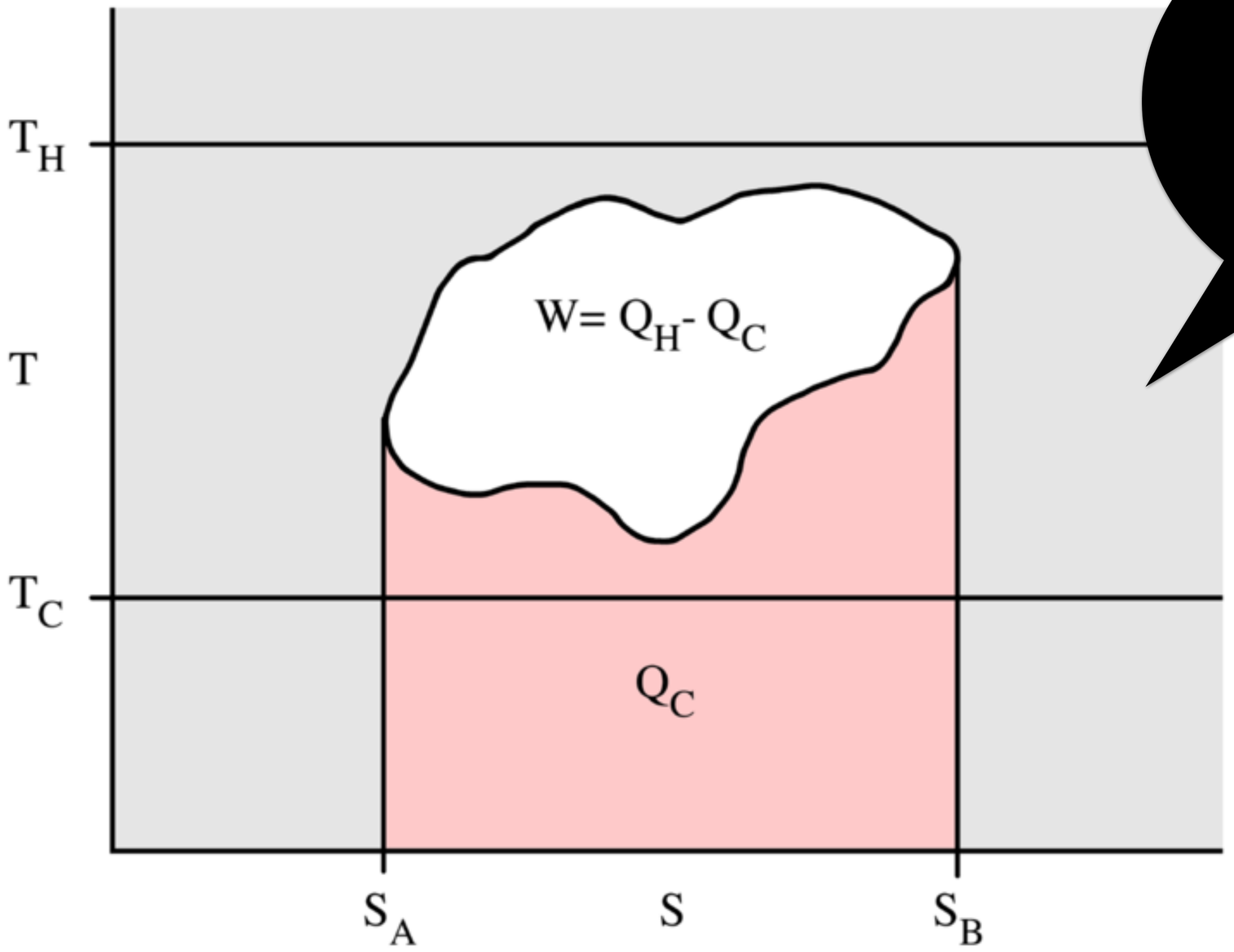
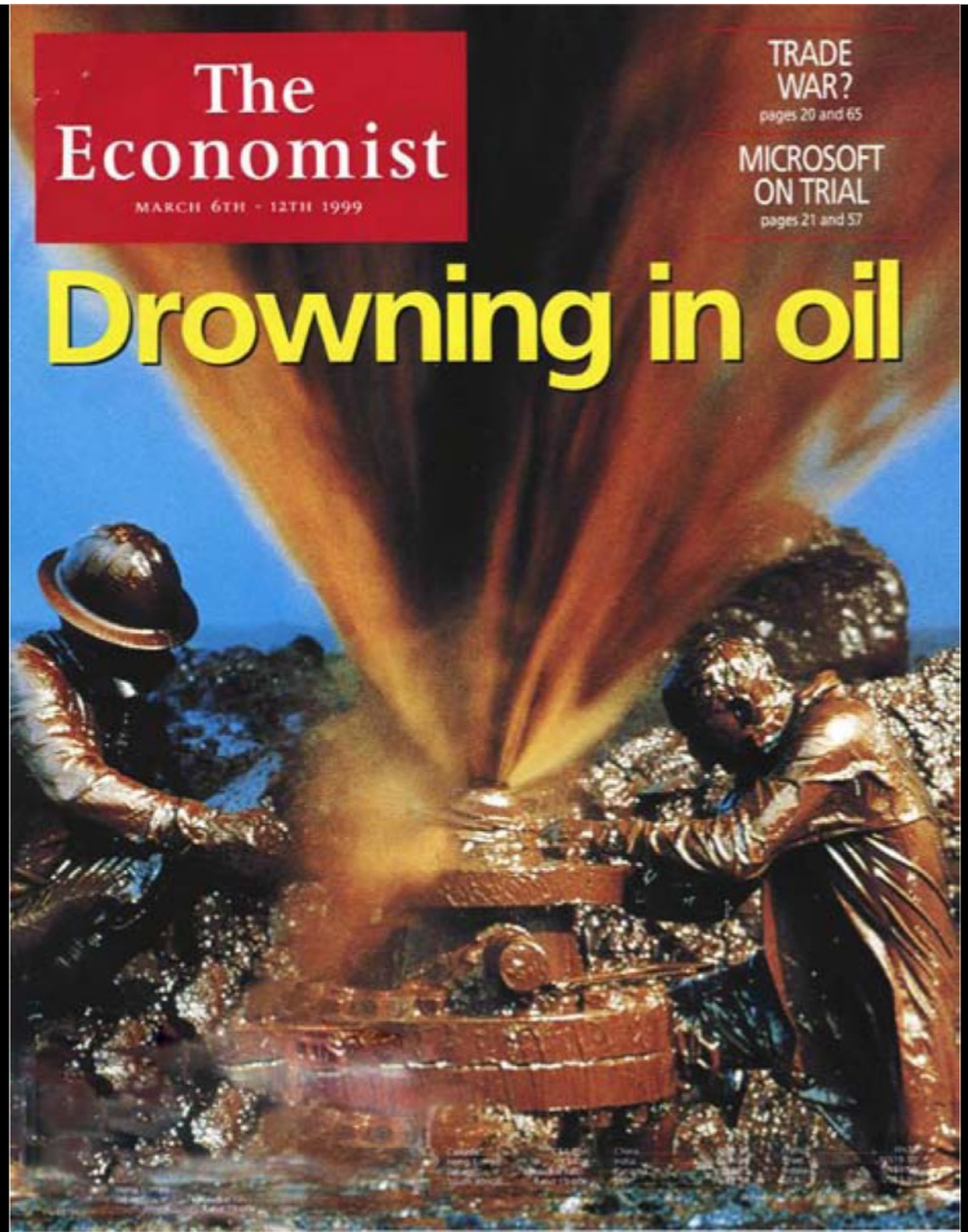
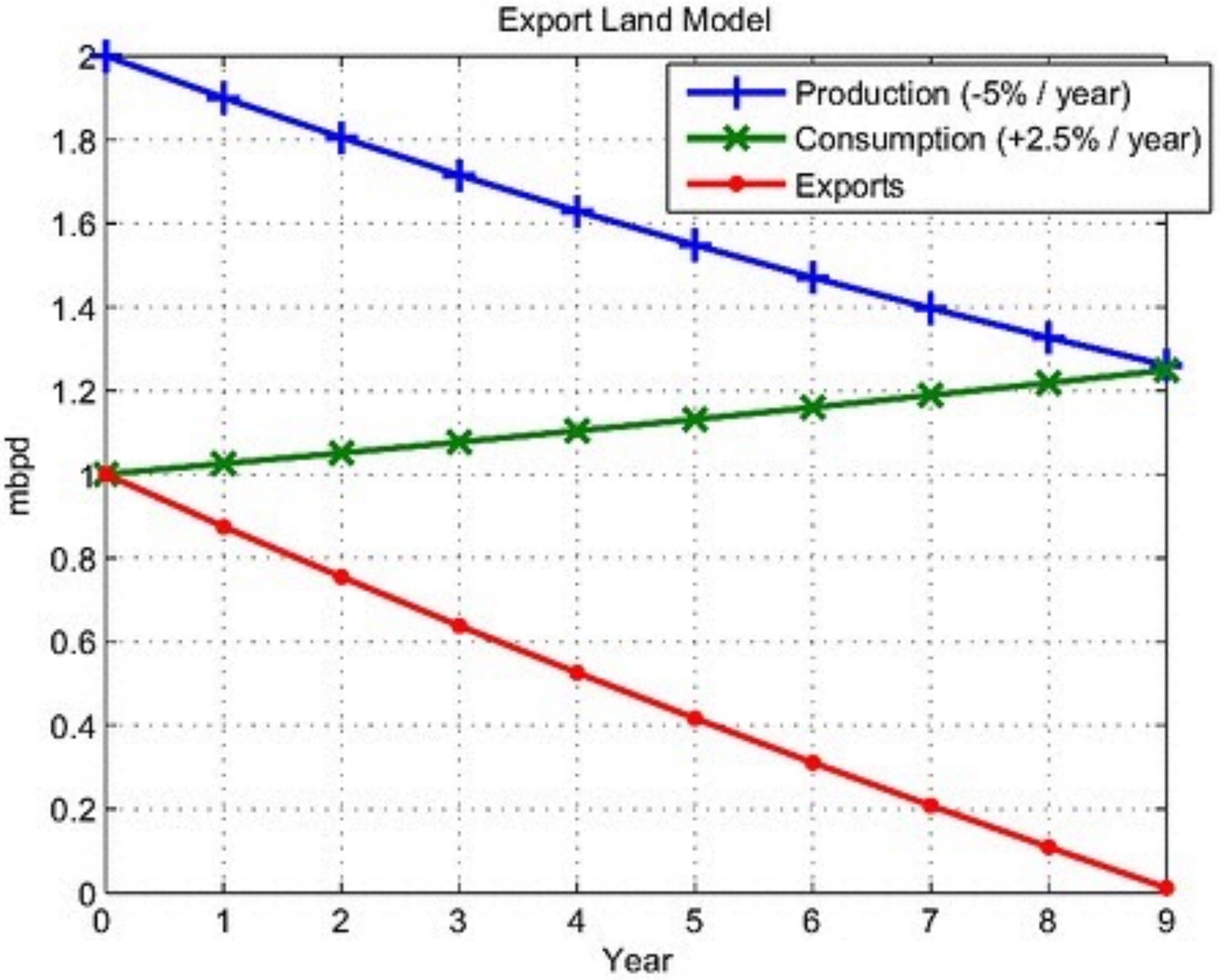


The limit is Carnot Efficiency

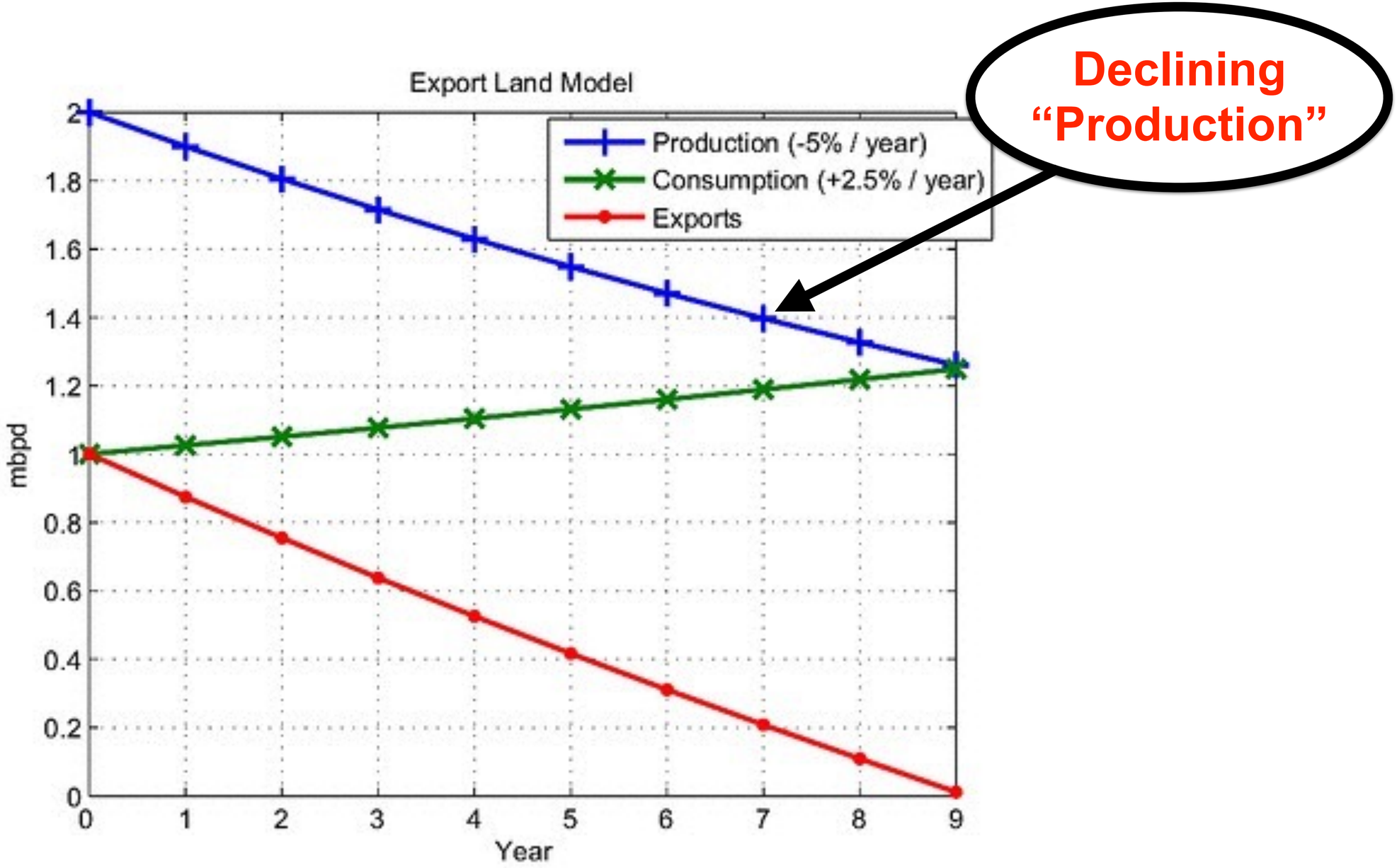
There’s a lot of hype about oil’s bright future



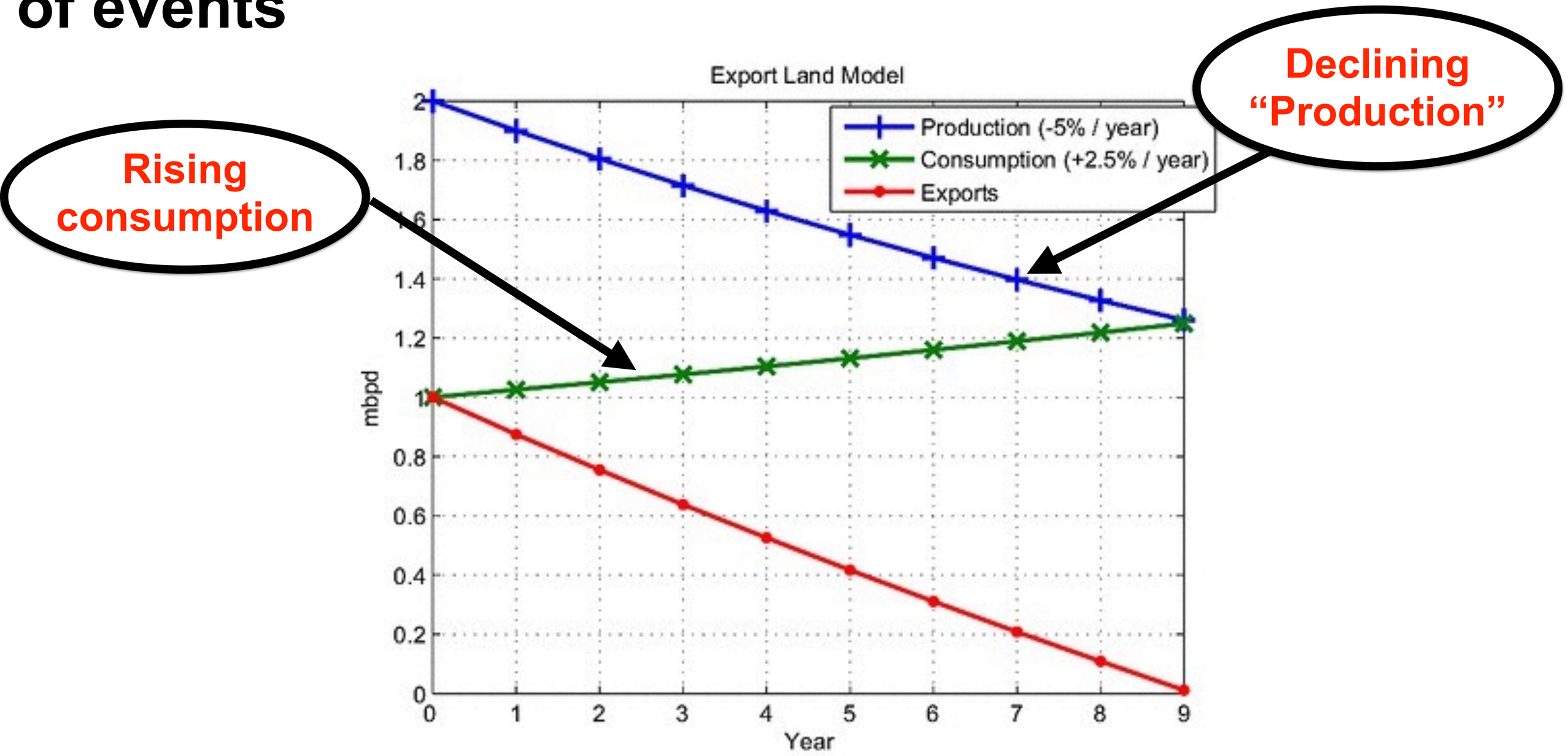
The export land model reveals a very different view of events



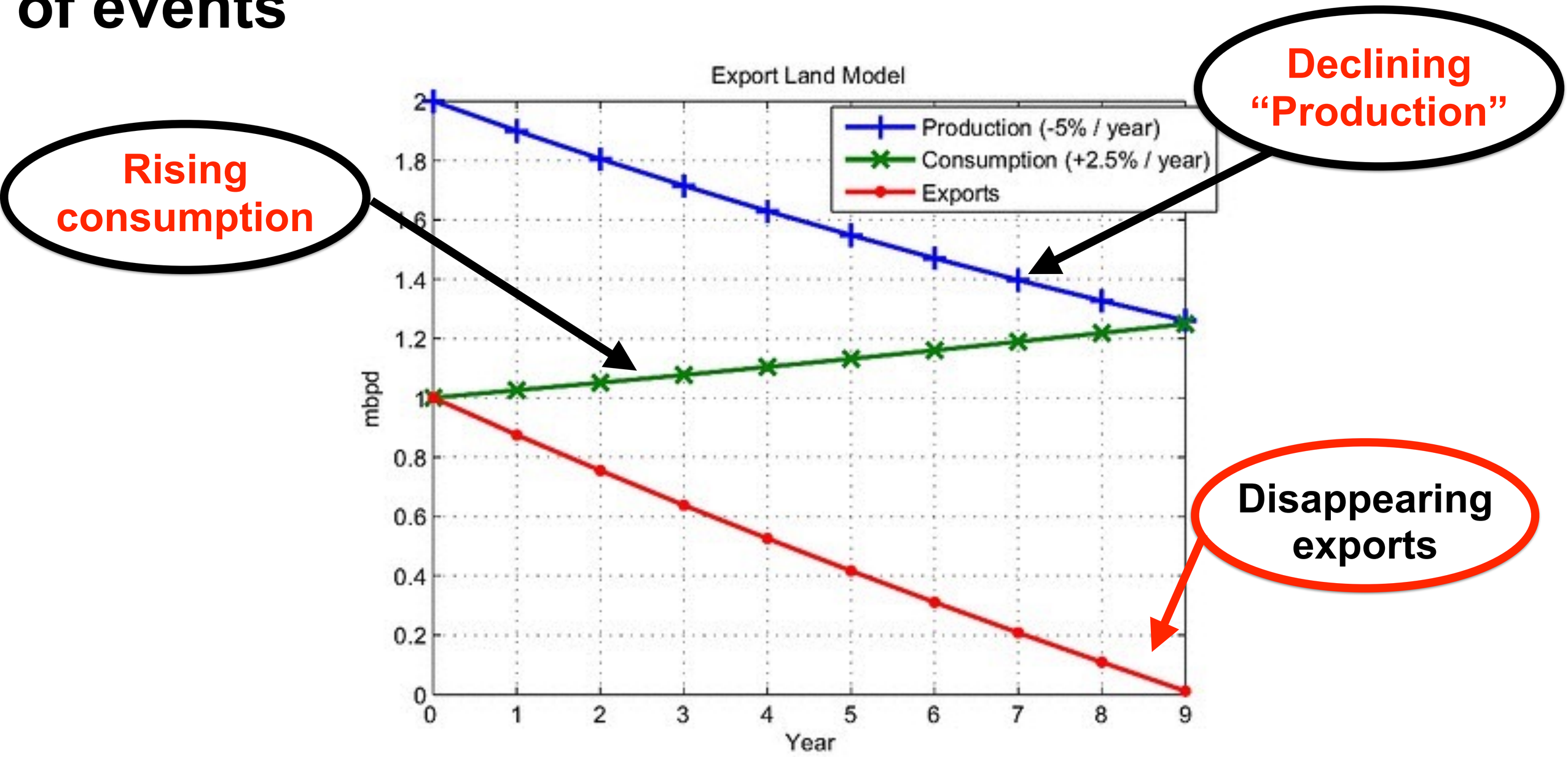
The export land model reveals a very different view of events



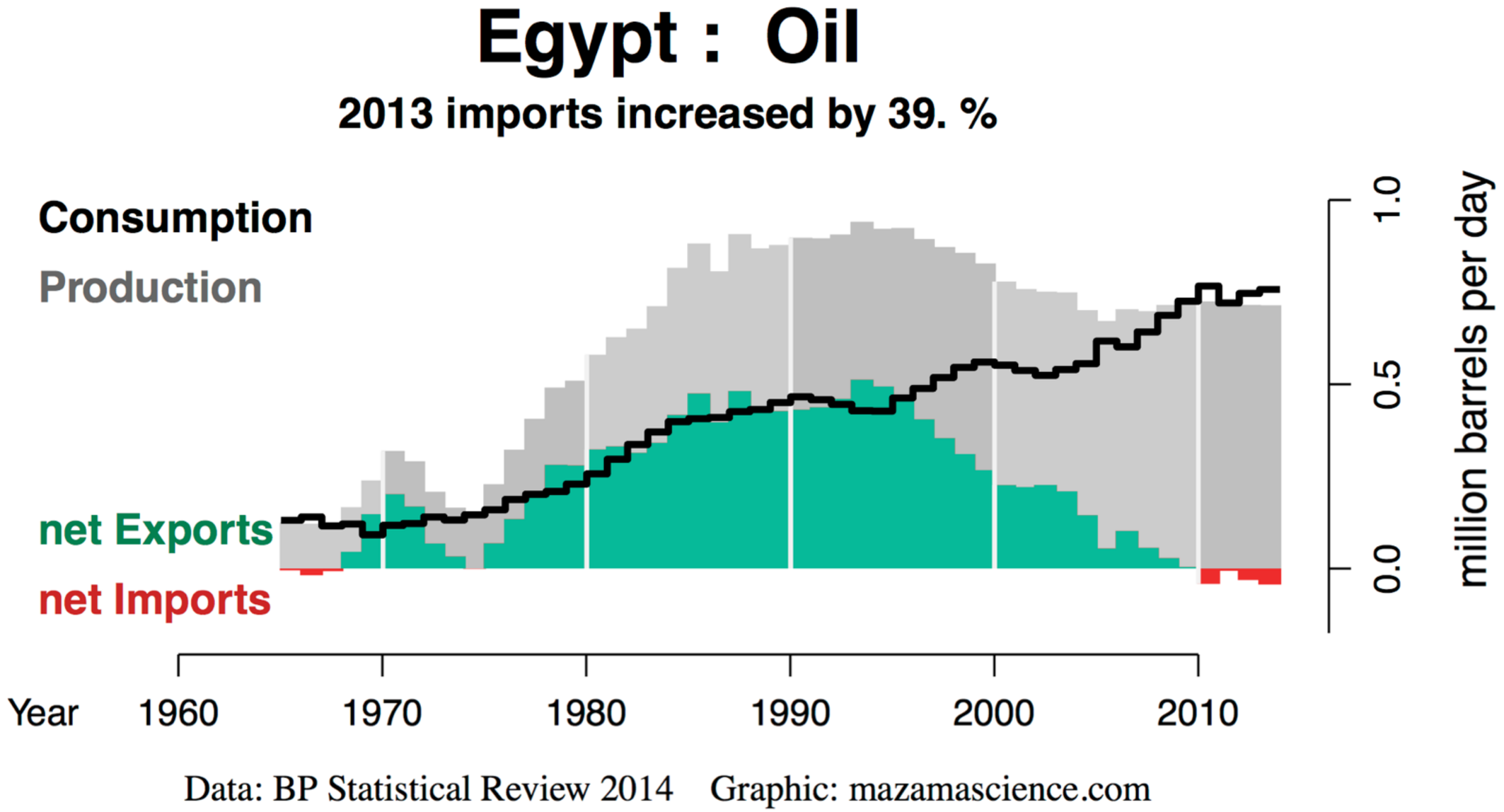
The export land model reveals a very different view of events



The export land model reveals a very different view of events



The export land model reveals a very different view



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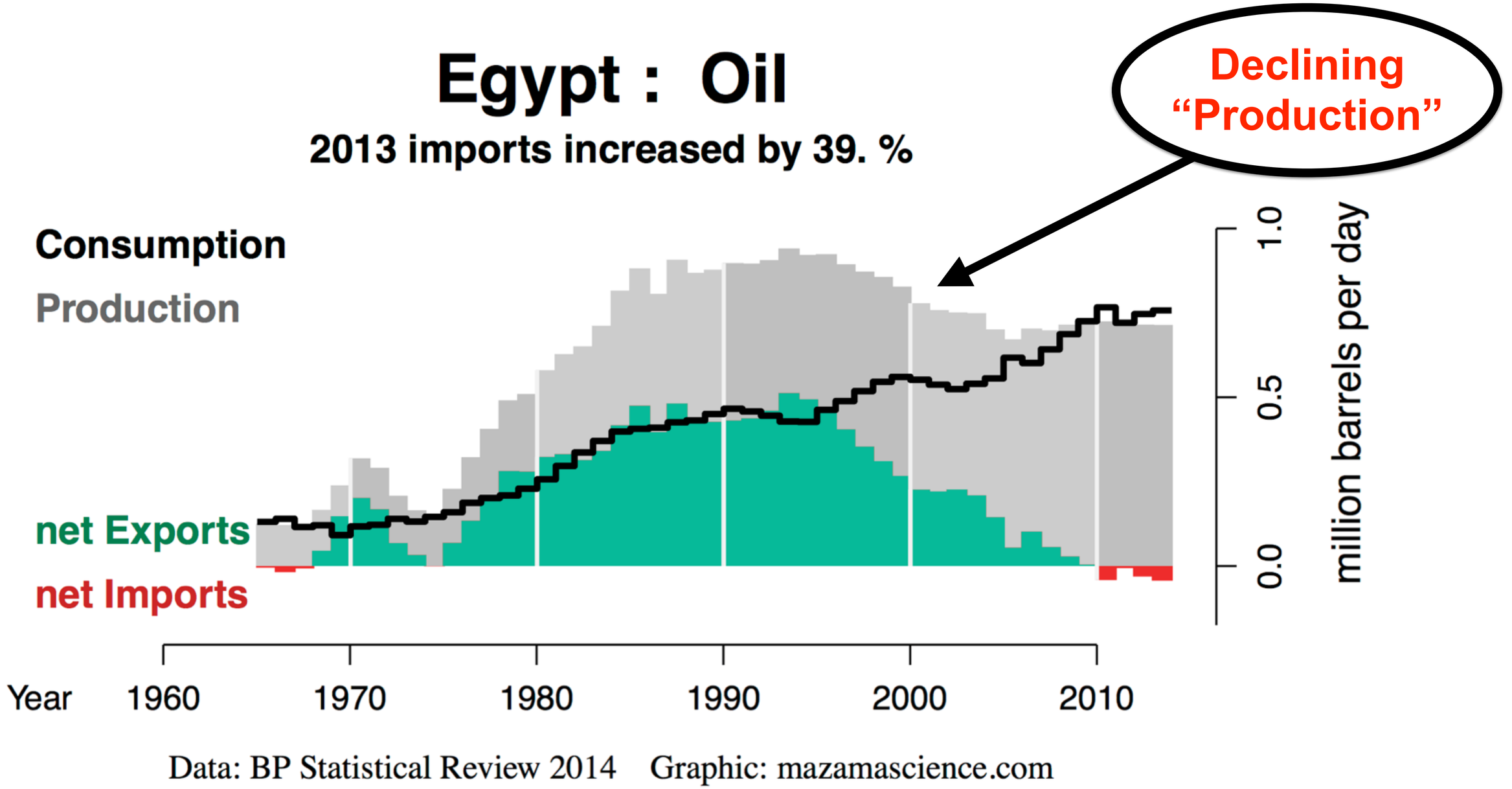

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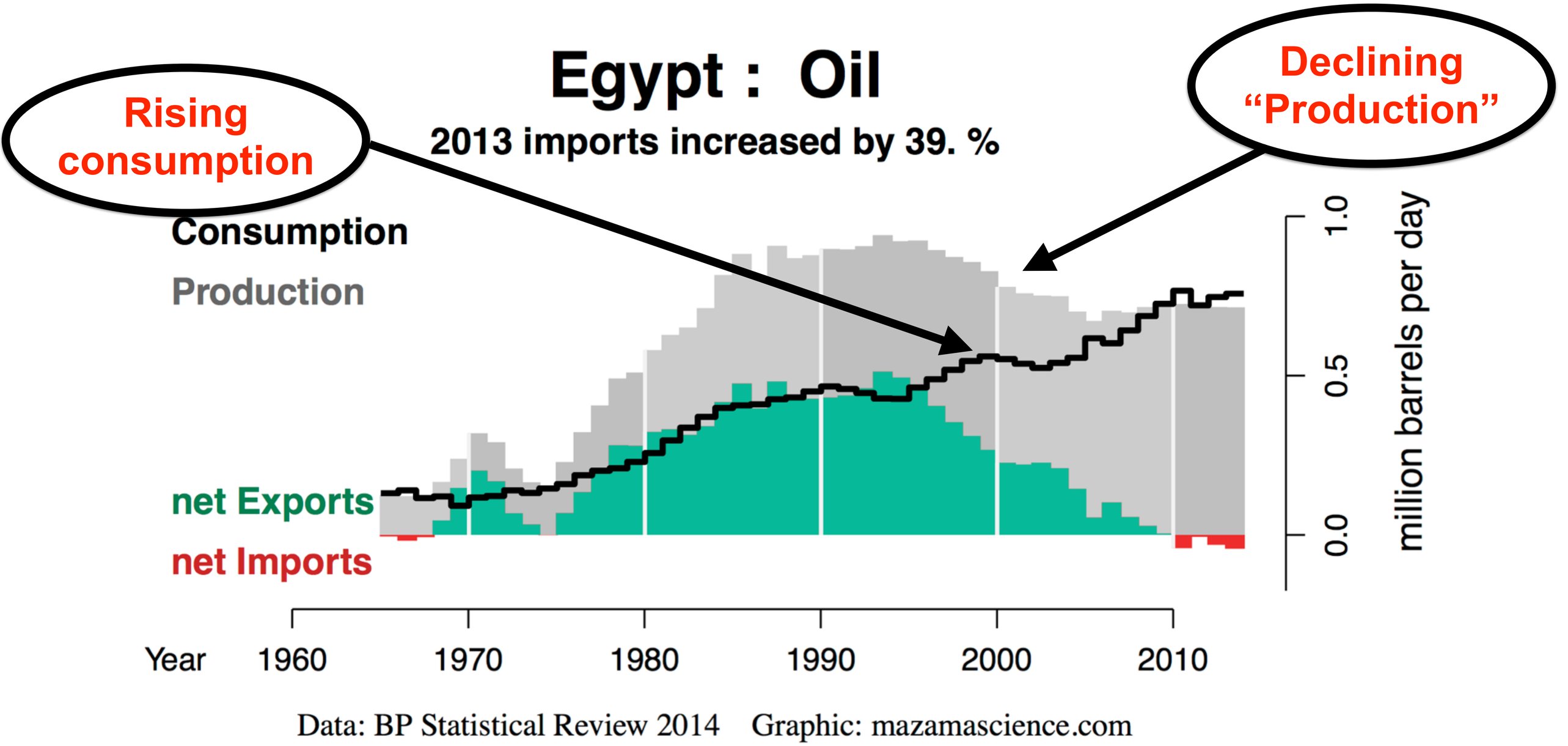
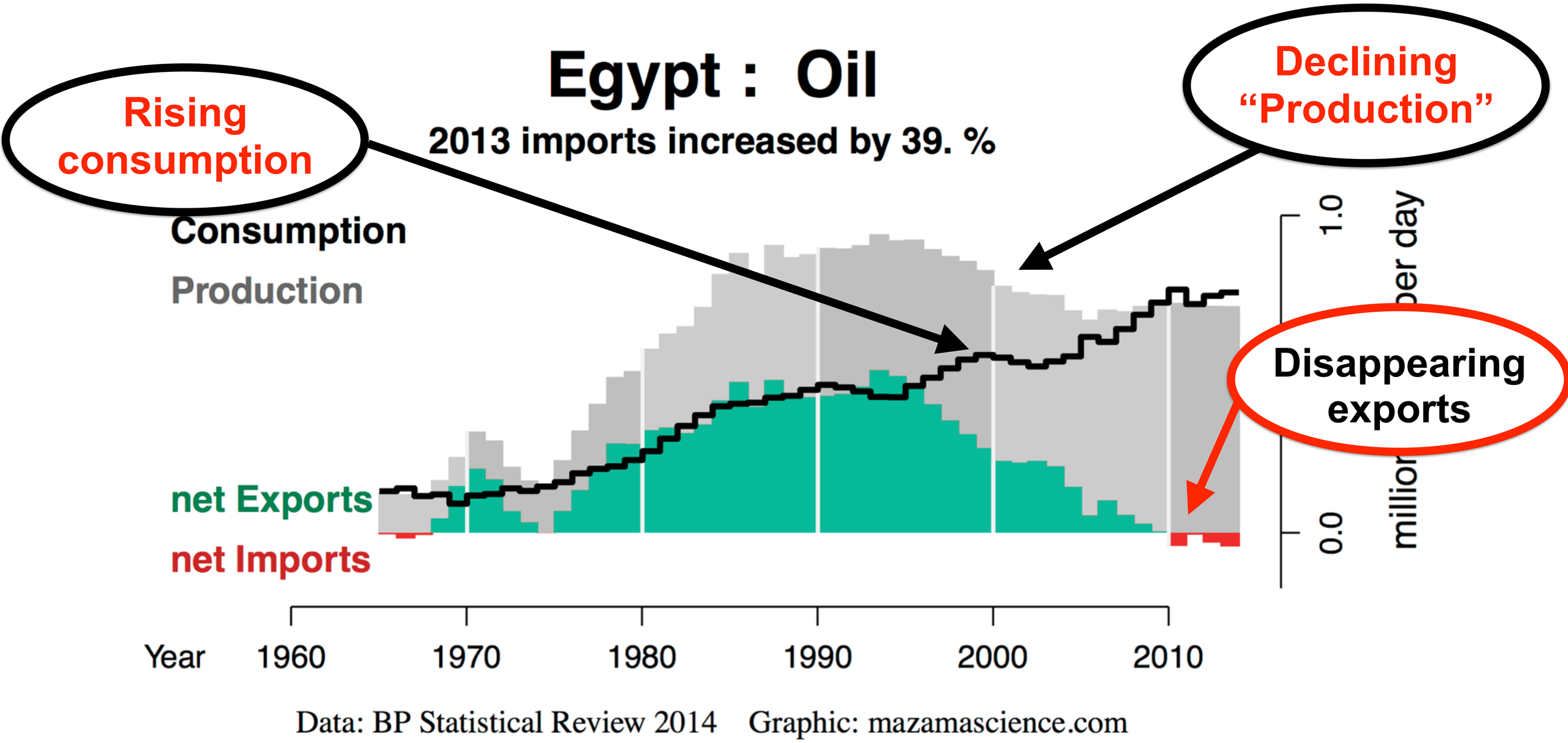
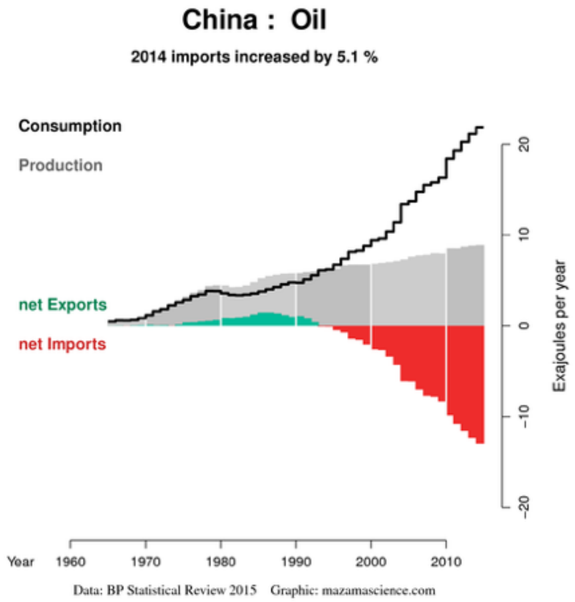


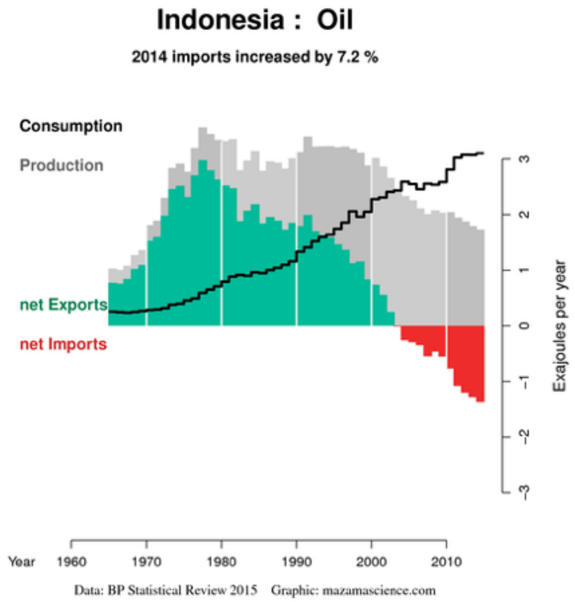
The export land model reveals a very different view

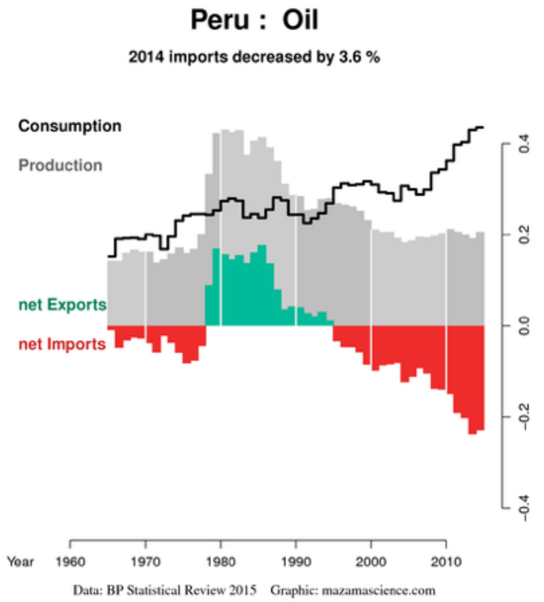


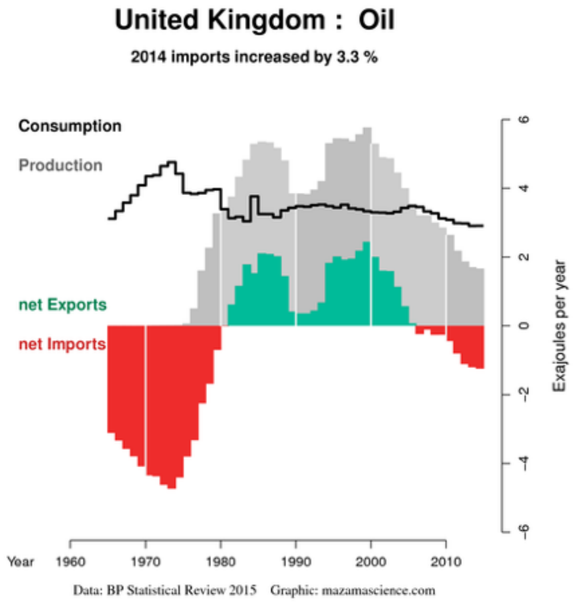
Data: BP Statistical Review 2014 Graphic: mazamascience.com

And Egypt has a lot of company









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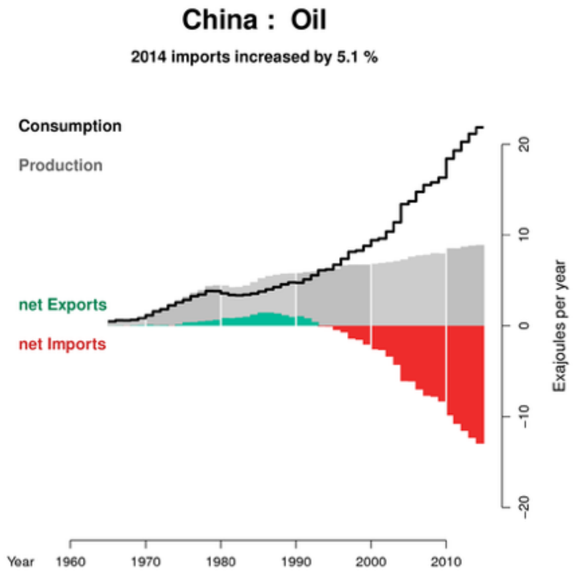
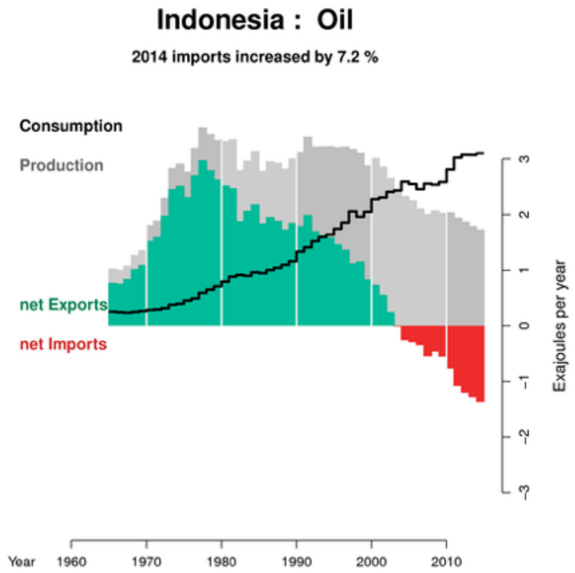
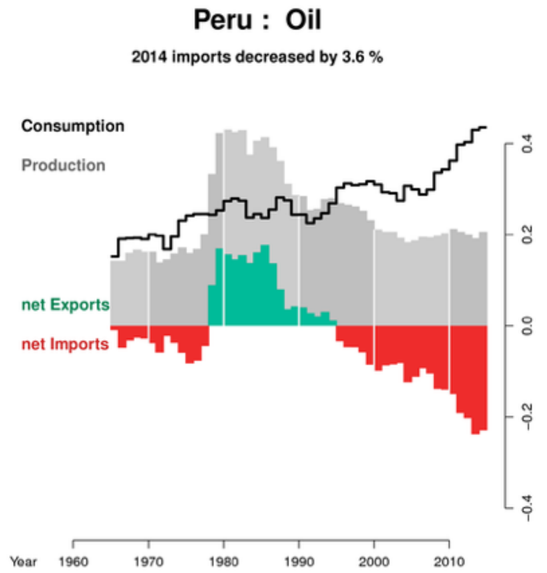
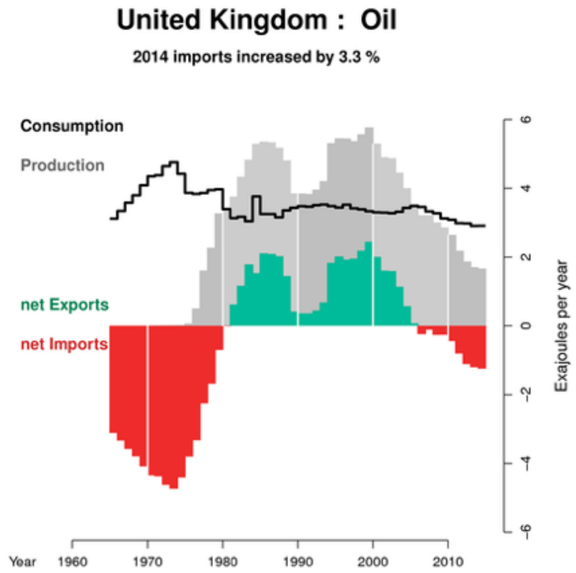
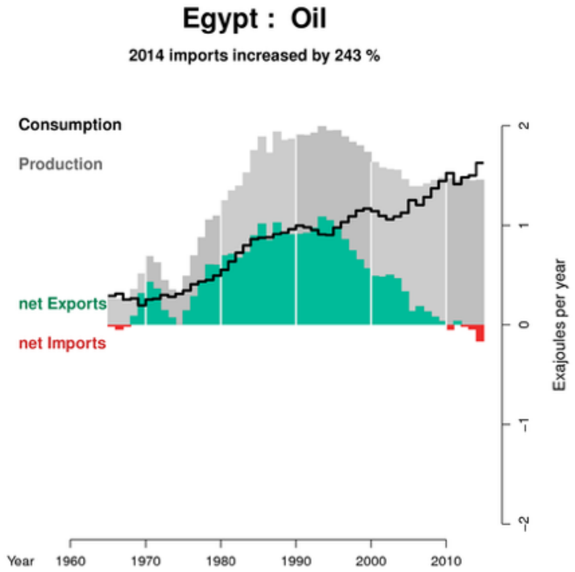
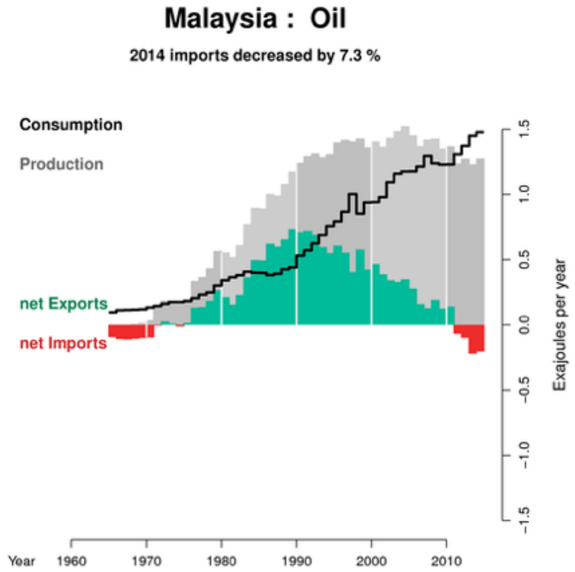


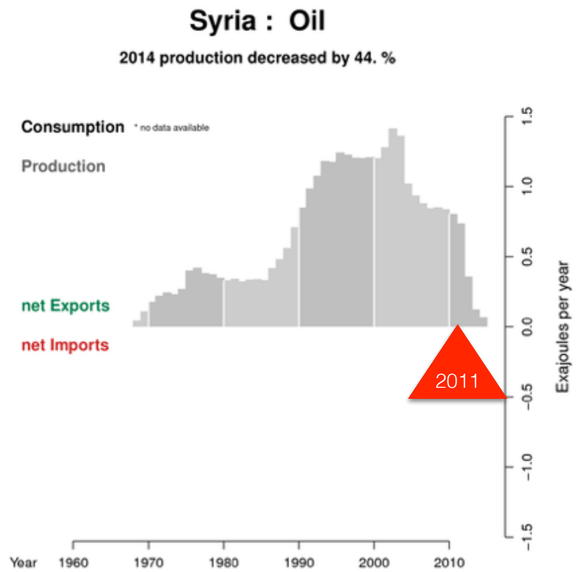


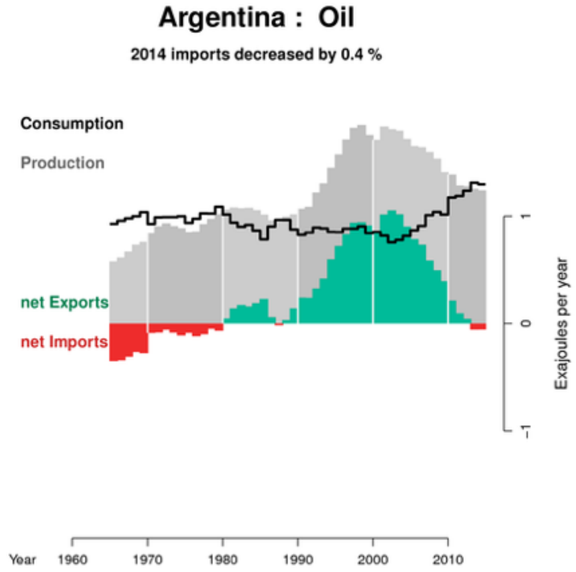




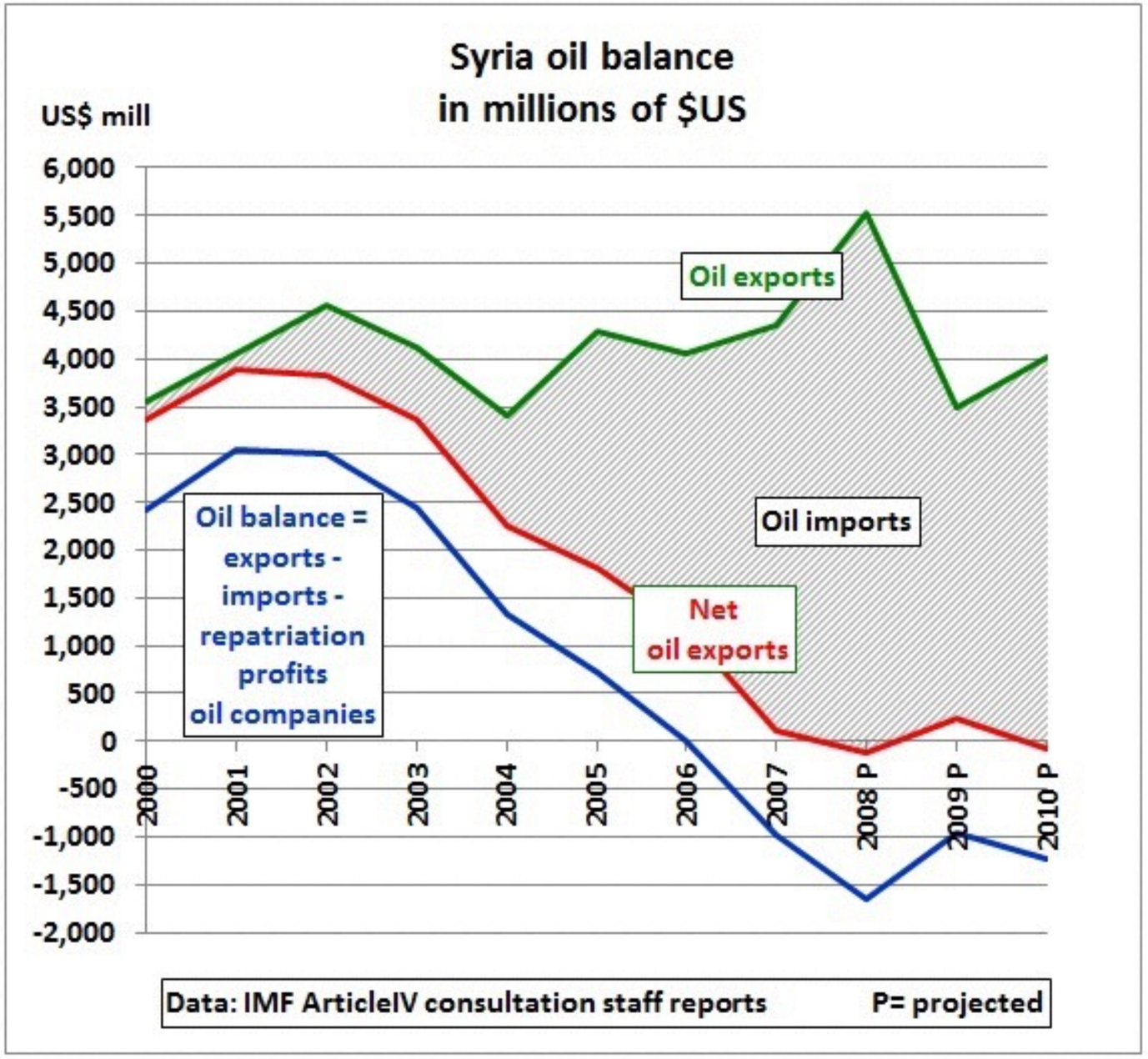








Syria is falling apart because of water and oil



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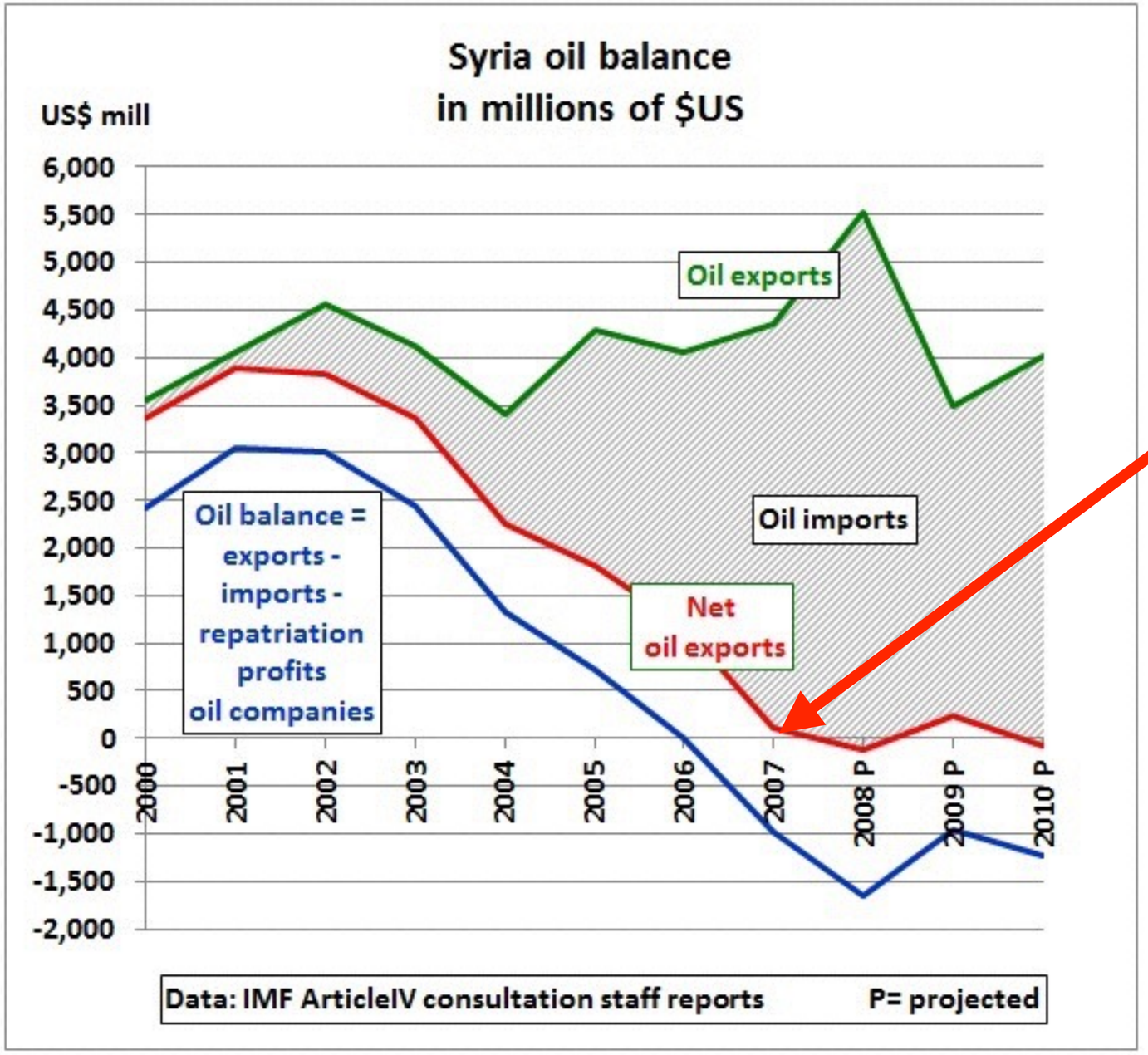

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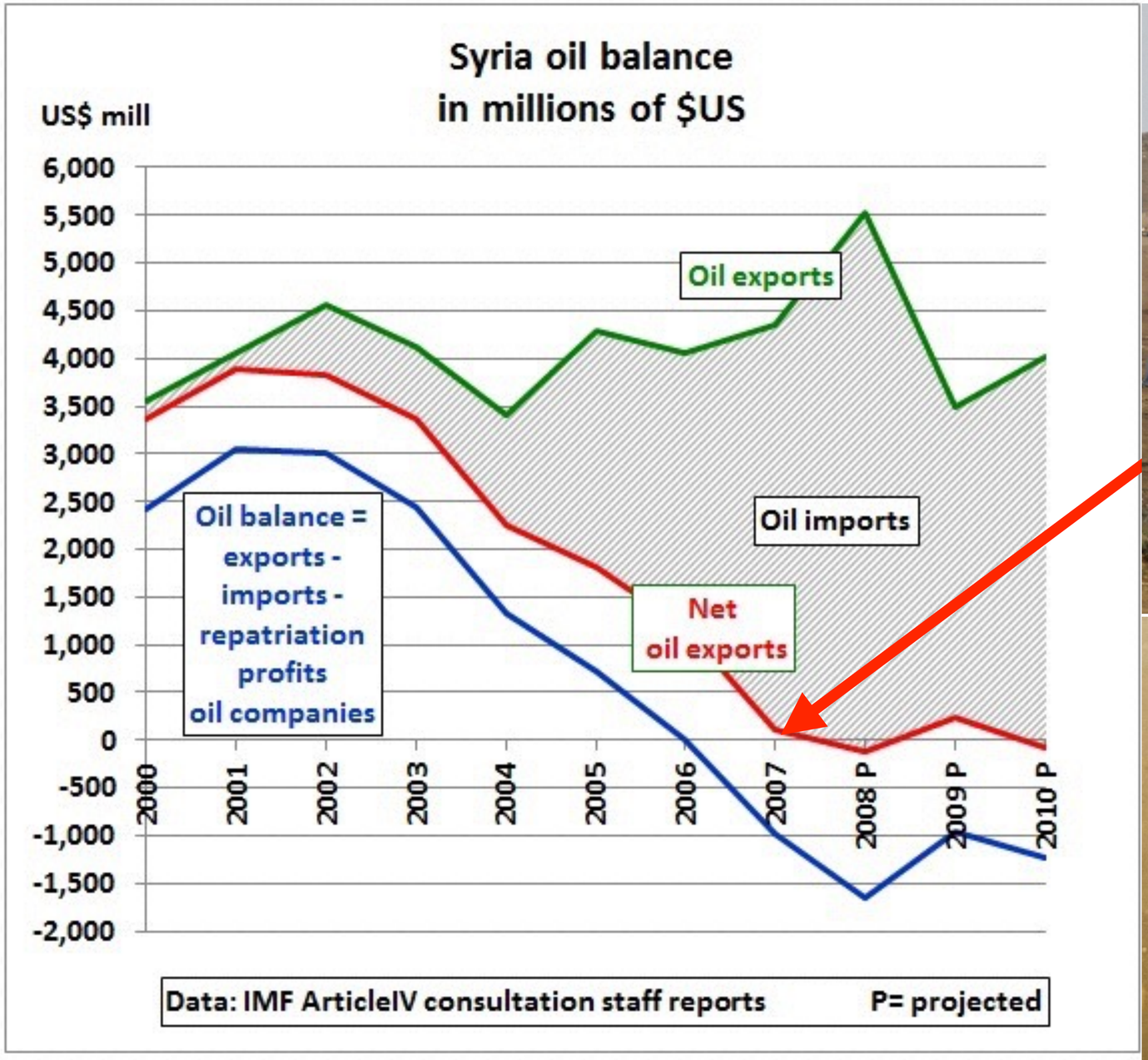
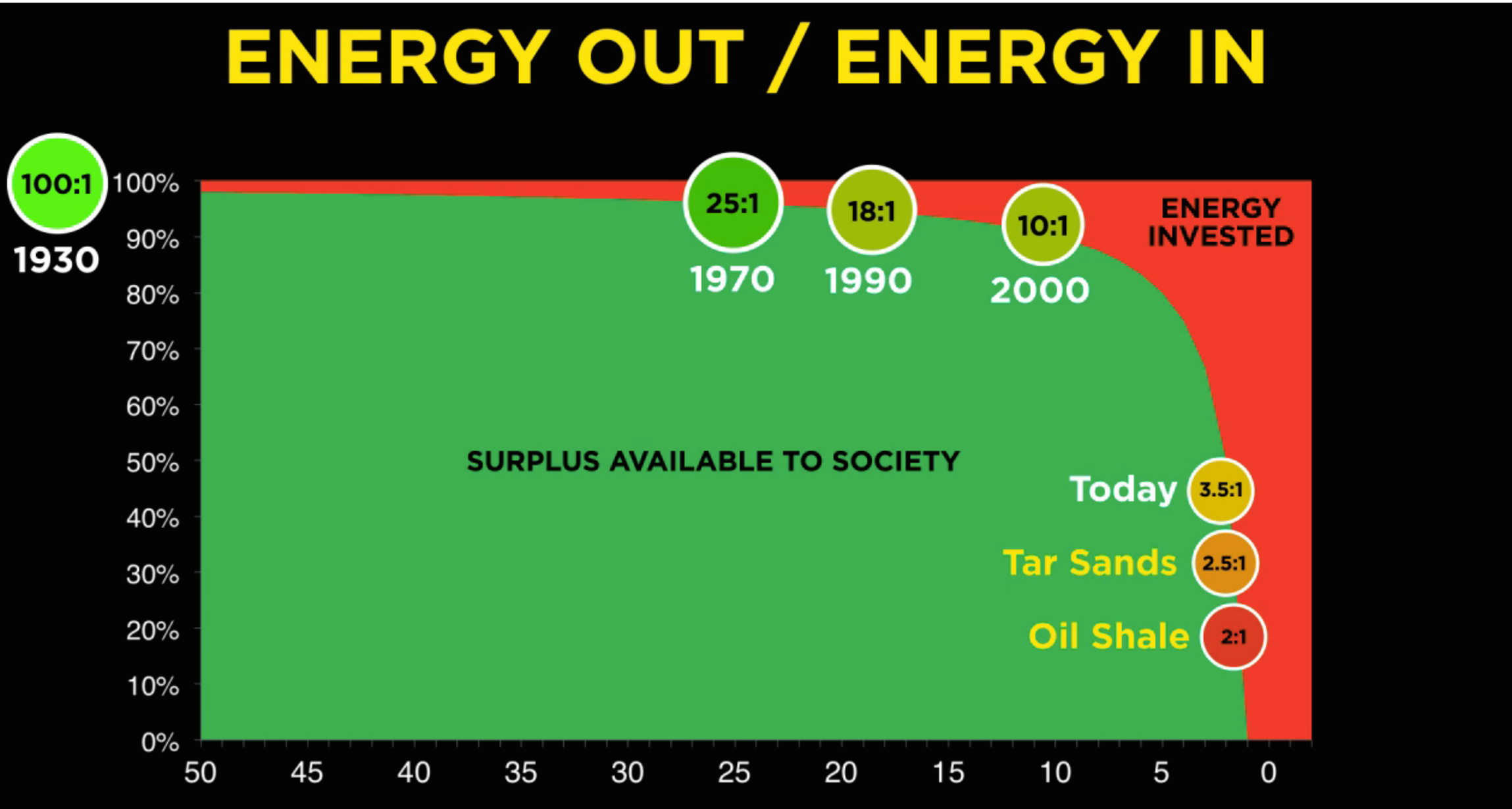


Economics is entirely dependent on net energy



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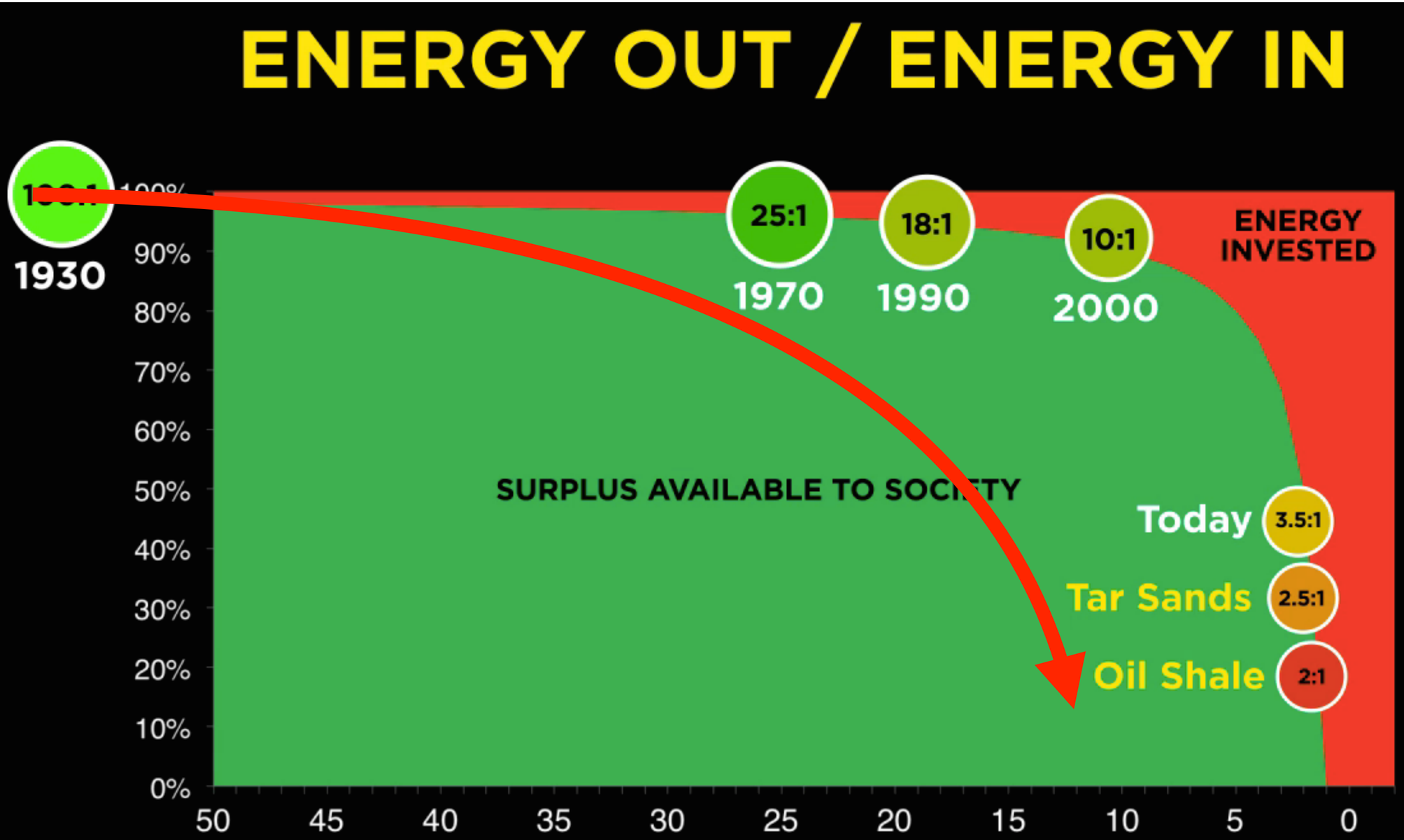


Oil refineries are energy hogs

Oil refineries are energy hogs

Oil refineries are energy hogs *and things can go wrong*

Oil refineries are energy hogs *and things can go wrong*

The *energy chain* for oil is actually pretty pathetic

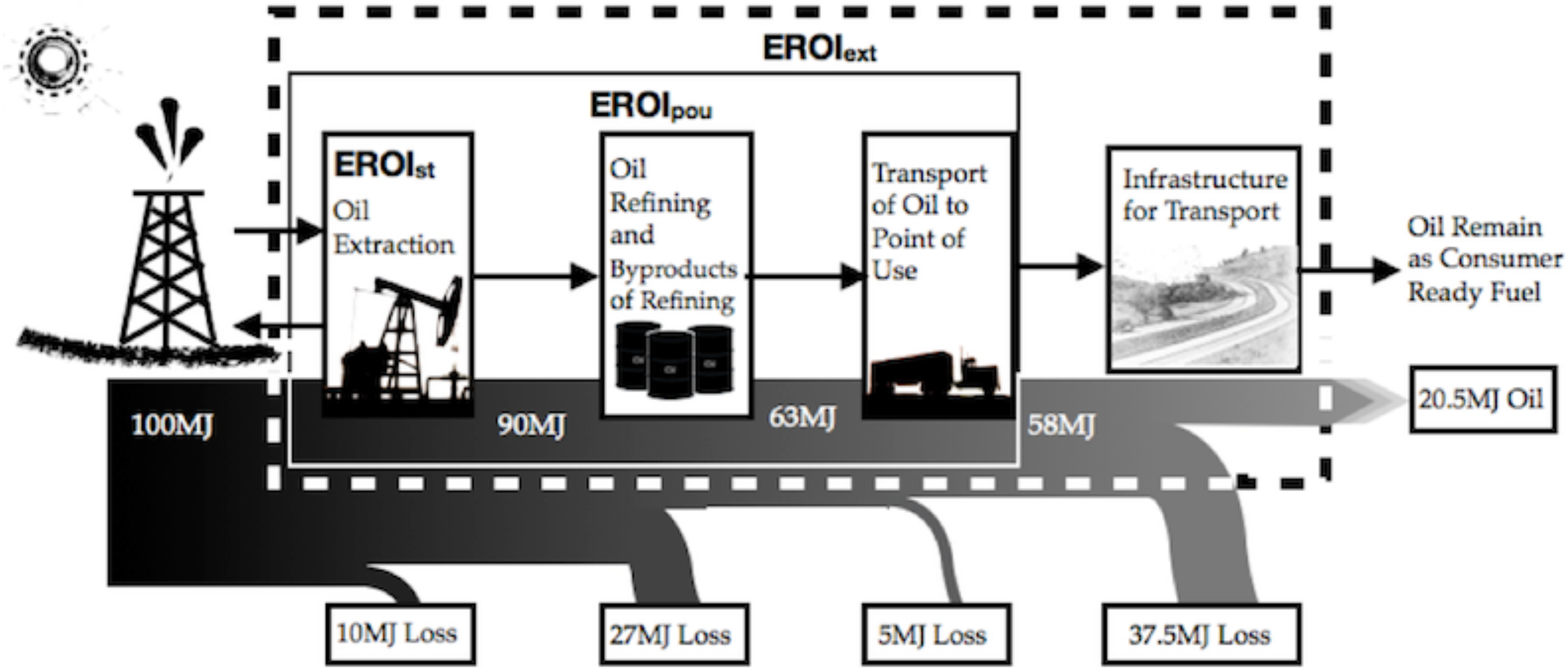
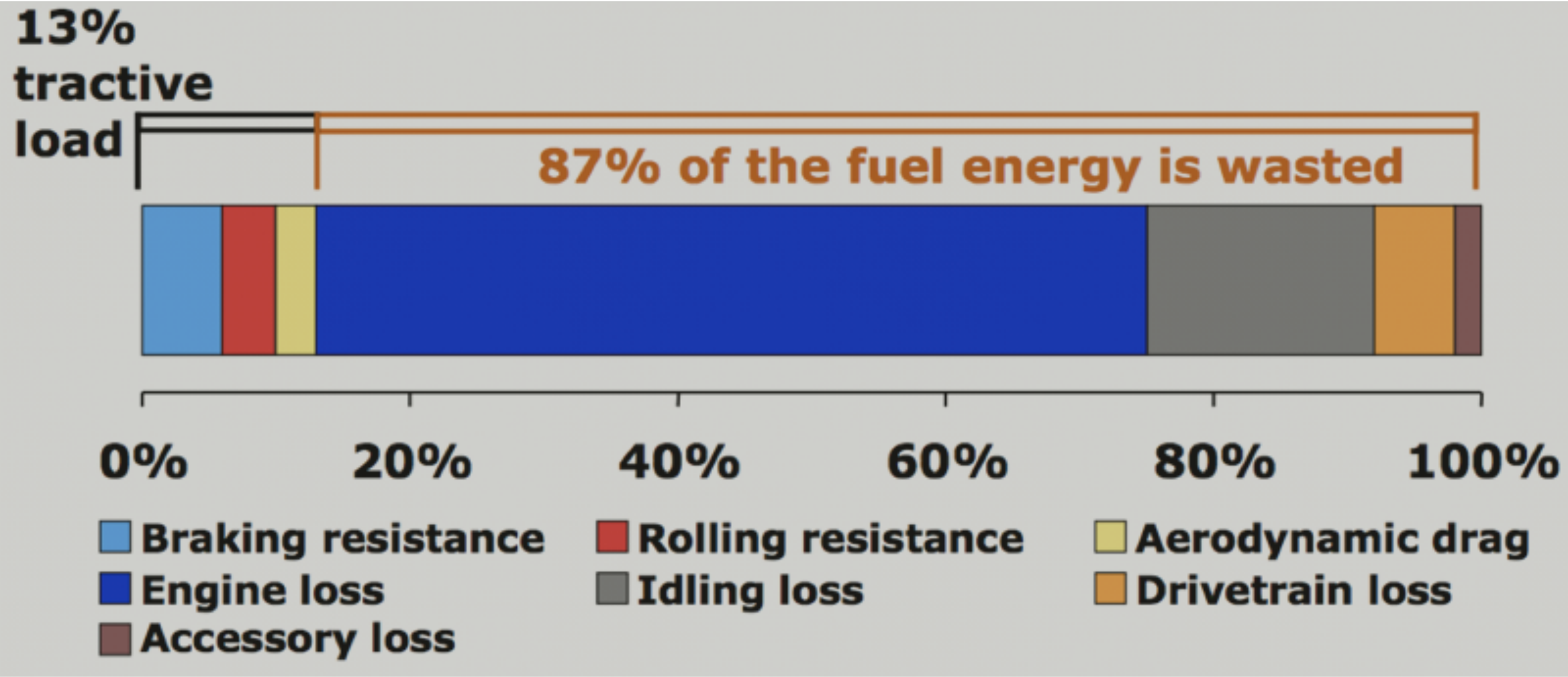


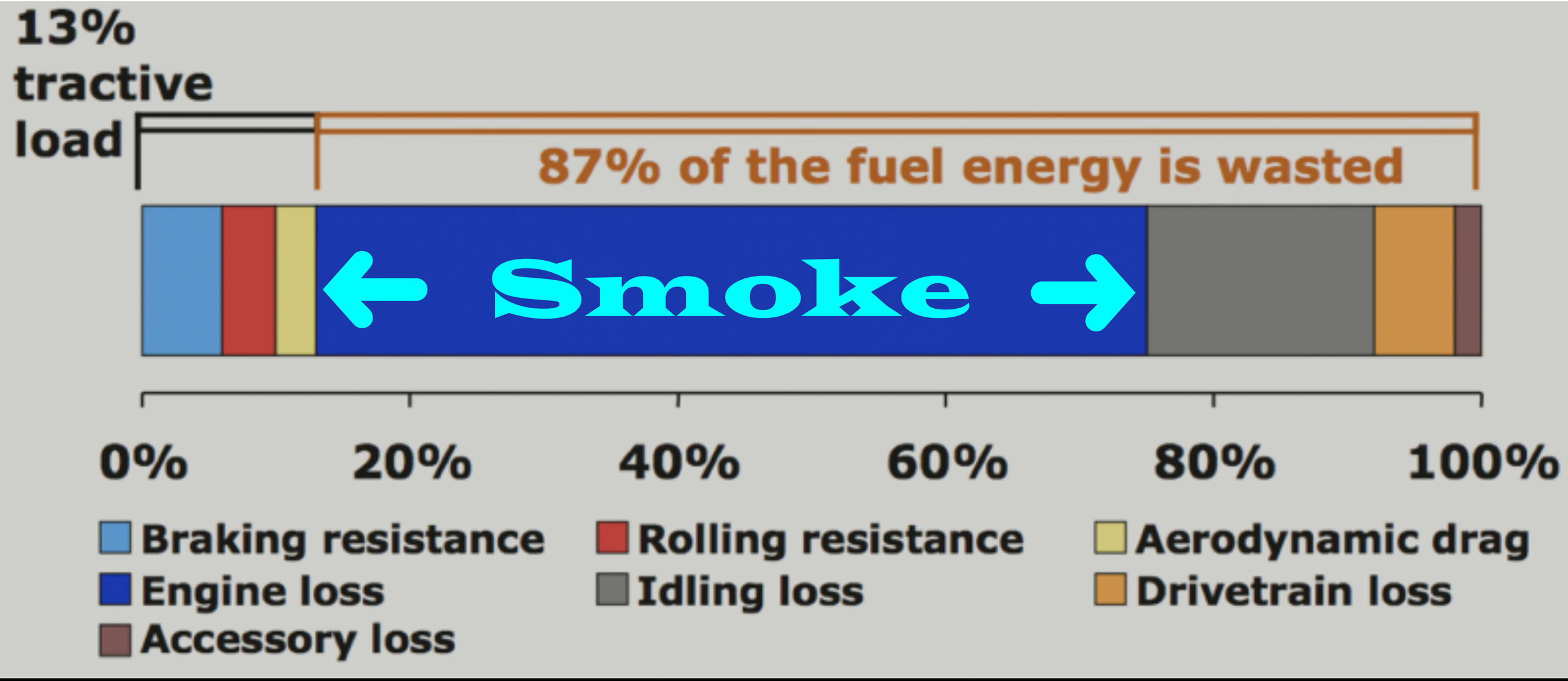
Figure 3: Boundaries of various types of EROI analyses (standard EROI ($EROI_{st}$), EROI at the point of use ($EROI_{pou}$) and extended EROI ($EROI_{ext}$)) and energy loss associated with the processing of oil as it is transformed from "oil at the well-head" to consumer ready fuels (figure adapted from Lambert and Lambert, in preparation [3]).

Cars are also energy hogs

You put gas in the tank and most of it goes up in *smoke*



You put gas in the tank and most of it goes up in *smoke*



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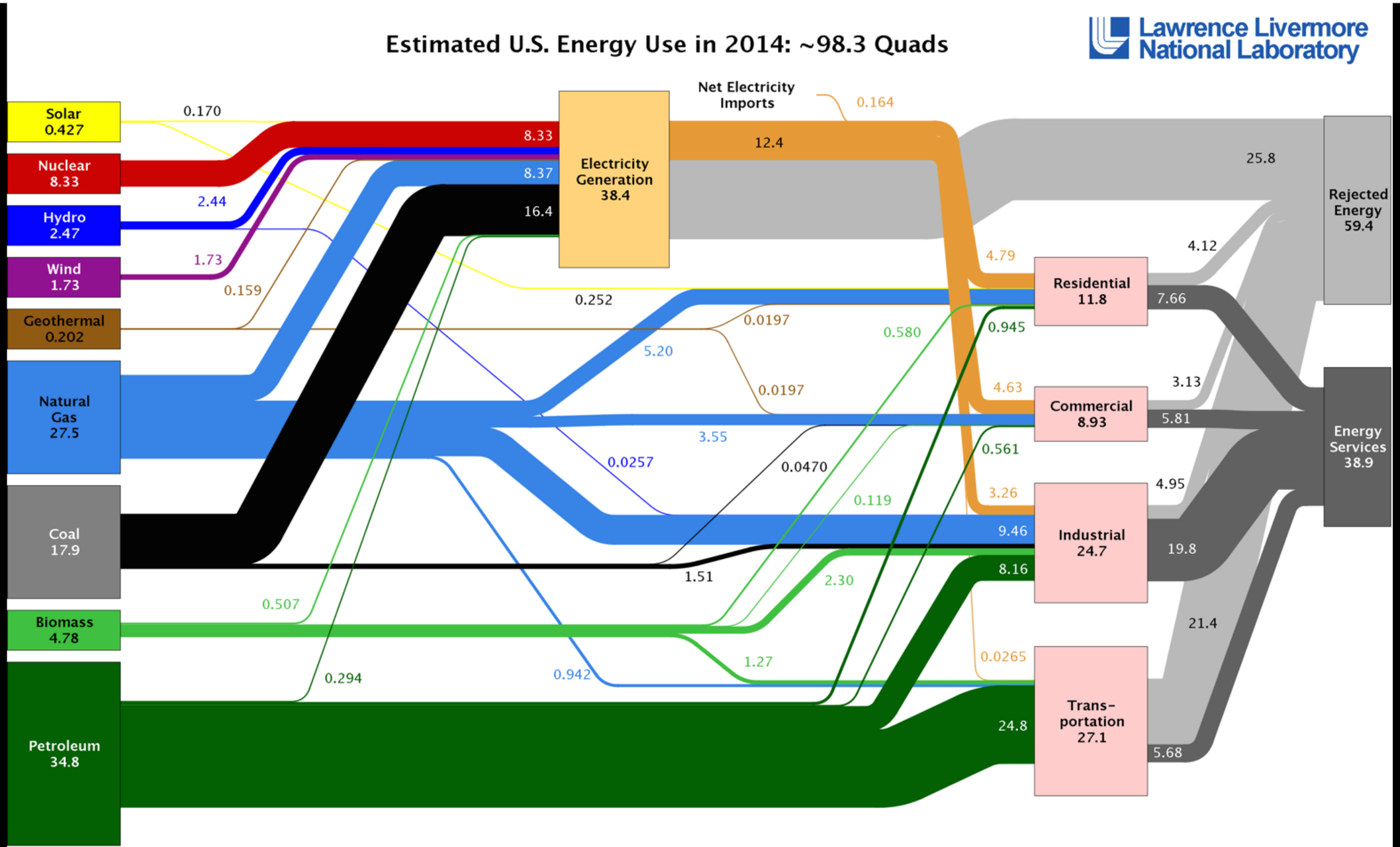
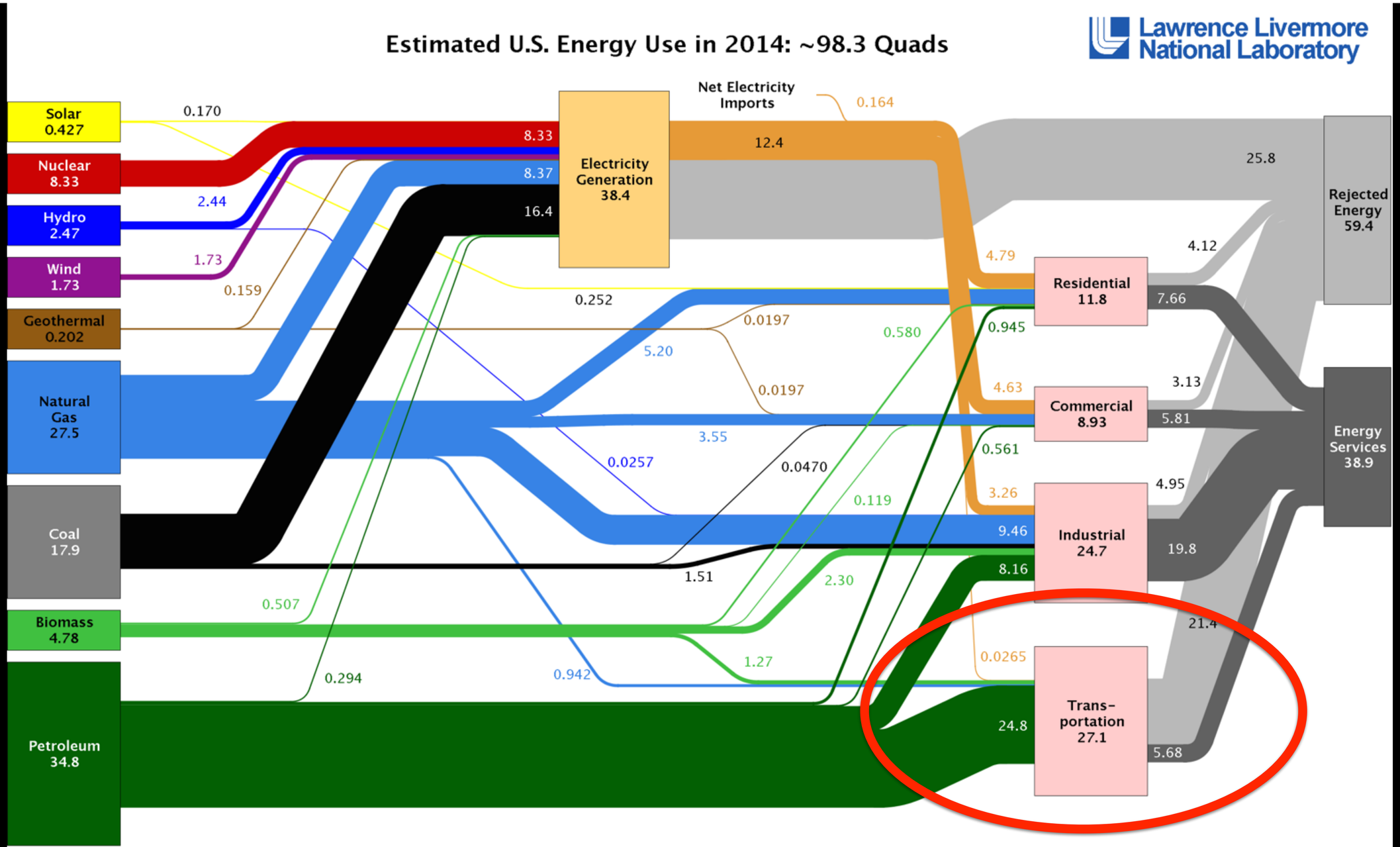
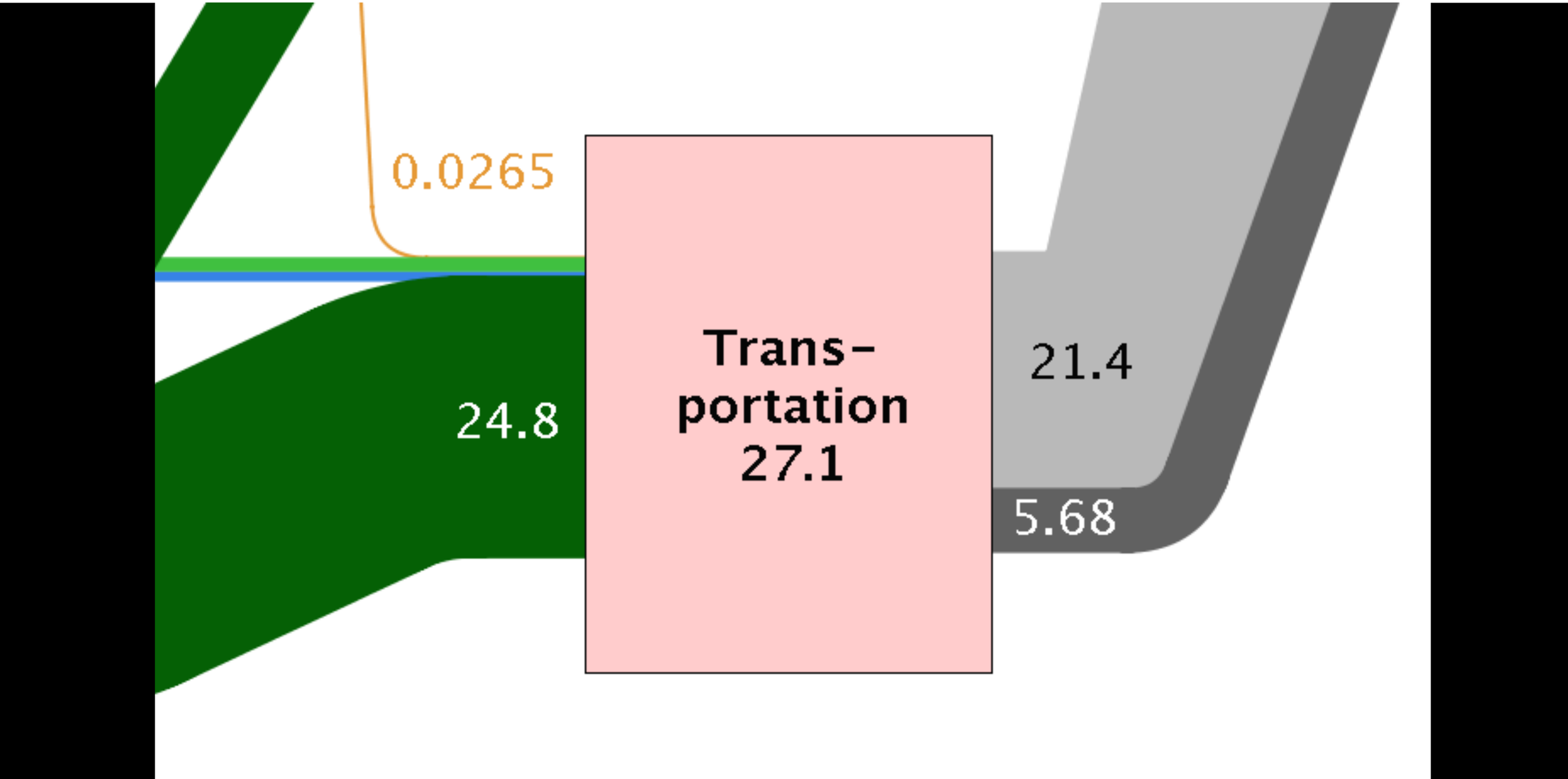


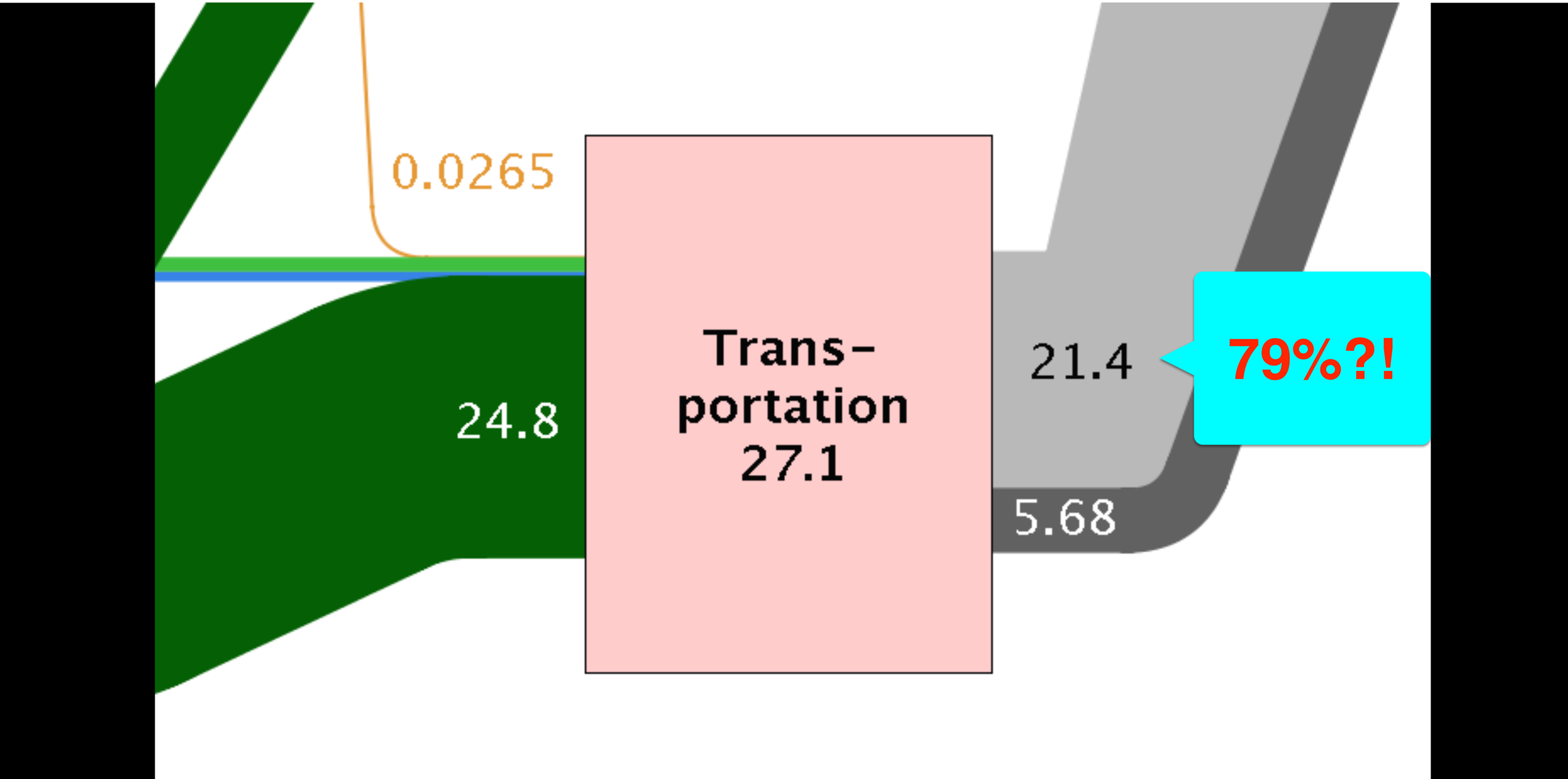
You put gas in the tank and most of it goes up in *smoke*



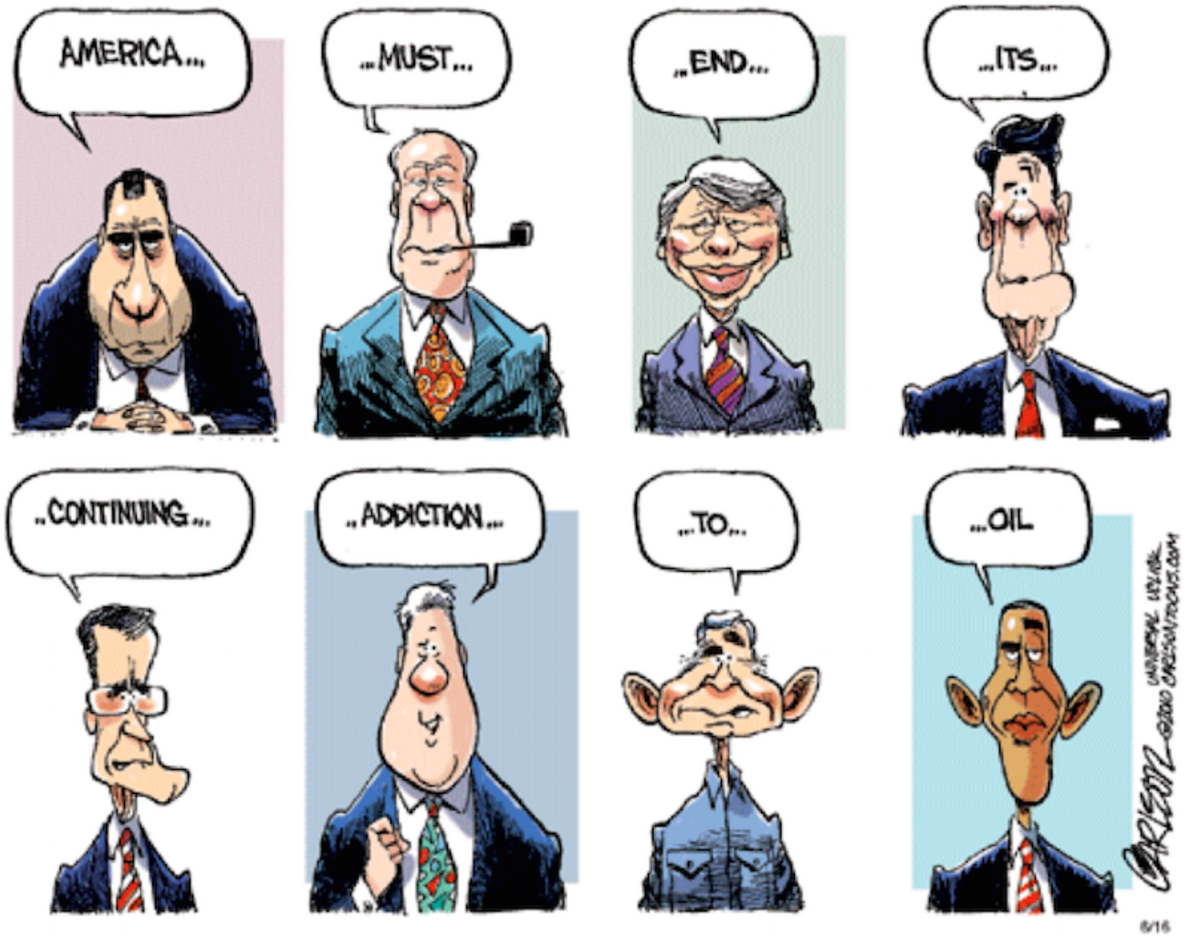
You put gas in the tank and most of it goes up in *smoke*



You put gas in the tank and most of it goes up in *smoke*



How is it possible for these trends to persist?



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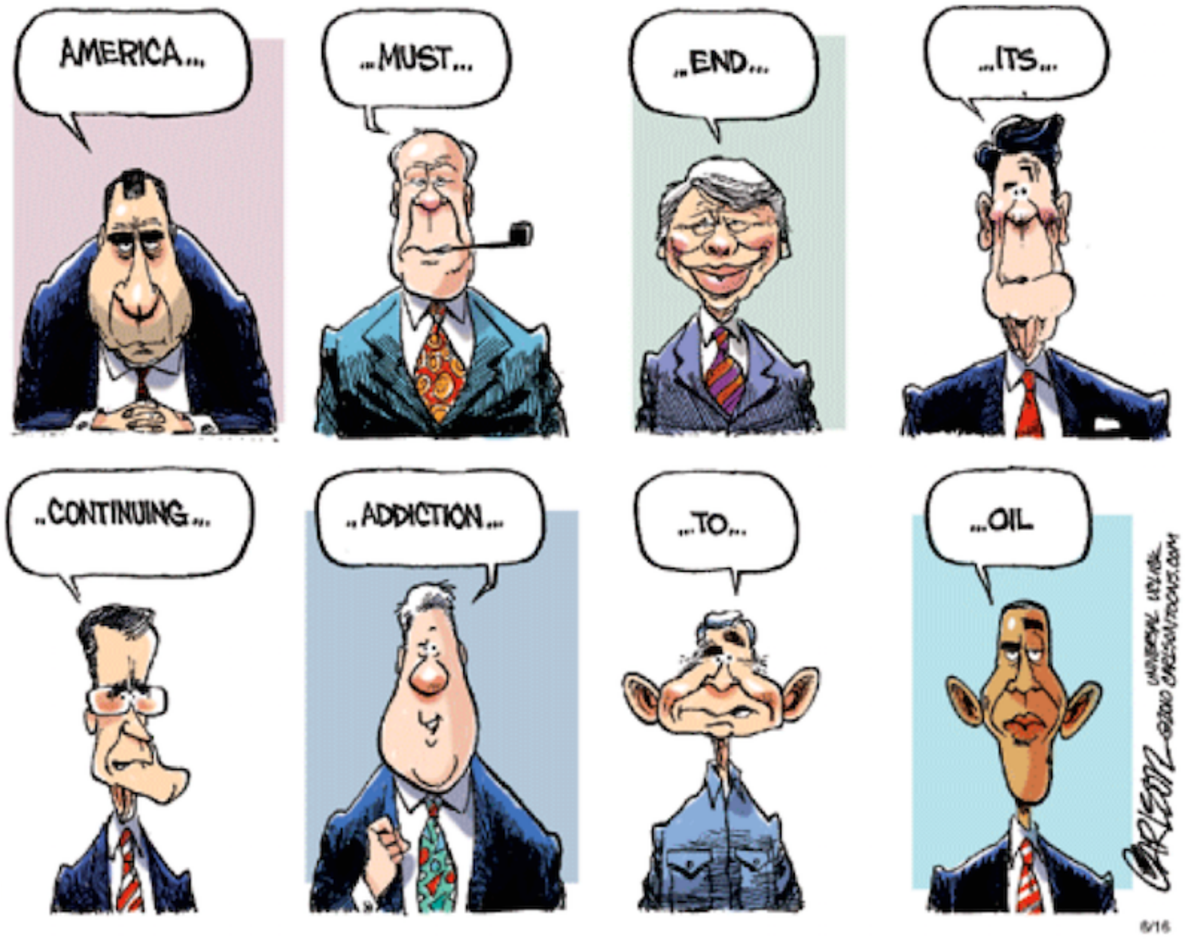
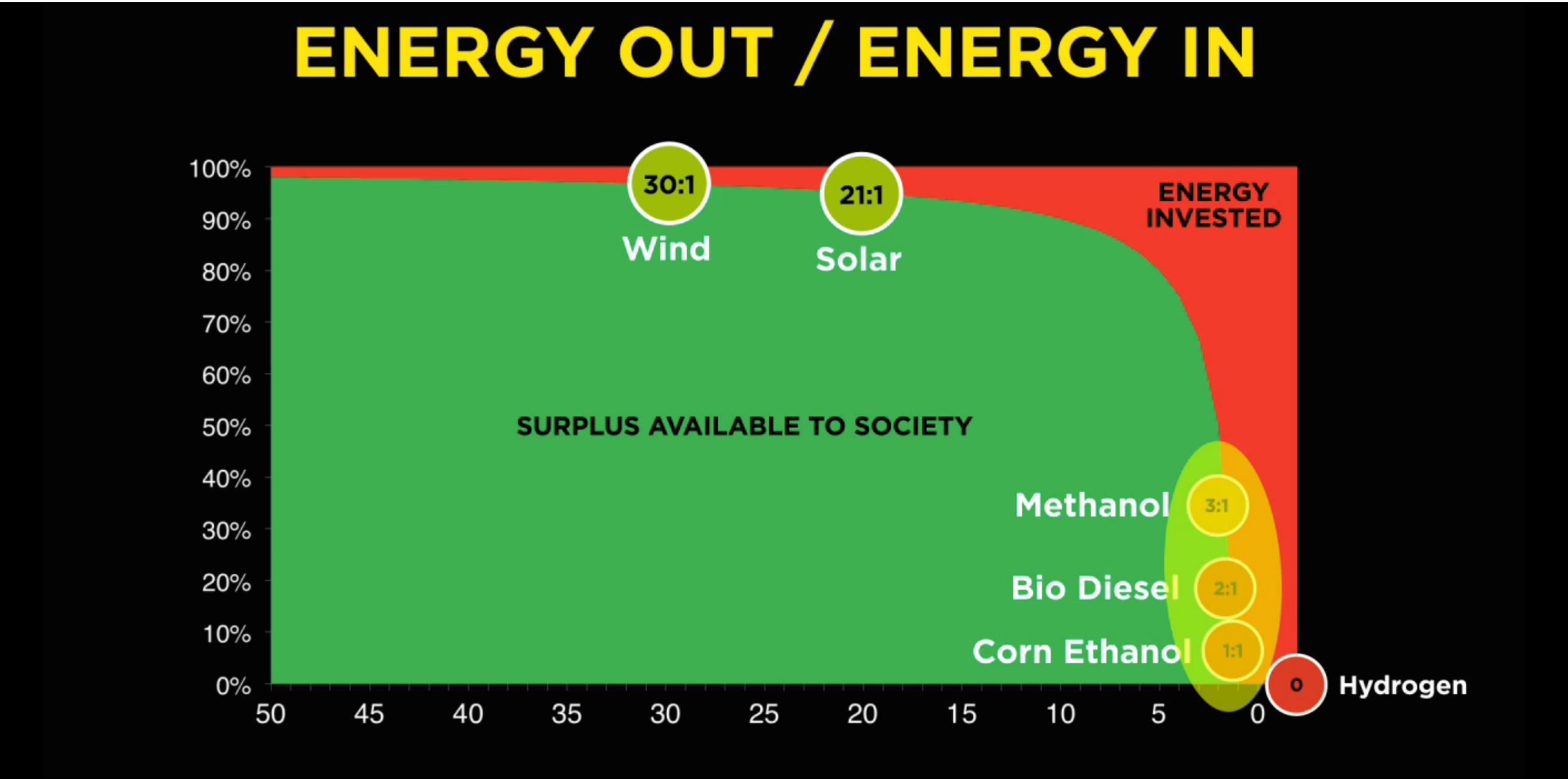


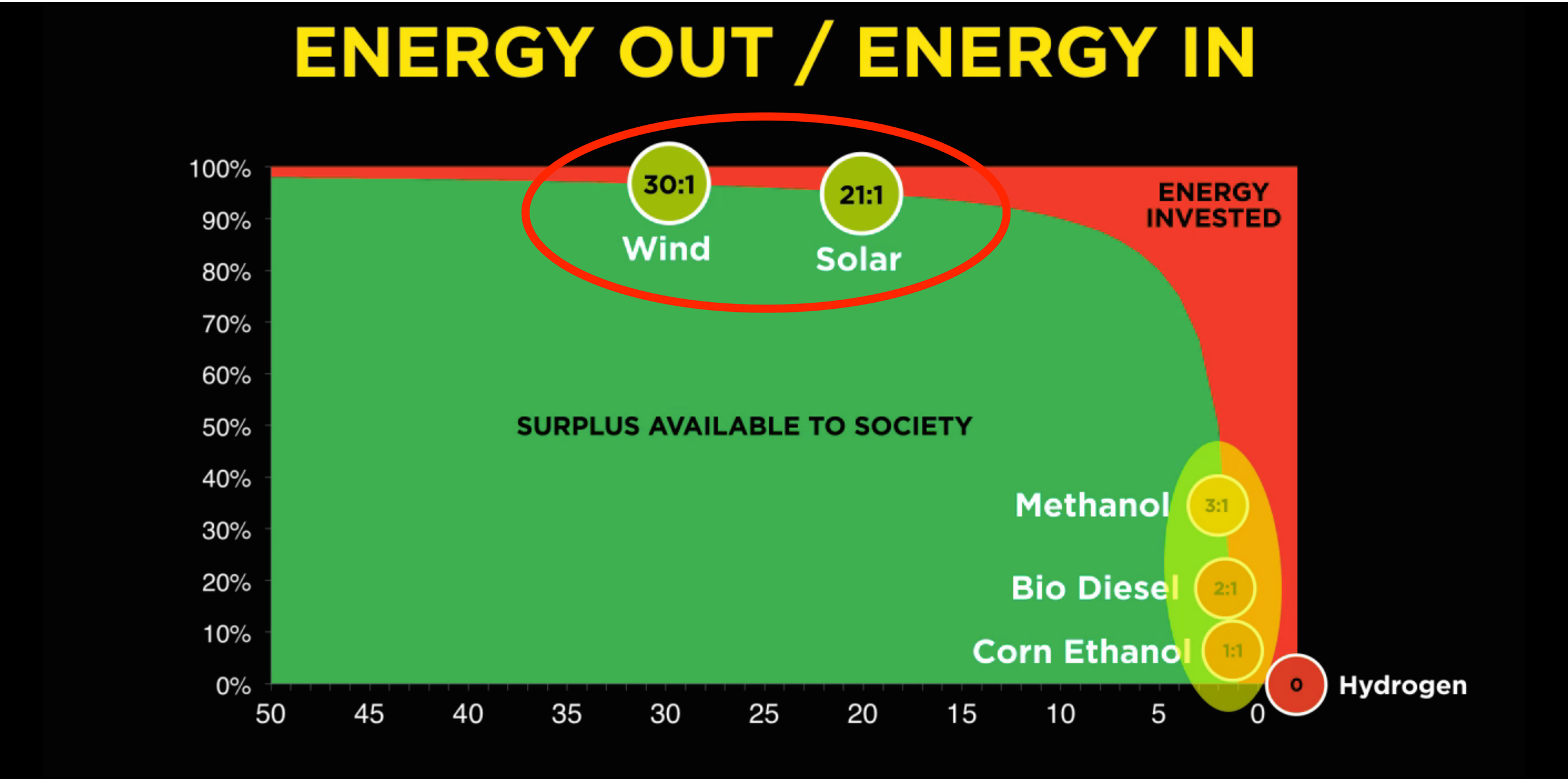
Economics is an instrument of policy

If all else fails, we do have alternatives

Net energy of solar (and wind) is now better than oil



Net energy of solar (and wind) is now better than oil



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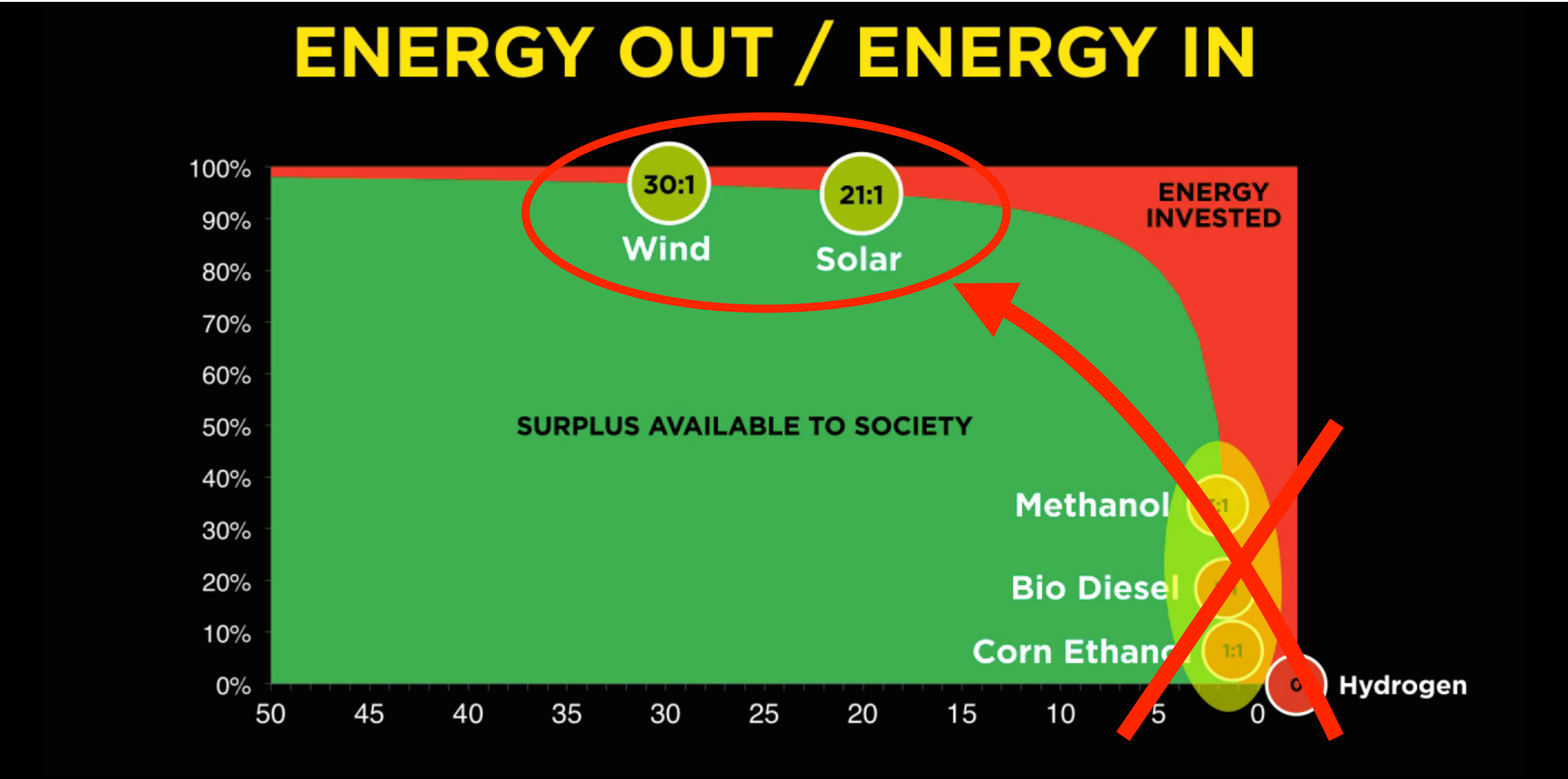
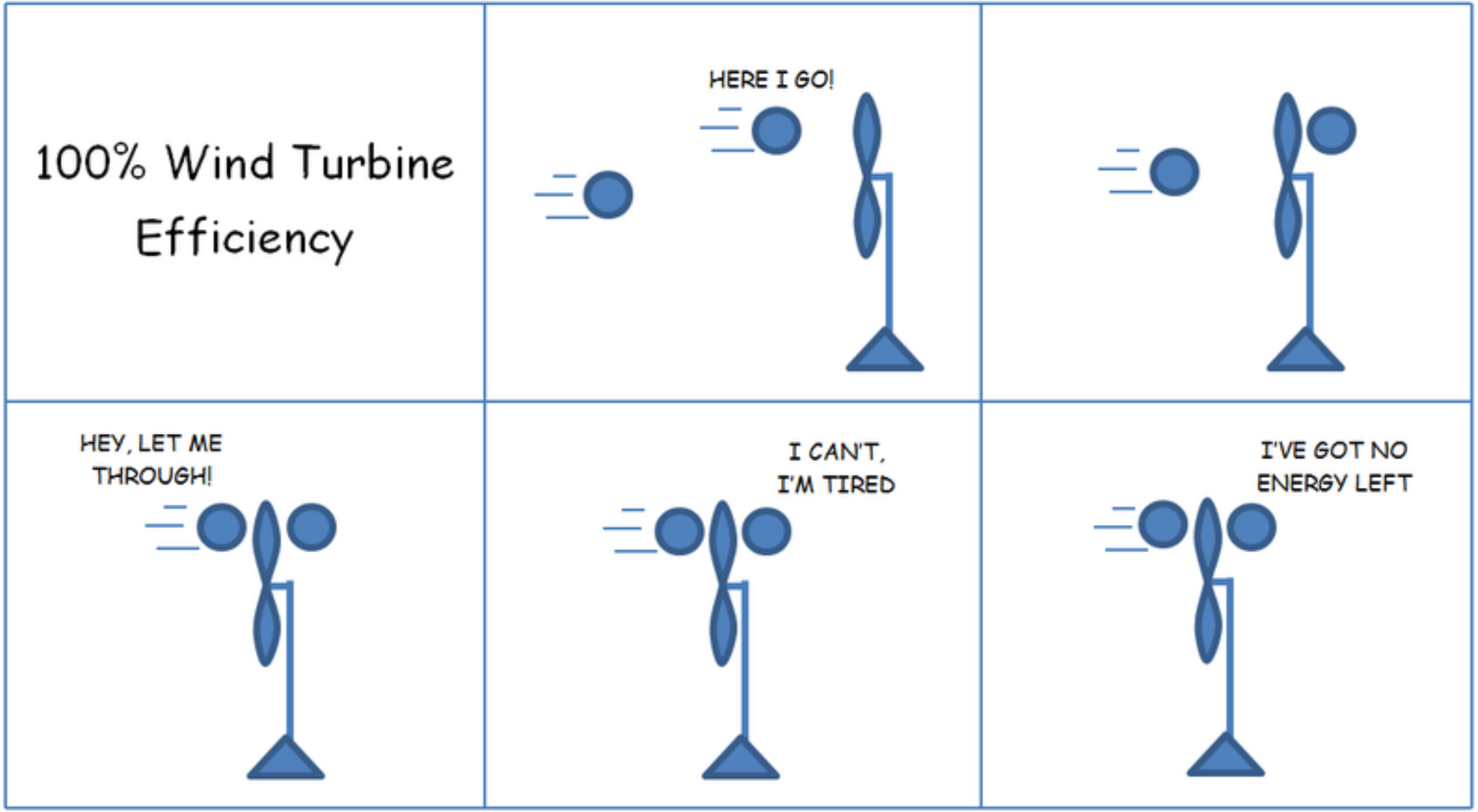


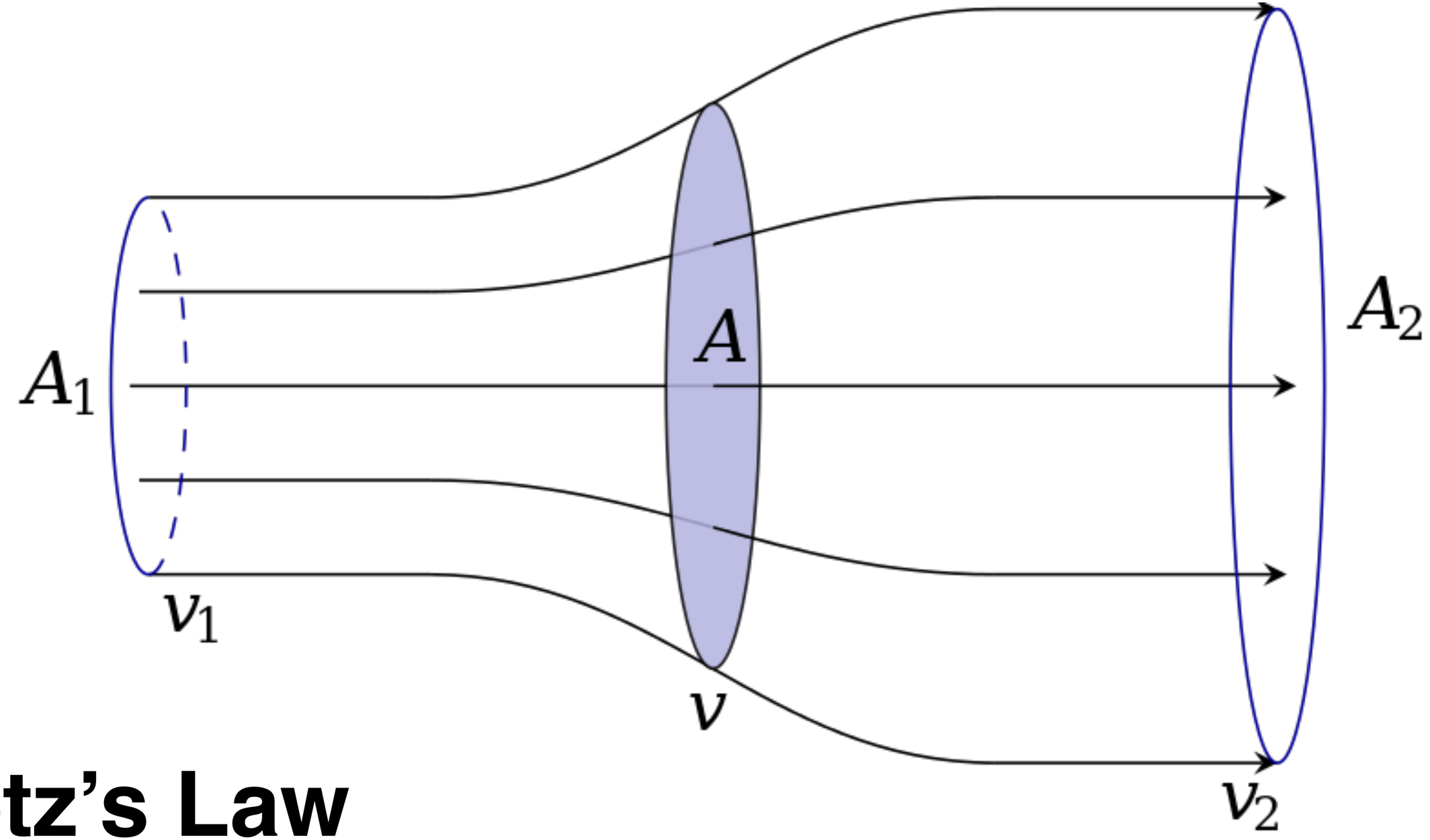
Wind energy is clean

Wind energy is clean

Wind inefficiency is just air flowing by …

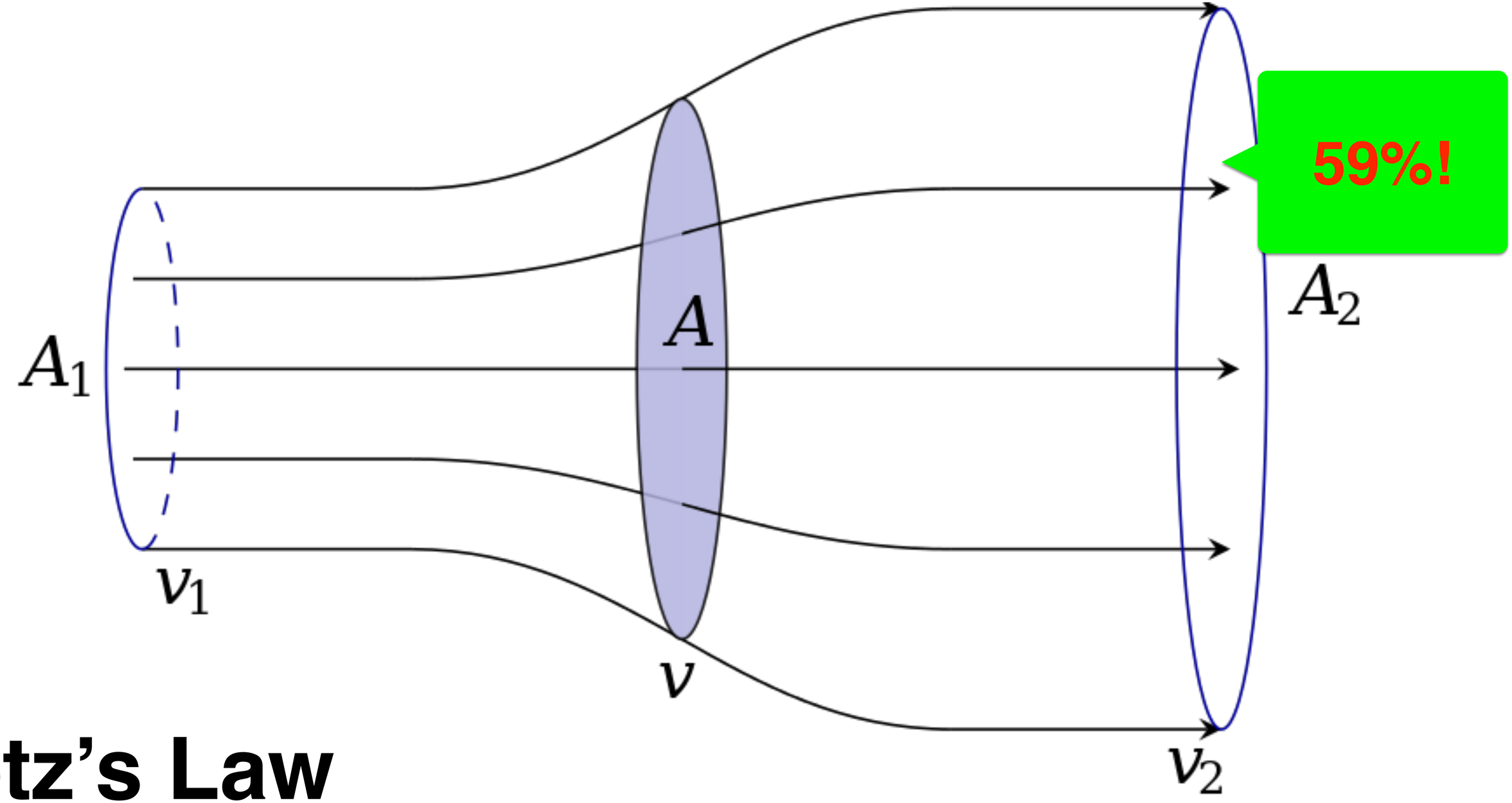


Wind inefficiency is just air flowing by …



Betz's Law

Wind inefficiency is just air flowing by …



Betz's Law

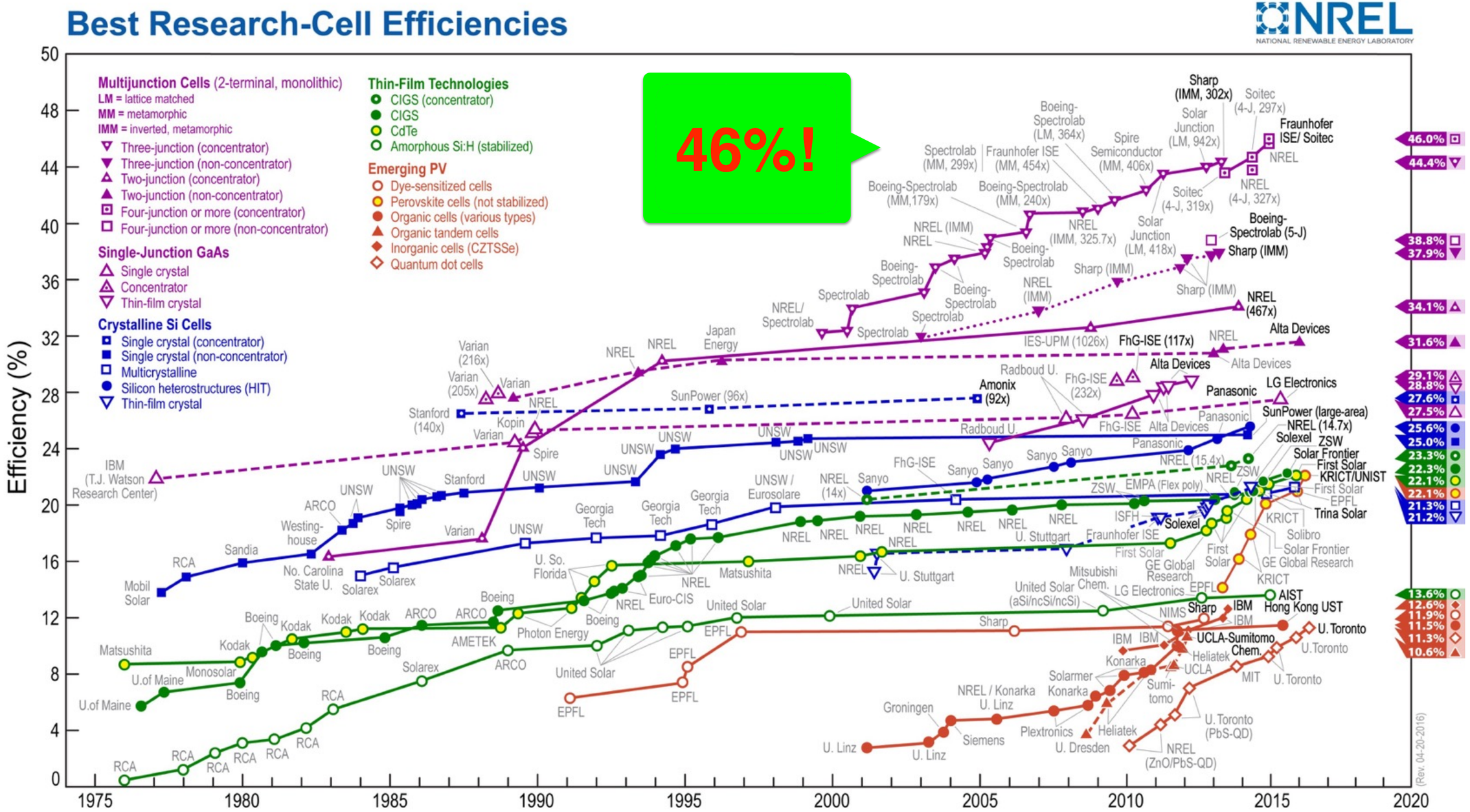
Solar energy is clean

SWENSON SOLAR

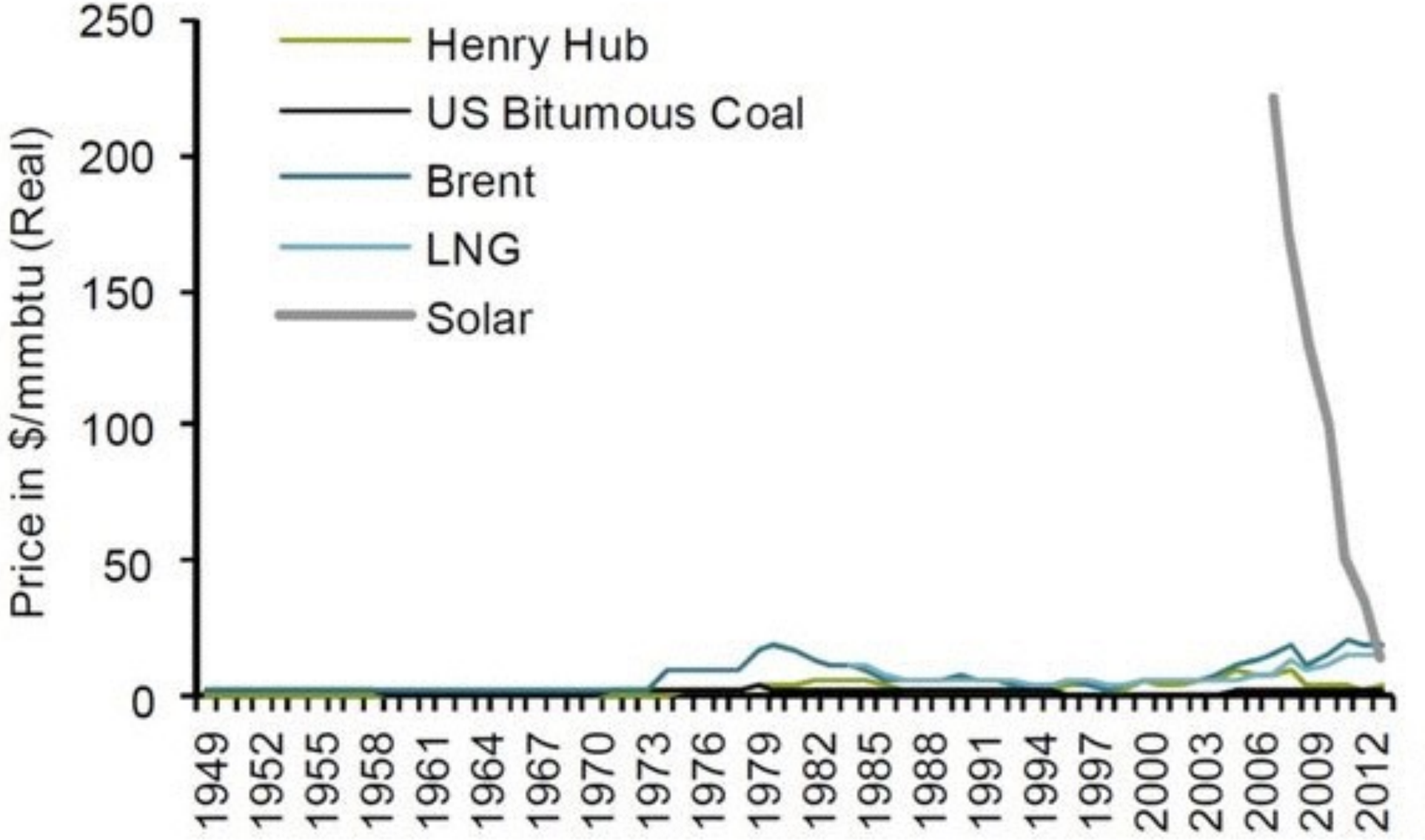
Solar energy is clean

SWENSON SOLAR

Solar inefficiency is just photons going into thin air



Meanwhile the cost of solar has dropped like a stone



And already some big players are betting on solar

Saudi unveils far-reaching plan to move away from oil

Ian Timberlake with Omar Hassan Abdulla in Kuwait

AFP

April 25, 2016

And already some big players are betting on solar

And already some big players are betting on solar

Saudi unveils far-reaching plan to move away from oil

Riyadh (AFP) - Saudi Arabia said Monday it would create the world's largest sovereign investment fund and sell shares in state energy giant Aramco under a vast plan unveiled to transform its oil-dependent economy.

The announcement of the long-term reform programme, dubbed "Vision 2030", marks the beginning of a hugely ambitious attempt to move Saudi Arabia beyond oil, the backbone of its economy for decades.

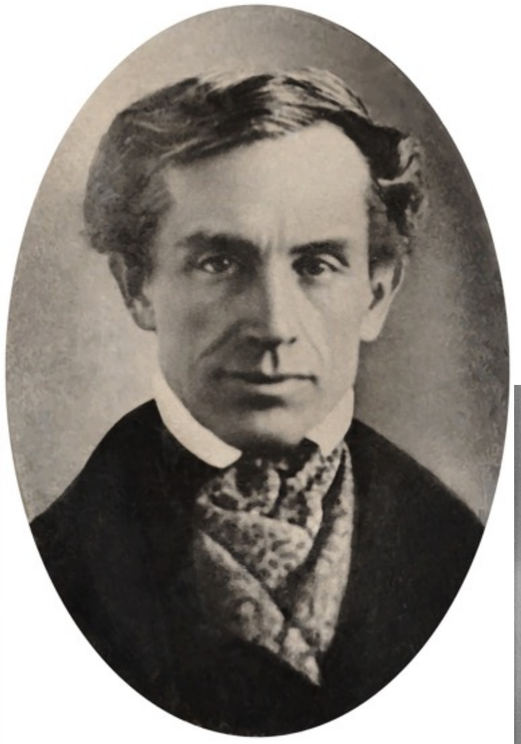
So where can we go from here?

From *Fire* to *Electricity*

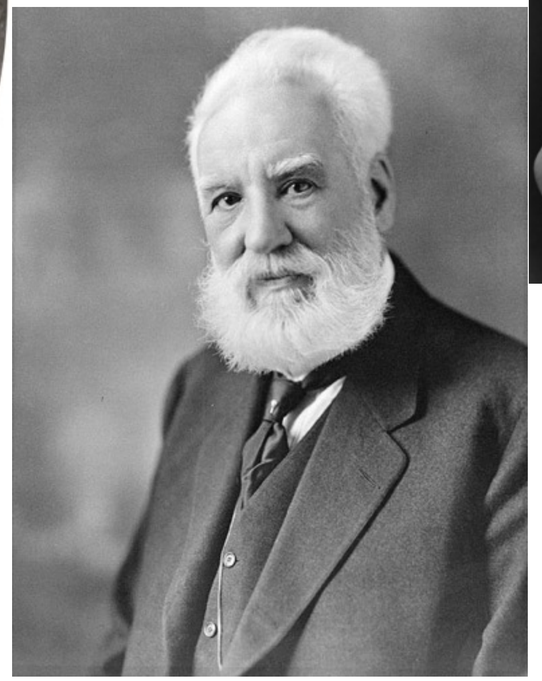
Electricity is very new to humanity

Franklin

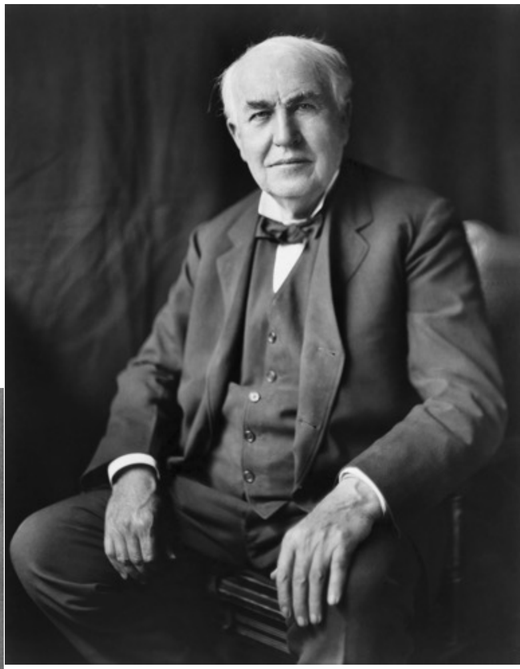
Volta



Morse



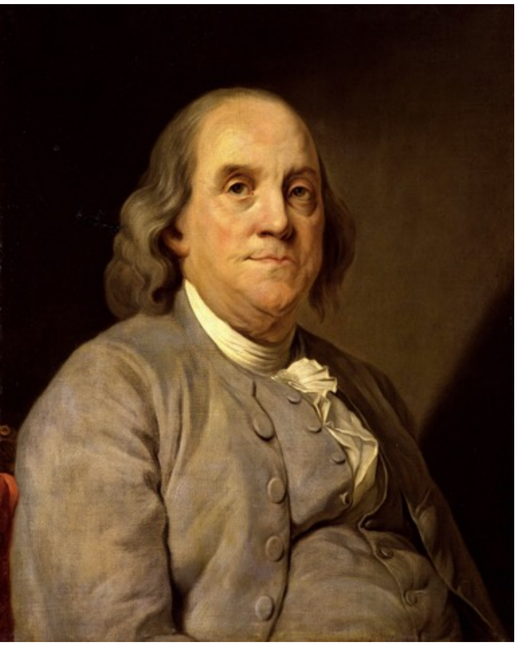
Bell



Edison

Electricity is very new to humanity

June 10, 1752



Franklin

Electricity is very new to humanity

1800

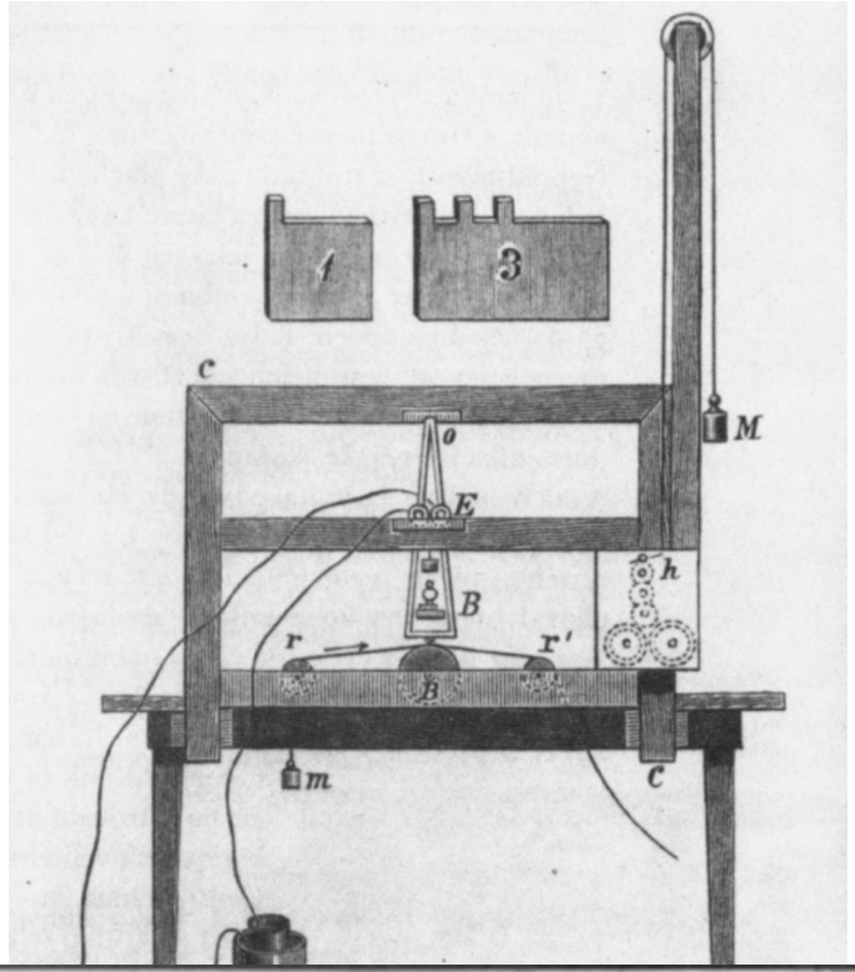
Volta

The battery

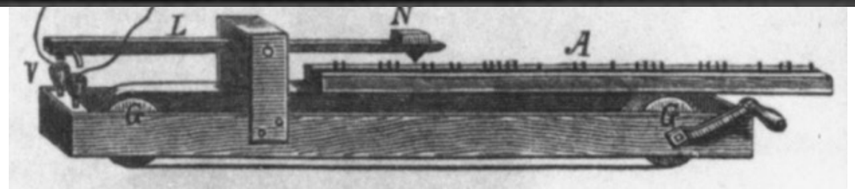
Electricity is very new to humanity

May 24, 1844

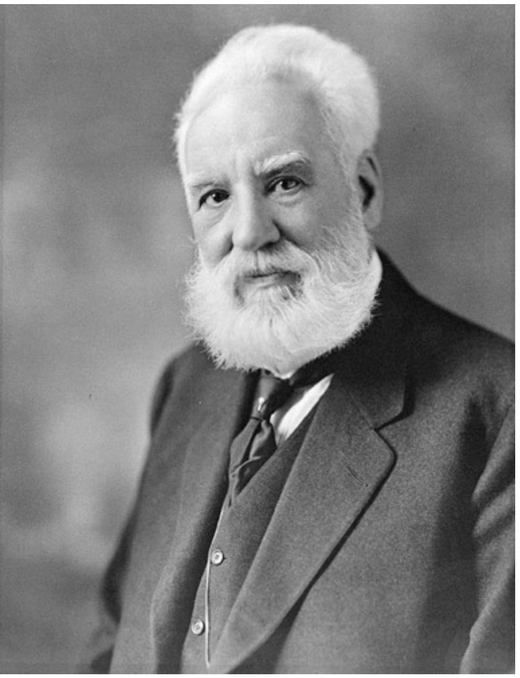
Morse



The Telegraph



Electricity is very new to humanity



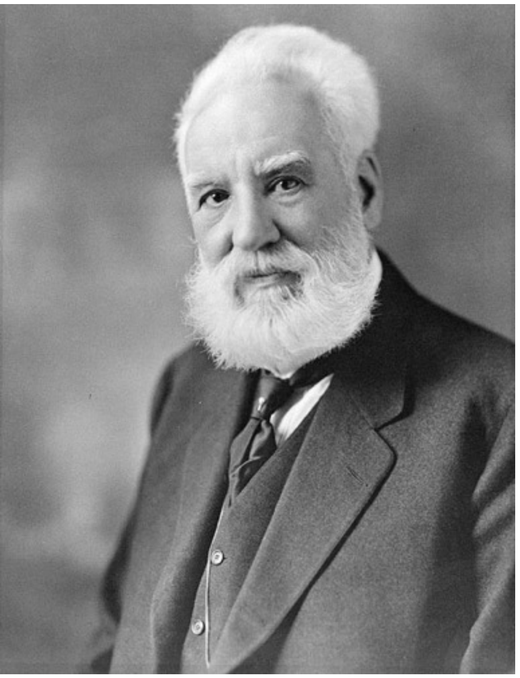
Bell

The Telephone

20 Patents

Electricity is very new to humanity

March 10, 1876



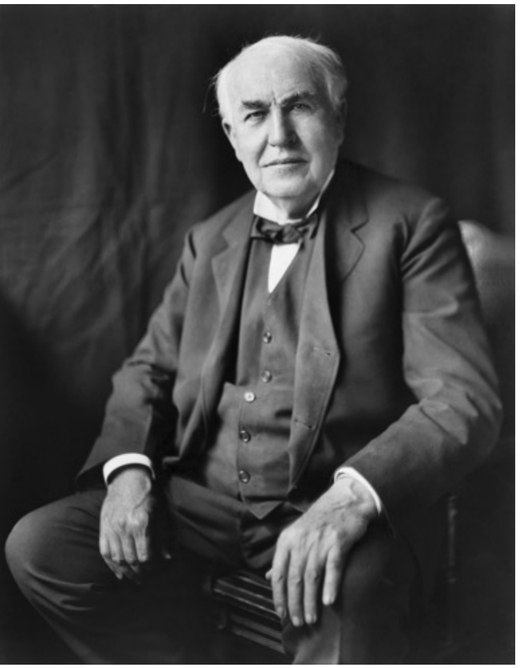
Bell

The Telephone

20 Patents

Electricity is very new to humanity

October 22, 1879



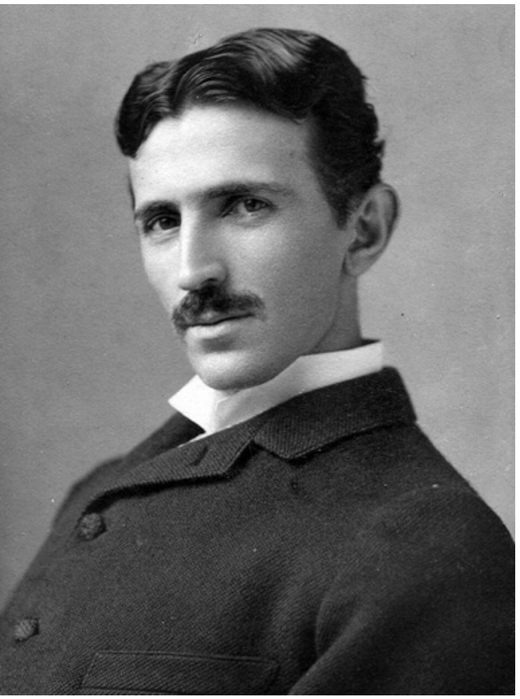
Edison

The light bulb

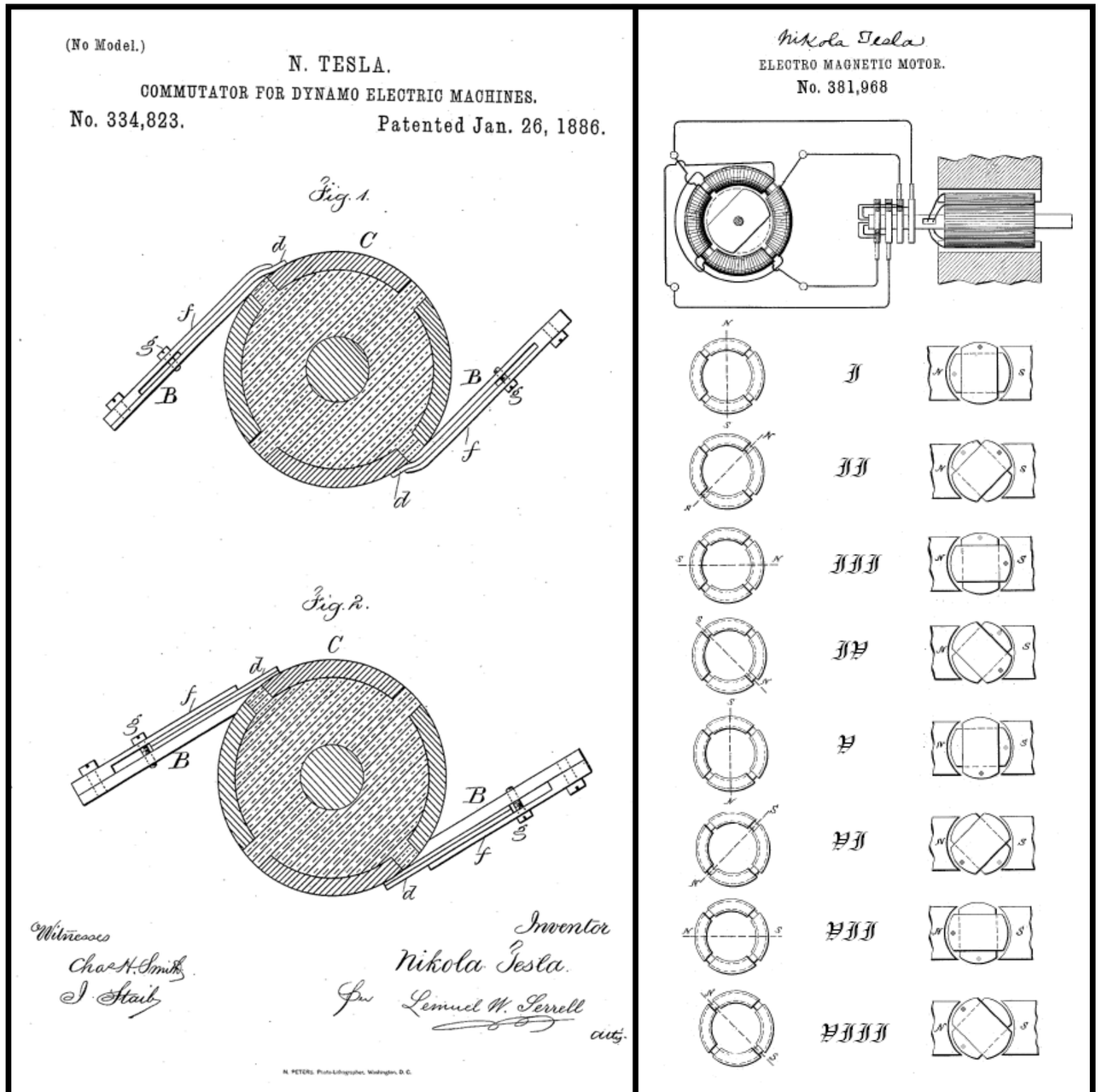
1,093 US Patents

Electricity is very new to humanity

January 26, 1886



Tesla



(No Model.)

N. TESLA.

COMMUTATOR FOR DYNAMO ELECTRIC MACHINES.

No. 334,823. Patented Jan. 26, 1886.

Fig. 1.

Fig. 2.

Witnesses
Chas. H. Smith.
J. Stahl.

Inventor
Nikola Tesla.
per Lemuel W. Serrell
atty.

N. PETERS, Photo-Lithographer, Washington, D. C.

Nikola Tesla.

ELECTRO MAGNETIC MOTOR.

No. 381,968

I
II
III
IV
V
VI
VII
VIII

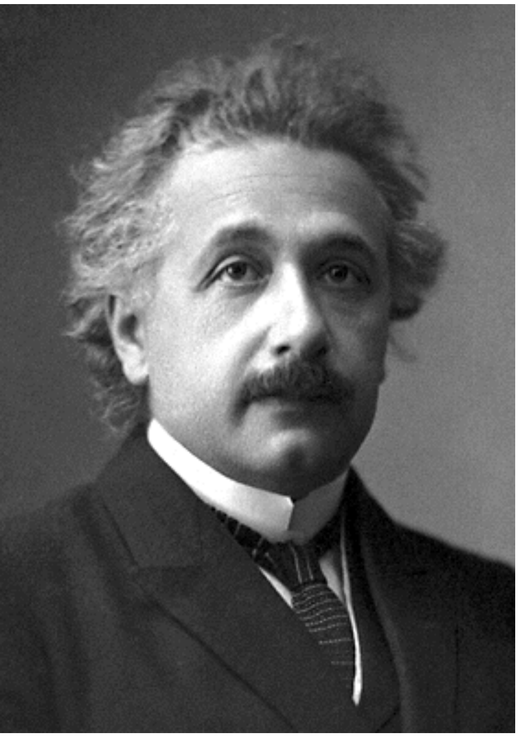
Commutator for Dynamo Electric Machines

May 1, 1888
The electro magnetic motor

111 US Patents

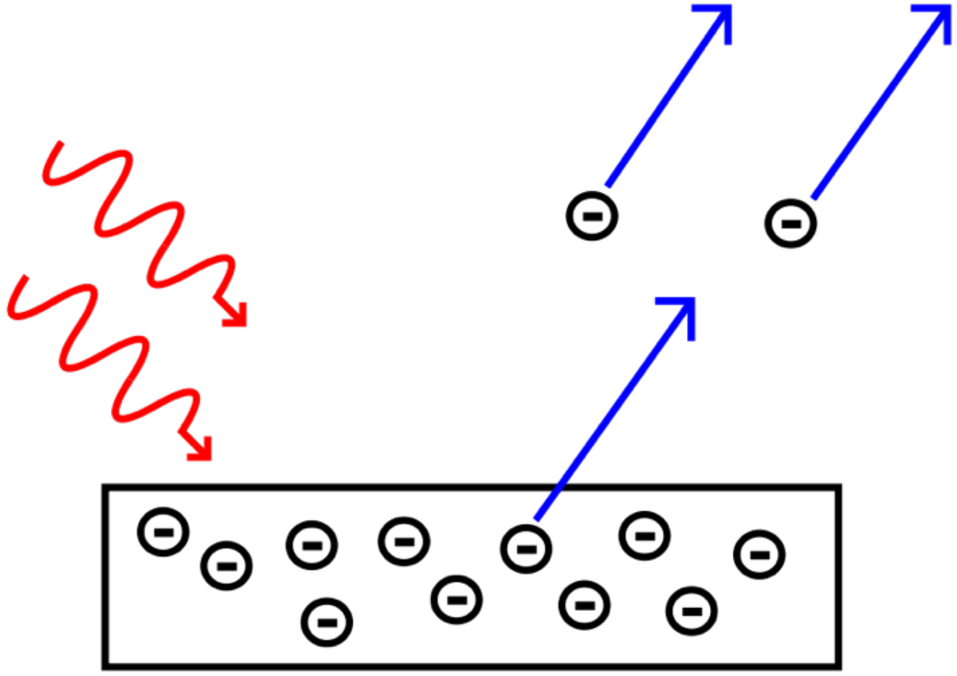
Electricity is very new to humanity

1921



Einstein

In 1921 Einstein was awarded the Nobel Prize in Physics, “for his ‘services to theoretical physics,’ in particular his discovery of the law of the photoelectric effect.”



Mechanical Engineering is doing *more with less*

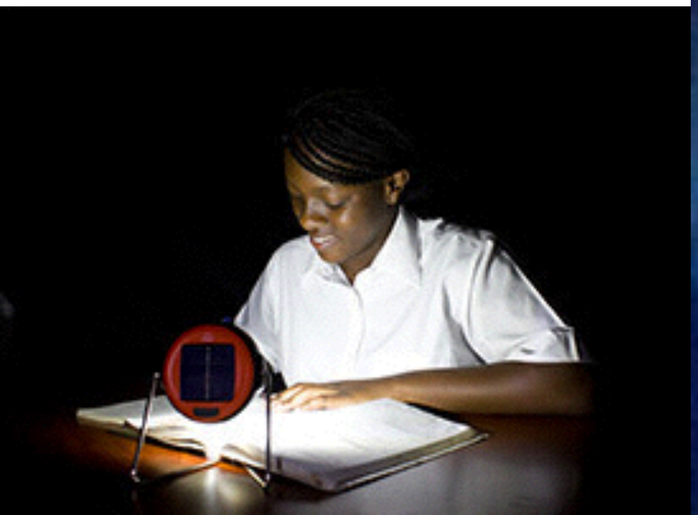
More with less — Lighting is improving rapidly

Good

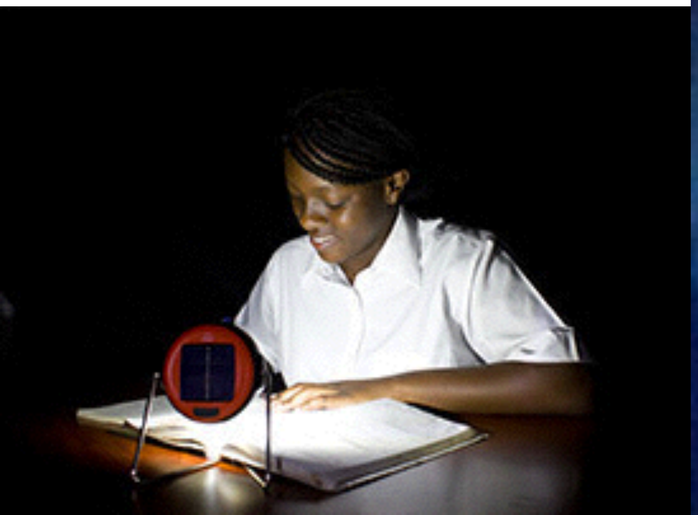
Better

Best

More with less — Lighting is improving rapidly



More with less — Lighting is improving rapidly

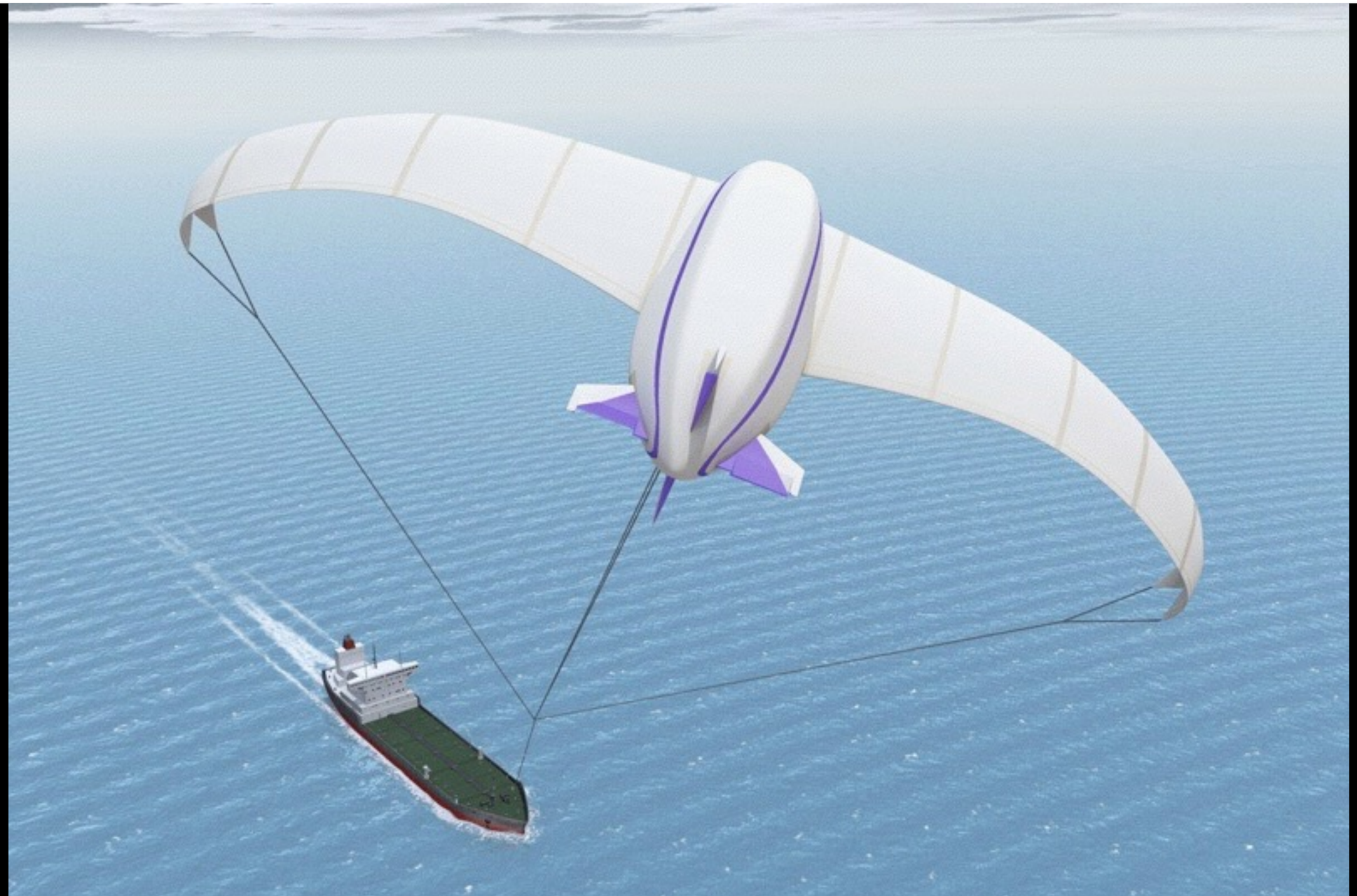


More with less — Solar cooking is now practical … thanks in part to crowd sourcing

More with less — Solar cooking is now practical … thanks in part to crowd sourcing

10X!

With the goal of reviving wind power for shipping …



2004

More with less — Kiteship made a world's record

2004

More with less — Kiteship made a world's record … which we've held for 11 years

GUINNESS WORLD RECORDS™

CERTIFICATE

A 420 m² (4,521 ft²) traction kite manufactured by KiteShip Corporation (USA) was used to propel an 8.5 tonne (18,740 lb) yacht near Sydney, New South Wales, Australia, on 6 December 2004, the largest kite ever used to pull a vehicle of any kind.

Keeper of the Records
GUINNESS WORLD RECORDS LTD

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Keeper of the Records
GUINNESS WORLD RECORDS LTD

2004

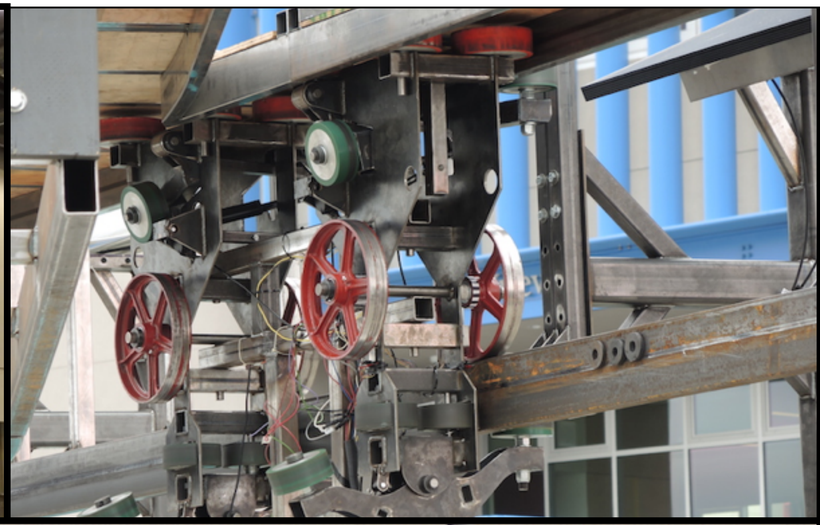
10X!

More with less — Solar mobility is the next big thing

More with less — Solar transit is becoming practical

More with less — Solar transit is becoming practical

And it’s happening right here at San José State!



And it’s happening right here at San José State!

And it’s happening right here at San José State!

And it’s happening right here at San José State!

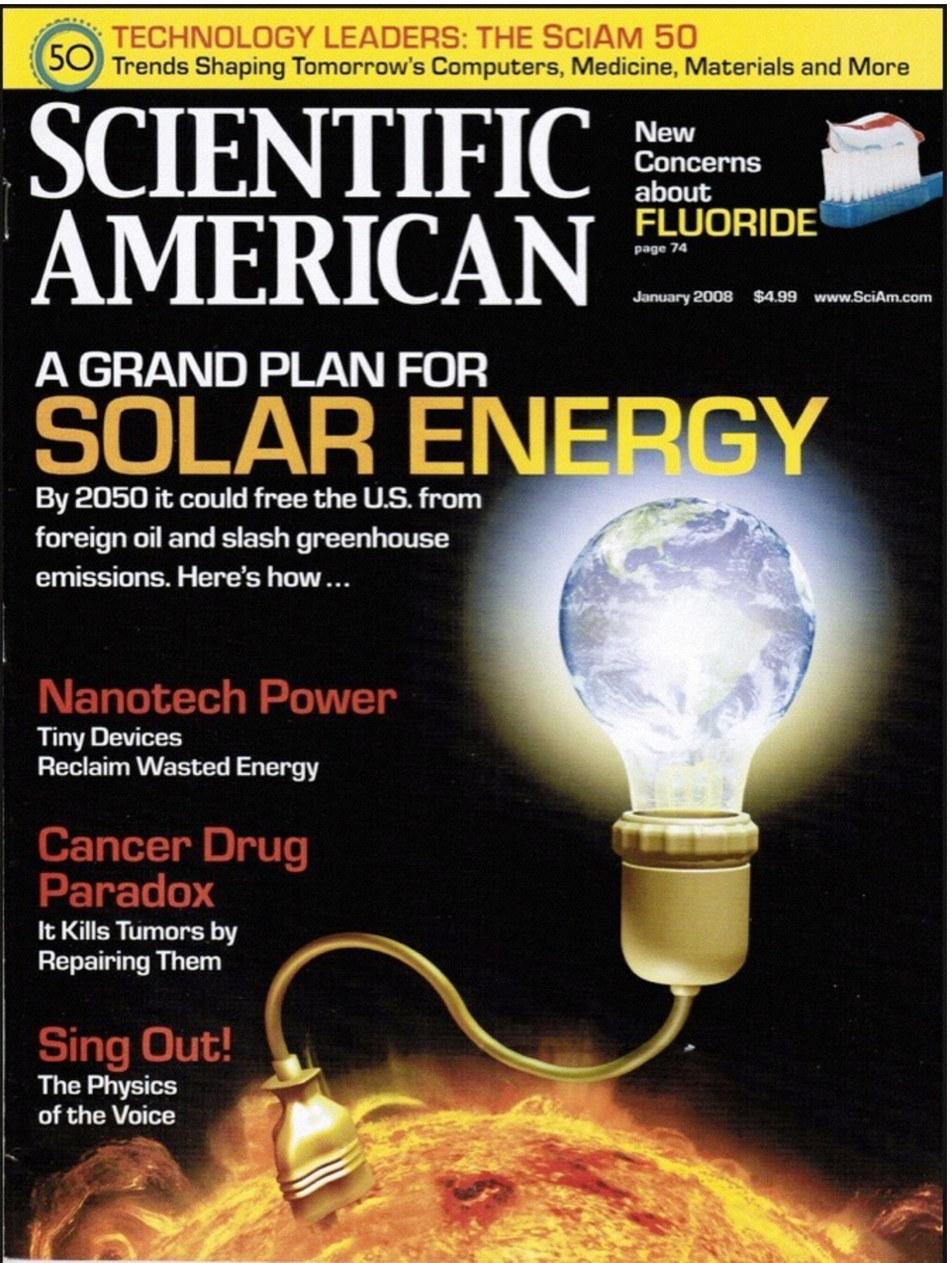
More with less — Buildings can be net zero energy

More with less — Buildings can be net zero energy

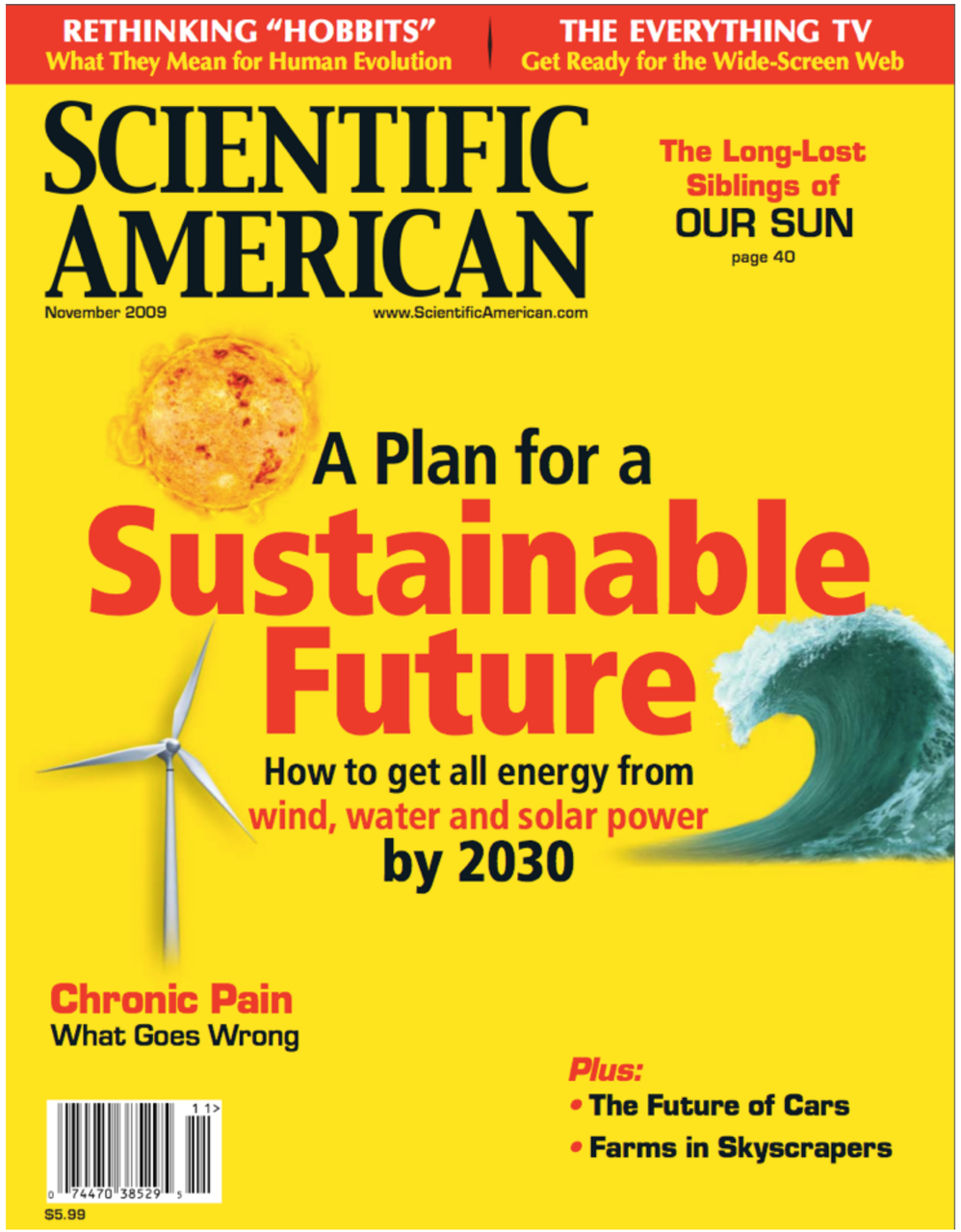
More with less — You can get water out of thin air

More with less — You can get water out of thin air

More with less — We can reach 100% solar quickly

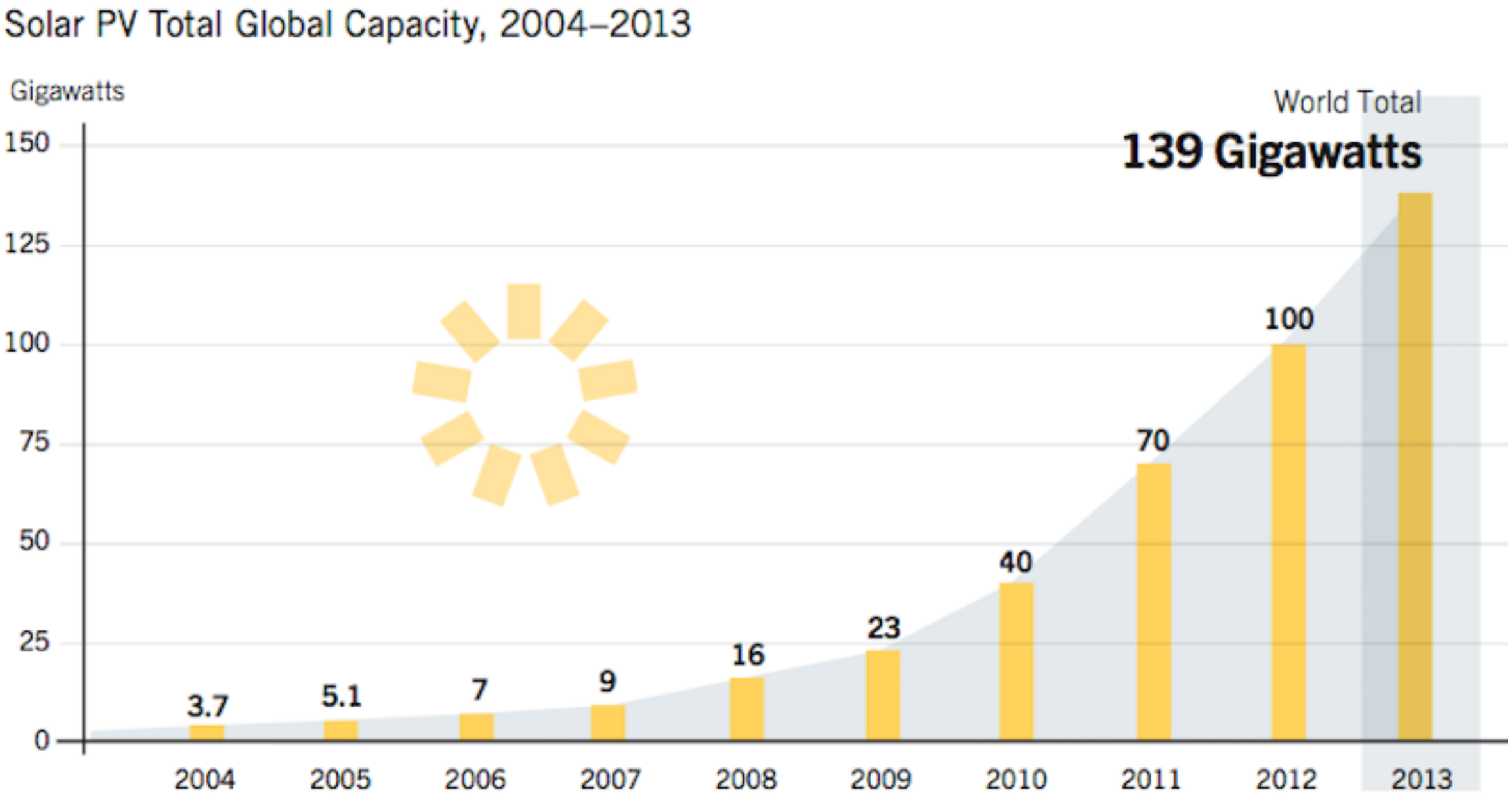


2008 for 2050



2009 for 2030

More with less — We can reach 100% solar quickly



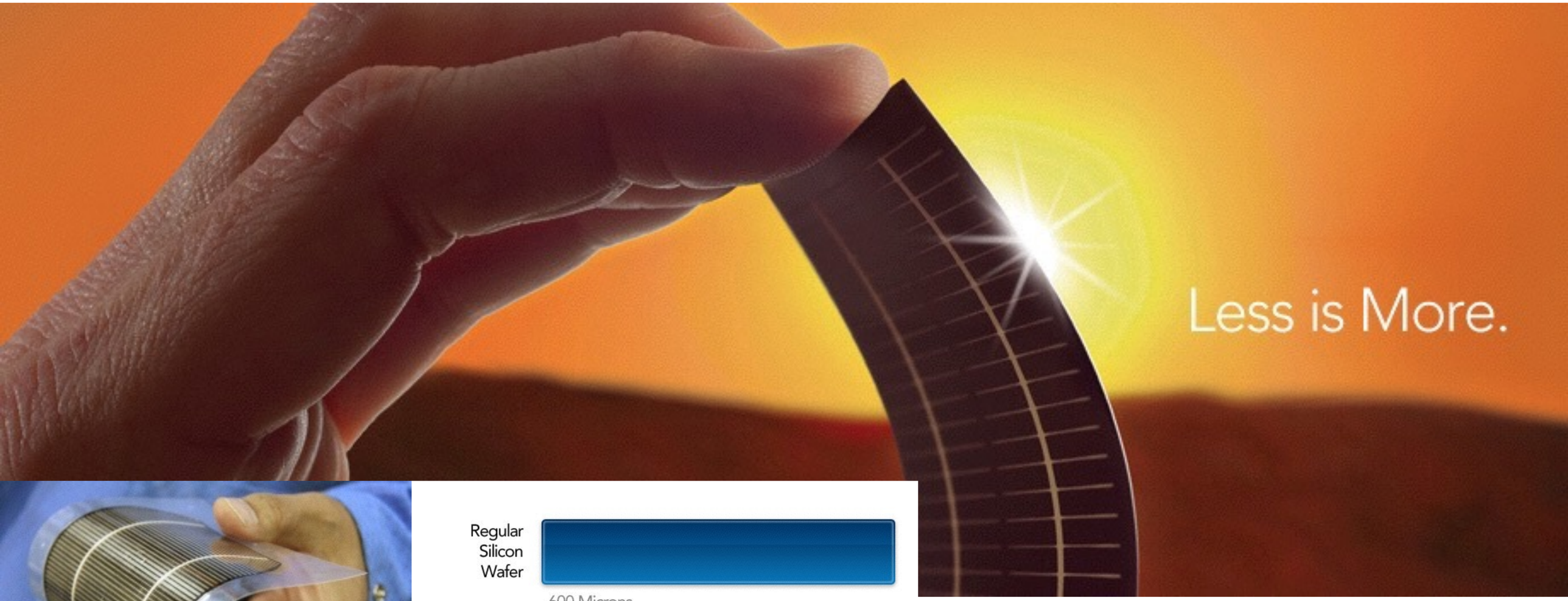
More with less — We can reach 100% solar quickly

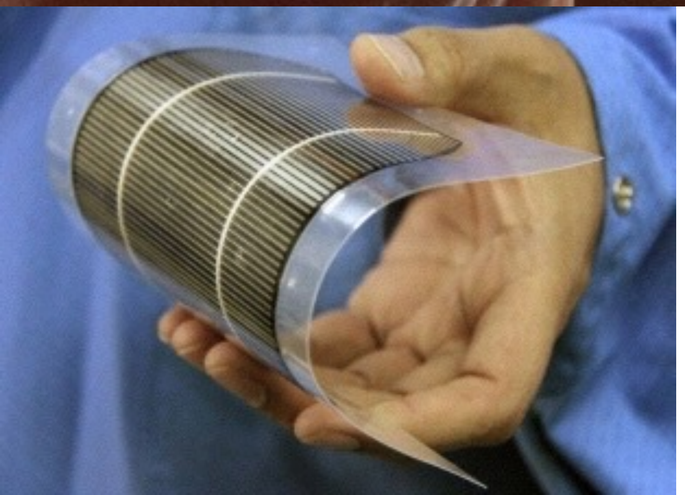
More with less — We can reach 100% solar quickly

More with less — We can reach 100% solar quickly

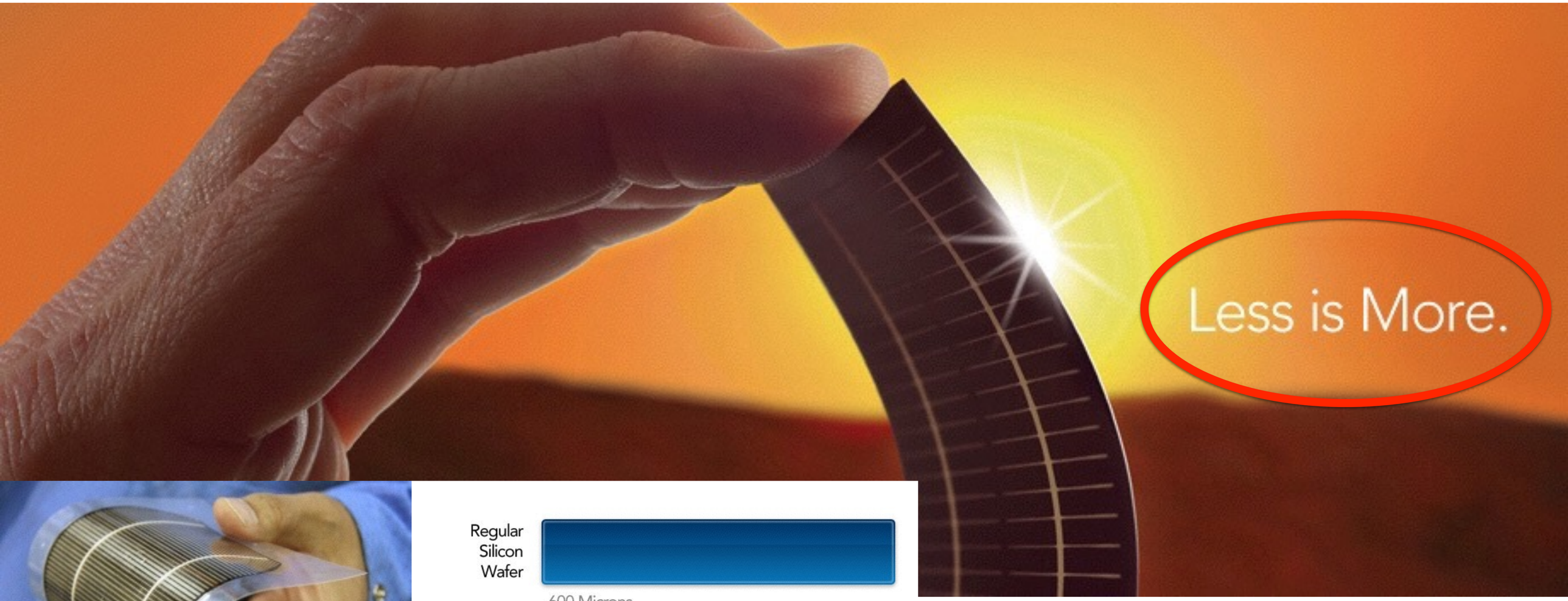
More with less — We can reach 100% solar quickly

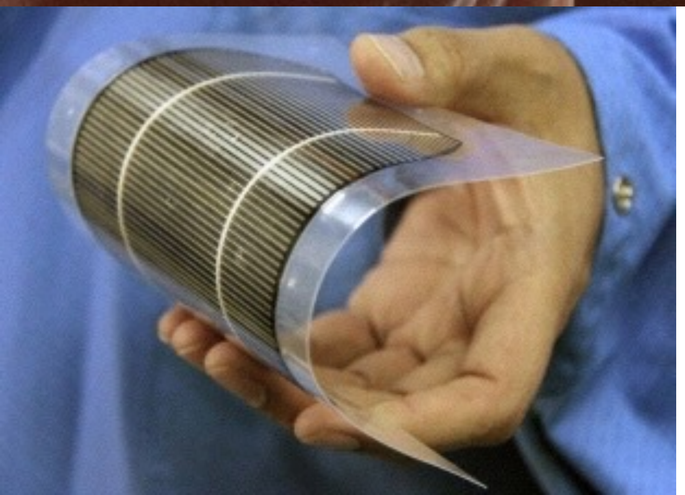
More with less — Solar cells keep getting thinner





More with less — Solar cells keep getting thinner





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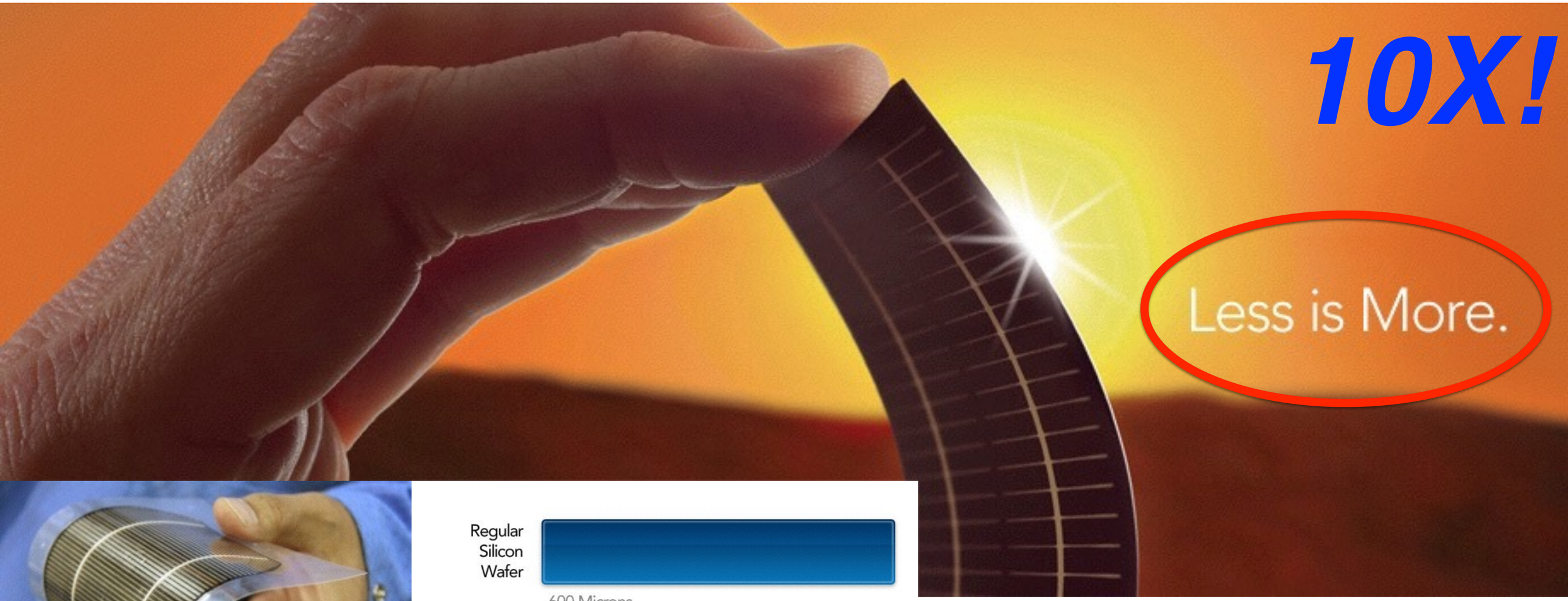
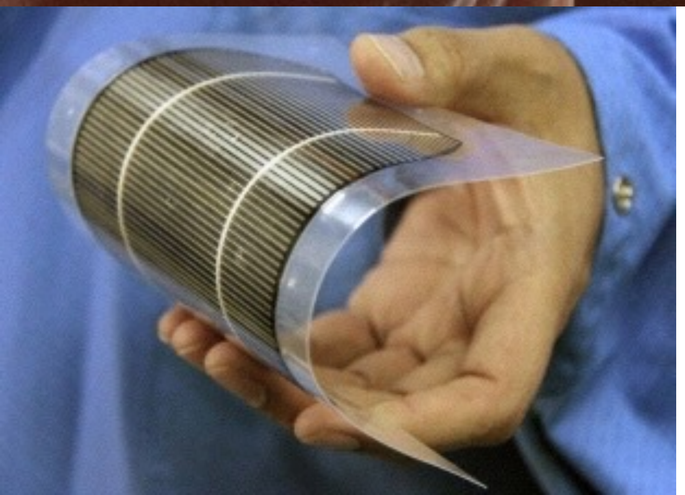
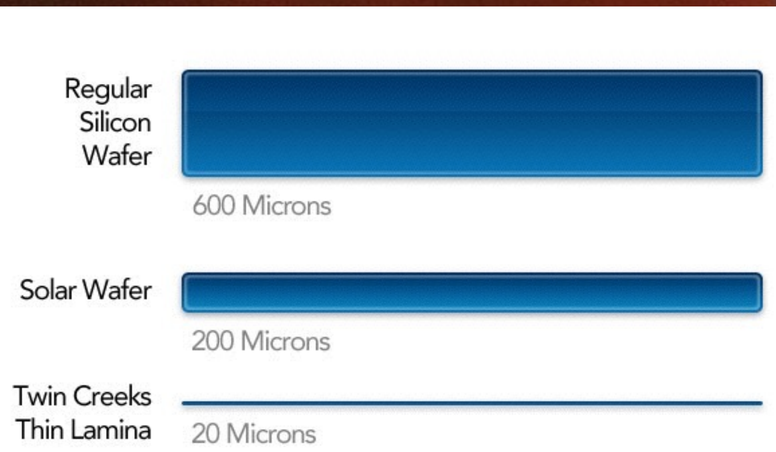
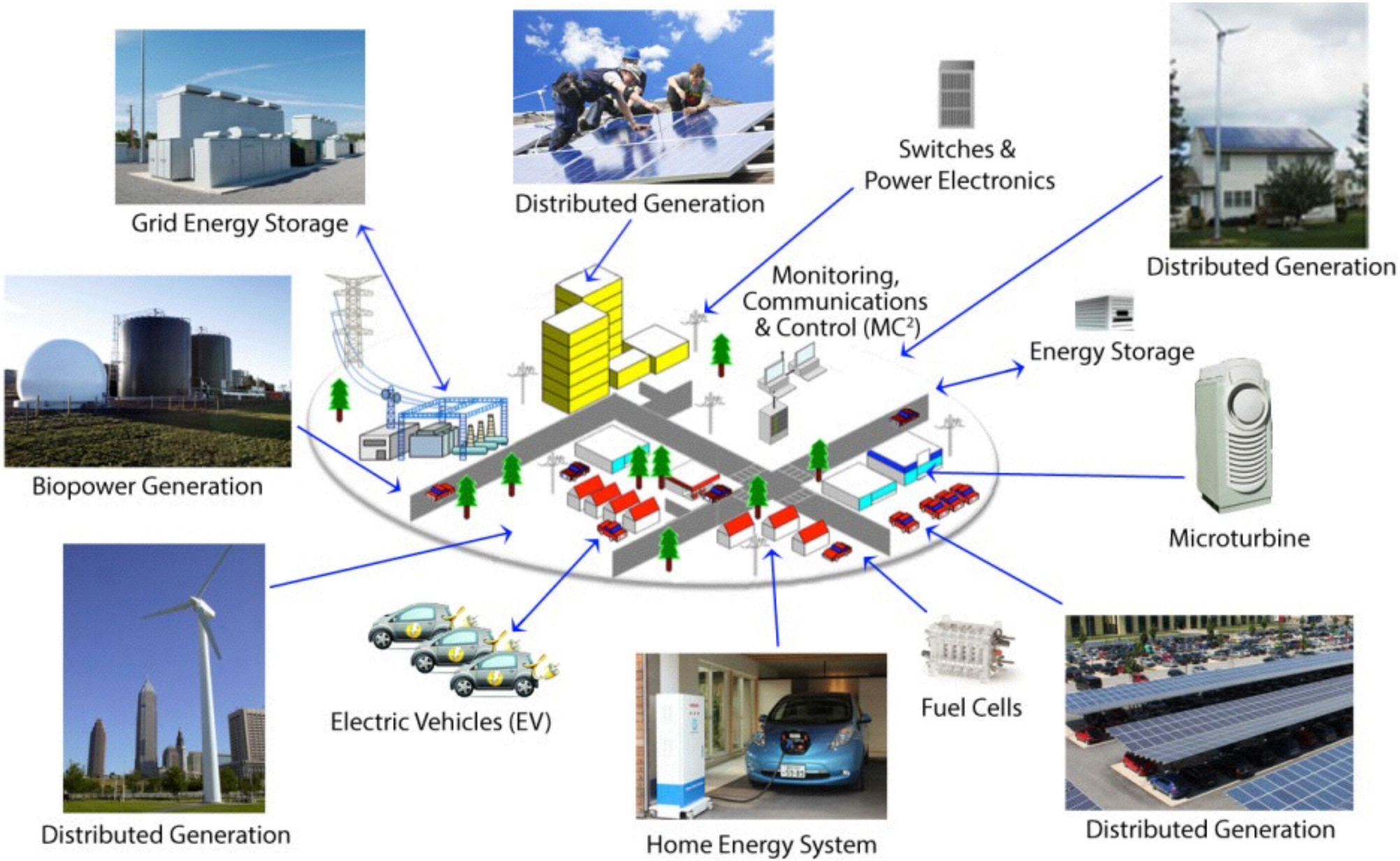


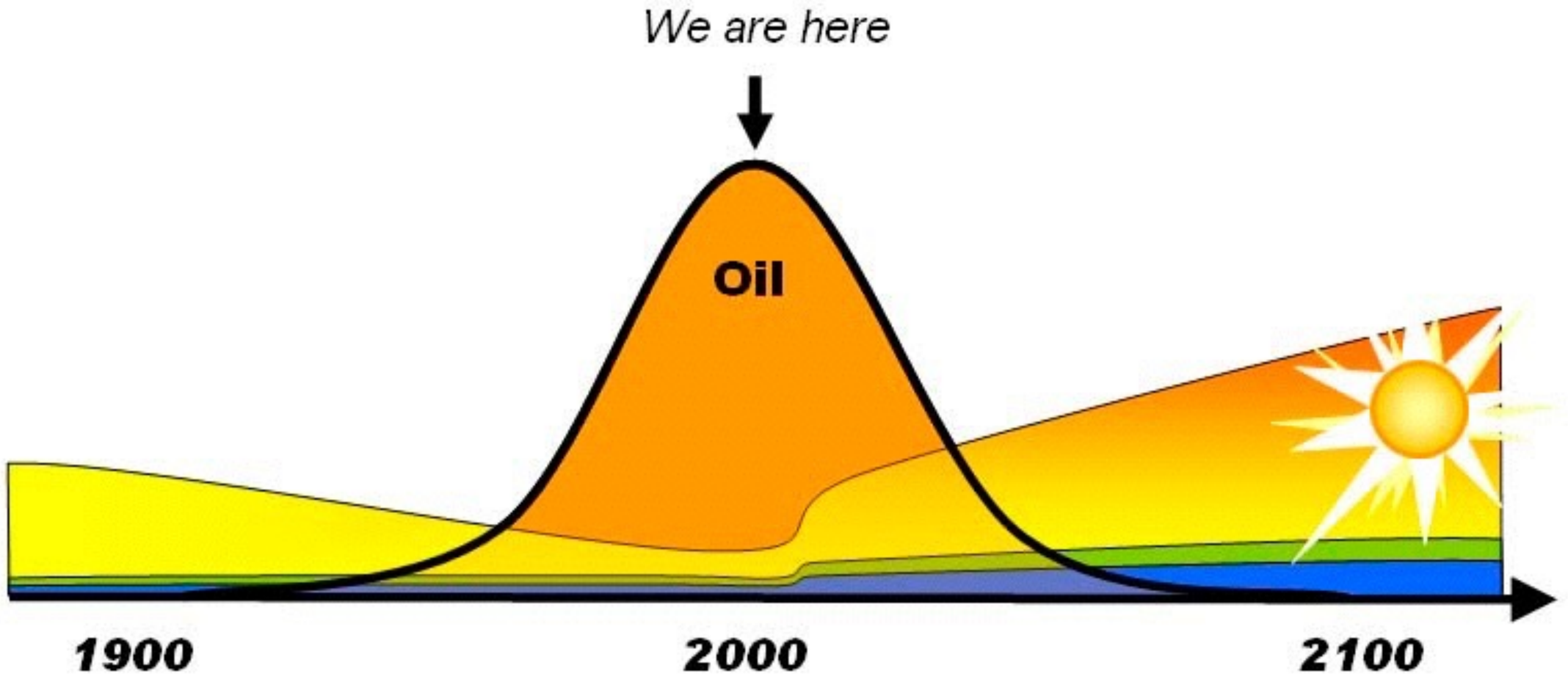




More with less — And we can manage intermittency



Wake up!!!



...to the power of Solar

In conclusion…

Crisis: Humanity is in the midst of an existential crisis. What is humanity's future?

Newsweek

TECH & SCIENCE

WE'RE RUNNING OUT OF WATER, AND CONSEQUENCES COULD BE DIRE

BY NATHAN HALVERSON ON 4/13/16 AT 11:01 AM

Woman wait to collect water in the drought stricken Somali region in Ethiopia, January 26. The drought relief effort in Ethiopia needs about $500 million to fund programs beyond the end of April to support 10.2 million people facing critical food shortages this year.

TIKSA NEGERI/REUTERS

Challenge: We can design and roll out systems that do *way* more with *way* less, *right now!*

Challenge: We can design and roll out systems that do *way* more with *way* less, *right now!*

Promise: Recent innovations show great promise and are finally getting real political support.

رؤيـــة VISION
2030
المملكة العربية السعودية
KINGDOM OF SAUDI ARABIA

Saudi unveils far-reaching plan to move away from oil

China proposes $50tn global renewable energy network

Published time: 1 Apr, 2016 14:34

A worker inspects solar panels at a solar farm in Dunhuang, 950km (590 miles) northwest of Lanzhou, Gansu Province. © Carlos Barria / Reuters

Grandpa has the final word

Grandpa has the final word

You got to stick to one t’ing and den drive it hard!

May the 4th be with you!

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