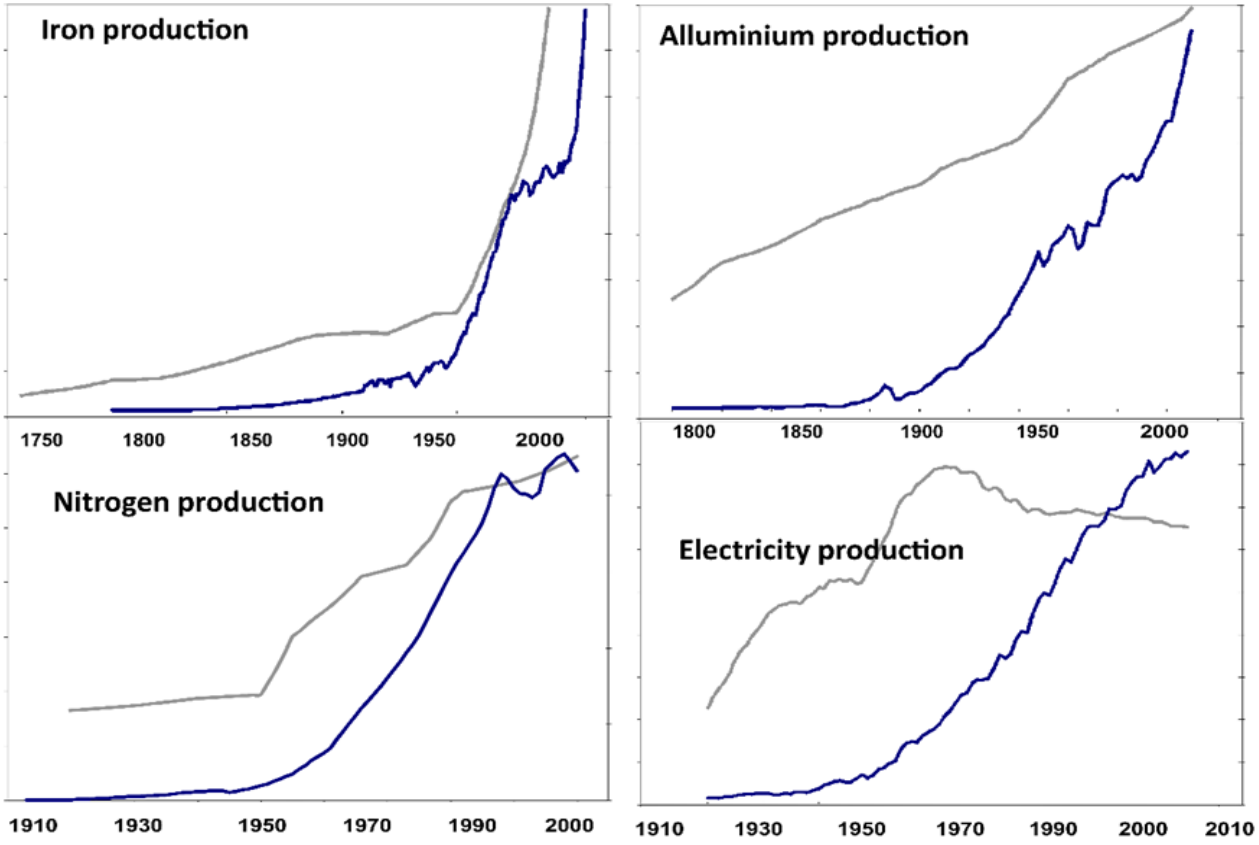
Rebound effect, should we care?

Franco Ruzzenenti

The rebound effect according to Garfield

A new efficient technology leads to more than expected energy consumption because of behavioural or structural changes

Evidence?



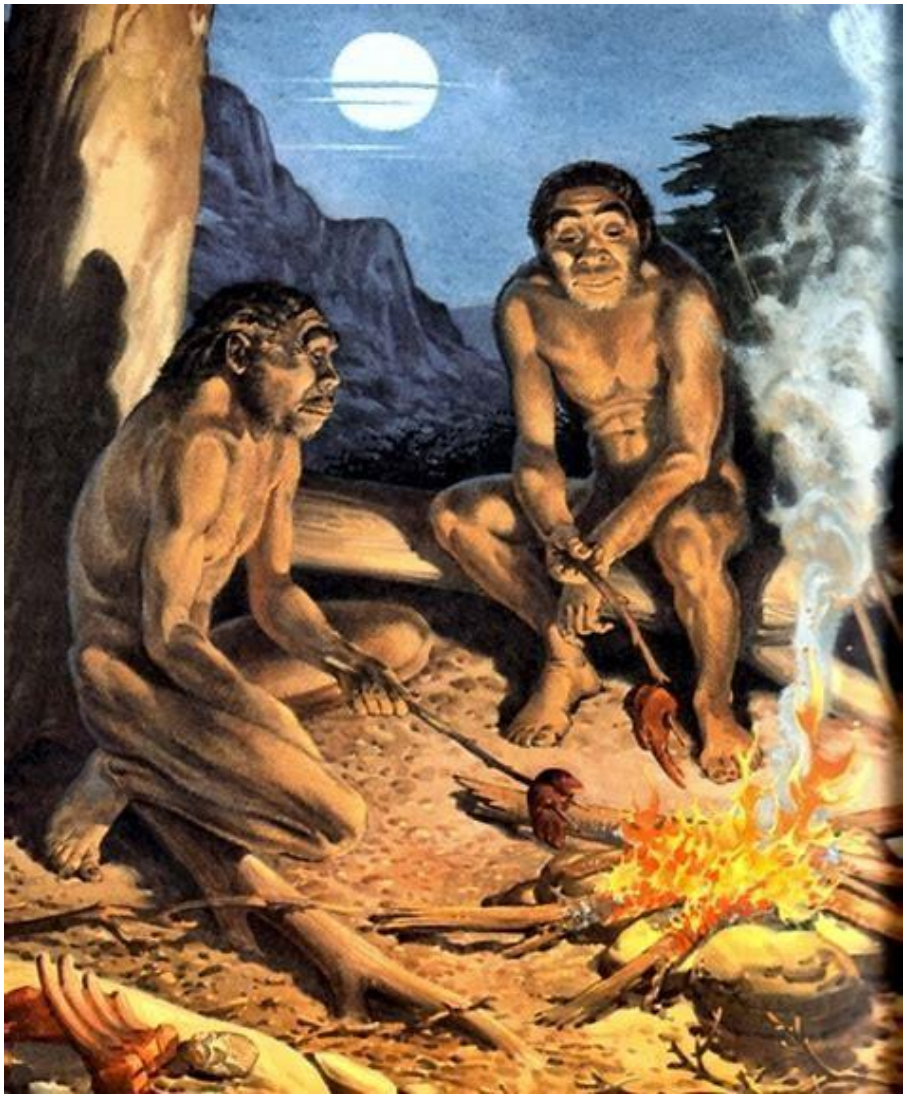
Blue= efficiency

Grey= energy use

Source: Dahmus, J.B., 2014. Can efficiency improvements reduce resource consumption?. Journal of Industrial Ecology, 18(6), pp.883-897.

combustion

For millennia mankind used combustion for heating, cooking and lighting until the invention of the steam engine, when, for the first time **combustion was employed to deliver mechanical work**…then everything changed. Still now combustion is the source now most of mechanical work.

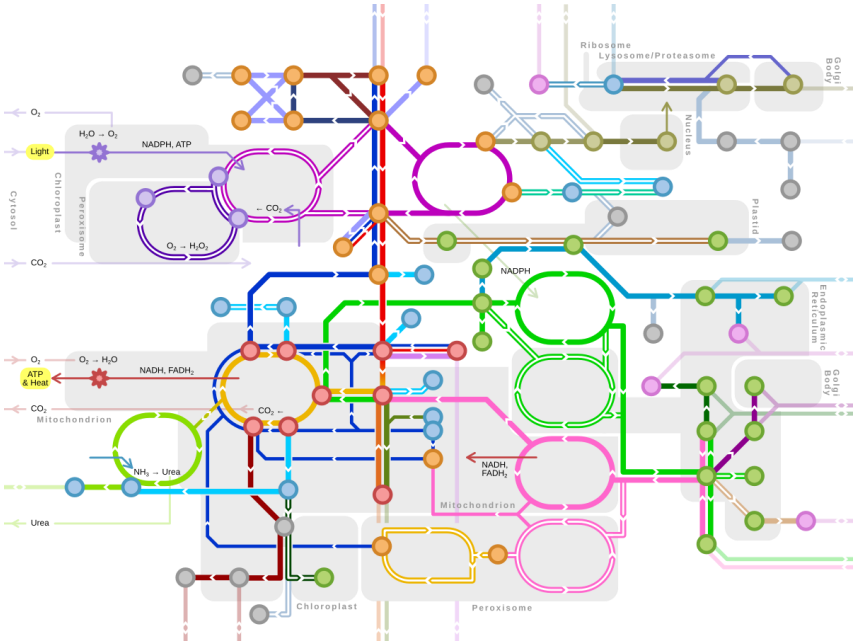


$$C_nH_m + N_2 + O_2 = CO_2 + (NO_x) + H_2O$$

STOICHIOMETRY OF COMBUSTION & CELL RESPIRATION IS (ALMOST) THE SAME

More power! (same efficiency 40%)

Faster speed: Complex metabolic pathway vs explosive reaction



Bigger scale: ~10^21

Lotka's maximum power principle

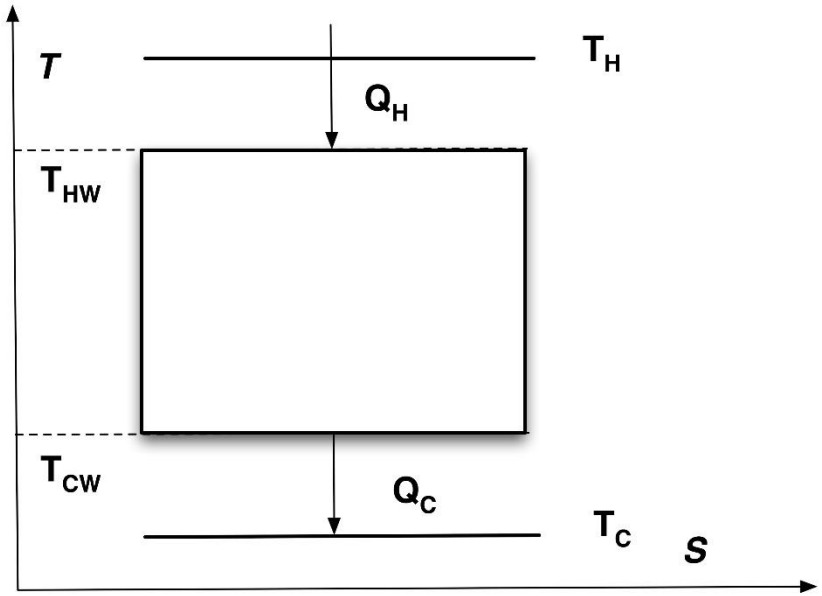
› "This at least seems probable, that so long as there is **abundant surplus of available energy** running "to waste" over the sides of the mill wheel, so to speak, so long will a marked advantage be gained by any species that may develop talents to **utilize this "lost portion of the stream**". Such a species will therefore, other things equal, **tend to grow in extent (numbers) and its growth will further increase the flux of energy through the system**." (Lotka, 1924)

Lotka's principle

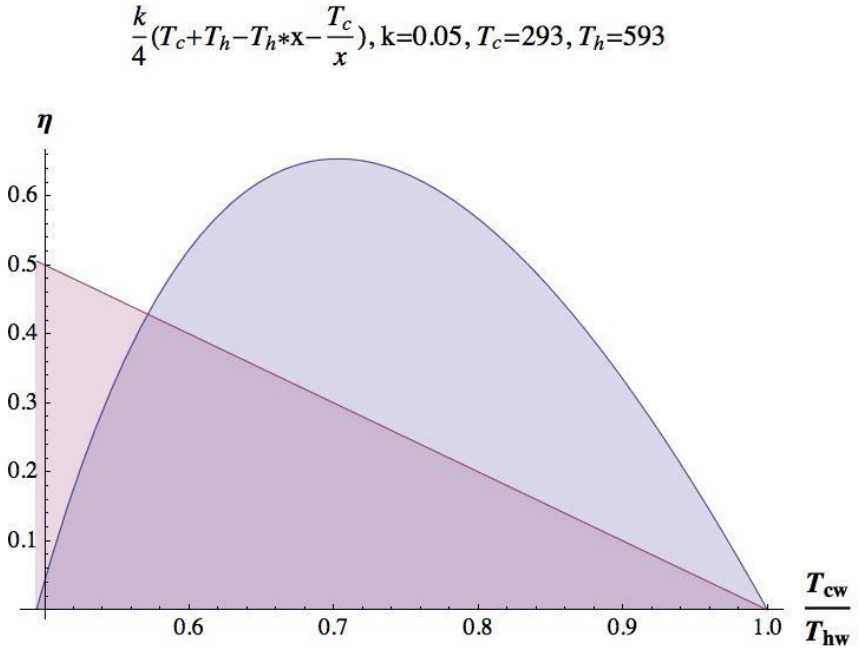
- Abundant energy: *maximize power*
- Scarce energy: *maximize efficiency*
- *Law of evolution: higer energy density rate (more complexity)*
- Abundant and scarce with what respect?

Finite-time thermodynamics

Temperature of the working fluid

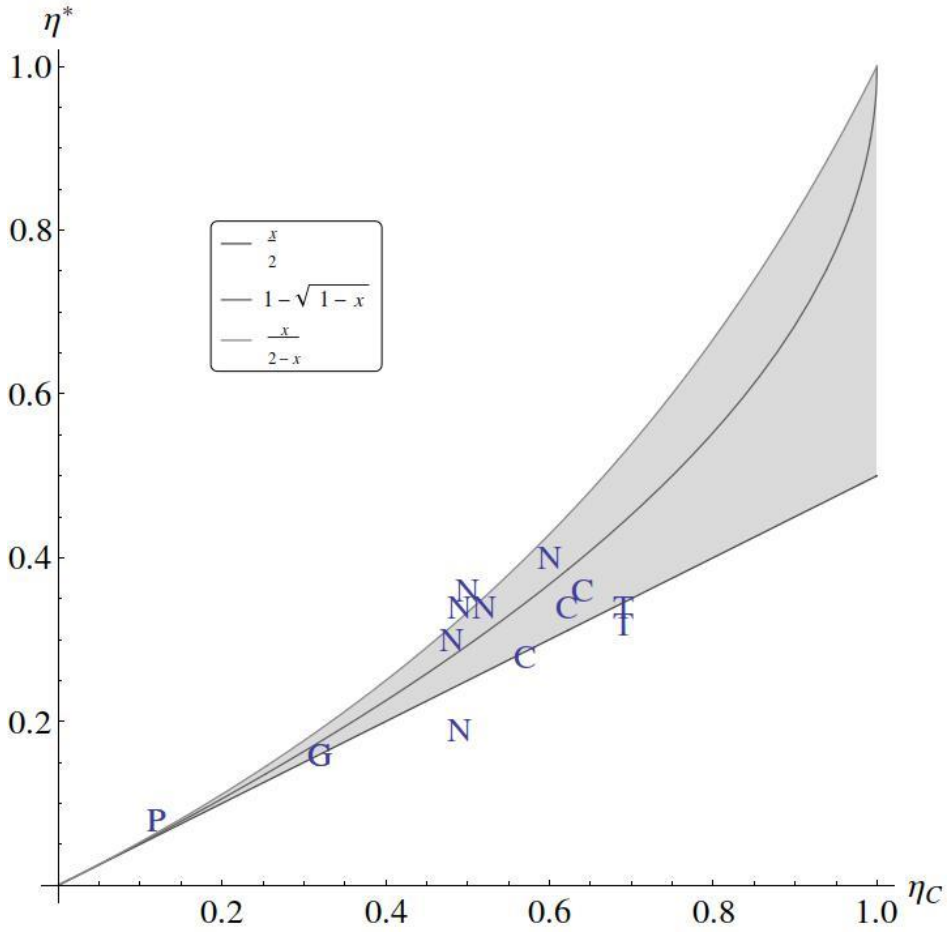


Efficiency at maximum power output



Curzon & Ahlborn, 1974

Evidence!



Ruzzenenti, Franco. "Hierarchies, Power and the Problem of Governing Complex Systems." In Complex Systems and Social Practices in Energy Transitions, pp.

Maximum power output

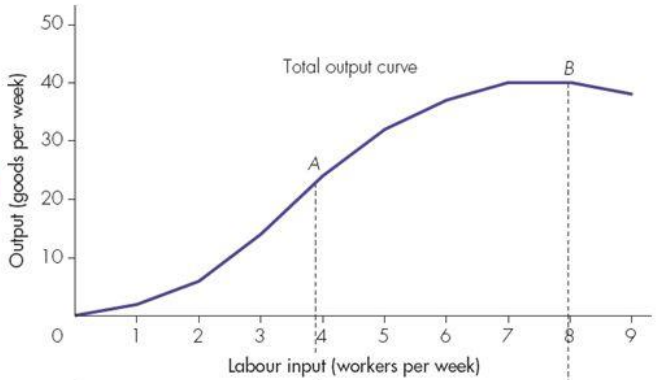
› "However, when the **cost of building an engine is much greater than the cost of fuel** (as is often the case), it is desirable to optimize the engine for maximum power output, not maximum efficiency "

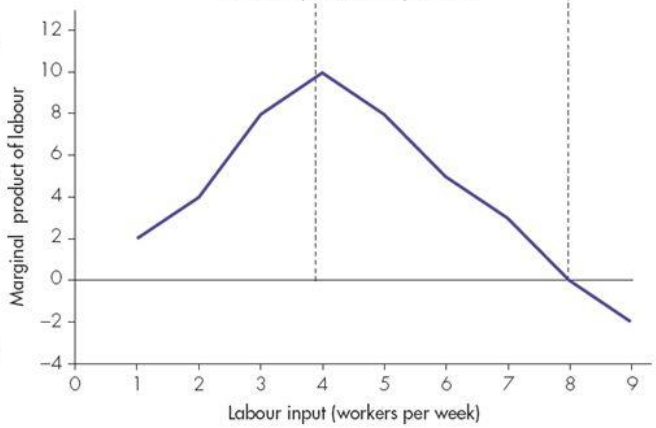
› Schroeder D., 2000. Thermal Physics, an introduction to. Addison Wesley Longman.

Capital is fixed, labour not (energy)

The law of diminishing marginal returns (cont.)

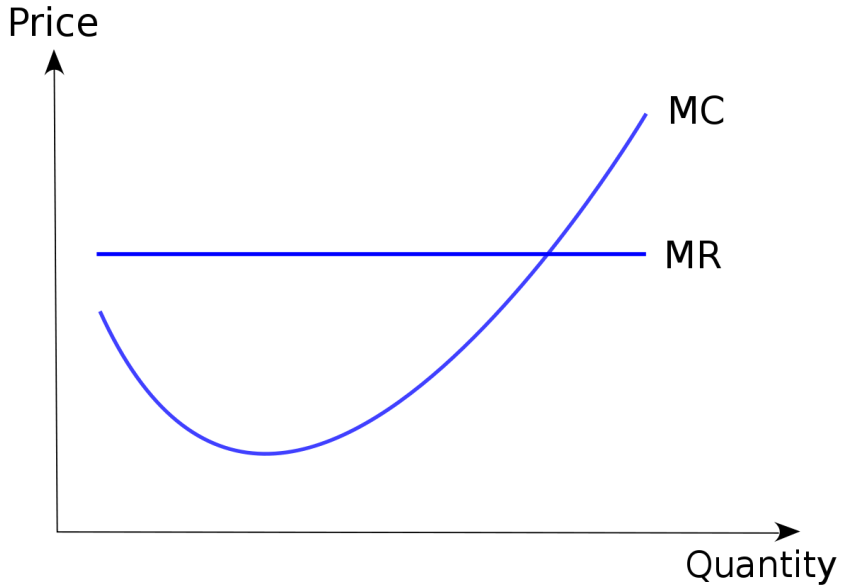
- The efficiency of the workers starts to decrease because, in the short run, the level of capital (the other input of production) is fixed and cannot be changed.
- e.g. the factory has 4 machines and there are 4 workers



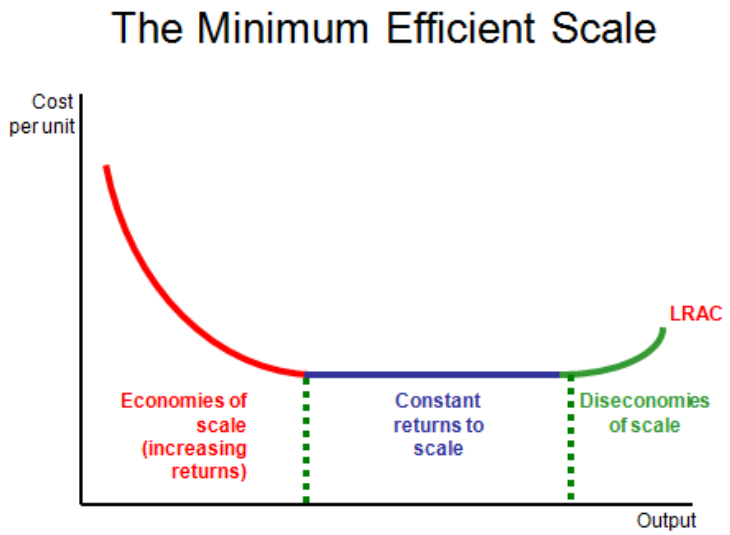


Increasing marginal returns

When marginal returns are decreasing there is optimal (efficient) level



When marginal returns are increasing, the more is the better (no efficiency)

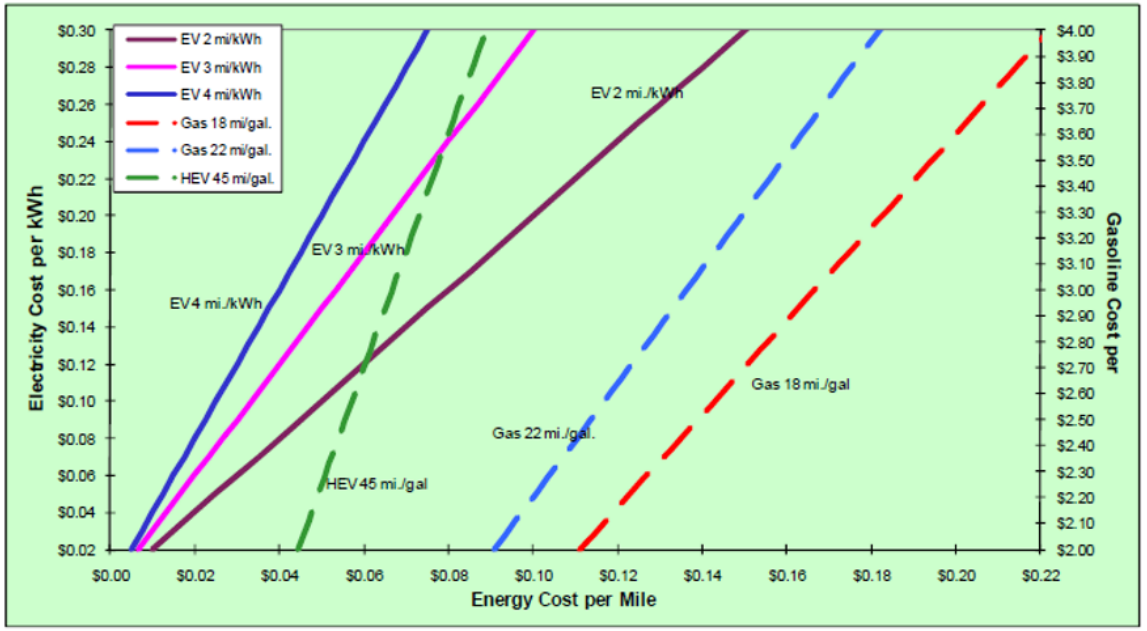


Variable cost are negligible or positive!

- Capital intensive: Petroleum industry or nuclear power
- Waste disposal (incinerators):waste is revenue
- Electric vehicles!

Even in U.S.A., what about EU?

A 2018 study from the University of Michigan's Transportation Research Institute found that **electric vehicles cost less than half as much to operate as gas-powered cars**. The average cost to operate an EV in the United States is $485 per year, while the average for a gasoline-powered vehicle is $1,117



Advanced Vehicle Testing Activity — Idaho National Laboratory

Comparing Energy Costs per Mile for Electric and Gasoline-Fueled Vehicles

EV envisaged rebound effect

- The average price of new passenger cars in Europe (EU-28) in 2017 was approximately 29K$.
- Average cost EV in USA (2016): 50K$ vs an average price of gasoline cars of 25K$

- In 2016 in USA EV were:
- Twice more expensive in capital costs
- Half cheaper in operating (variable) costs
- Economy of scale!

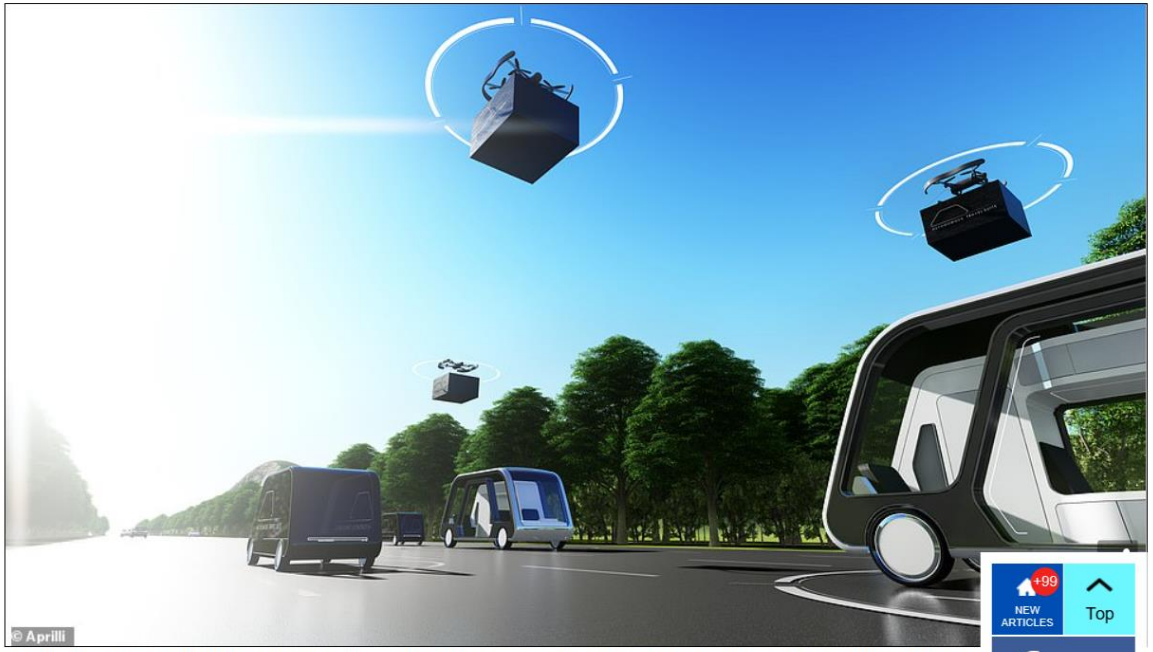
EV envisaged rebound effect 2

- Lotka's law: energy will become abundant!
- Green paradox: moral licensing
- Self-driving cars: relaxed biological limits
- Structural change: from urban sprawl to urban mergence
- Structural change 2: car will become a living space (office, motels, etc.)

"The robotic hotel room on wheels - is this the future of travel"

- Will the 40 minutes communting distance law hold true in the future?
- 1.30 minutes is about 20% of free time of a day (8-8-8)
- from Egyptians until the "green revolution", 20% of the populationwas urbanized (80% pesants)

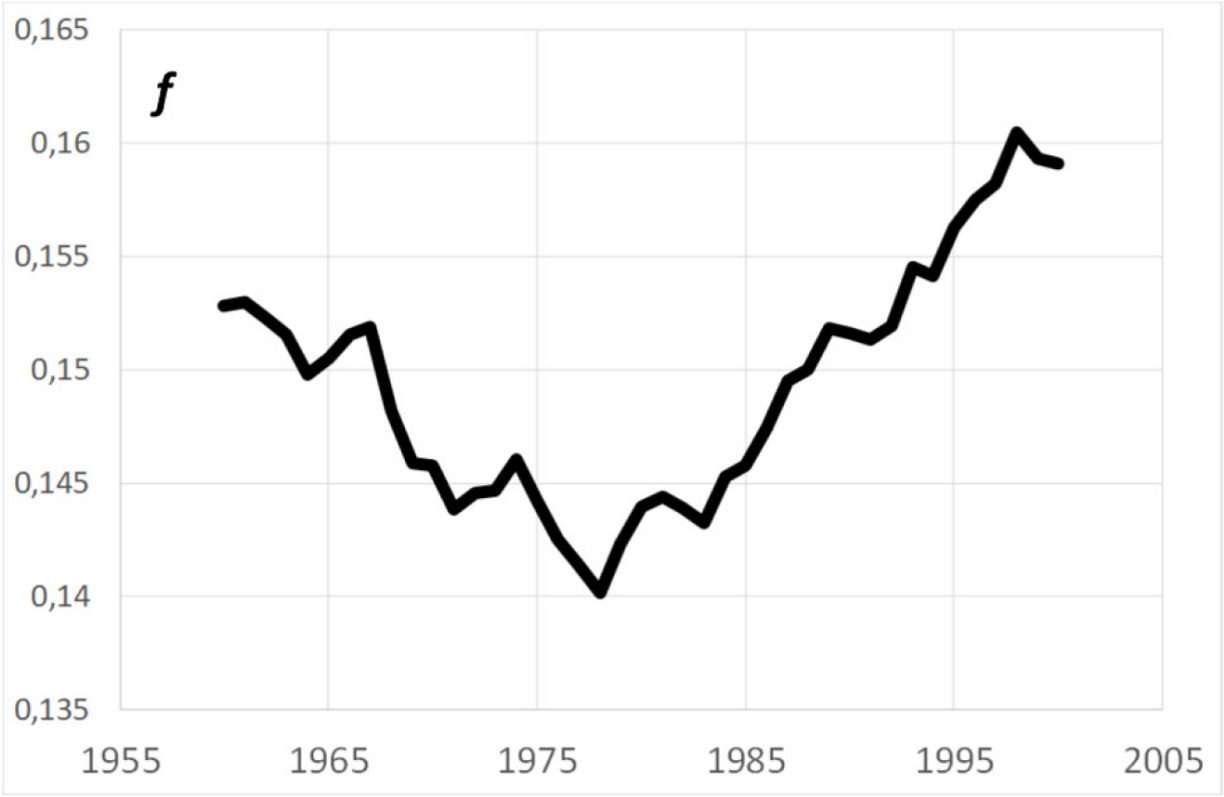
Toronto-based Aprilli Design Studio has designed a hotel suite housed within a self-driving vehicle



Renderings reveal how the battery-powered hotel-room-on-wheels includes panoramic windows, a double a shower room and a retractable roof where room service can be dropped off via drones

https://www.dailymail.co.uk/travel/travel_news/article-6409525/The-robotic-hotel-room-wh

Structurak change ***is*** symmetry breaking



Ruzzenenti F., Picciolo F., Garlaschelli D., Basosi R. (2012) Spatial effects in real networks: measures, null models, and applications.Phys. Rev. E 86

Looking for partners:

ENVISAGING THE UNINTENDED CONSEQUENCES OF SOCIO-TECHNICAL INNOVATIONS IN THE TRANSPORT SECTOR

What are the most promising social innovations in the transport? (urban context, developin and emerging countires)

Past analysis + future visions

Electro mobility + automatation (self-driving casr)

Unintended consequence

Multi Level Perspective and Network Theory