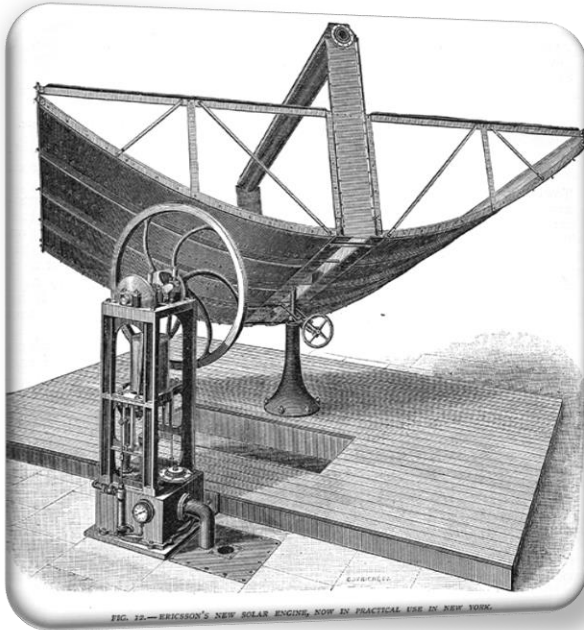


# Quo vadis?

## Att tänka om framtiden

Björn Sandén  
Chalmers



“... the gradual exhaustion of the coal fields will inevitably cause great changes in regard to international relations, in favour of those countries which are in possession of continuous sun power”

“The time will come when Europe must stop her mills for want of coal. Upper Egypt, then, with her never ceasing sun power, will invite the European manufacturer to remove his machinery and erect his mills on the firm ground along the side of the alluvial plain of the Nile, where sufficient power can be obtained to enable him to run more spindles than a hundred Manchesters.”

John Ericsson, Engineering 13 October, 1870



2

lärdomar

Historia



Vart är vi på väg,  
**till** något eller **från** något?

1

Attraktorer

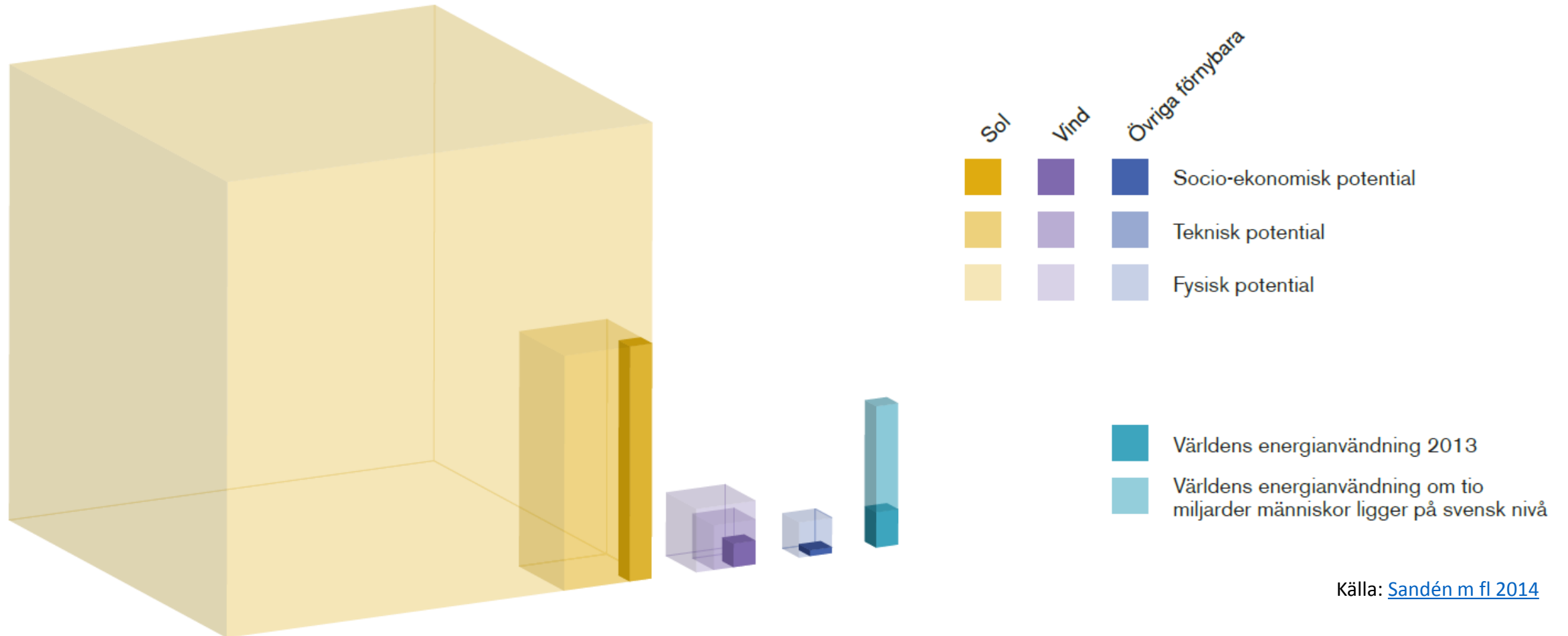




**5 000 gånger mer solenergi per år  
än världens användning av fossila bränslen**



# Den "socioekonomiska" potentialen kan vara 10 ggr större än dagens energianvändning

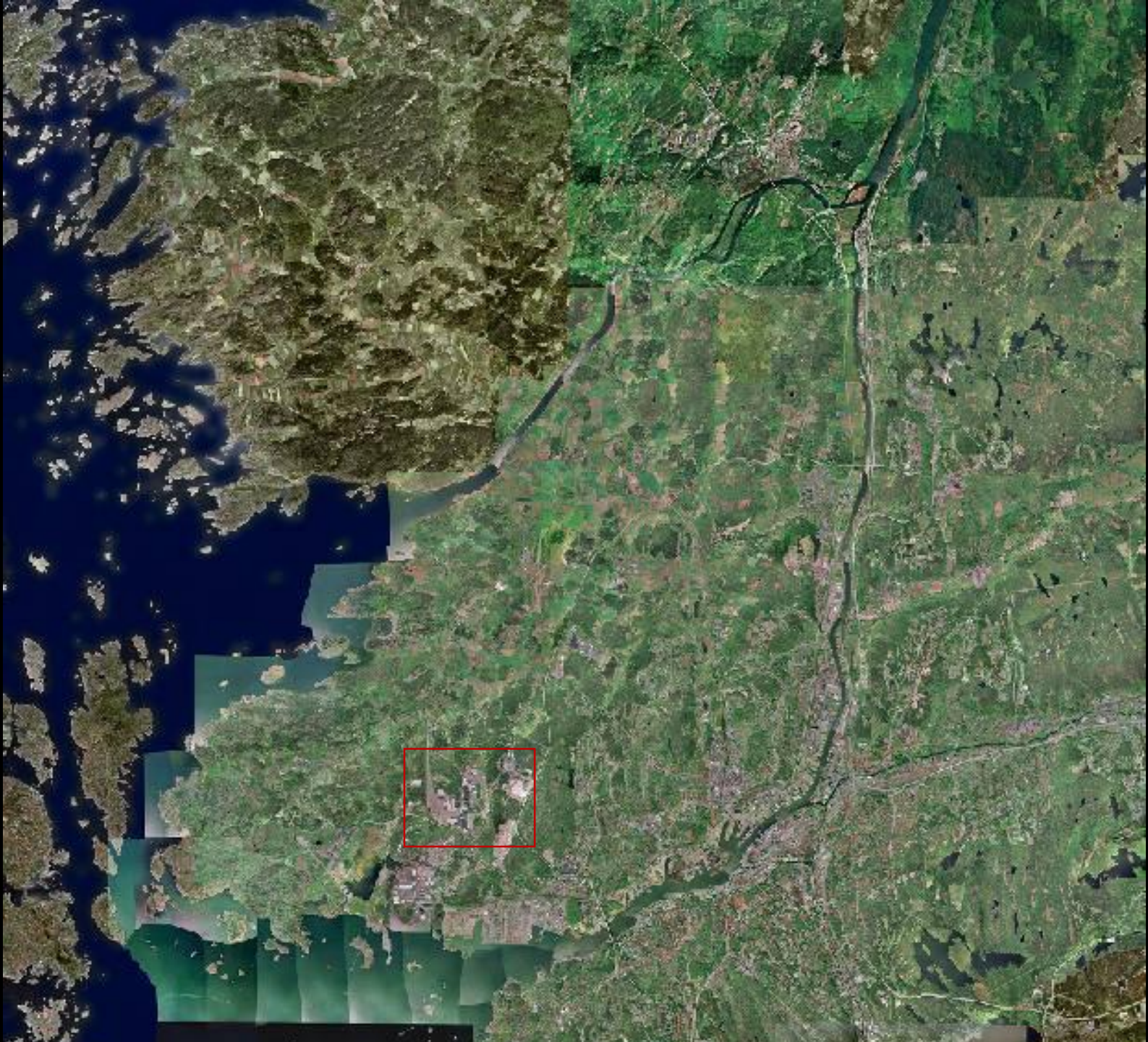


# Ytbehov för 60 000 bilar på Hisingen

1:a generationens biodrivmedel

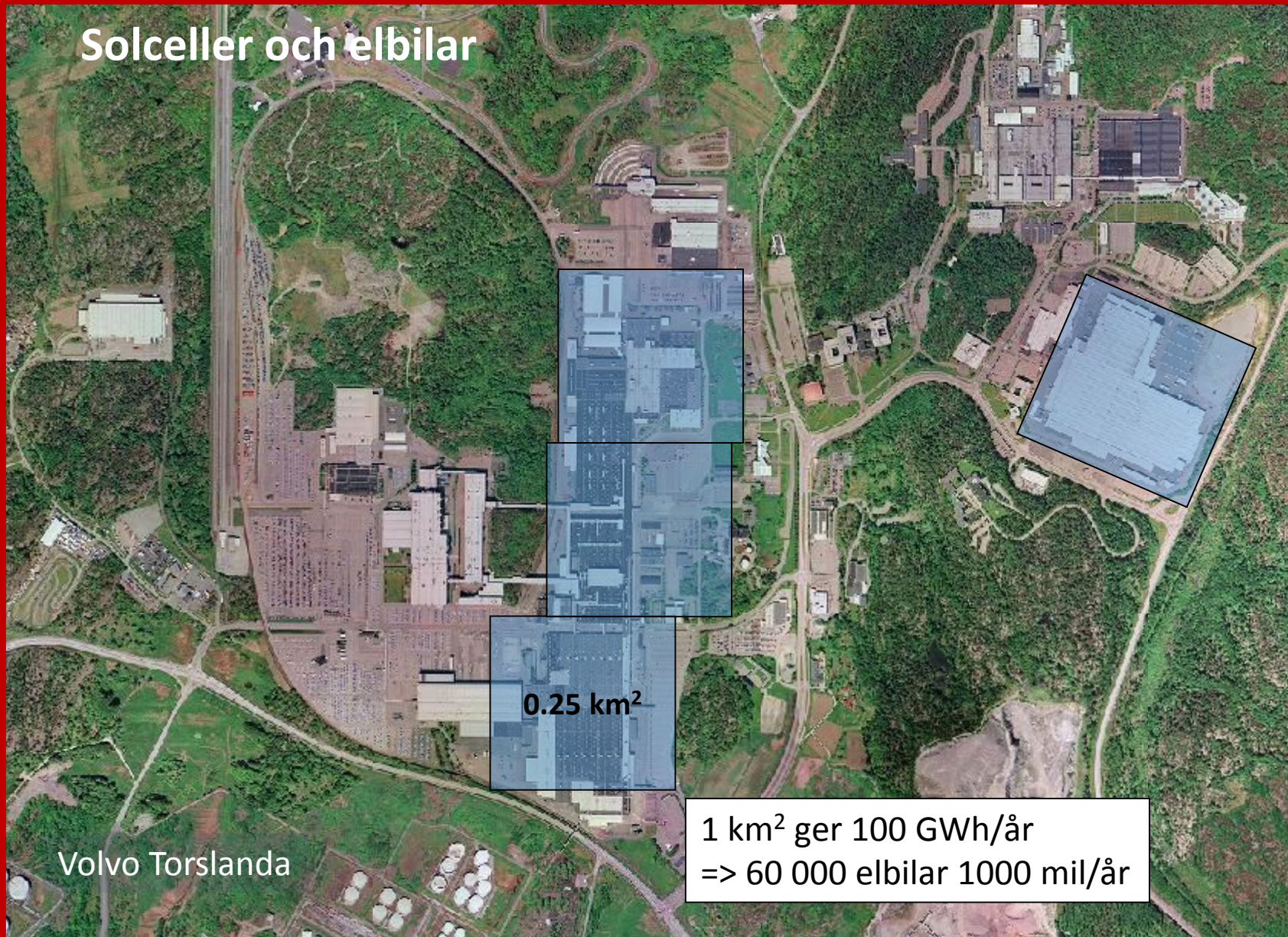
2:a generationen







## Solceller och elbilar



0.25 km<sup>2</sup>

1 km<sup>2</sup> ger 100 GWh/år  
=> 60 000 elbilar 1000 mil/år

Volvo Torssländan

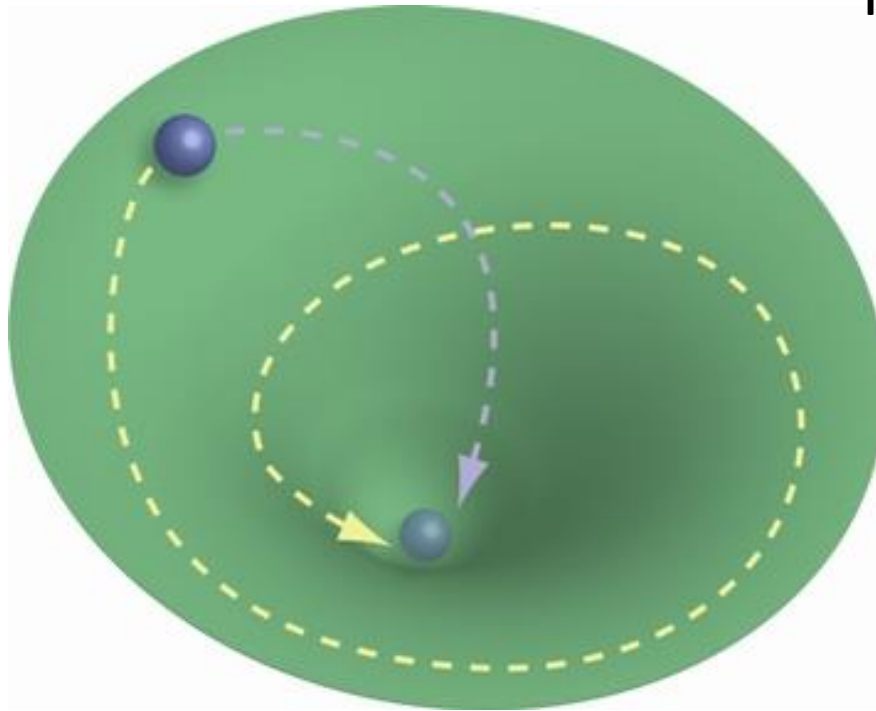
Solceller och  
Vätgas

Volvo Torslanda

0.25 km<sup>2</sup>



# Attraktor



Mot effektivare användning av **energiressursen**

**Och andra resurser?**

Människor (arbetstid)

Material

**Inte bara statisk effektivitet**

Resiliens

# Jordbruksrevolutionen

Jord- och skogsbruk  
Medelgod ytverkningsgrad  
( $<1 \text{ kWh/m}^2\text{yr}$ )



Samlare och jägare  
( $<0.01 \text{ kWh/m}^2\text{yr}$ )



# Den industriella revolutionens två akter

Energi, material och kunskap

Jord- och skogsbruk  
Medelgod ytverkningsgrad  
( $<1 \text{ kWh/m}^2\text{yr}$ )



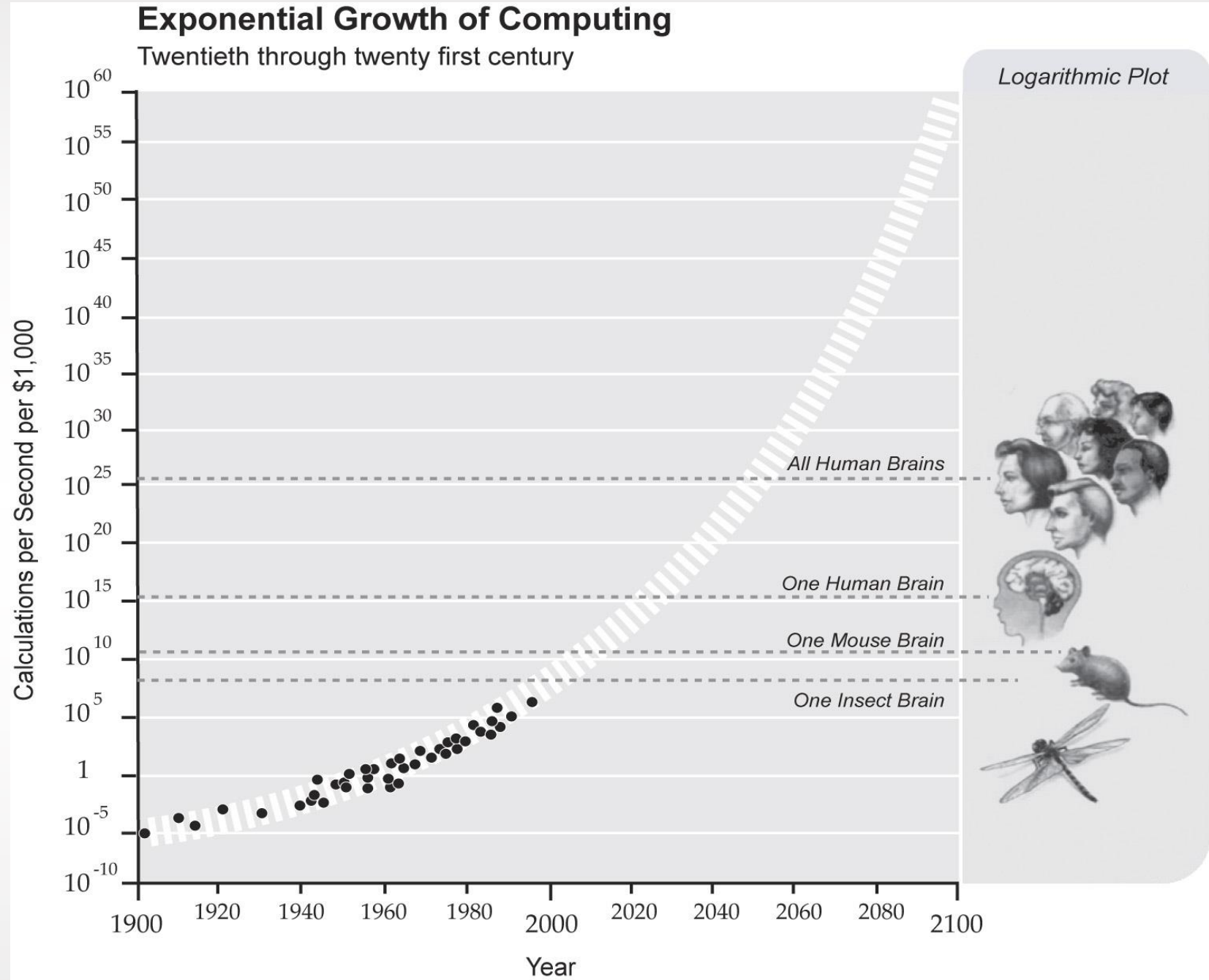
Fossila bränslen



Solbruk  
Hög ytverkningsgrad  
( $>100 \text{ kWh/m}^2\text{yr}$ )



# Singulariteten...



# Men...

Utvecklingen tar fart på  
allvar mer än 100 år efter  
John Ericssons död



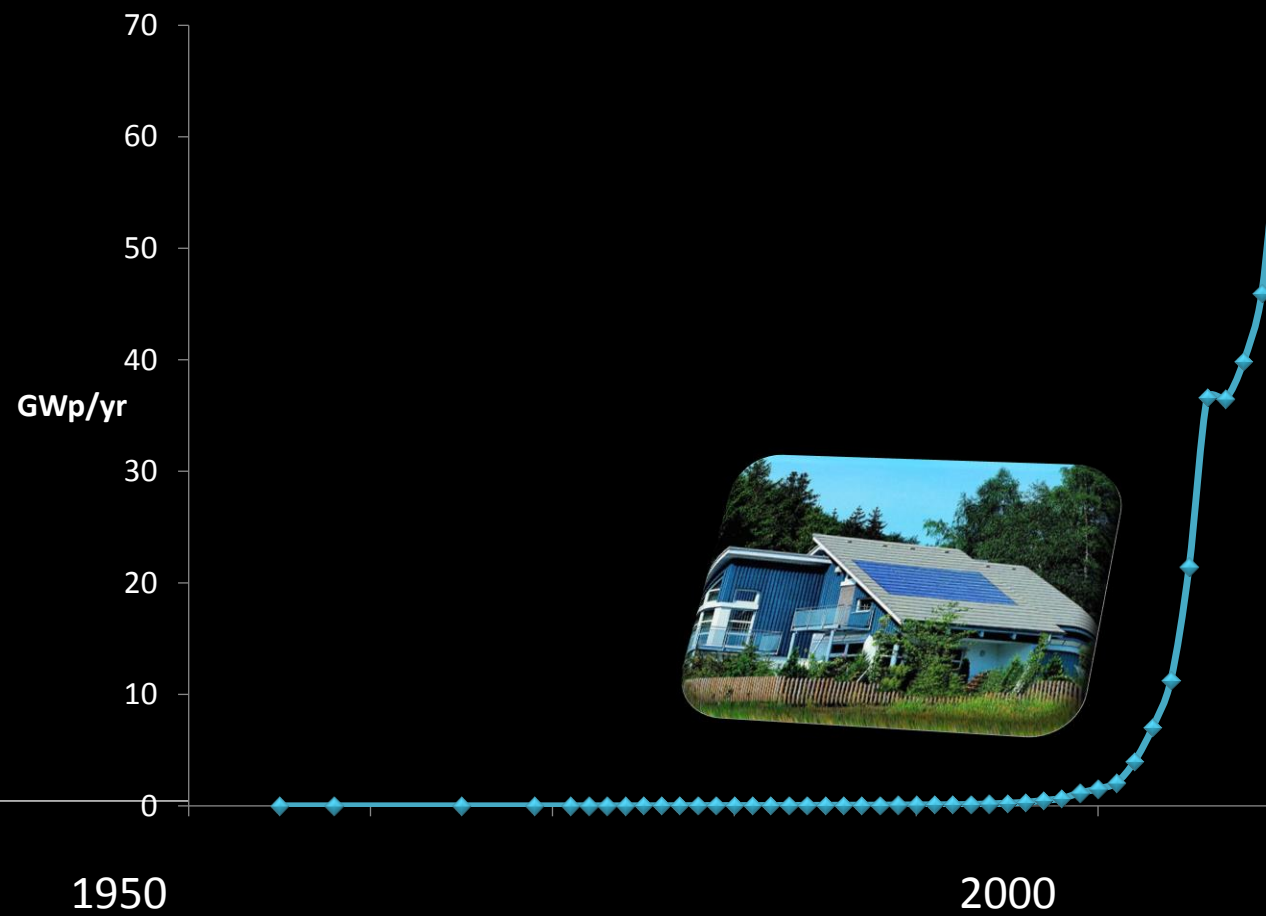
**JOHN ERICSSONS GRAV, Filipstad.** John Ericsson, propellerns uppfinnare, föddes vid Långbanshyttan nära Filipstad 1803 och avled i New York 1889. Året därpå nedsattes hans stoft

**VÄRMLAND 37**

STF



1900



2000



2

Historia



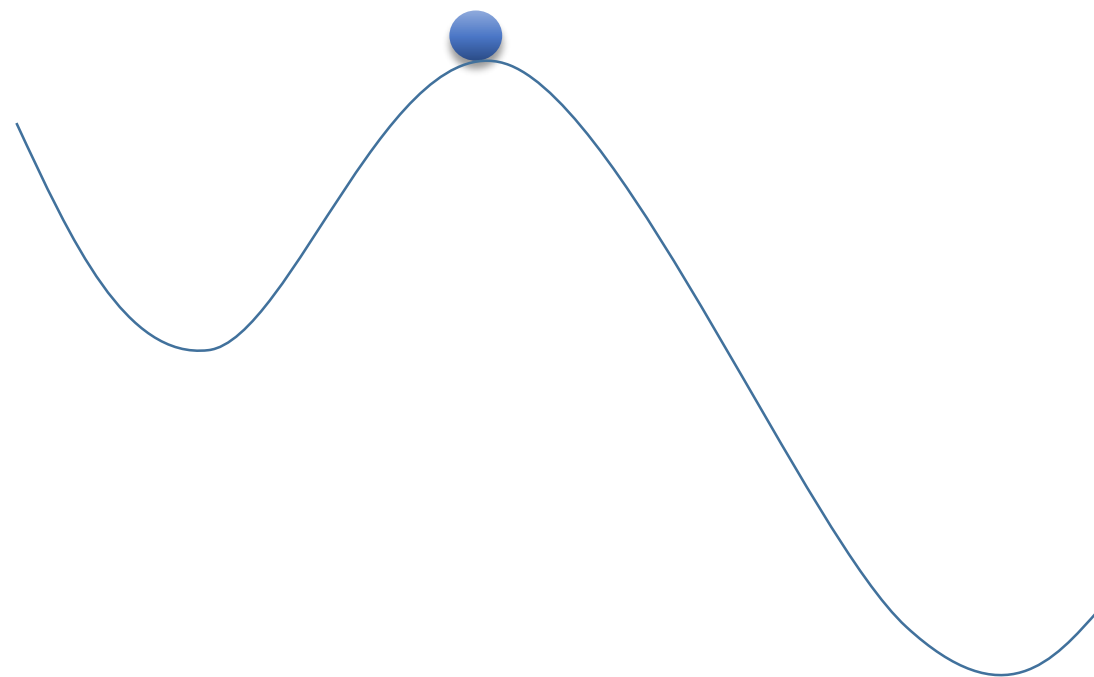
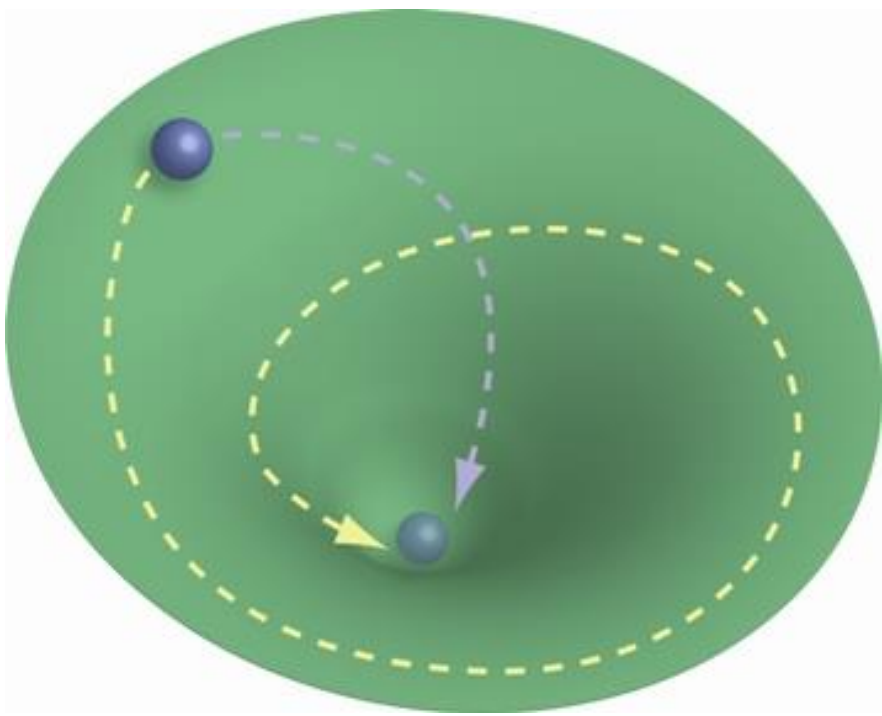
Vart är vi på väg,  
**till** något eller **från** något?

1

Attraktorer



# Teknikinlåsning



Flera attraktorer

dynamic energy of 3702 foot-pounds is transmitted by the radiant heat, per minute, for each square foot; hence 370,200 foot-pounds for an area of 10 ft. square. If we divide this sum by the adopted standard of 33,000, we ascertain that 110 square feet of surface exposed to the solar rays develop continuously 3.3 horse power during the hours a day, within the limits of latitude before mentioned. But engineers are well aware that the whole dynamic energy of heat cannot be utilized in practice by any engine or mechanical combination whatever, nor at all approached; hence I have estimated, in order not to overstate the capability of the new system, that a solar engine of 1-horse power demands the concentration of solar heat from an area of 10 foot squares. On this basis I will now proceed to show that those regions of the earth which suffer from an excess of solar heat will ultimately derive benefits resulting from an unlimited command of motive power which will, to a great extent, compensate for evils hitherto supposed not to be counterbalanced by any good. Before entering on this task of estimating the results of utilizing sun power, it will be well to ascertain, as closely as we can, the mechanical devices by means of which we propose to avail ourselves of the fuel contained in that great store-house from whence it may be obtained free of cost and transportation. The solar engine, we have seen, is composed of three distinct parts. The engine, the steam generator, and the mechanism by means of which the feeble intensity of the sun's rays is augmented to such a degree that the resulting temperature will exceed that of the lowest pressure of steam available in an efficient engine. As to the motor itself, it suffices to say, that it is essentially a modern steam engine utilizing, to the fullest extent, the mechanical utility of the steam generated by the concentrated solar rays. Regarding the steam generator, it will only be necessary to state that it is not exposed to the action of fire, cylinders, or soot, and therefore can only suffer from the slow action of ordinary oxidation. We have already considered the mechanism by means of which the solar heat is concentrated and the temperature raised above that of the water in the steam generator. Regarding this mechanism—the concentration apparatus, it may appropriately be noted—it will be costly; it will be heavy (and finally the question will be put, is it liable to derangement and expense to keep in order?) I will answer these questions in the same order in which they have been asked. The cost is moderate. The weight is small—indeed lighter than the most valuable piece of the concentration apparatus. As to bulk, this apparatus is composed of small parts readily put together. Regarding durability, the first need only be pointed out, that certain metals however thin, if kept dry, may be exposed to steam's rays during an indefinite length of time without appreciable deterioration; hence, unlike the furnaces of steam boilers, which soon become unworkable, structures protected on the exterior by insulating plates, cannot be rendered unworkable from the mere action of the sun's rays. Another question will be asked, whether the solar engine will answer as well on a large as it does on a small scale? The following reply will ostensibly dispose of this proposition. It is not necessary, nor intended, to make in advance, the size of the apparatus by means of which the solar intensity has been successfully concentrated and the temperature sufficiently elevated to generate steam for the engines which have been built. The maximum size adopted has been adequate to utilize the radiant heat of a sunbeam of 35 square feet section. The employment of an increased number of such structures will therefore be resorted to when greater power is wanted, as we increase the number of landials when we desire to perform an additional amount of work. The motor itself, the steam cylinder and other parts, will obviously be proportioned as in present with reference to the pressure of steam employed and the work to be done.

Applicable to our introductory remarks, it is not proposed, in the first instance, to apply solar engines in those where there is no steady production. The isolated districts of the earth's surface suffering from an excess of solar heat being very numerous, our space only admits of a glance at the more important localities. An examination of the extent of these will show that the field for the solar engine, even with the proposed restriction, is not very contracted. There is a nameless region extending from the north-

west coast of Africa to Mongolia, 9000 miles in length, and nearly 1000 miles wide. Besides the Northern African deserts, this region includes the southern coast of the Mediterranean east of the Gulf of Cadex, Upper Egypt, the eastern and part of the western coast of the Red Sea, part of Syria, the southern part of the eastern prairies of the Supharates and Tigris, Eastern Arabia, the greater part of Persia, the extreme western part of China, Tibet, and, lastly, Mongolia. In the western hemisphere, Lower California, the Ishland of Mexico and Guatemala, and the west coast of South America, for a distance of more than 9000 miles, suffer from continuous intense radiant heat.

Comparisons of the solar energy wasted on the vast areas thus specified would present an amount of radiant force almost beyond conception. Let us, therefore, merely estimate the mechanical force that would result from utilizing the solar heat on a strip of land, a single mile in width, along the northern western coast of America; the southern coast of the Mediterranean before referred to; both sides of the Isthmus of Suez in Upper Egypt; both sides of the Euphrates and Tigris for a distance of 450 miles above the Persian Gulf; and, finally, a strip one mile wide along the southern portion of the shores of the Red Sea, before-mentioned. The aggregate length of these strips of land, without account being taken of the distance, exceeds 8960 miles. Adopting this length and a width of one mile as a basis for computation, it will be seen that the amount of solar heat which the southern coast alone covers 493,050 millions of square feet. Dividing this by the area necessary to produce 1-horse power, we learn that 32,300,000 solar engines, each of 100-horse power, could be kept in constant operation, during one hour a day, by utilizing only that heat which is now wasted on a very small fraction of the land extending along the base of the water fronts of the embayed regions of the earth.

It will be well that these extravagant figures are viewed with a great deal of skepticism. This consideration, however, cannot fail to excite us to a closer and more exhaustive of the real fields will inevitably cause great changes in regard to international relations. In favor of those countries which are in possession of conditions and power. Upper Egypt, for instance, will, in the course of a few years, gain a great advantage, and attain a high political position, on account of her perpetual sunshine and the consequent command of unlimited modern forces. The time will come when Europe must stop her snail's pace west of the Nile. Upper Egypt, then, with her never ceasing sun power, will invite the European manufacturer to remove his machinery and erect his mill on the fine ground along the sides of the fertile plain of the Nile, where sufficient power can be obtained to enable him to run more spindles than a hundred Manchester.

I reserve for another occasion, the consideration of the important question: To what extent can the irregular sunshine of Europe be rendered available in producing a regular motor, by the employment of alternately accumulating and drawing upon reserved force?

New York, September 23, 1870.

THE FRENCH EXHIBITION, 1871.—The palaces and colonnades comprising this work in the Bois des Clous for the International Exhibition of 1871. We understand that it is the intention of Her Majesty's Commissioners to invite artists and exhibitors of all Arts and Crafts to inspect these palaces shortly.

RAILWAYS IN OHIO (N.Y.).—The Provincial Council of Ohio (N.Y.) recently passed a resolution in favor of selling state 600,000 acres for the purpose of guaranteeing interest on the capital required for the extension of a Southern Branch Railroad to Cleveland. The Bank of Ohio is said to favor the enterprise.

THE MANACORE WAGON SERVICE.—The important condition of some of the works of our water supply system has caused a general extension during the month. A considerable amount of work has been executed, and we have the report of the Manacore Water Supply Committee, dated the 10th inst. Mr. Christopher, and two other gentlemen, Mr. McKenna, &c.

PETROLEUM.—The Petroleum Producers' Association, representing 48 districts in the Pennsylvania oil region, has made its report for August. The amount delivered during the month was 516,679 barrels, the production having been 520,078 barrels. The average daily production was 16,776 barrels. The increase in the aggregate production over the corresponding production in July was 94,271 barrels. The capacity of iron tankage in the 48 districts was 1,358,447 barrels, and the quantity of oil stored at the close of August was 825,884 barrels.

RANDOM NOTES FROM THE NORTH OF INDIA.

In this country we are all waiting anxiously for the wholesale experiment which is about to be tried by the Public Works Department, namely, the construction by the State, through the agency of their own engineers, of the inland network of new railways. During the last few years there was great activity in surveying operations, and we heard of railway projects in all directions, but as yet, except in the case of the Pajulo line, these projects have not assumed any concrete form. It would appear that no decision has yet been arrived at by those at the head of affairs, as to the character of the new lines, these being strongly advocated by occasional individual (Gladstone and narrow gauge), while others hold that it would be wiser to touch the present Indian gauge. This question has not to be settled, and a little further experience soon taken on here will show us how much and how much to a railway and in a department where not time is still tenderly cared and nurtured.

It took nearly twenty years' discussion before settling on the system that irrigation is beneficial to India, and that irrigation works should, without delay, be pushed forward, and now that that point has been settled (although there is but little evidence of such a conclusion in the actual results of construction), the next question for consideration, and discussion, is whether an irrigation canal is to perform the work of fertilizing the land only, or whether it is to combine irrigation with irrigation. In the latter case it is neither one thing nor the other; its channel is too slow to prevent deposit of silt, and too fast for irrigation; a slow velocity traverses less of water by evaporation and absorption, and by resubstituting a wide bed, (an as to carry a sufficient volume of water for irrigation) an expensive soil is obtained. The construction of an irrigation canal and navigation canal are quite distinct; the one should discharge a sufficient quantity of water to maintain motion; while the other, in its perfect and irrigation, should be as nearly as possible a still-water channel, and yet in the face of all this, which must be clear to any practical engineer, those are those who cling with wonderful tenacity to the construction of navigation and irrigation, although some begin to see that most canal above of experience consider such a water as available and useful (in a financial sense of the word) to an irrigation project.

During the past few years canal officers have been much occupied in surveying and preparing estimates for proposed new works, and many projects (some of which still lie untraced in each canal's commission) have lately been submitted to Government. It is very remarkable that in a case of these new canals, and now that it does, and is so generally made, it will be impossible to say whether that enterprise intended to carry out the great irrigation works in this country, at which the Government have been so long.

The further survey that if we find in our water supply bodies to be empty barometers to tell us how low the water is to a great extent, from the various projects, for while the practical mind is busy with the question of the rivers still drainage the power of the Government, it is not possible to say that the majority of the Government with reference to the carrying out of those projects, while others estimate the canal that will be necessary to bring water to the head of the great river, the railway department, and to the traveler from the south, the railway department of the Ganges late Inspector, and of irrigation.

Whatever the case may be there is no doubt that irrigation is, for the time being, called by the people, and that the work of extension of railways.

THE PENNSYLVANIA CANALS.—The Belgian and French canals are in fact the efforts of the war were made in the last external assistance for the canal, and now that French industry is producing the French demand for Belgian coal is naturally declining. The Ministry of Belgium will have to see checked by the interruption of railway communication.

THE PUBLIC WORKS DEPARTMENT OF INDIA.—The Public Works Department has a right to complain of the delay in the issue of the new rules on salary. Some months ago the Secretary of State's despatch, authorizing the grant of the higher rate of pay to railway engineers, in satisfaction of his formal sanction to the general scheme, was published in the Gazette, and though formalities are being taken care can have been no necessity on this occasion for a strongly enforcing the general principles of concentration. Several suggestions have been offered on the point. One suggestion is that the case has been given, but that it is not likely. It is likely that the matter can have been again referred to the Duke of Argyll, for although the Duke's name is not in the list of the names of the members, Lord Mansfield would hardly consent to this. A more probable suggestion is that the matter was proposed in a way to show the way home, and as nothing declared that he had not done so, the Government's heart has been left at the last. It is not clear how far is planned for the Canal in this direction. It is not clear about the use of private contractors of an organized service—graduated proceeds—licensed and on the spot, and then to all these and a great deal of the Canal's work, and that they had, and that their relations with the public and the Government were not clear. And when the matter is so far on to be opened, they find that they really have no alternative to open, and that the canal has not been from having proceeded—Plover.

**PETROLEUM.**—The Petroleum Producers' Association, representing 48 districts in the Pennsylvania oil region, has made its report for August. The amount delivered during the month was 516,679 barrels, the production having been 520,078 barrels. The average daily production was 16,776 barrels. The increase in the aggregate production over the corresponding production in July was 94,271 barrels. The capacity of iron tankage in the 48 districts was 1,358,447 barrels, and the quantity of oil stored at the close of August was 825,884 barrels.

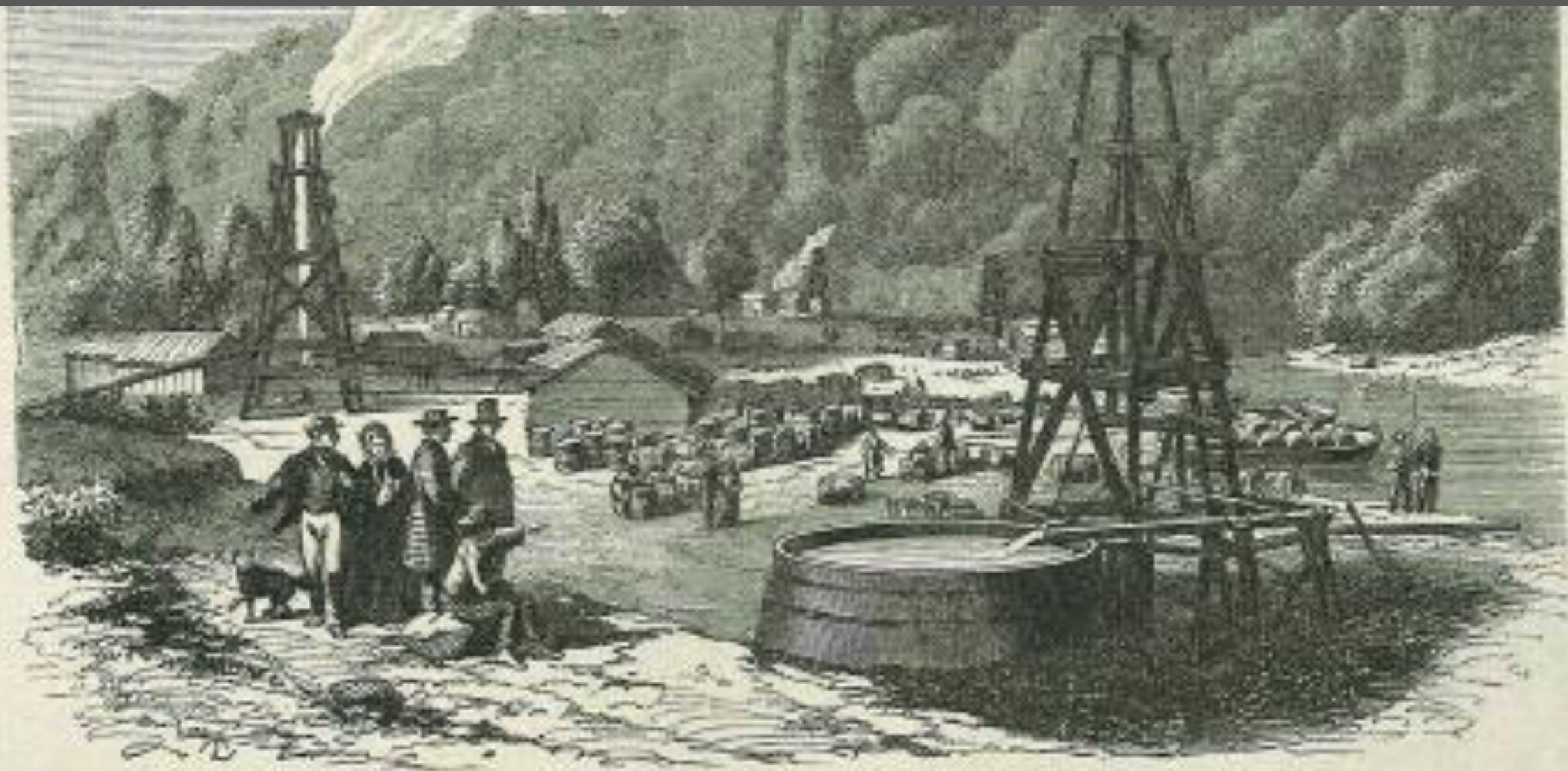
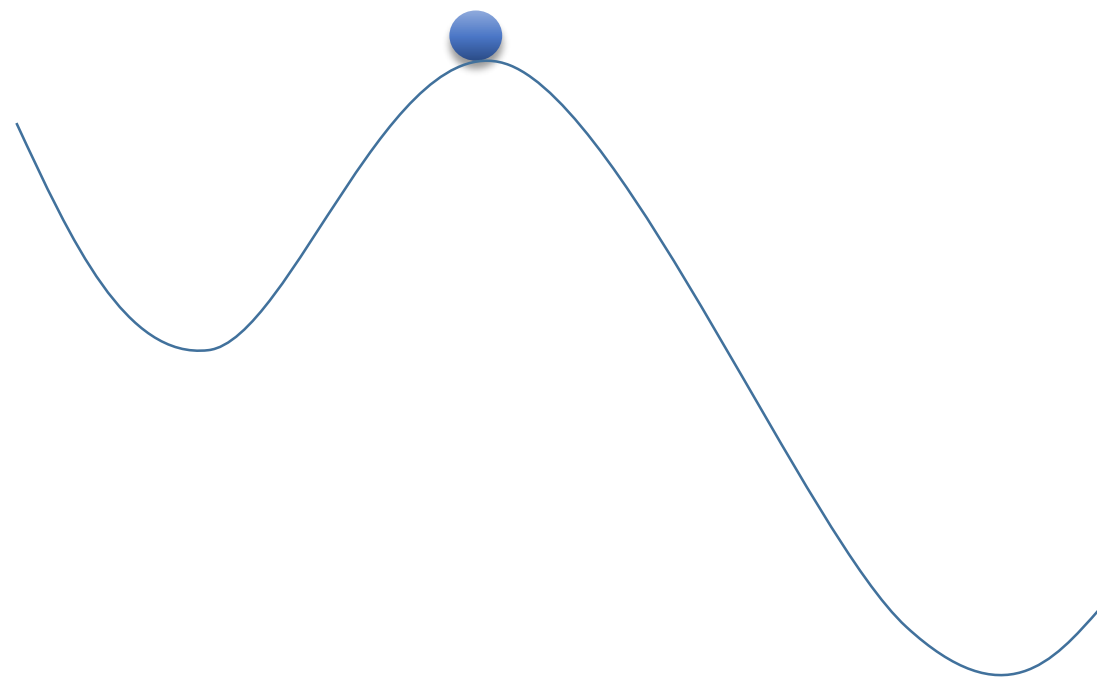
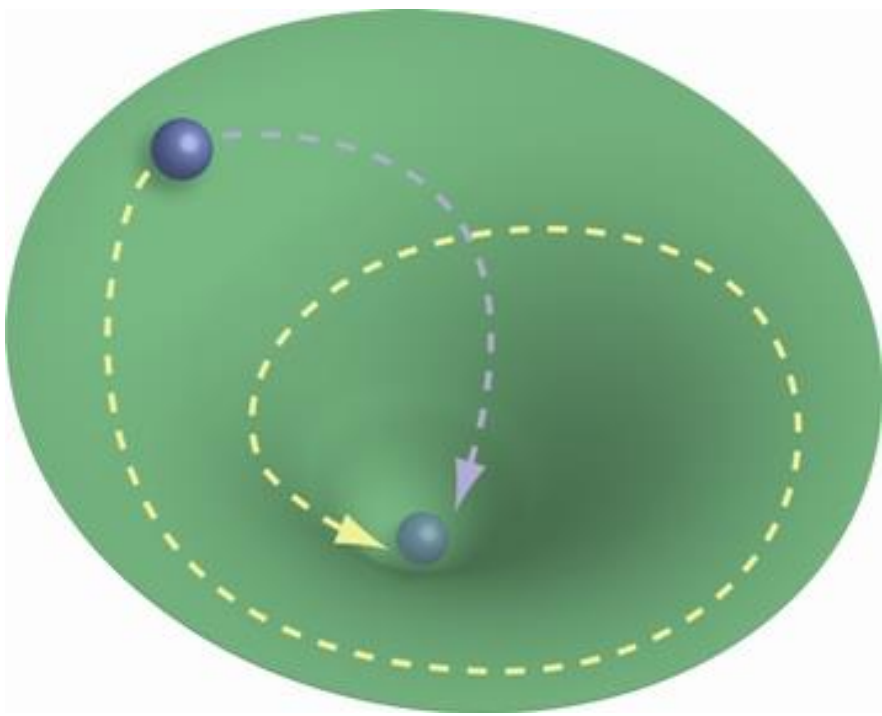


Fig. 121. Bergpoljeðunnar í Pennsylvanía.

Historien spelar roll

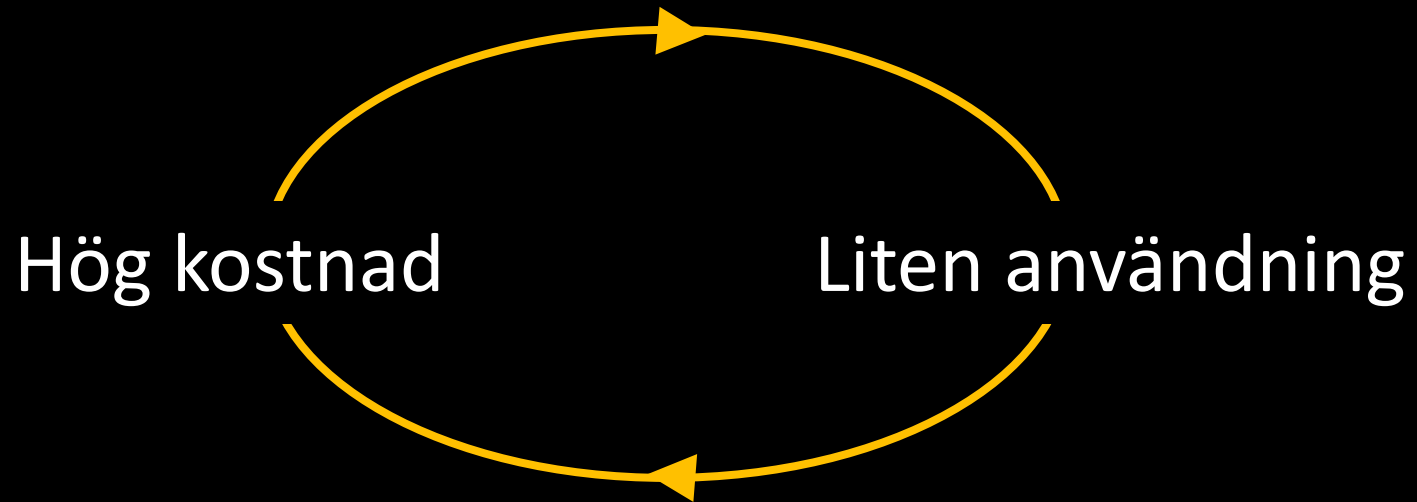


# Teknikinlåsning



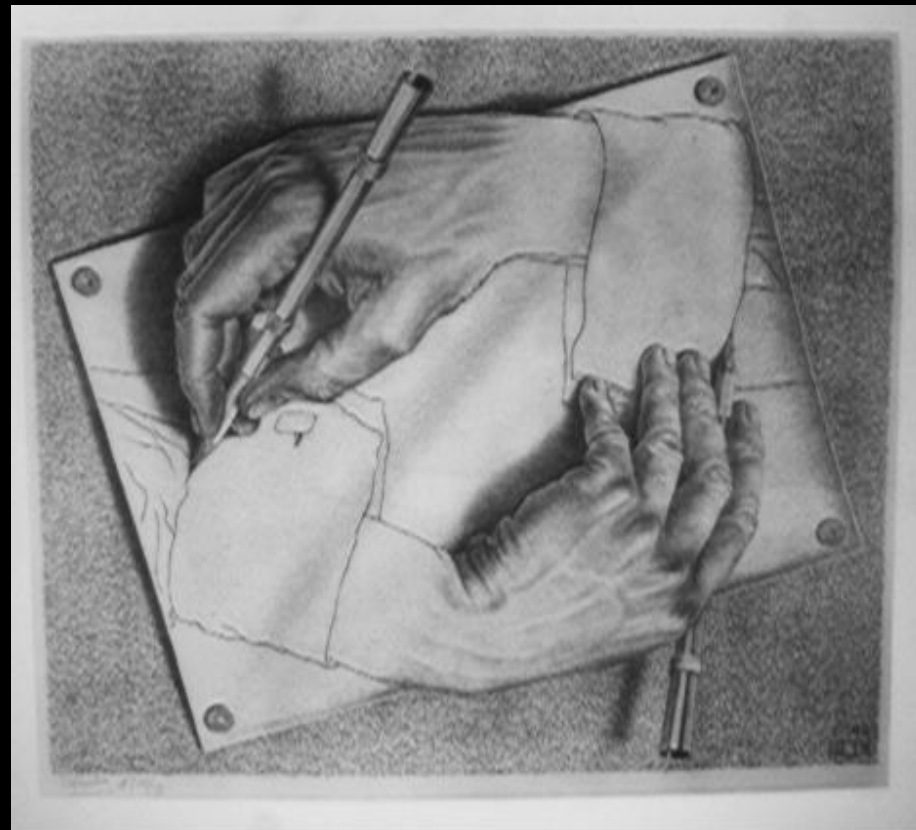
Flera attraktorer

## Den tekniska utvecklingens moment 22



**Teknikinlåsnig**

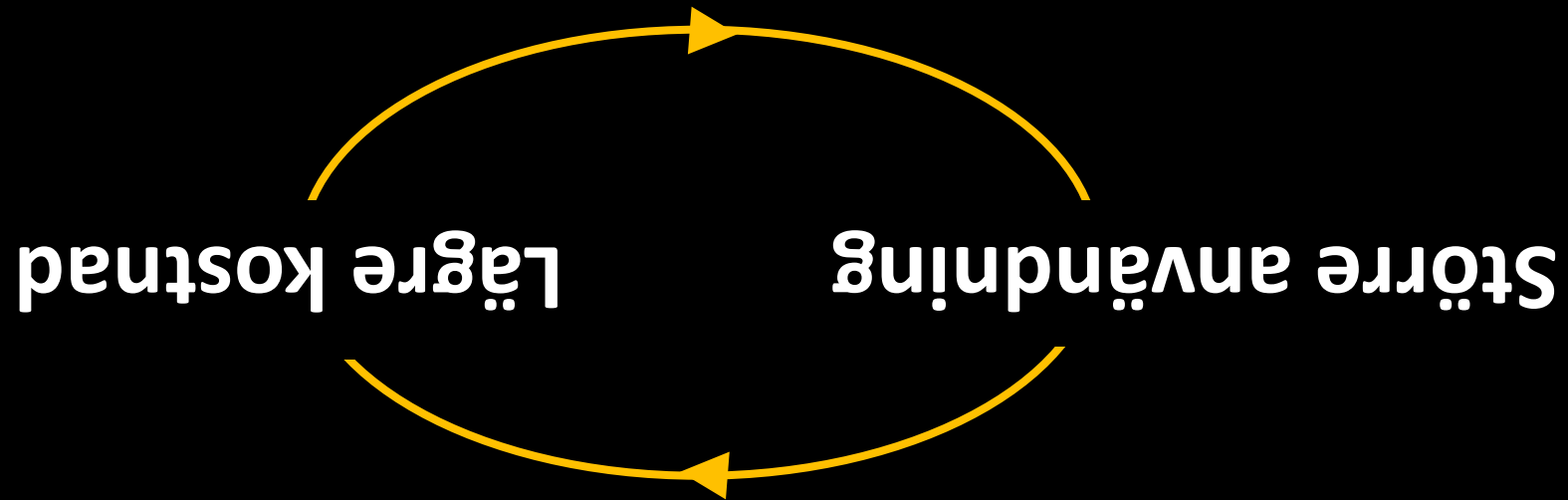
## Den tekniska utvecklingens moment 22



Kan vi ta oss ur teknikinlåsningar?

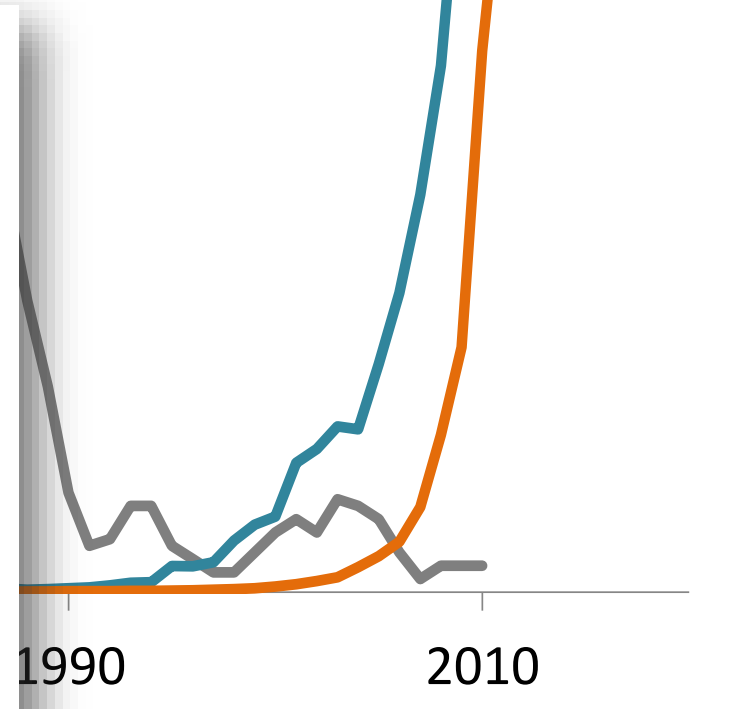
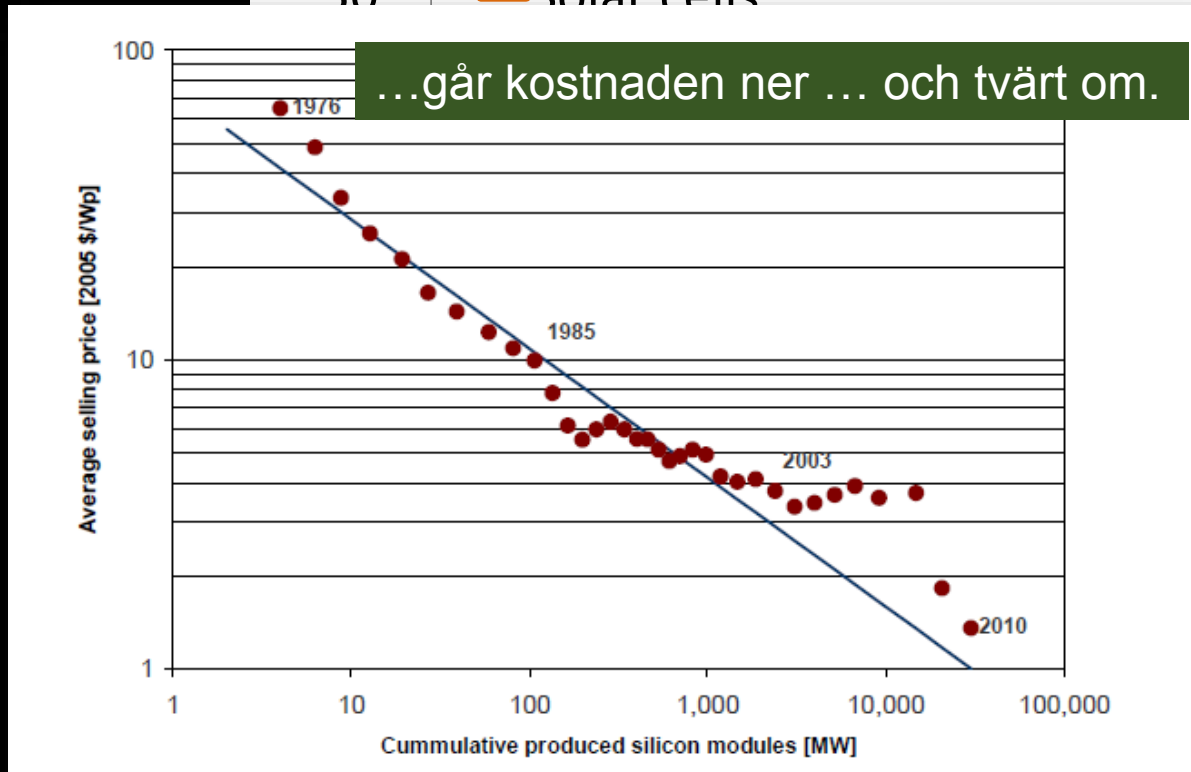
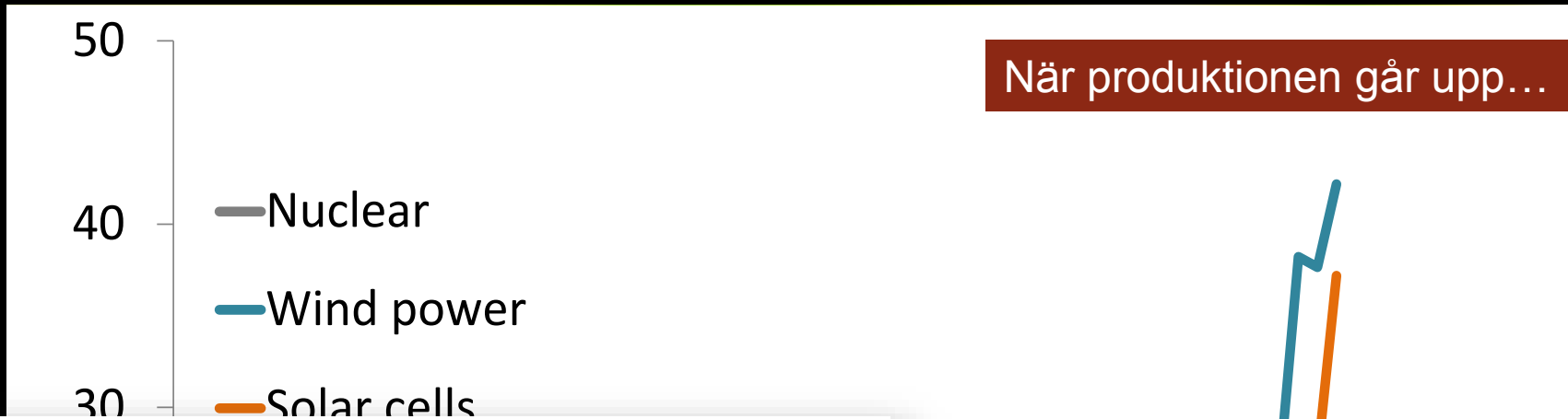


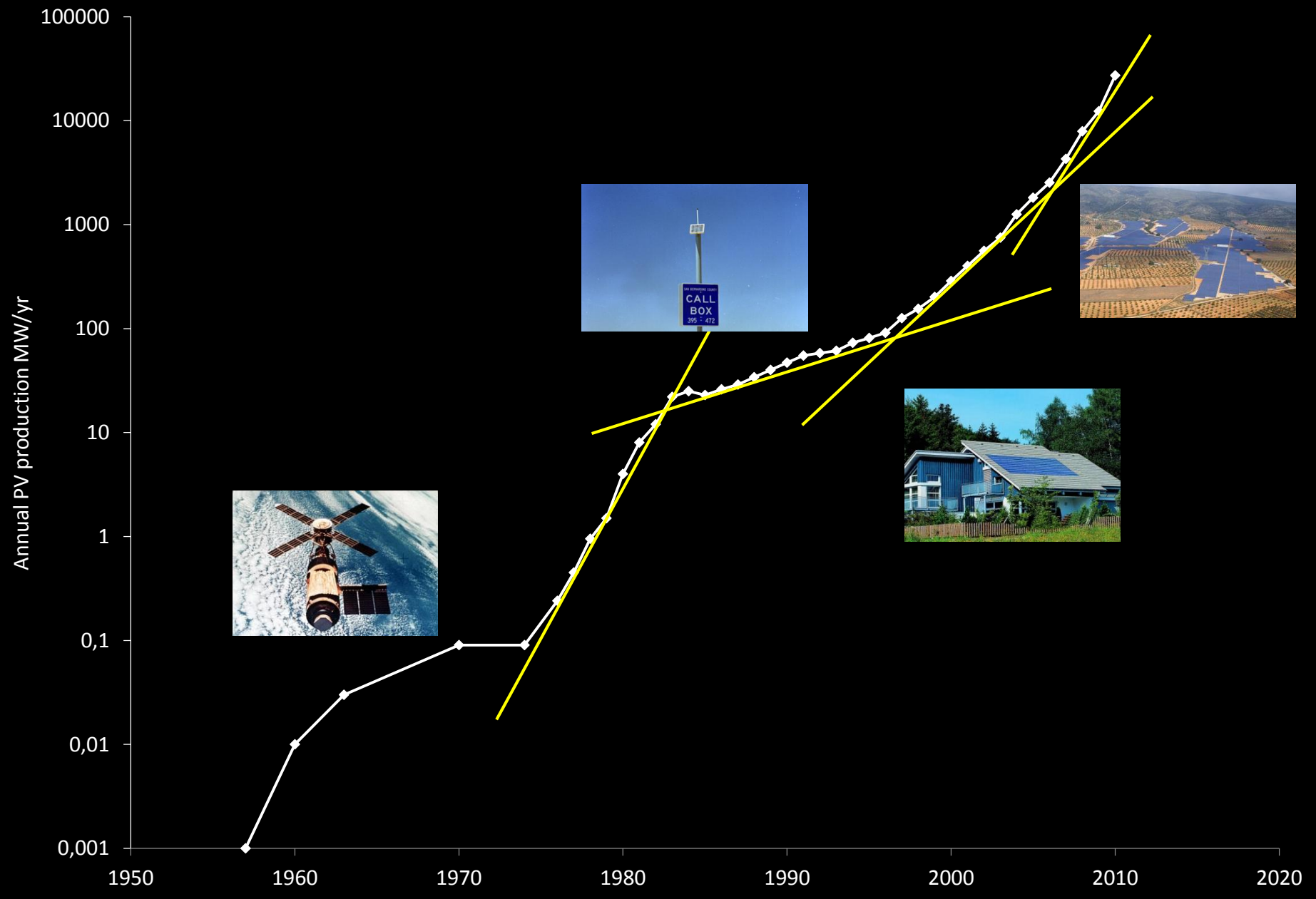
# Den tekniska utvecklingens **motor!**



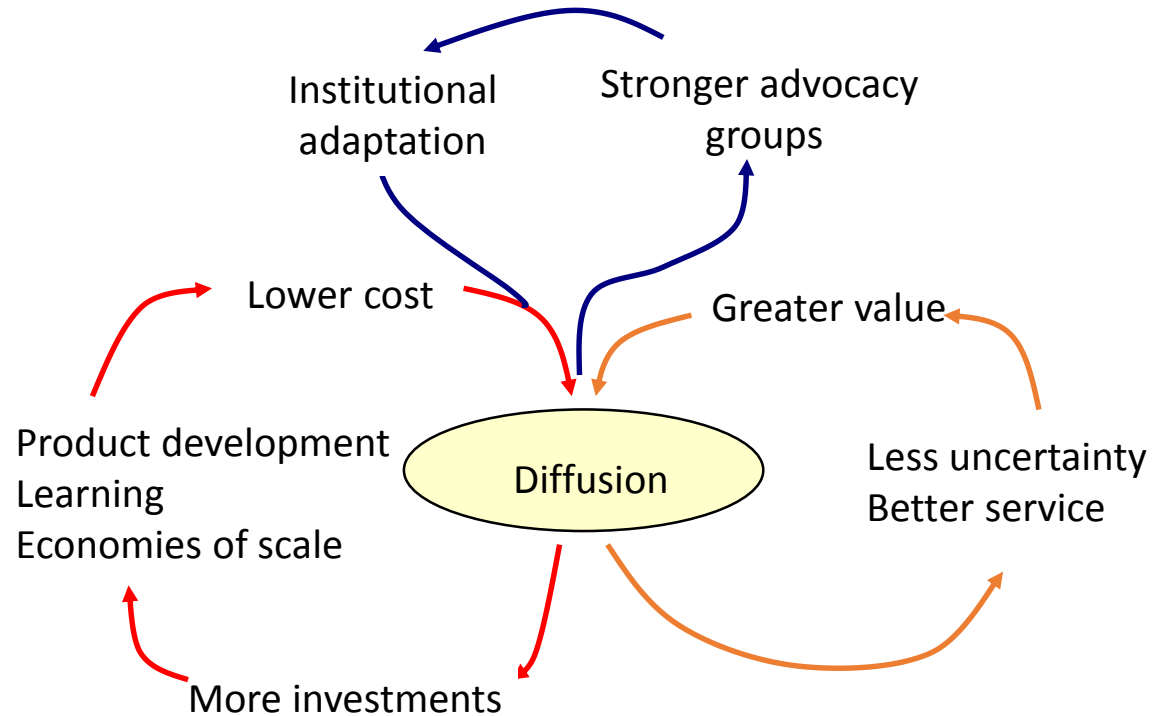
Kan vi ta oss ur teknikinlåsningar?

# Nya lösningar växer fram





# Positiv återkoppling skapar systemförändring



## Strukturer byggs upp och stabiliseras

- Teknisk infrastruktur
- Kapitalansamling
- Arbetskraft och utbildningssystem
- Kunskap och forskningsfält
- Lagar, regler och standarder
- Visioner och attityder

**Hur ser en  
riktig cykel ut?**



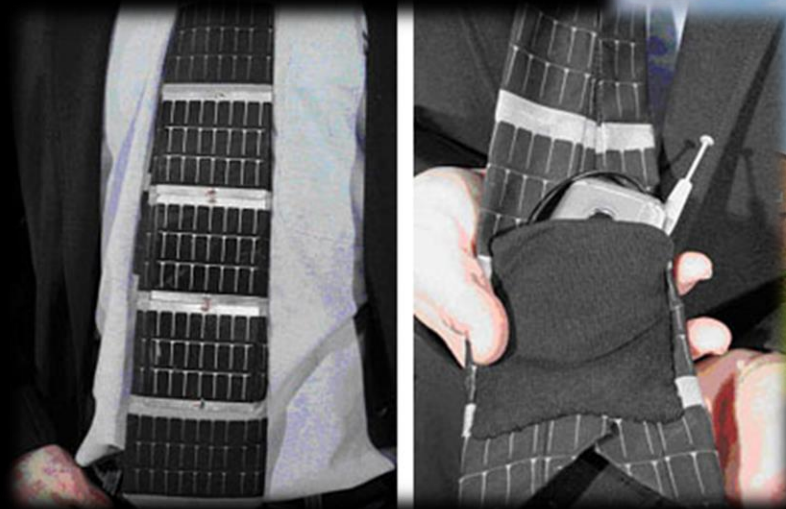
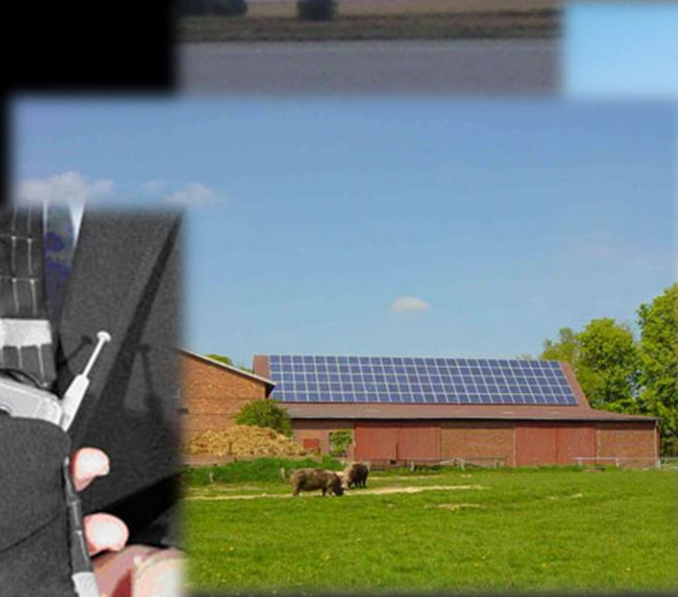


"The ordinary"



”The safety bicycle”

Hur ser ett  
riktigt kraftverk ut?







**Hur ser en riktig fabrik ut?**



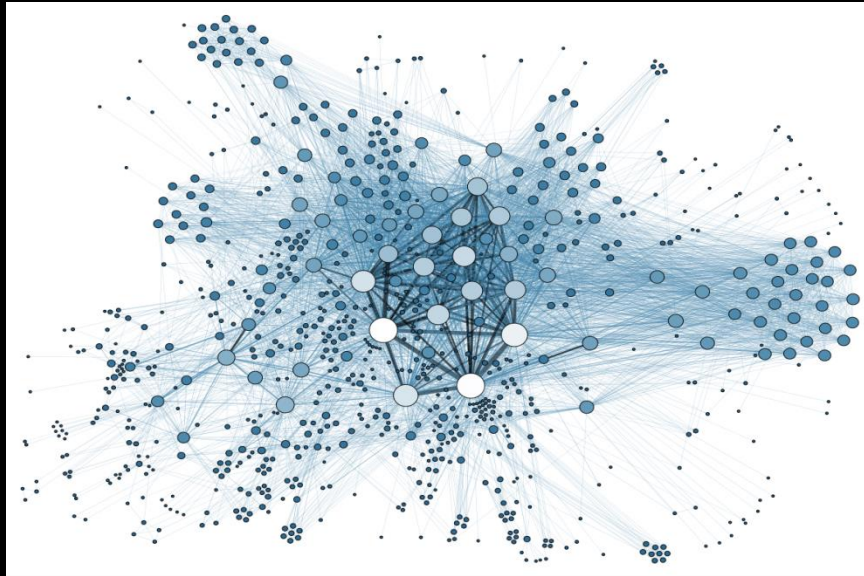
*"There is not reason for any individual to have a computer in their home."*

Ken Olson, President Digital Equipment Corp. 1977

# UTVECKLINGEN KAN TA OLIKA VÄGAR

## World Wide Watt Web

Nätverk som optimeras av någon annan  
"Skönt att slippa tänka på det också!"



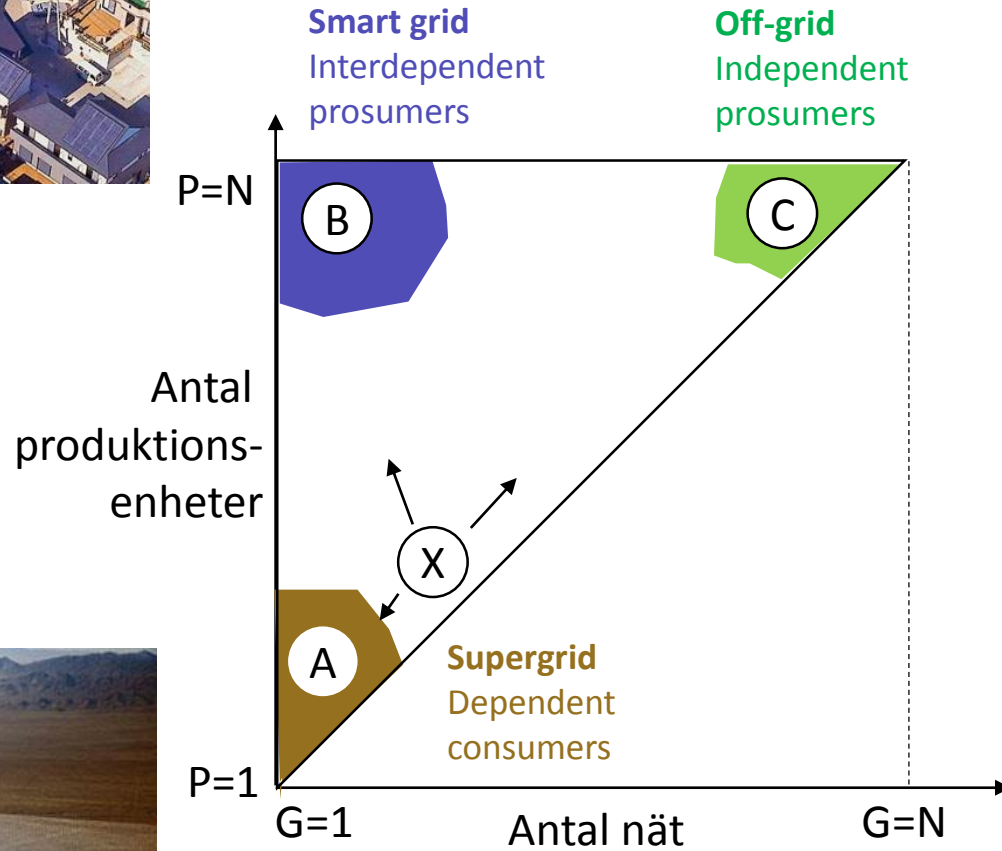
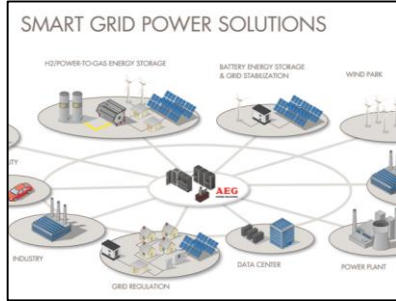
## Munkmodellen

Självförsörjning och lokal lagring  
"Jag vill inte dela gräsklippare med grannen!"



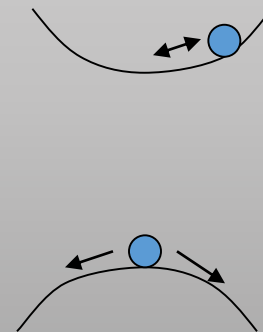
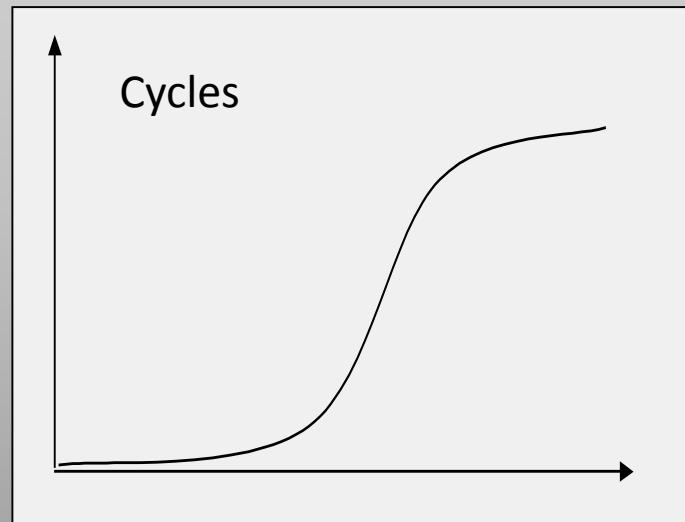
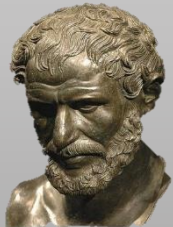
Supergrid eller smartgrid?

# Tre alternativa elsystemframtidar



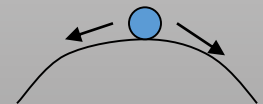
# Perspektiv på förändring och stabilitet

## Mekanistiska systemperspektiv (i kombination evolutionära)



Negativ återkoppling  
Jämvikt, stabilitet  
(Neoclassisk ekonomi)

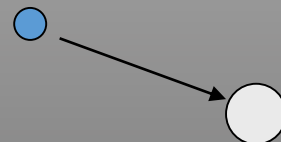
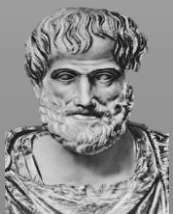
Begränsade  
resurser  
(av något slag)



Positiv återkoppling  
Instabilitet, spårberoende  
"History matters"

Lärande,  
effektivisering,  
kopiering

## Teleologiskt system perspektiv



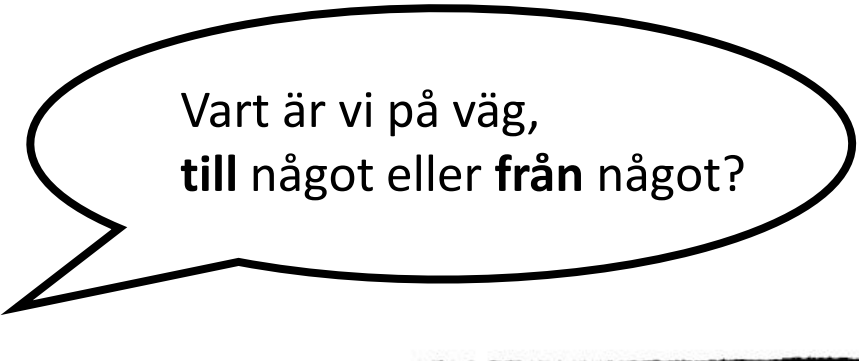
Målstyrning eller fatalism  
Utopi, dystopi

Lärande &  
strukturutveckling

Positiv  
återkoppling

Potential &  
begränsning

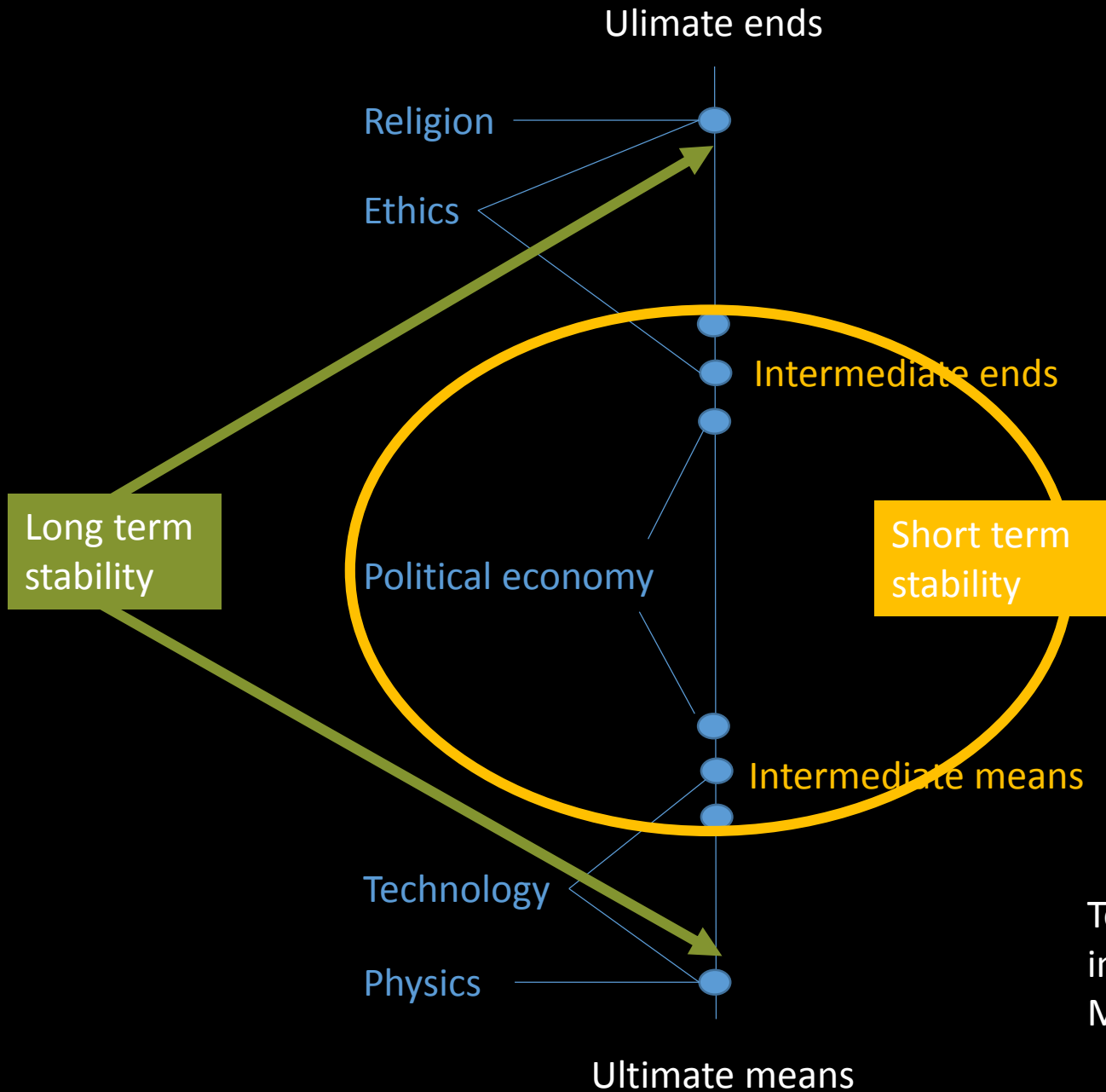
Negativ  
återkoppling



Vart är vi på väg,  
**till** något eller **från** något?

Historia

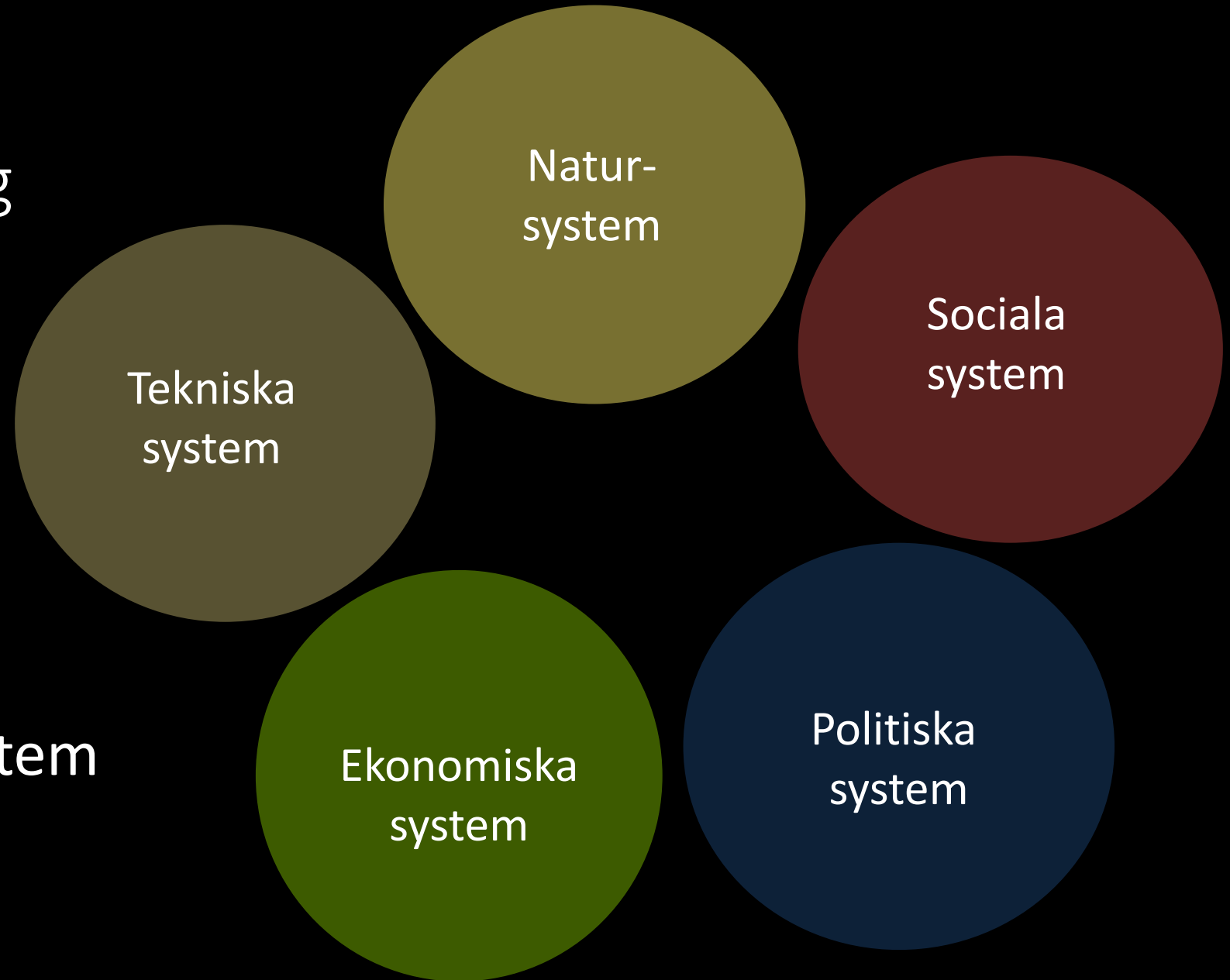
Attraktorer



Towards a Steady state economy (1980)

To much focus on the intermediates.  
Mistaking means for goals.

Vi behöver  
kunskap om  
systemförändring

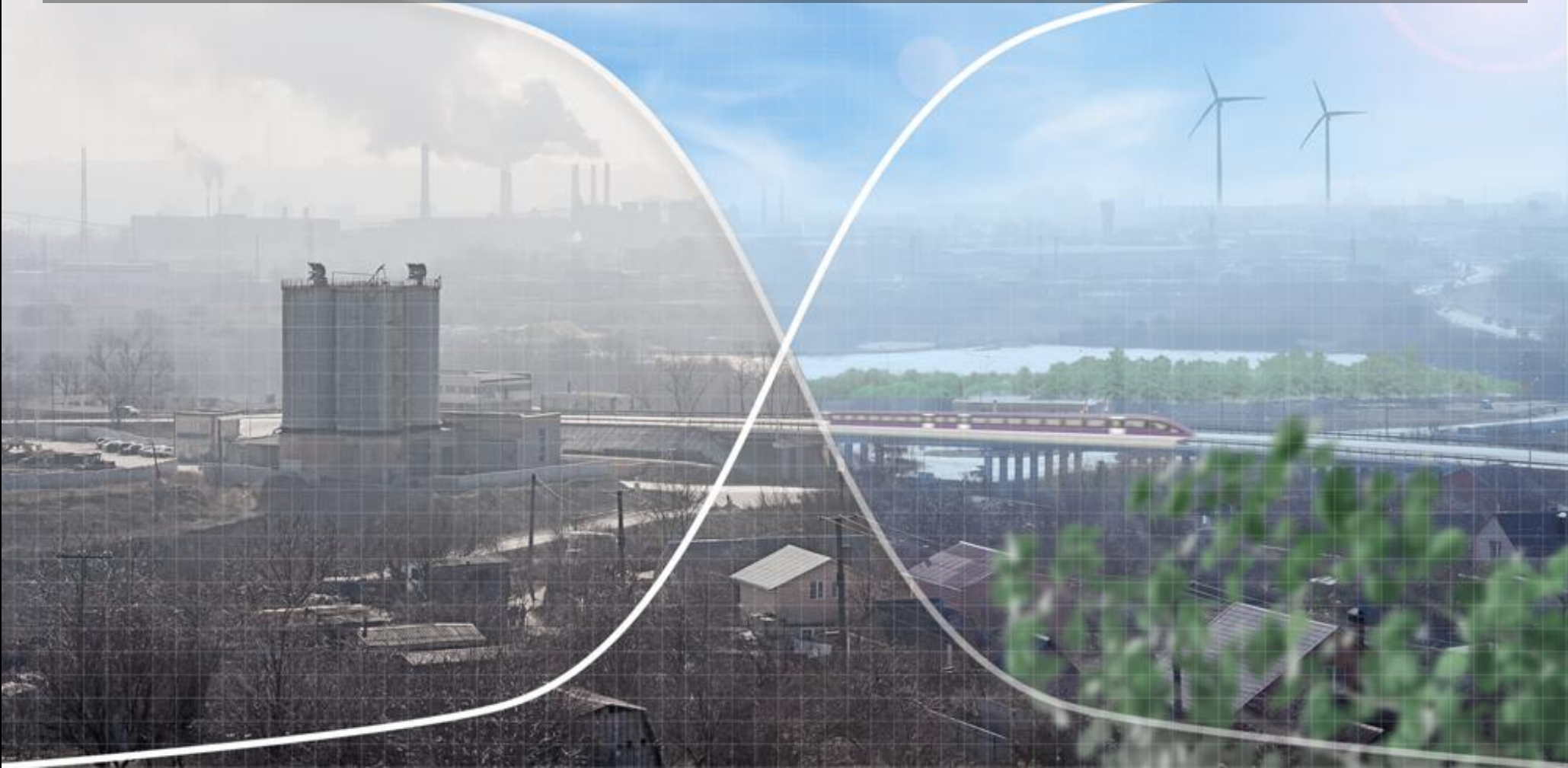


- Sociotekniska system
- Mekanismer
- Tidsskala

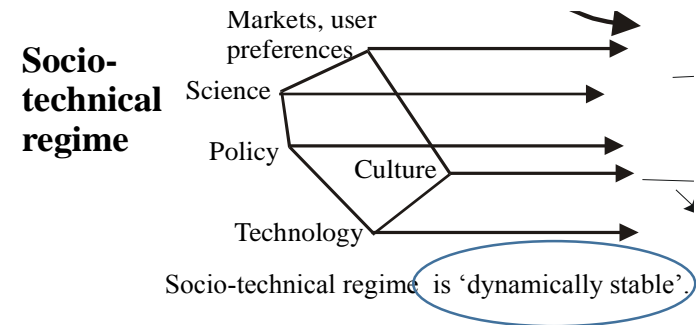


## Hållbarhetsomställningar (Sustainability transitions)

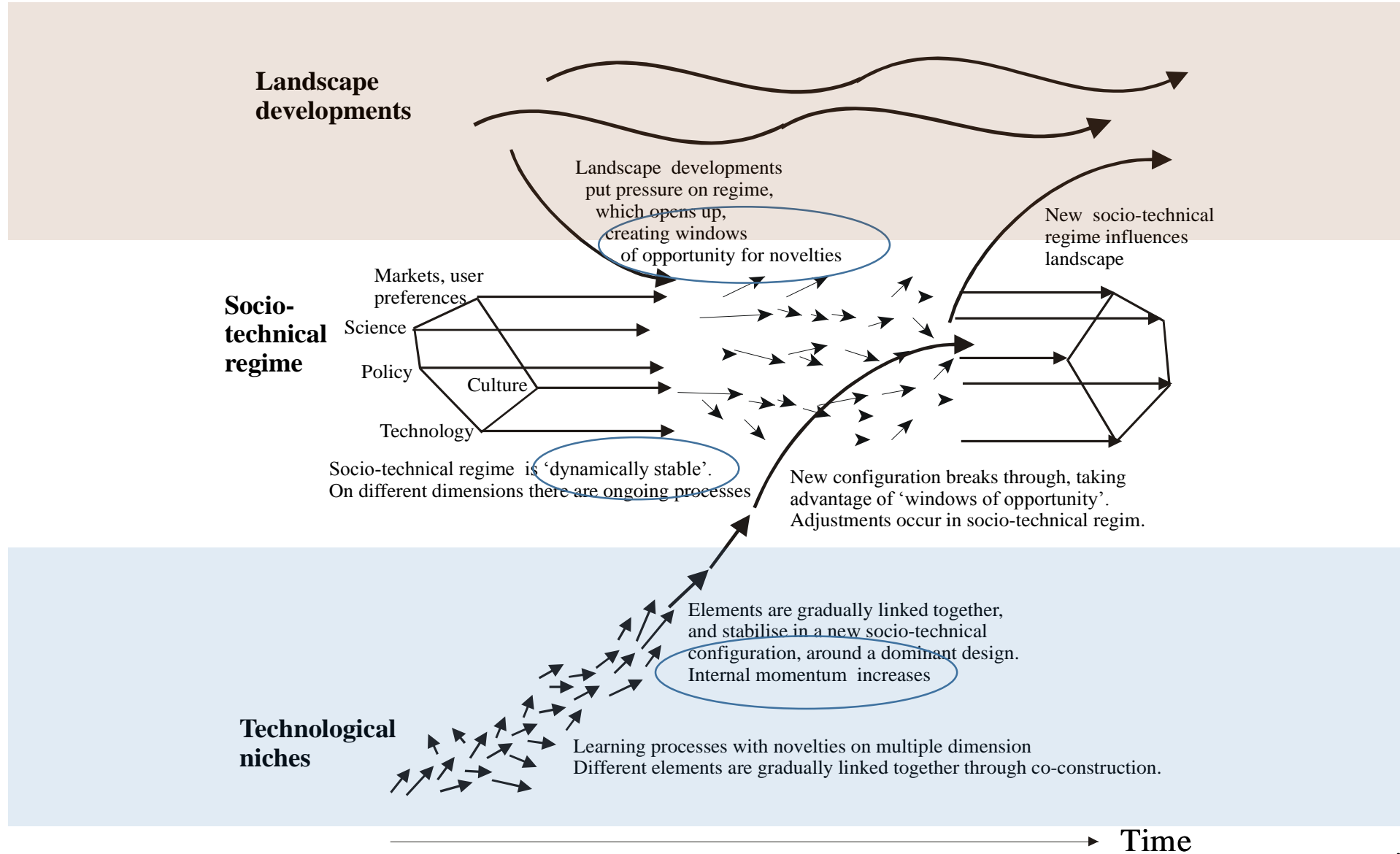
är komplexa förändringsprocesser som typiskt tar flera decennier och leder till radikal förändring av stora sociotekniska system (t.ex. energisystemet).



# "The multi-level perspective" on technological transitions



# "The multi-level perspective" on technological transitions



## Hållbarhetsomställningar (Sustainability transitions)

är komplexa förändringsprocesser som typiskt tar flera decennier och leder till radikal förändring av stora sociotekniska system (t.ex. energisystemet).



Hur kan olika **aktörer** påverka och hur påverkas de av omställningar?

Hur påverkar/påverkas **teknik**?

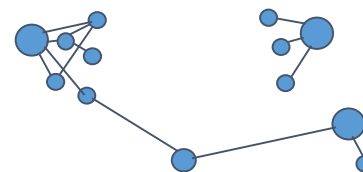
Hur påverkar/påverkas **lagar, regler och normer**?

# Teknologiska innovationssystem (TIS)

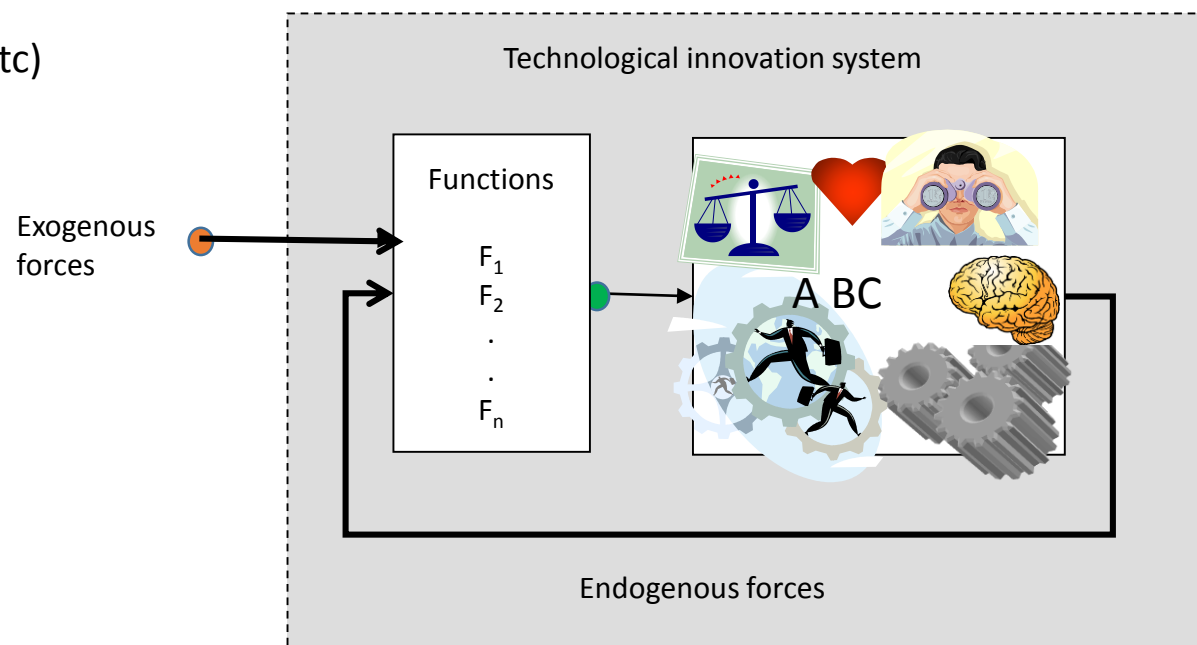
## Functions

1. Knowledge formation
2. Entrepreneurial experimentation
3. Guide the direction of search
4. Resource supply (capital, raw materials, skilled workers etc)
5. Market formation
6. Legitimation
7. Create positive externalities (share knowledge, etc)

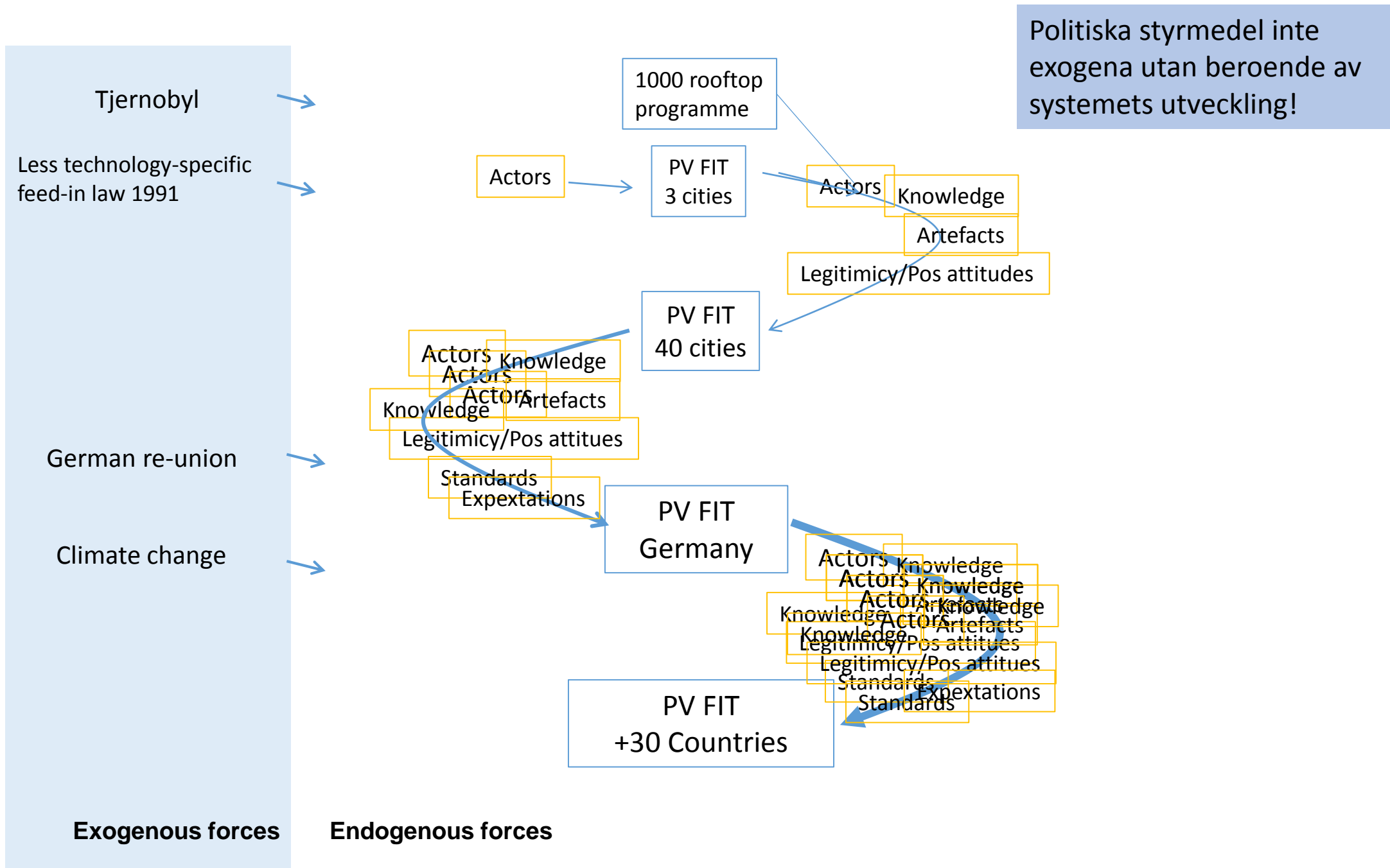
- Hur påverkar man sociotekniska system?
- Vilka hinder stoppar utvecklingen och spridningen av X?
- Hur kan dessa hinder undanröjas och hur kan systemet formas?



Aktörer,  
teknik,  
regler

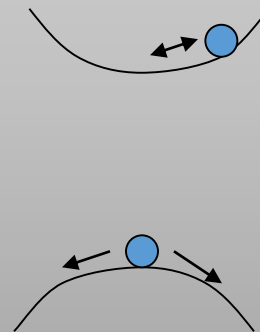
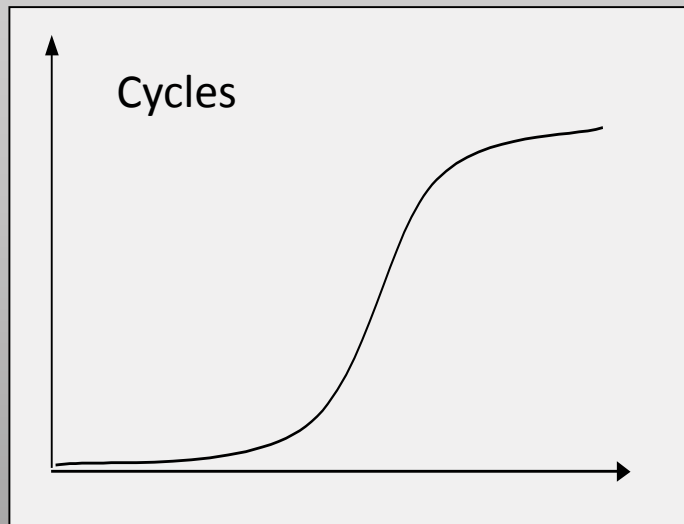
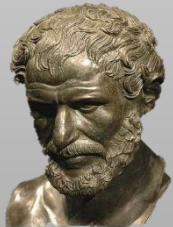


# Institutional evolution (the PV Feed-in tariff)



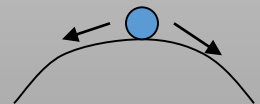
# Hur kan/bör man intervensera i och påverka system?

## Mekanistiska systemperspektiv (i kombination evolutionära)



Negativ återkoppling  
Jämvikt, stabilitet  
(Neoclassisk ekonomi)

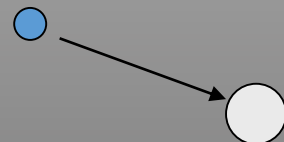
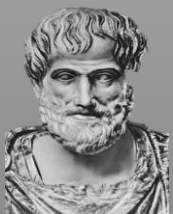
"Beskatta"  
Förskjuta jämvikt



Positiv återkoppling  
Instabilitet, spårberoende  
"History matters"

"Odlå"  
Stimulera  
Innovation

## Teleologiskt system perspektiv



Målstyrning eller fatalism  
Utopi, dystopi

"Planera"

# Ett styrningsdilemma

Om små händelser kan skicka oss i olika riktningar...

...kan vi inta lite på att individuella beslut av många per automatik leder oss i en fördelaktig riktning (den osynliga handen)  
*(Ekonomins överhöghet över politiken).*

Vi behöver långsiktigt kollektivt tänkande och planering  
*(Politikens överhöghet över ekonomin)...*

....men planering på lång sikt är nästan omöjligt pga. av utvecklingens oberäknelighet.



# CHALMERS INITIATIVE FOR INNOVATION AND SUSTAINABILITY TRANSITIONS

Ett gemensamt initiativ från Chalmers och VGR för att skapa...

- En kompetensnod
- En arena för utbyte och lärande

**IST** 2017

*Tack!*

