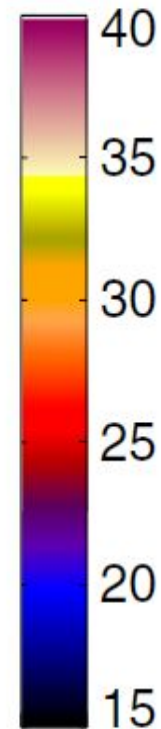


F

# The impending catastrophe and how to plan for it

Paul Cockshott



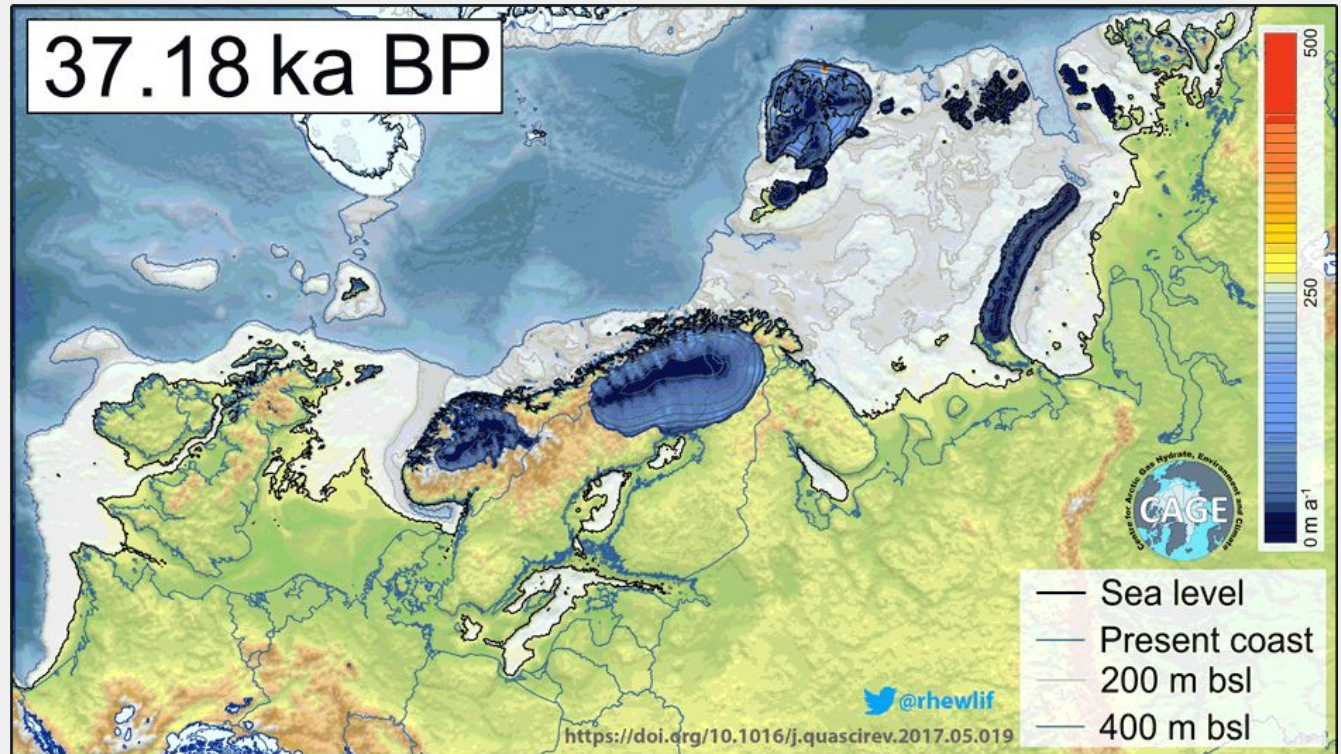
$T_{W(max)}$  (°C)

---

# Outline

1. Environmental context and threats
    - a. Deep history
    - b. Food constraints
    - c. Heat constraints
  2. Structural changes in the mode of material production
    - a. What will go
    - b. What must replace it
  3. In-kind economy versus money economy
    - a. Cybernetic regulation
    - b. Replacing money
-

# A different Europe

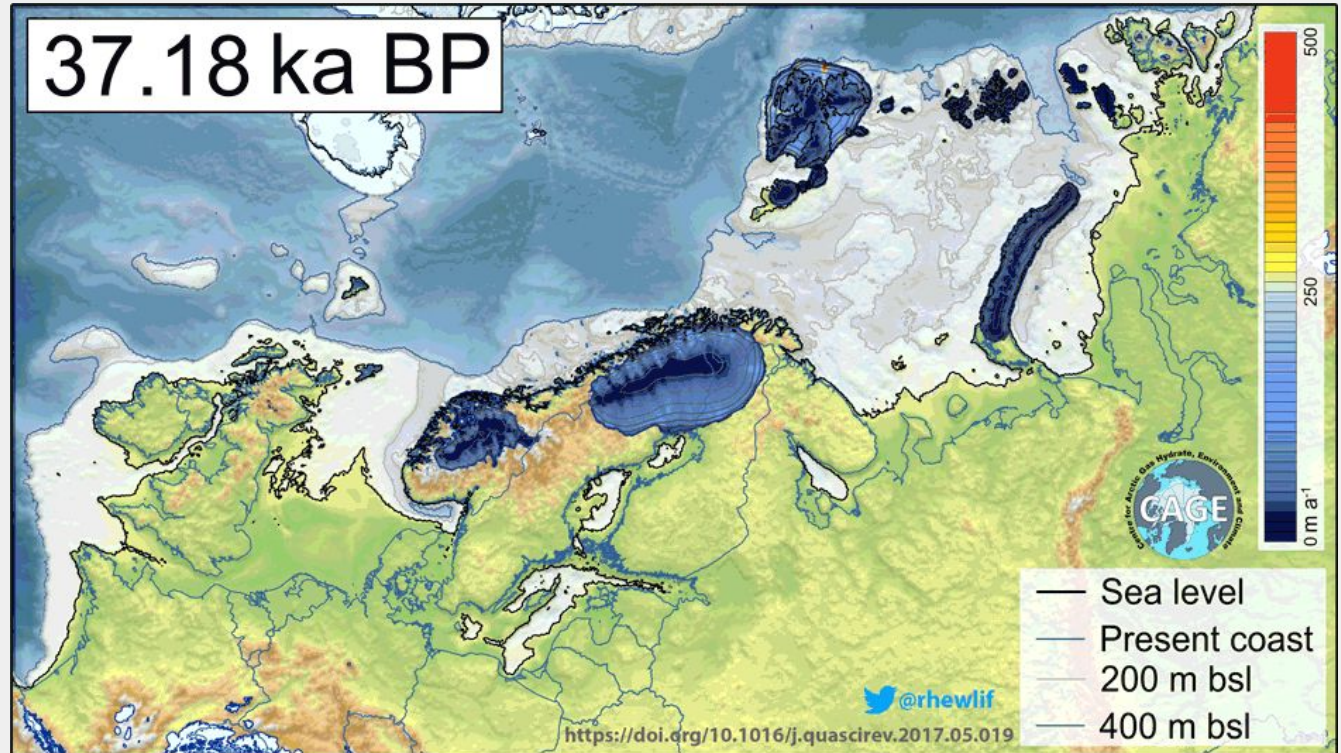




# A changing Europe

Coastlines have radically changed

Climate has been radically different



# A previous Europe

Coastlines have radically changed

Climate has been radically different

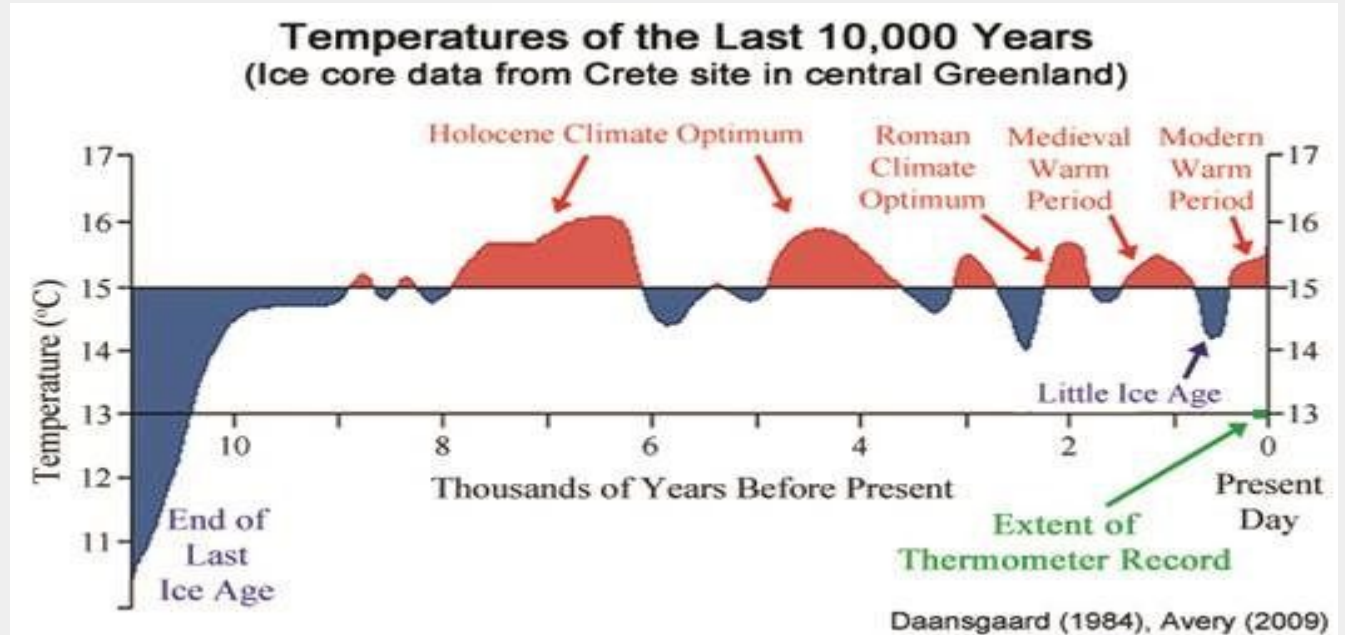
At the last ice age only Spain Italy and the Balkans would have been suitable for agriculture



# Only 4 degrees

A 4C change is all that it took to go from Ice age Europe

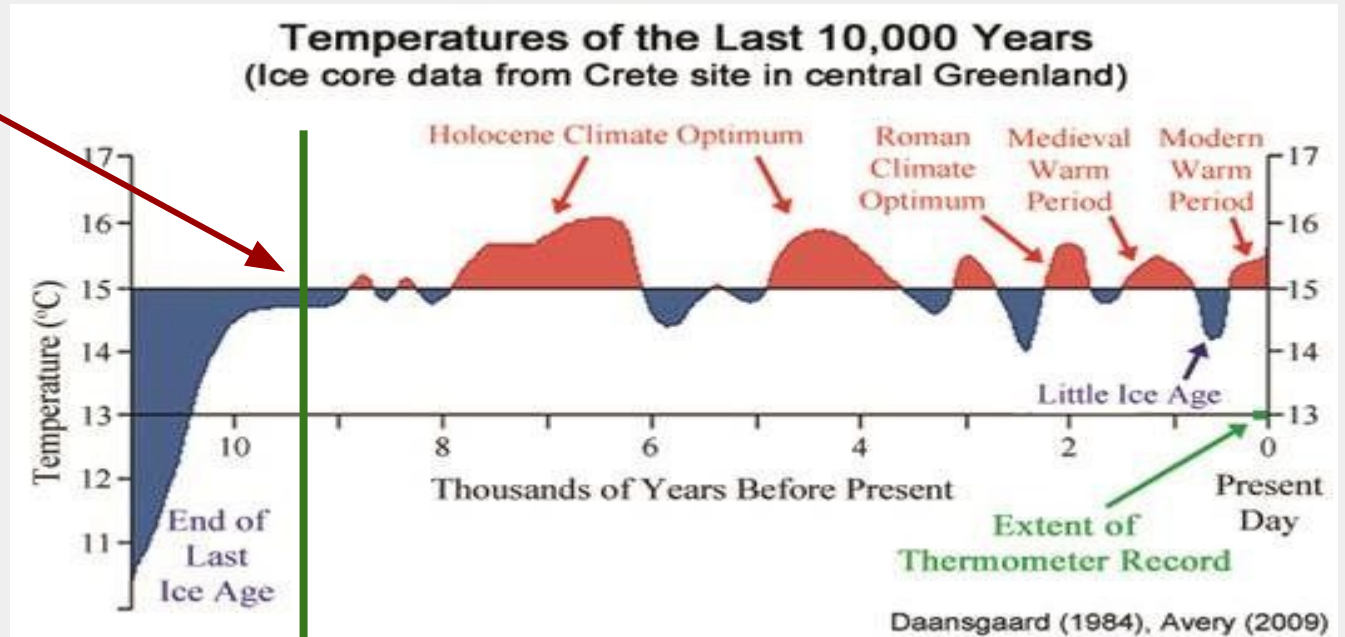
Associated with a 100 ppm increase in CO<sub>2</sub>, comparable to human releases



# Only 4 degrees to first town

Catal Huyuk  
7500BC

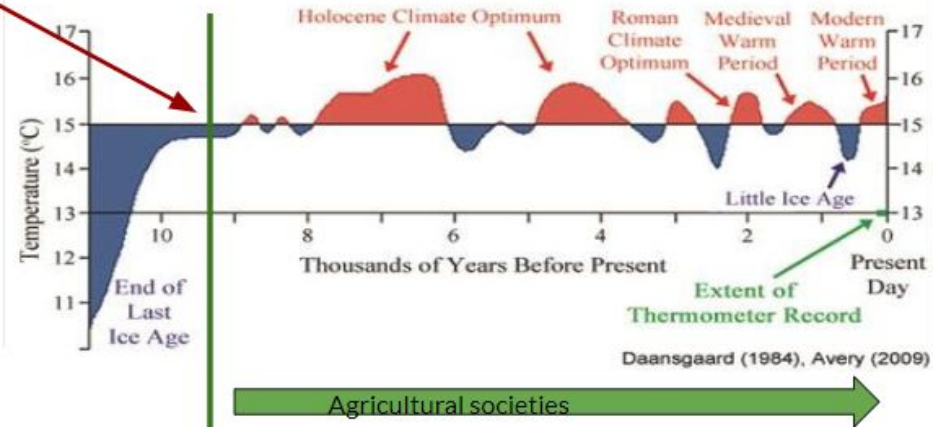
A 4C change is all  
that it took to go  
from Ice age Europe



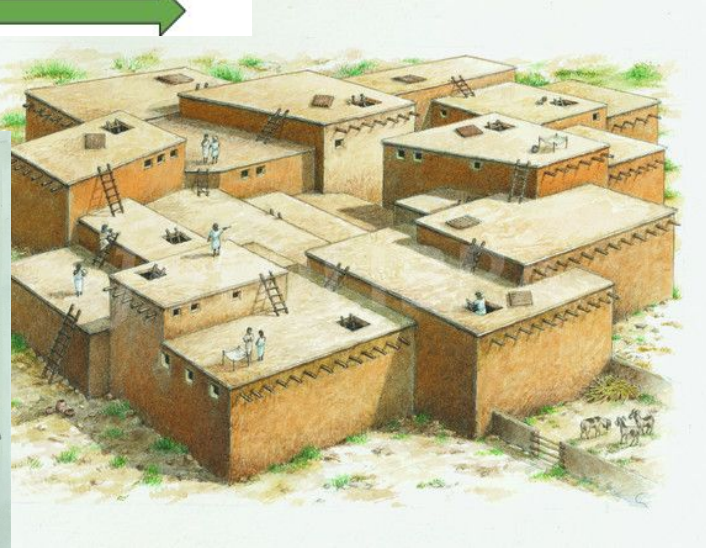
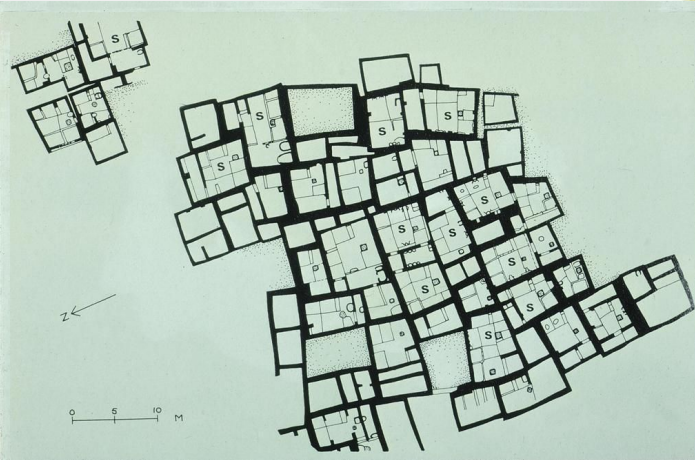
Agricultural societies



**Temperatures of the Last 10,000 Years**  
(Ice core data from Crete site in central Greenland)



# Where it was





# Redwood (metasequoia)



California now

These stumps  
are in the  
Canadian Arctic



# High arctic redwood forest



What is now barren arctic waste was warm enough for California type vegetation,  
Fossils there include Alligators!  
But this climate is within the range of projected changes over the next two  
centuries.

---

# Climate change -> social change

- End of the Ice Age
  - Extinction of the pleistocene megafauna
  - Hunting no longer viable lifestyle
  - Forced adoption of agriculture in Anatolia
  - Expansion of Indo European peoples from Anatolia -> European society.
-



---

# Energy change -> social change

- Feudal Europe
    - Natural energy sources, muscles, horses, water wheels, charcoal fuel
  - Exhaustion of forest fuels,
    - use of coal, new energy sources, steam power -> Capitalist Europe
  - End of fossil fuel,
    - Global warming -> ?????
-

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# **We face comparable changes**

It is difficult to overestimate the changes that are going to occur in the next two centuries, but here are some impressions

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# Planning for the end of capitalist civilisation

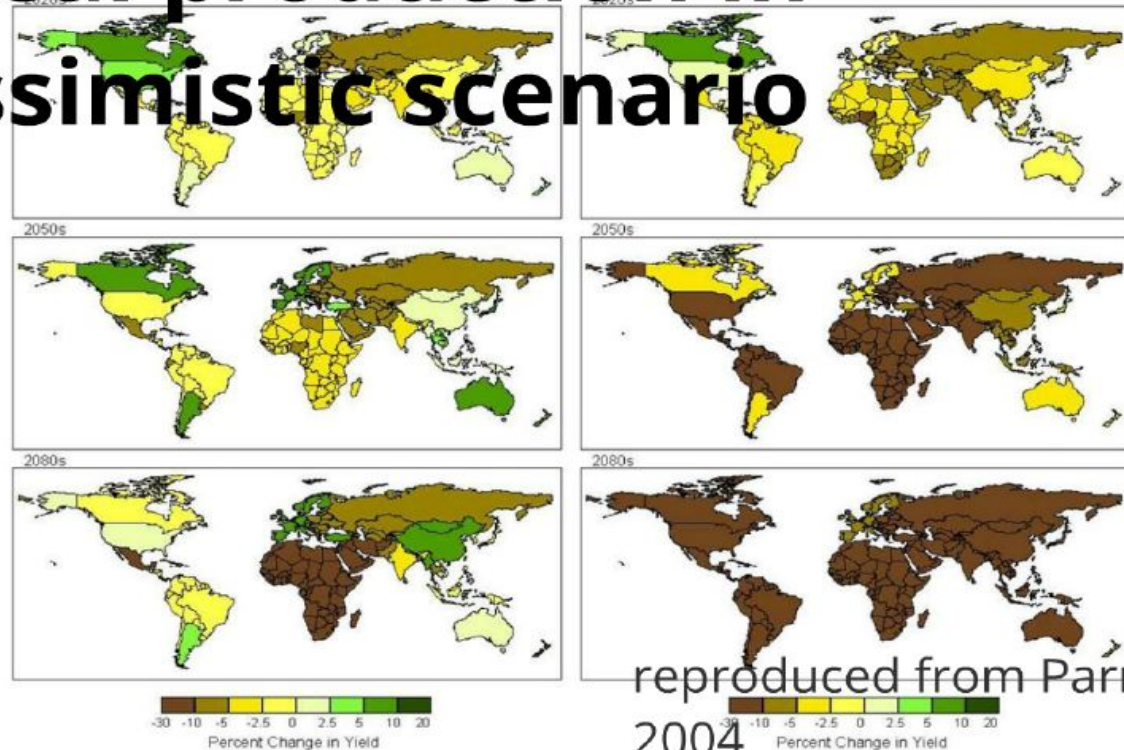
The four Fs

- Food
  - Fuel
  - Fire
  - Flood
-

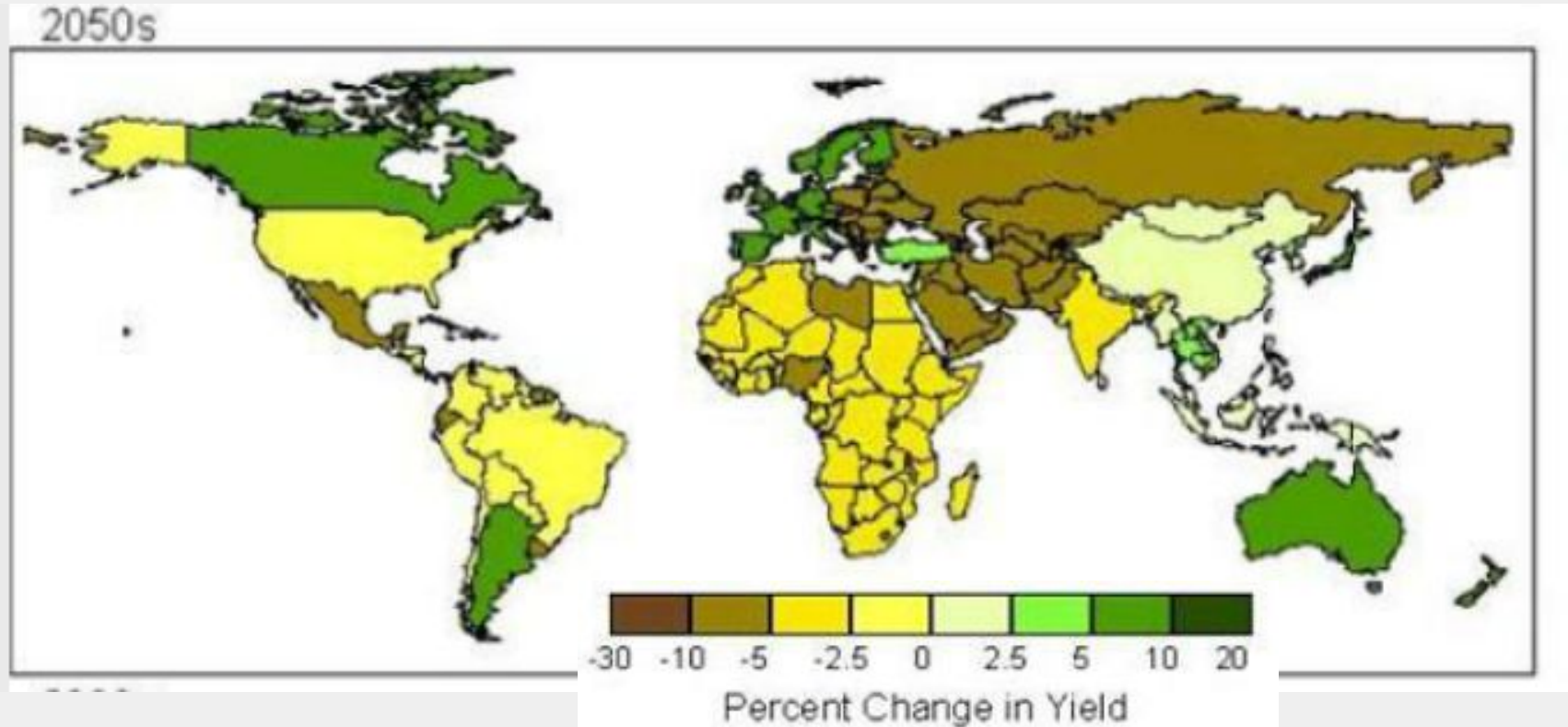


# Coming food crisis

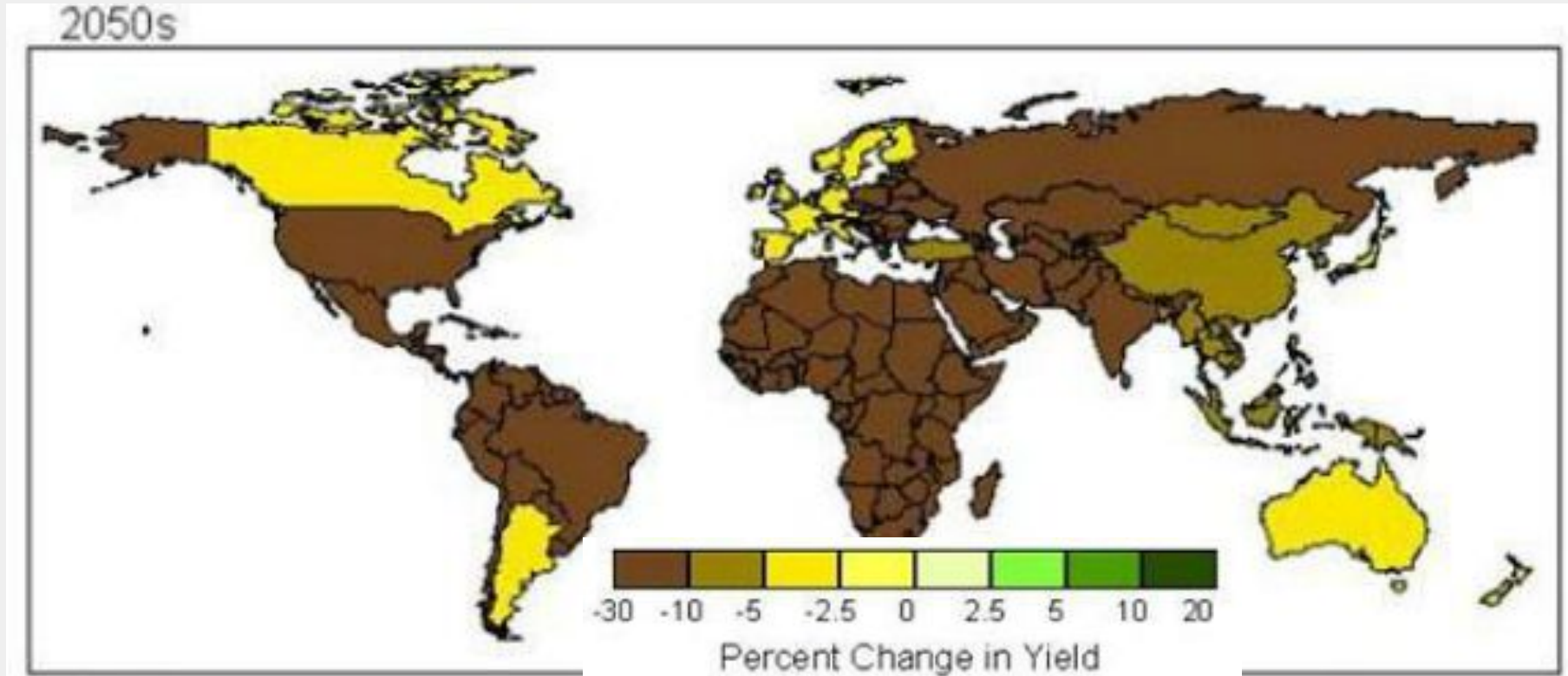
## cereal production in pessimistic scenario



# Best case scenario 2050



# Worst case scenario 2050





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# Predictions

Long term rise in world food prices

Increase in famines when there are widespread harvest failures

Unavailability of imported animal feedstuffs - failure of Brazilian and US soy production.

Necessity for food planning in Europe to ensure self sufficiency in face of declining yields.

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# End of Fuel

IPCC (2013) estimate that to prevent catastrophic climate change total emissions must not exceed 800 billion tonnes of carbon.

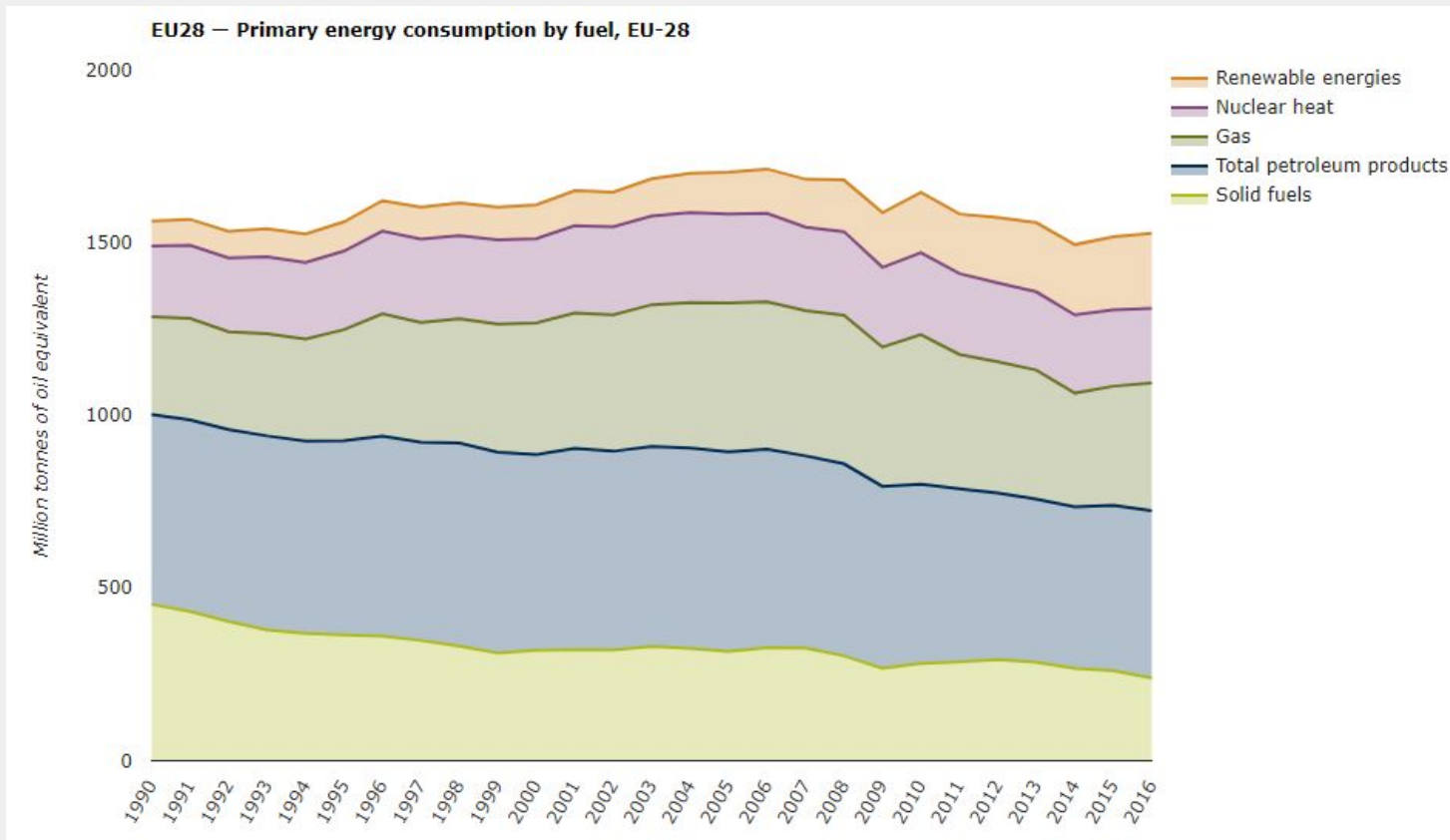
In 2013 we had 270 billion tons left that we could still use, at rate of 11 billion a year.

In 2019 we have about 205 billion margin, implying we must totally stop using fossil fuel by 2037, a bit longer if we allow for tail off.

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# Current energy sources, Europe

Fossil fuel  
provided  
72 % in  
2016  
Down from  
78% in 2005



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# Implications

Plan to reduce from 72% to 0% in 25 years, fall of about 3% a year, 5 times faster than is being achieved now.

Not only close down all coal oil and gas power stations, but build enough new nuclear and wind ones to replace other energy uses in heating, transport and process energy.

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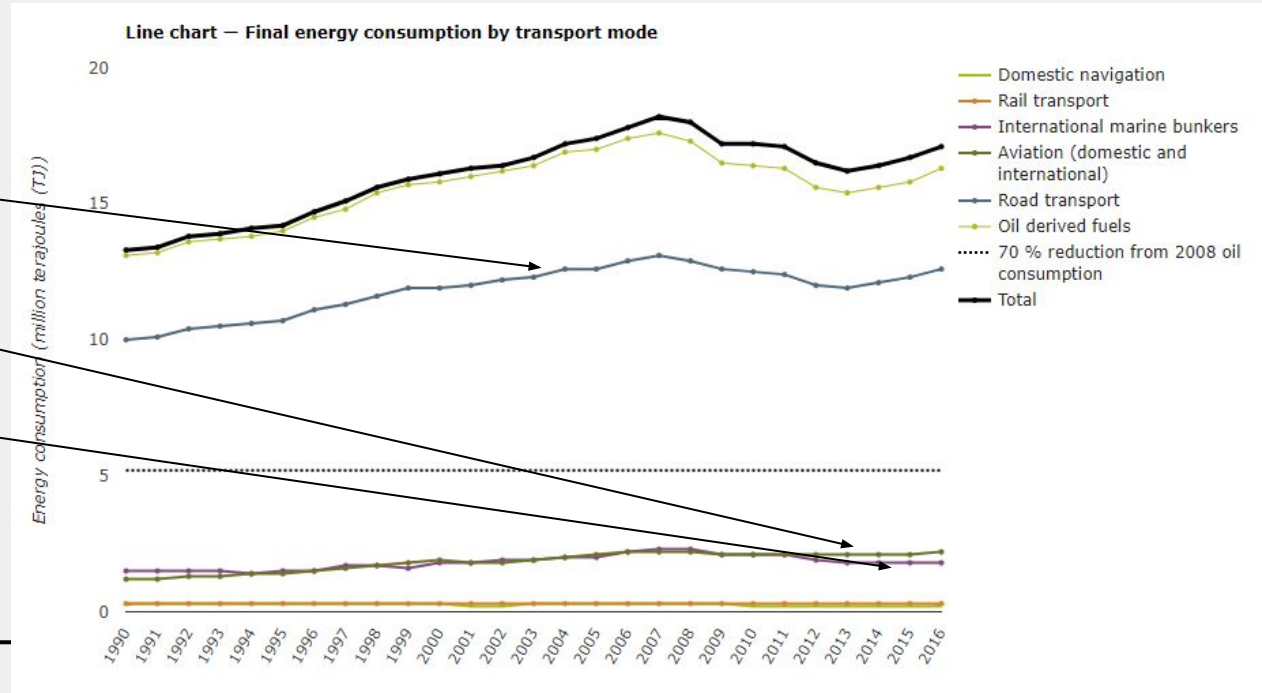
# Transport energy sources and use

Big users are

Road vehicles

Aircraft

Ships





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# Road transport

Biggest single use of fossil fuel plan to :

- Immediate ban on manufacture of fossil fuel cars and busses
    - Slightly later ban for lorries and agricultural vehicles since electric designs not yet available
  - Big expansion of rail network to handle long distance freight which will not be practical with battery lorries
    - Battery lorries to deliver from rail terminal to sites within towns
    - Factories will need railway sidings
-

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# Implications

Investment in many more high speed rail lines.

This will have to take place much more rapidly than currently done in Europe

China's rail plan shows that this is possible

Scale down the tourist industry even so.

Close many airports

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# Air transport

This will have to be largely run down.

Hydrogen fueled planes are possible but

- Seating capacity reduced
  - Fuel costs much higher due to energy inefficiencies :  
electrolysis, then pressurisation and refrigeration, then  
thermal loss in engines
-

# САМОЛЕТ ТУ-156 С ДВИГАТЕЛЯМИ НК-89

## Tu 156 H2 prototype

Large bulky fuel tank

Reduced seating

High fuel cost



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# **Ships**

Globalisation was based on the marine diesel engine.

Only alternatives :

- Nuclear ships ( too expensive and risky for commercial use)
  - Wind power, proven but expensive in manpower
  - Liquid ammonia by Haber Process burnt in gas turbines, practical but again expensive
-



# Modern Wind ships

Flettner rotor uses small power supply to rotate a cylinder in the wind and develops thrust due to the Magnus effect

Feasible, but cargo capacity will be much lower than current bulk carriers.

*Far less freight shipped from Asia to Europe after transition!*



colorize-it.com

# Steel

Steel production is major source of CO<sub>2</sub>

Capitalist civilisation built on steel, if coal based steel production phased out what are implications?



# There are alternatives

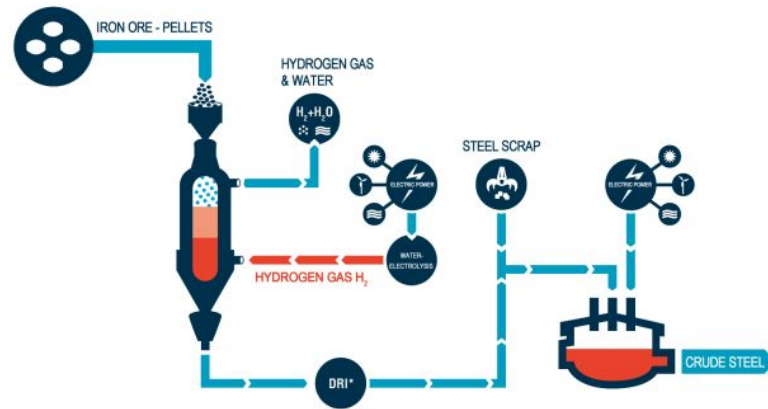
But

Cost per ton will be significantly higher since hydrogen from electrolysis is more expensive than coke

The process is endothermic so additional heat needed

Big capital cost of replacing existing steel plant in a short period

## Hydrogen based Direct Reduction



\* Direct Reduced iron

Source: Steel Institute VDEh

- Use of Hydrogen to replace Carbon in basic steel making
- Need for hydrogen produced via water electrolysis using electric power from regenerative energy sources
- Intermediate solution uses natural gas until sufficient carbon free electricity will be available
- Good symbiosis of steel sector with power sector and hydrogen gas providers
- Projects: MACOR/SALCOS, HYBRIT, H2Steel (H2Future, SuSteel)

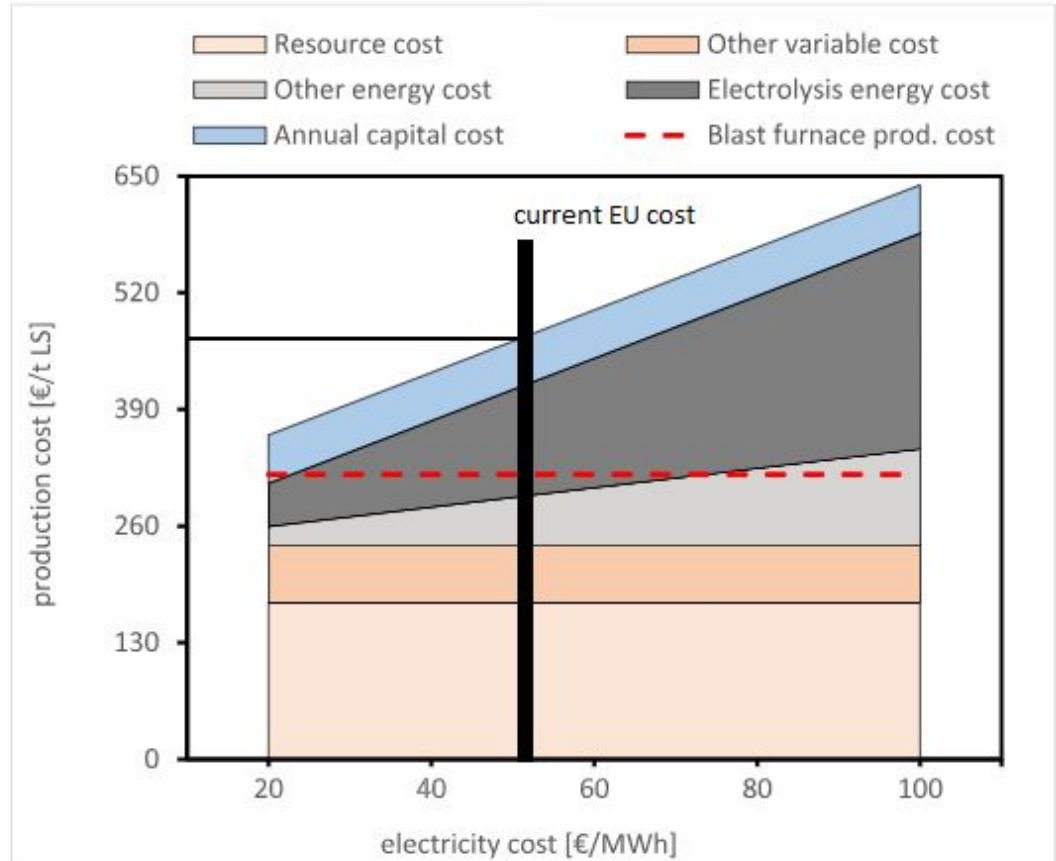
# How much more costly

But

Cost per ton will be significantly higher since hydrogen from electrolysis is more expensive than coke

Increase in steel cost of perhaps a third.

Implication that we will use less steel, an need a lot of power plants to produce the hydrogen circa 100TWh extra for Germany alone





A photograph of a forest fire. Bright orange and yellow flames are visible at the base of several dark tree trunks. The background is filled with smoke and more fire, creating a hazy, intense orange glow. The scene is captured from a low angle, looking up at the trees.

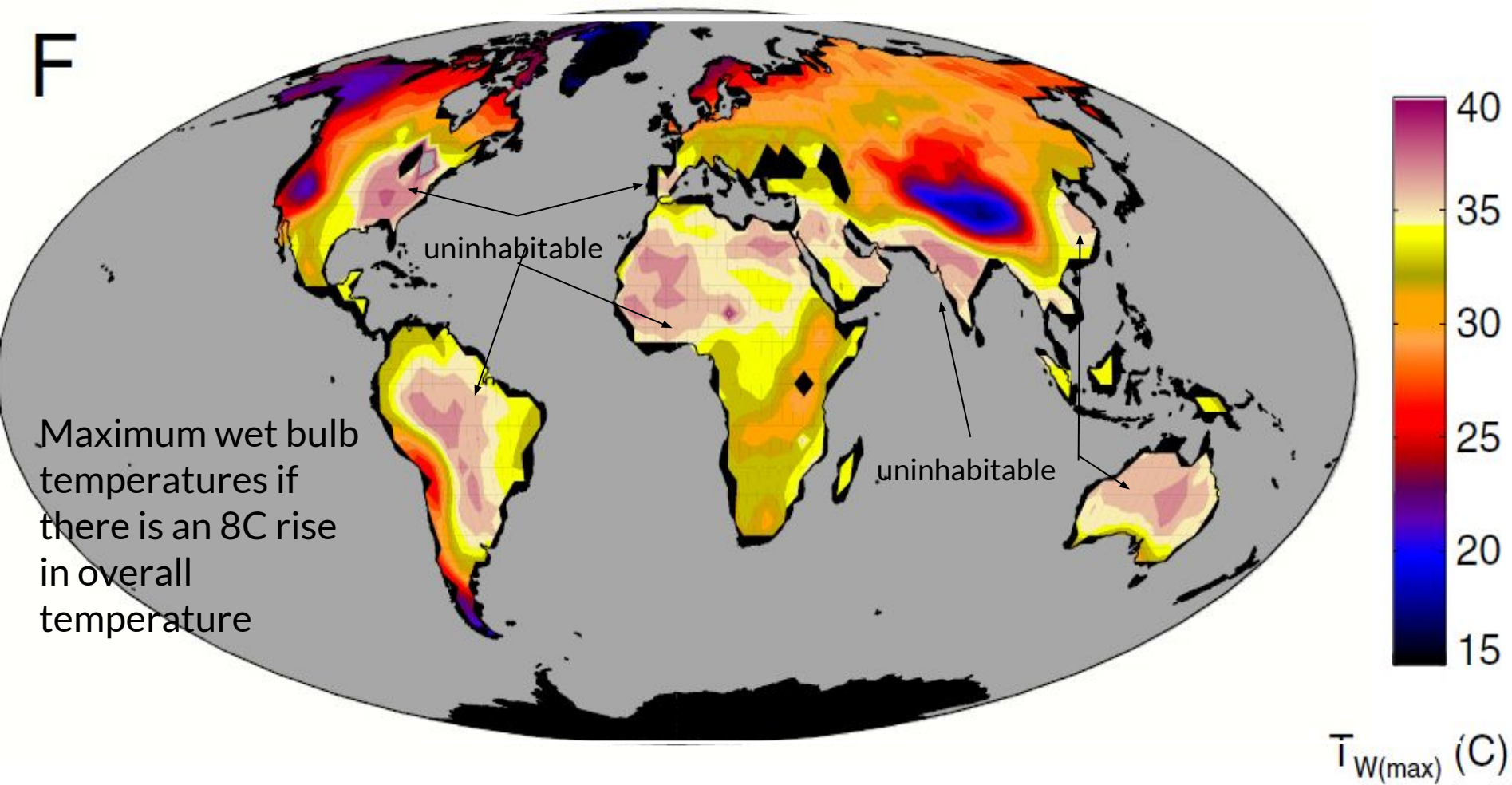
# Fire

There are direct risks associated with rising temperatures

- Heat waves bring frequent wildfires
- Deaths from heatstroke
  - In 2003, more than 70,000 people across Europe died in a sweltering heatwave
- If wet bulb temperatures rise above 35C people will die if not in air conditioned buildings



F



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# Worst case

That is for a worst case 'Eocene' scenario, but

- Business as usual could give such results in the mid 2100s
  - Sudden phase changes associated with thawing resulted in 5C jumps in only 10 years at end of Ice Age
  - Feedback from methane, melted arctic ice etc, can result in non-linear effects
-

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# Order of changes

Food problems and fuel changes have a timescale of the next 20 years

Severe Heat problems could start by last half of century

After that will come centuries of rising sea levels

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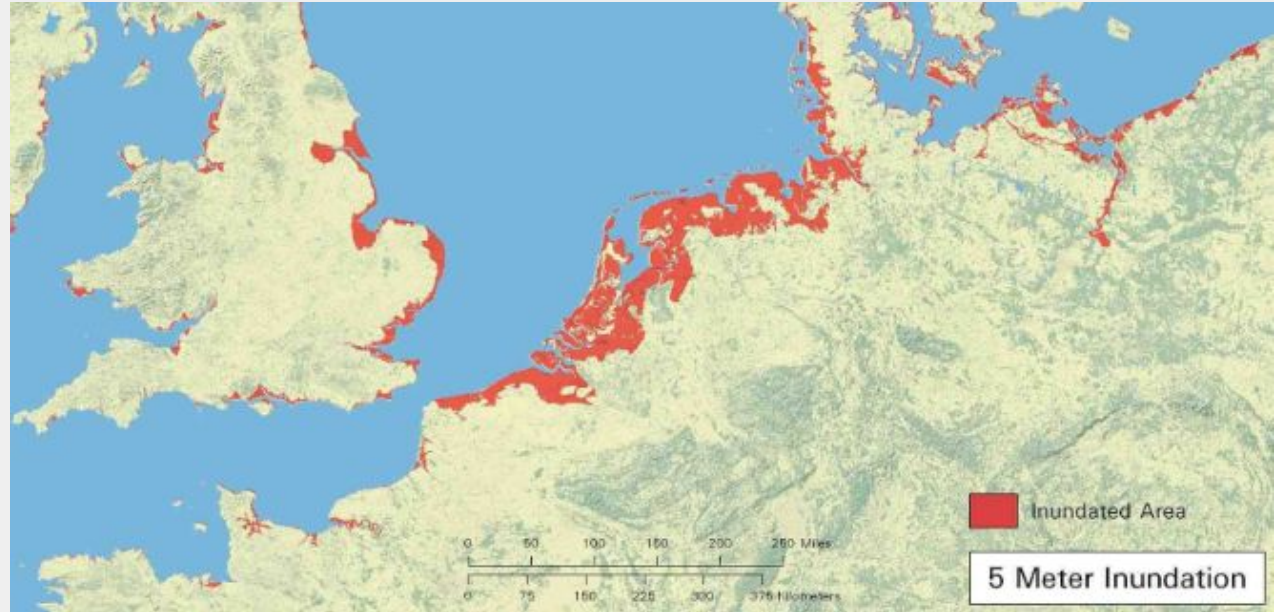
# —

## Implications

Abandon coastal cities

Build new ones on higher ground

Move ports up river as old ones flood



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# Population movement

## Heat stress

Deliberate depopulation of low altitude Southern parts of the continent, either permanently or in summer.

Migration north or to new towns in the mountains.

## Flood danger

Abandonment of coastal and flood plains permanently.

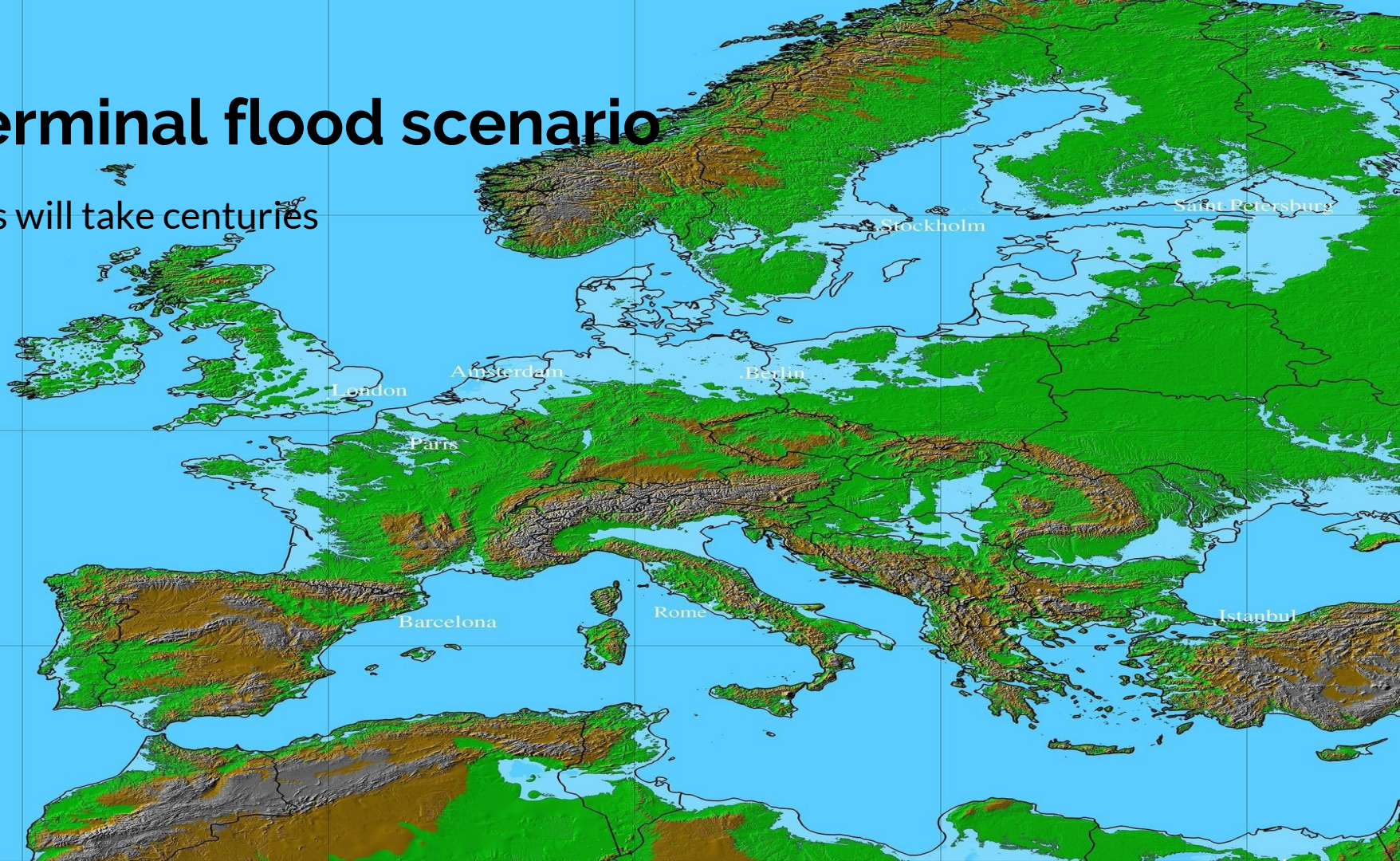
Rehousing tens of millions of people to higher ground

---



# Terminal flood scenario

This will take centuries





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# Heat and Social Change

The last great  
warming moved  
Europe from  
hunting to  
agriculture.

What social  
change with this  
warming bring?

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# Social change

The restructuring of the economy that is needed is huge

- Huge investments
- Huge movements of population
- Massive changes in infrastructure

Such change has only been achieved before in 2 cases

1. War time mobilisation of the economy
  2. First Soviet 5 year plans
-

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# Only two big options

1. State capitalism
2. Full socialist planned economy

Let's look at each, but first the common features of both

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# Common features

The state plans the main features of the economy in material terms not money terms

The state directs labour from inessential to essential sectors

Various forms of rationing imposed on private consumption

The state finances the needed investment

Investment in new infrastructure etc around 45% of economy  
( Chinese experience)

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# State capitalist option

Most production still in private firms, but firms work under state direction on state orders

Labour supply rationing, inessential sectors like banking, advertising, sales promotion have employment quotas reduced.

Carbon rationing

Extensive state rights to requisition land etc for national use.

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# Labour rationing

Labour supply will soon be the major constraint on achieving the levels of infrastructure investment needed.

Occupations categorised according to how vital they are to achieving the goals of environmental adaptation, direction of labour out of services into agriculture, construction and capital goods sectors.

Wartime experience shows that this becomes necessary within a couple of years of mobilising the economy

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# Carbon rationing

Based on the US system of petrol rationing during the 1970s oil crisis

- All citizens get equal carbon ration
- Can sell these if they are in excess of their own need
- Commercial firms have to buy the rations from citizens
- Garages etc will buy up unwanted rations
- Total ration reduces each year in predictable way

Economic effect redistributive to those on low incomes

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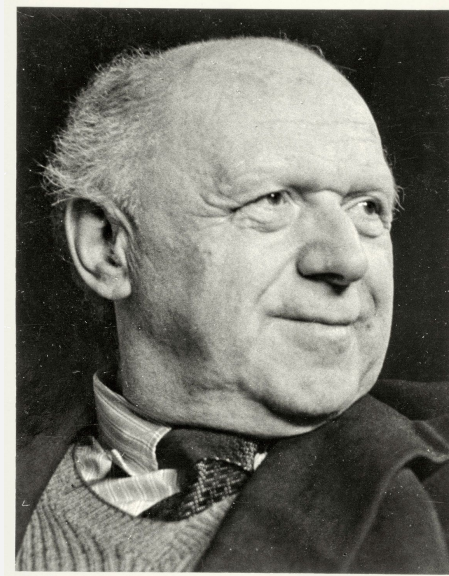
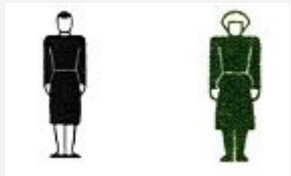
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# Financing

State spends what it needs from newly created money which it then mops up using tax and bond issues

- Income tax levels set to reduce luxury expenditure to a minimum
    - In 1945 UK income tax on the very rich was at 97.5% for example
  - Tax on bank deposits to encourage buying of state bonds
-

# In-kind economy versus money economy



Otto Neurath



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# Socialist option

All major firms either become state owned or become workers cooperatives

Coop firms still work under state direction to meet essential environmental targets

State purchasing boards for agriculture and private farmers have to meet planned targets for quantity and composition of food supplies in face of impending shortages

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# Cybernetic planning

Computing technology in Europe mature enough to allow in kind detailed planning down to the individual barcode level.

Plan drawn up using linear programming or more modern techniques to

1. Use all labour resources
  2. Meet carbon and other environmental targets
  3. Meet in real-time essential consumer needs
-

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# From labour rations to labour prices

The socialist option will also be labour constrained.

This can be systematically dealt with by moving from pricing in money to pricing in hours of labour.

State budgets expressed in hours directly translate into the share of the labour force used.

Workers get paid 1 hour labour credits for each hour worked.

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# Labour credits vs money

- Public labour credits do not circulate
- Can only be used by the person who did the work
- Income tax deducted at source
- Eliminates both tax avoidance and black markets

For comparison a 1 hour credit would be worth about 30 Euro at current levels of productivity

Eliminates social and sex income inequalities

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# But is this technically feasible?

Can you do economic calculation the way Neurath proposed in terms of material goods and labour?

Will explain this looking at computing labour content, other aspects require a more sophisticated computer science argument that we have published in journals.

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# Plans and computers

- Starting with Von Mises, conservative economists argued that effective socialist planning was impossible because:
  - No – effective cost metric in absence of market
  - Complexity too great – millions of equations argument.

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# Millions of equations

- Computers obviously change this as they can solve millions of equations
- Need to be quite precise about how many million equations and just how hard they are to solve
- This is a branch of complexity theory

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# I/O table

|         | rubber | steel | oil | zinc | cotton |
|---------|--------|-------|-----|------|--------|
| rubber  |        |       |     |      |        |
| steel   |        |       |     |      |        |
| oil     |        |       |     |      |        |
| zinc    |        |       |     |      |        |
| cotton  |        |       |     |      |        |
|         |        |       |     |      |        |
| labour  |        |       |     |      |        |
| outputs |        |       |     |      |        |

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# Use of I/O table

- From the I/O table one can compute how much of each intermediate product required to produce each final product.
- In particular we can compute the labour content of each output.

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# Computability of labour content

- Suppose we have 10,000,000 different types of goods produced in an economy (Nove quotes this)
- Labour content given by the matrix equation
  - $\lambda = A\lambda + \ell$
- Where  $\lambda$  is a vector of labour contents,  $\ell$  a vector of direct labour inputs and  $A$  an input output matrix
- Clearly too big to invert, matrix is even too big to store in a computer containing :  $10^{14}$  cells.



---

# Gaussian solution impossible

I am making  
conservative estimates  
of single processor  
speeds here  
100 Mflop effective

| products   | multiplications | time taken   |                             |
|------------|-----------------|--------------|-----------------------------|
|            |                 | uniprocessor | Multiprocessor, 100<br>core |
| 1000       | 1,000,000,000   | 10 sec       | 0.1 sec                     |
| 100,000    | $10^{15}$       | 4 months     | 27 hrs                      |
| 10,000,000 | $10^{21}$       | 317,000 yrs  | 3,170yrs                    |

---

# Gaussian solution impossible

| products   | multiplications | time taken   |                          |
|------------|-----------------|--------------|--------------------------|
|            |                 | uniprocessor | Multiprocessor, 100 core |
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| 100,000    | $10^{15}$       | 4 months     | 27 hrs                   |
| 10,000,000 | $10^{21}$       | 317,000 yrs  | 3,170yrs                 |

Clearly this is impossible !



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# Simplification

- Matrix is sparse, most elements are zero
- Replace by linked list representation, we estimate the number of inputs directly used in a product is logarithmic in the size of the economy.
- Solve iteratively - use about 10 iterations,
- Complexity of order  $n \log n$  in number of products. We estimate that it takes a few seconds on a modern machine.

---

# Sparse representation

- Each production process represented by a list of pairs ( input code, quantity)
- On average a process can then be represented in about 100 cells instead of 10,000,000

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# Iterative solution

- We only need to know labour values to about 3 significant figures.
- Initially just include direct labour inputs.
- The produce second estimate taking into account indirect inputs. Repeat this step about 10 times.
- You end up with a figure accurate to about 3 digits.

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# Iterative solution feasible

These timings are based on actual measurements in experiments, Cottrell, Allin et al. "Is Economic Planning Hypercomputational? The Argument from Cantor Diagonalisation." *IJUC* 5 (2009): 223-236.

| products   |  | Time taken       |
|------------|--|------------------|
|            |  | 3Ghz xeon 1 core |
| 10,000     |  | 1.6sec           |
| 100,000    |  | 5.8sec           |
| 1,000,000  |  | 68.2sec          |
| 10,000,000 |  | 12 mins          |

Measured

Projected

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# Conclusions

- Europe faces potentially catastrophic changes
  - These can be reduced but not eliminated by directive planning
  - The planning can be either state capitalist or socialist and will involve radical changes in social relations.
  - In either case extensive use will have to be made of modern computational methods
-