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Energy mix and climate change
From Descartes to Alain

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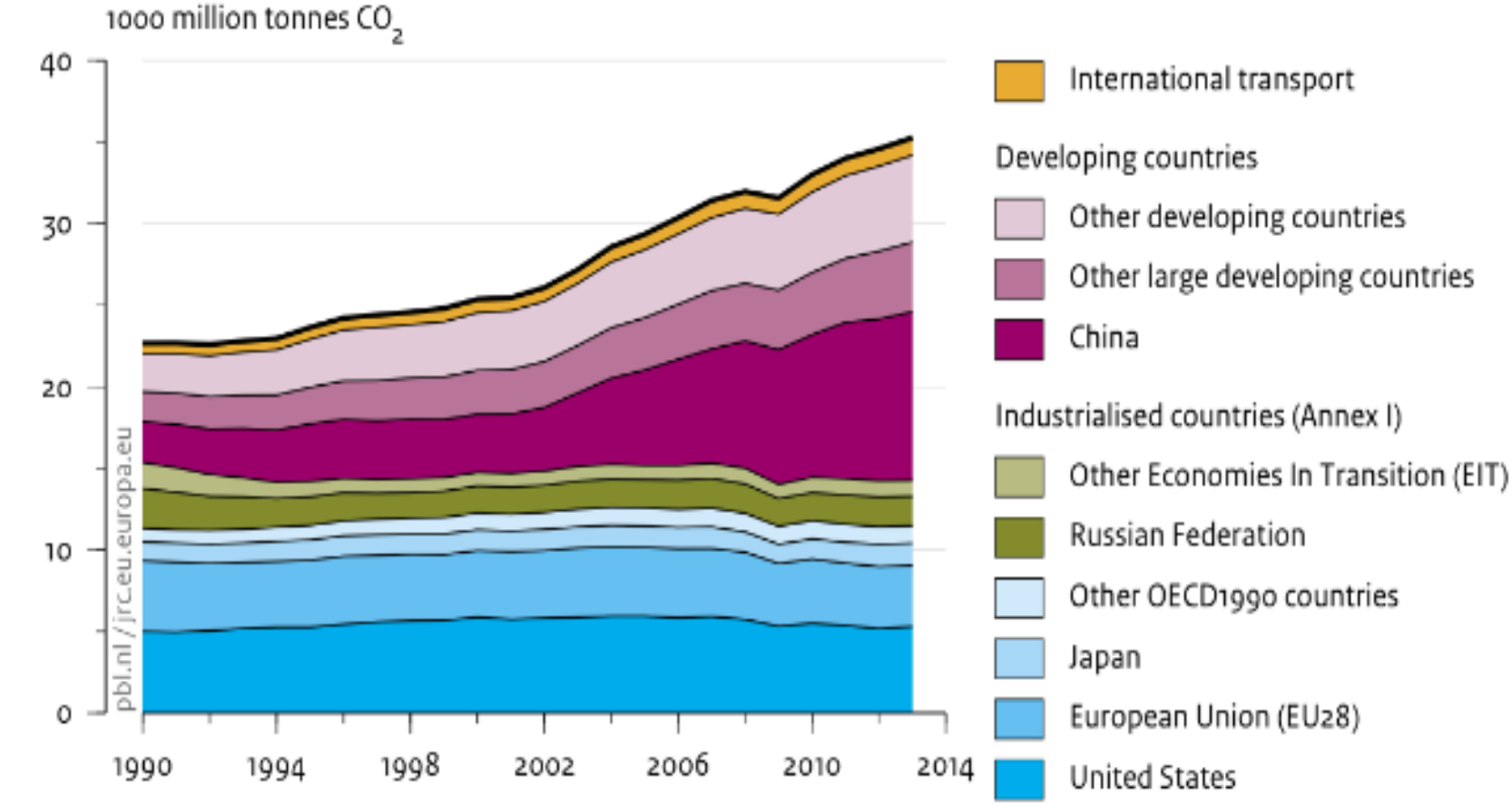
Le bon sens est la chose la mieux partagée car chacun pense en être si bien pourvu, que même ceux qui sont les plus difficiles à contenter en toute autre chose, n'ont point coutume d'en désirer plus qu'ils en ont.

Common sense is the best shared quality because everyone expects to be so well off , that even those who are most difficult to satisfy in everything else , have no desire of more common sense than they have .

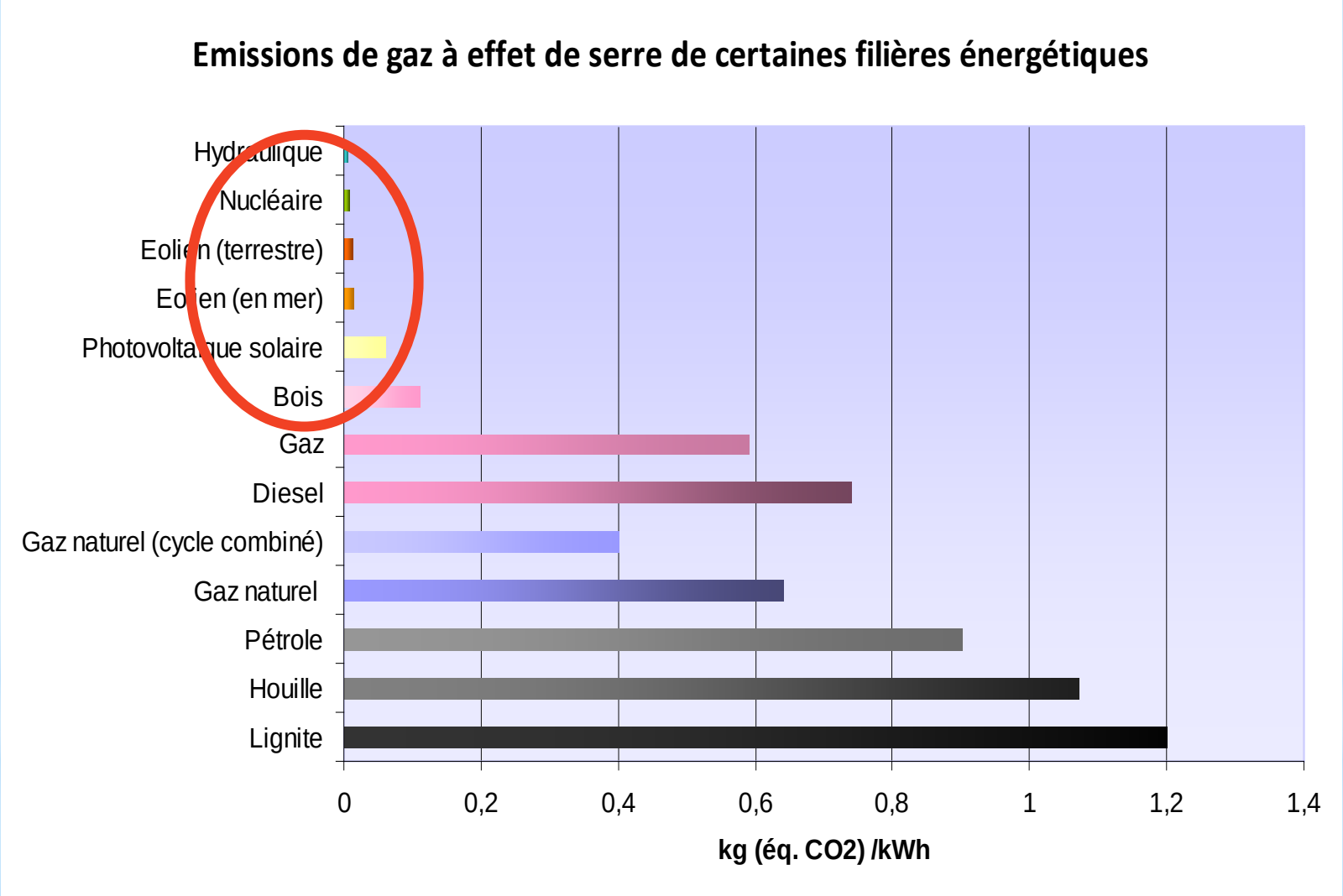
Descartes, Discours de la méthode

FIGHTING GLOBAL WARMING:
PRODUCING LESS CO2 for ENERGY ?…beyond claims, facts

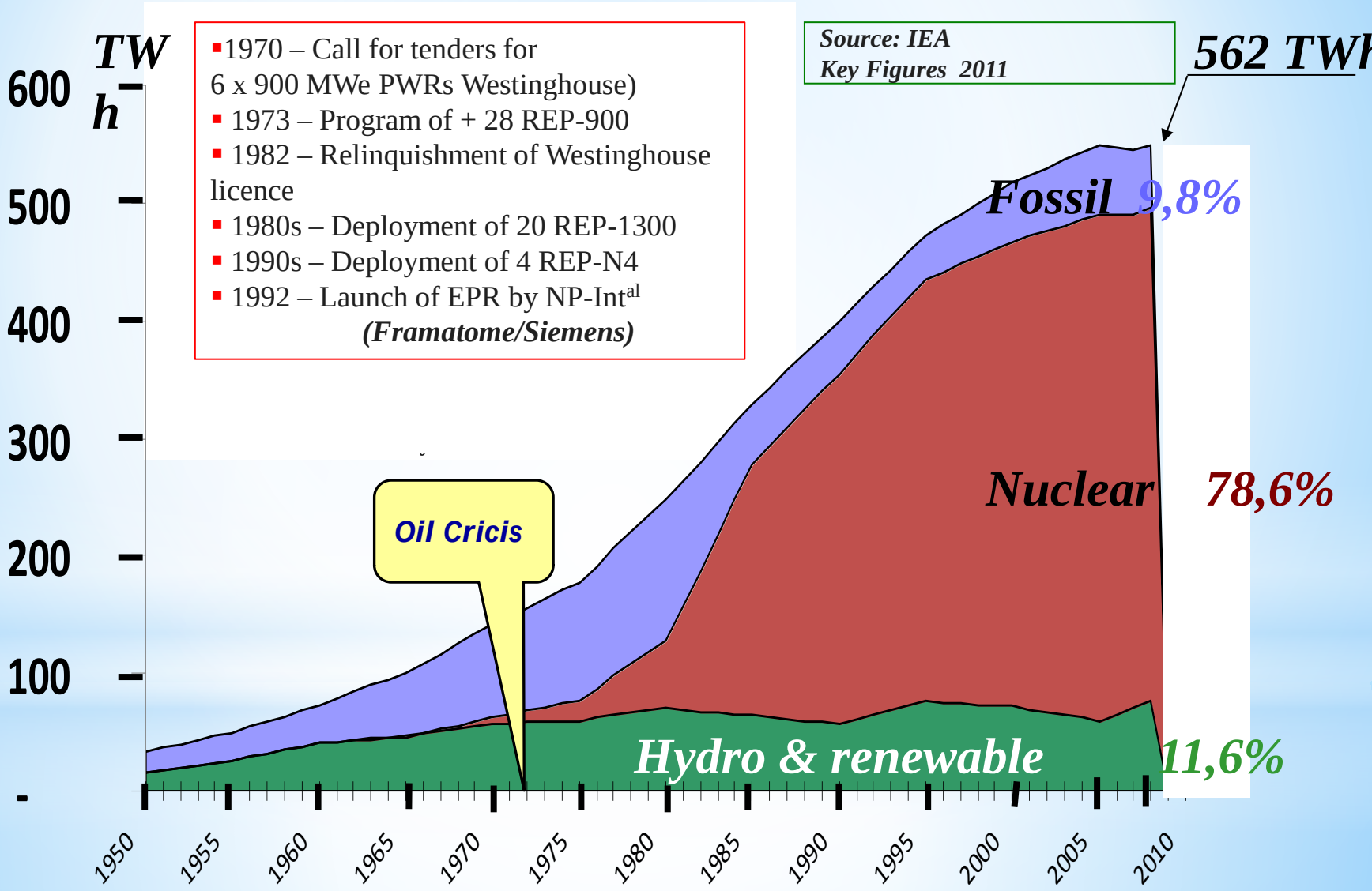


Source: EDGAR 4.2FT2010 (JRC/PBL 2012); BP 2014; NBS China 2014; USGS 2014; WSA 2014; NOAA 2012

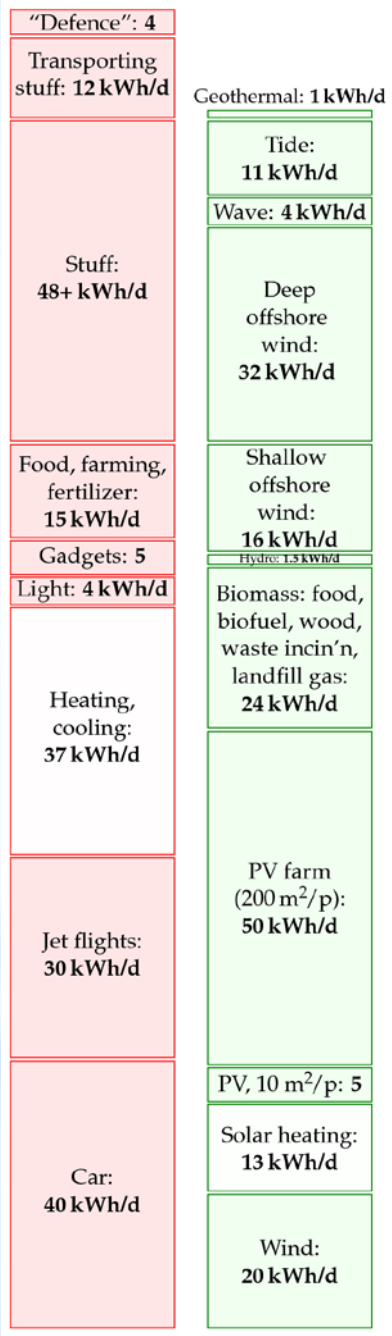
Energy production and greenhouse gases…



ENERGY TRANSITION TOWARD DECARBONATED ELECTRICITY, IN FRANCE…HAS ALREADY OCCURRED…IN 1973 !!!



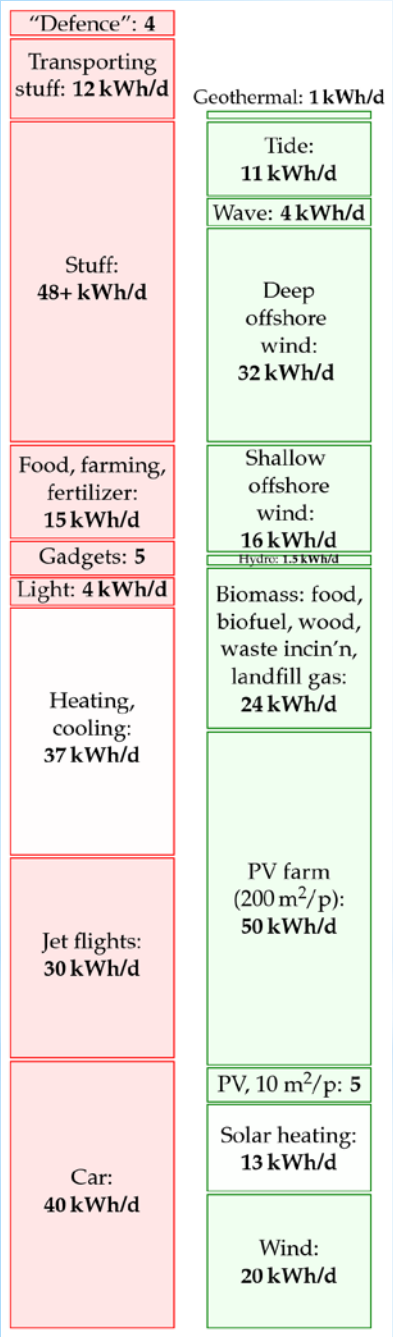
Consumption/ day/person



Maximum energy production per day per unit surface

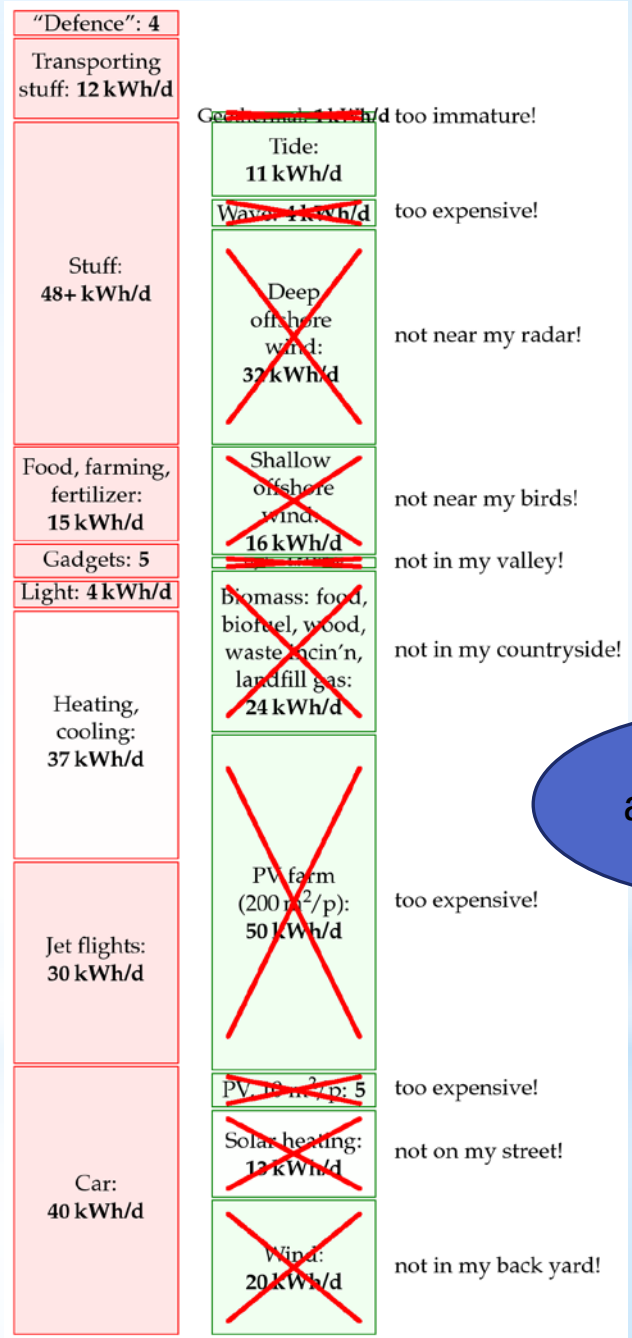
Production per day per person

Population density

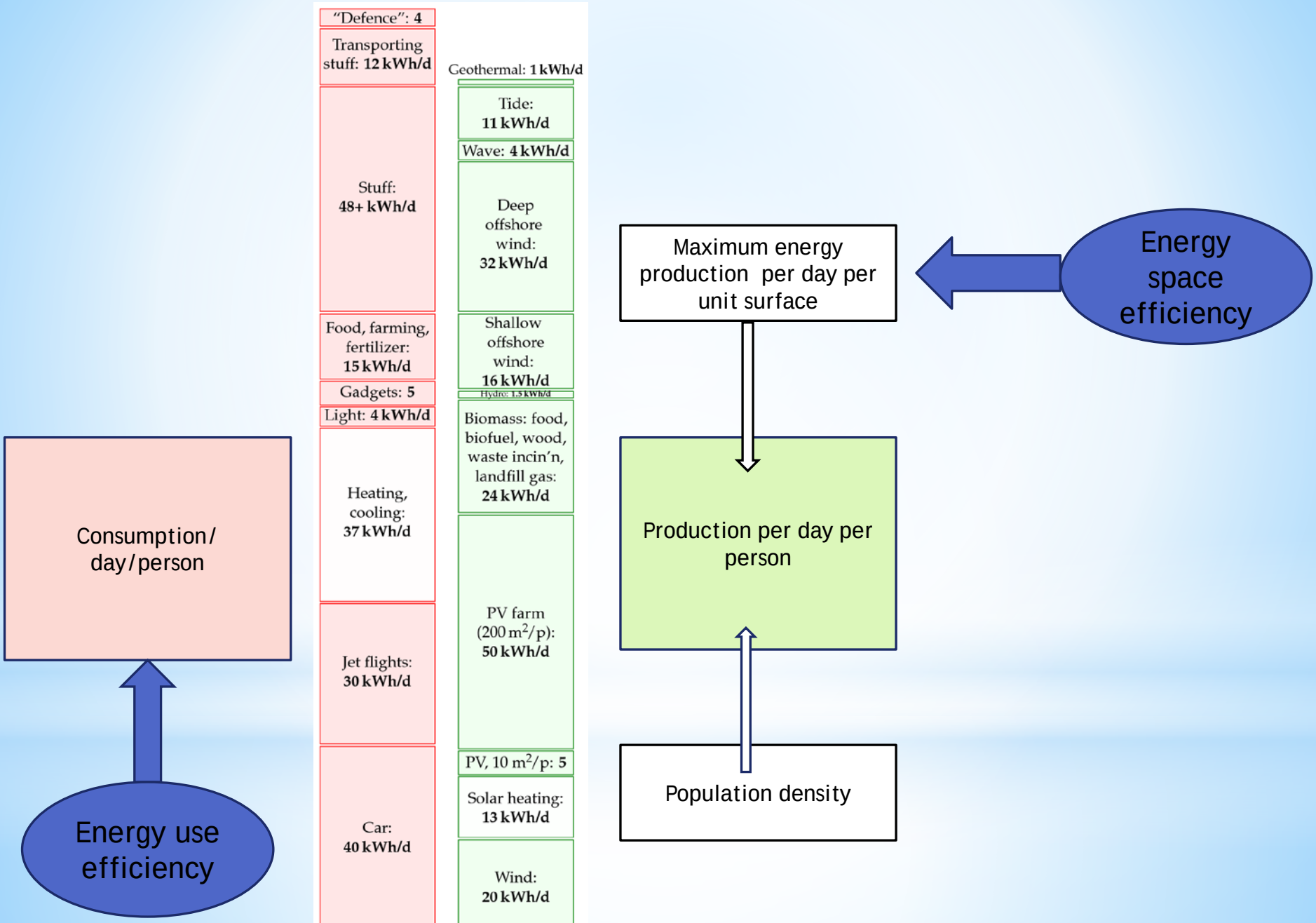


Renewables energies Cannot provide the match alone unless a very substantial decrease in energy consumption is enforced

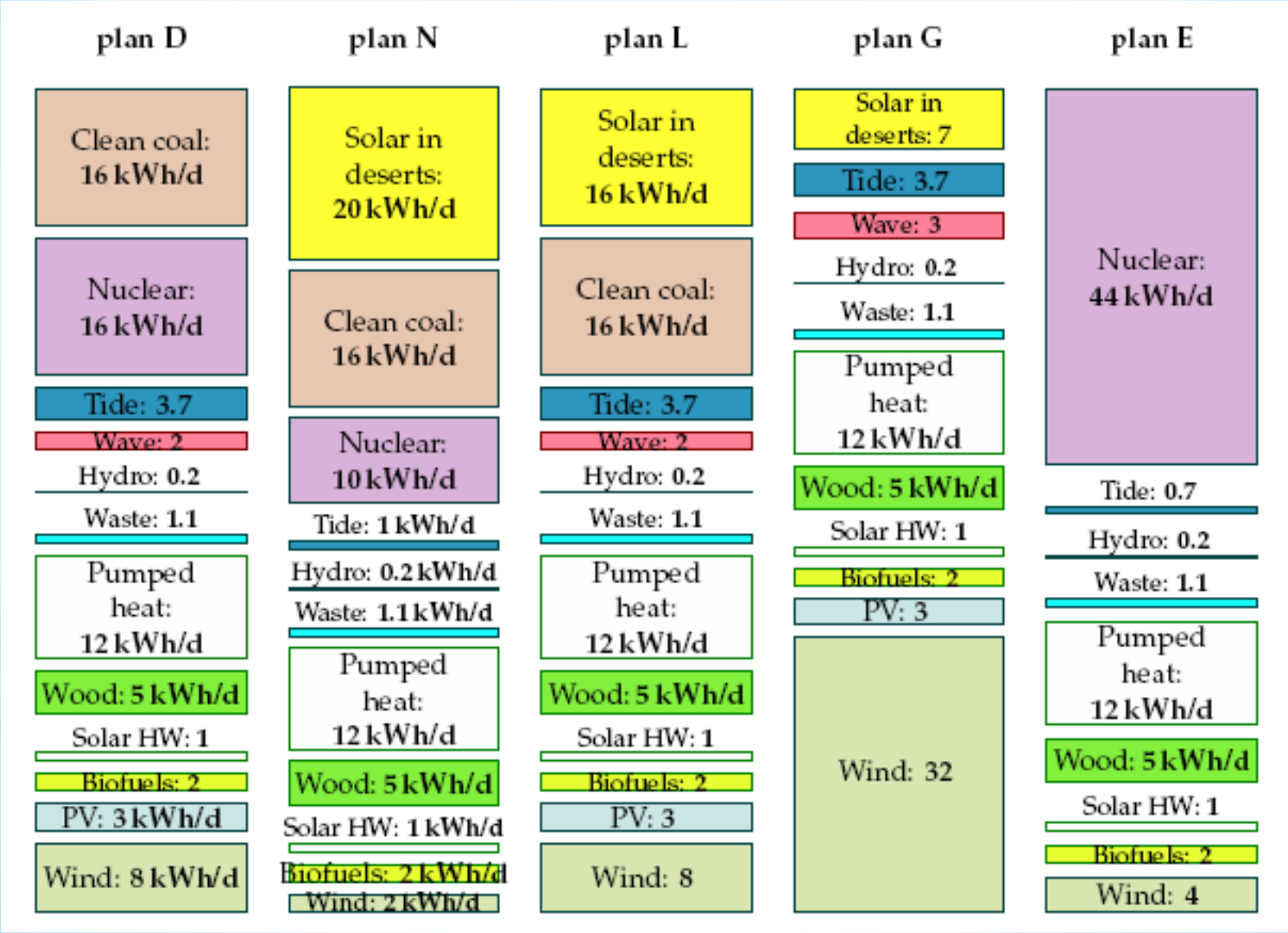
This is true even for a country desindustrialised as UK



Additionnal acceptability issues


"Defence": 4
Transporting stuff: 12 kWh/d
Stuff: 48+ kWh/d
Food, farming, fertilizer: 15 kWh/d
Gadgets: 5
Light: 4 kWh/d
Heating, cooling: 37 kWh/d
Jet flights: 30 kWh/d
Car: 40 kWh/d
Geothermal: 1 kWh/d
Tide: 11 kWh/d
Wave: 4 kWh/d
Deep offshore wind: 32 kWh/d
Shallow offshore wind: 16 kWh/d
Hydro: 1.5 kWh/d
Biomass: food, biofuel, wood, waste incin'n, landfill gas: 24 kWh/d
PV farm (200 m²/p): 50 kWh/d
PV, 10 m²/p: 5
Solar heating: 13 kWh/d
Wind: 20 kWh/d
Consumption/ day/person
Energy use efficiency
Maximum energy production per day per unit surface
Energy space efficiency
Production per day per person
Population density

Possible energy mix (feasability) (D.McKay).



Reaching a realistic energy mix ?

Space and matter must be <u>available</u>
=> Material intensity index

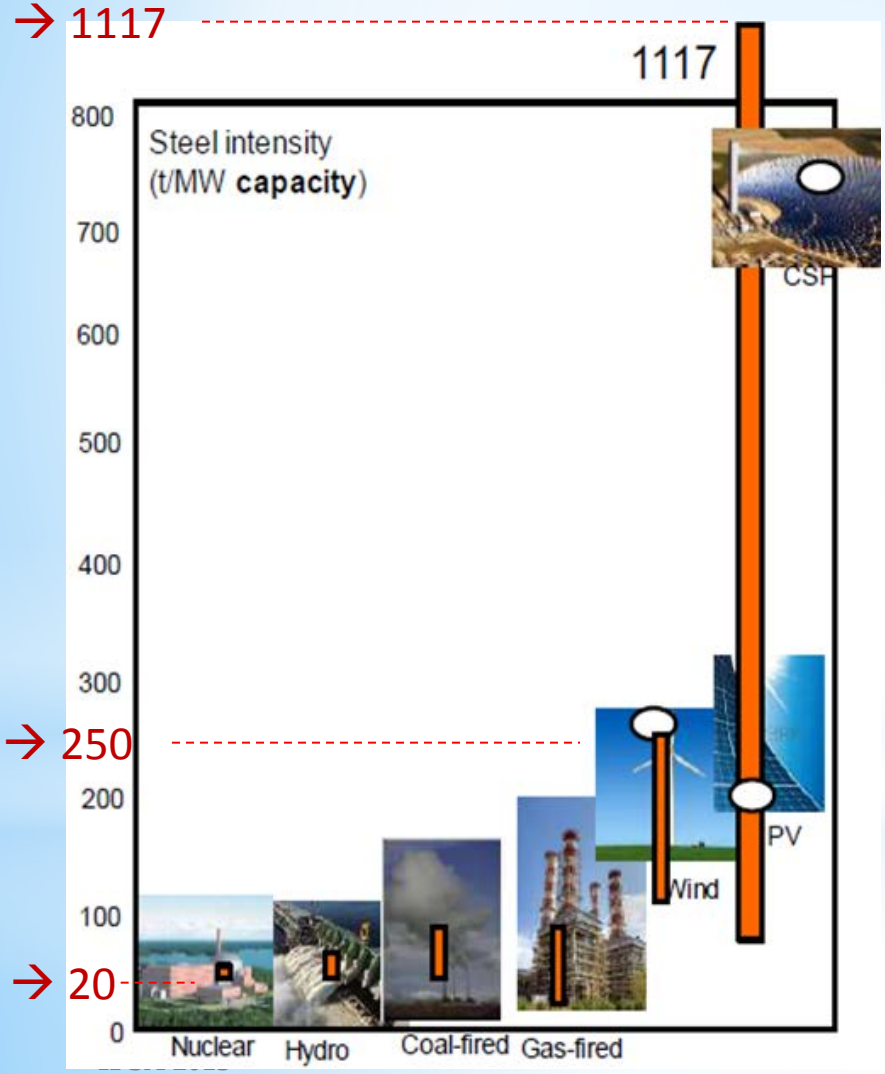
Things must add up : averaged over the « economic domain », the production must add up to the level of consumption…

⇒ Possible correction due to networks
⇒ Possible corrections due to storage

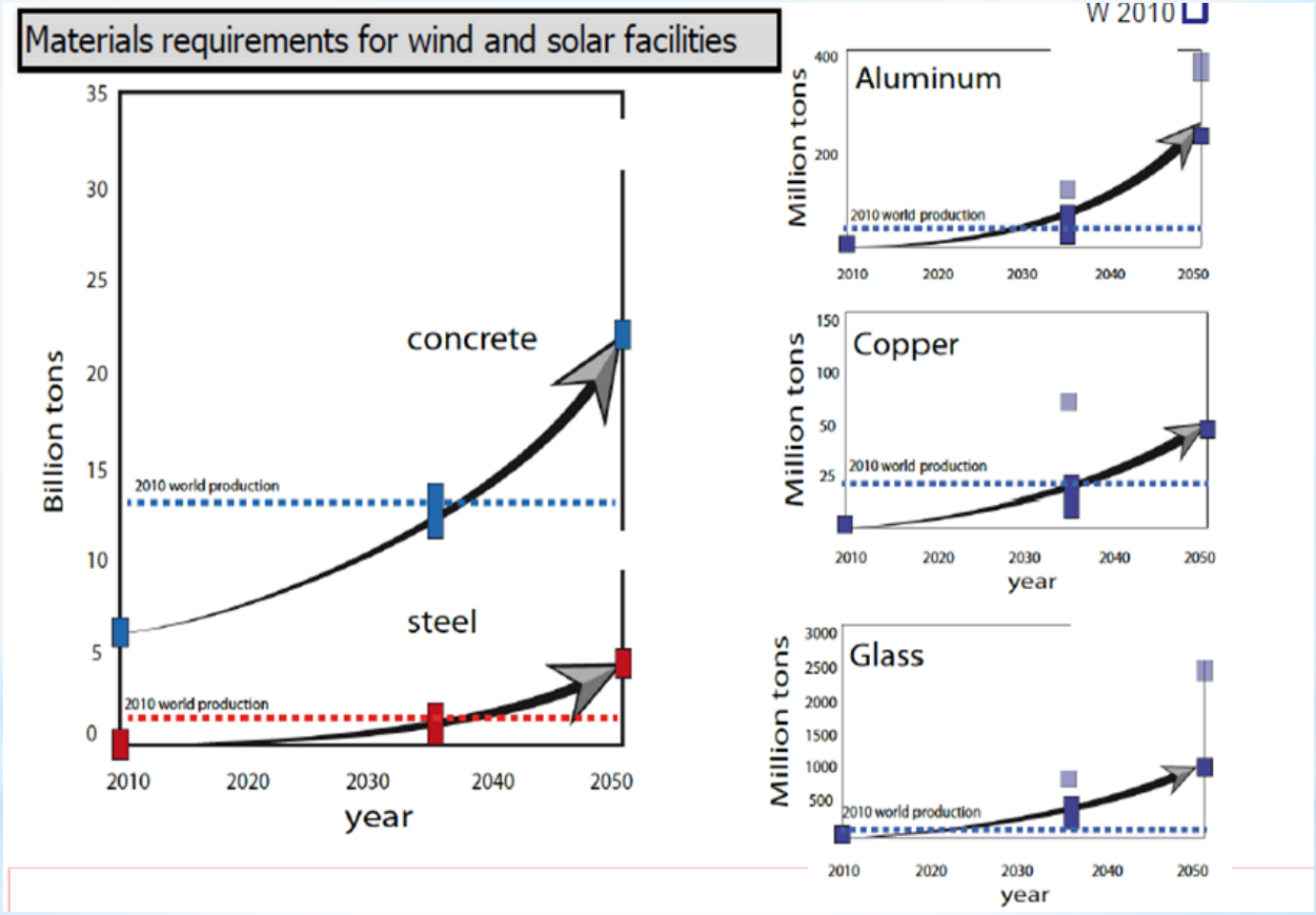
Is it even feasable ?

1. Materials intensity index

MATERIALS TENSION



Wind turbine 6 MW with rotor >150m
1500 t of steels -
+ Rare earth permanents magnet…
Nd, Dy, Sm, Gd, or Pr

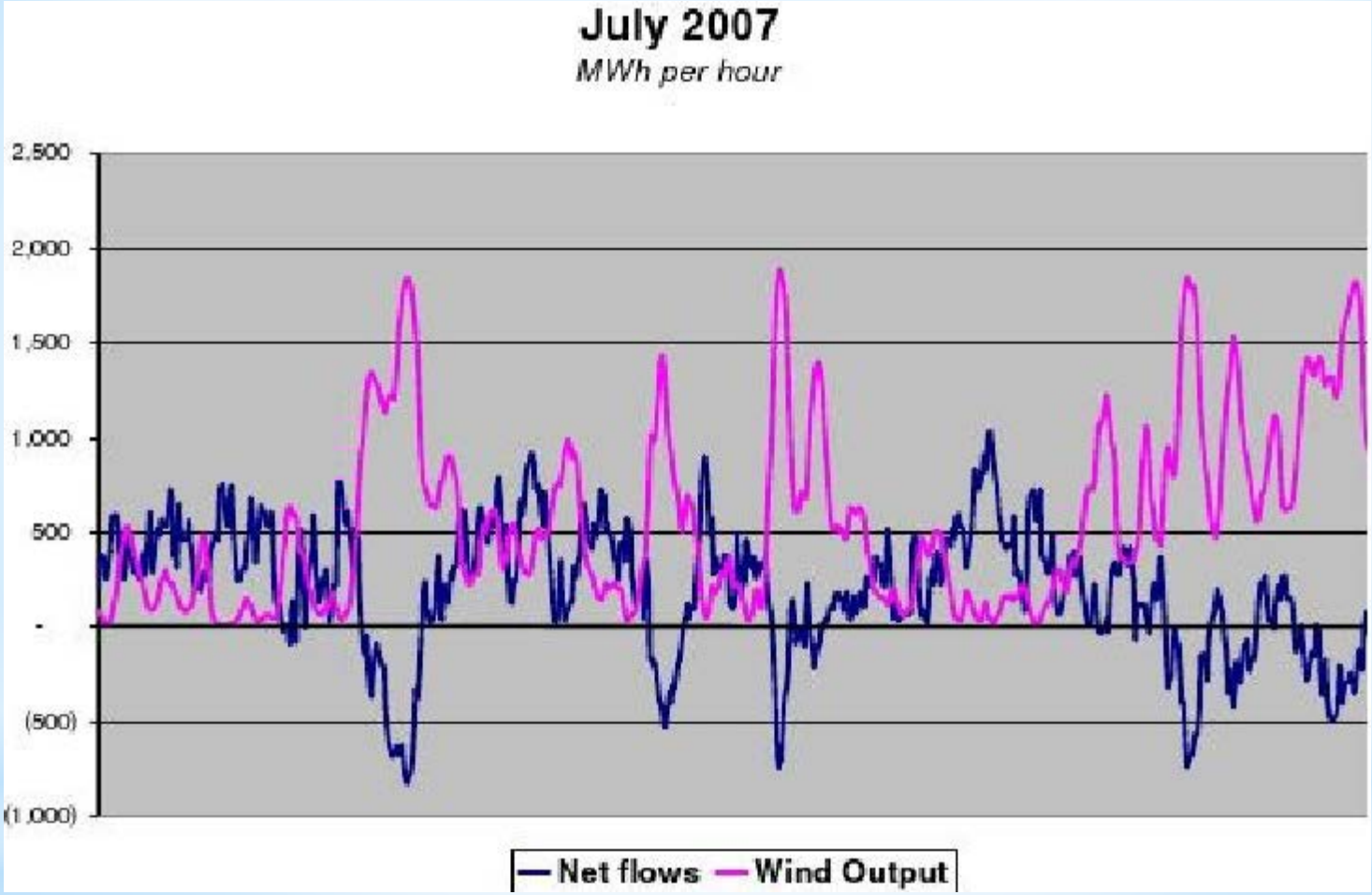


In 2050 , the cumulative amount of concrete, steel, Al, Cu and glass sequestered In wind and solar facilities will be 2 to 8 times the 2010 total world production

Is it even feasable ?

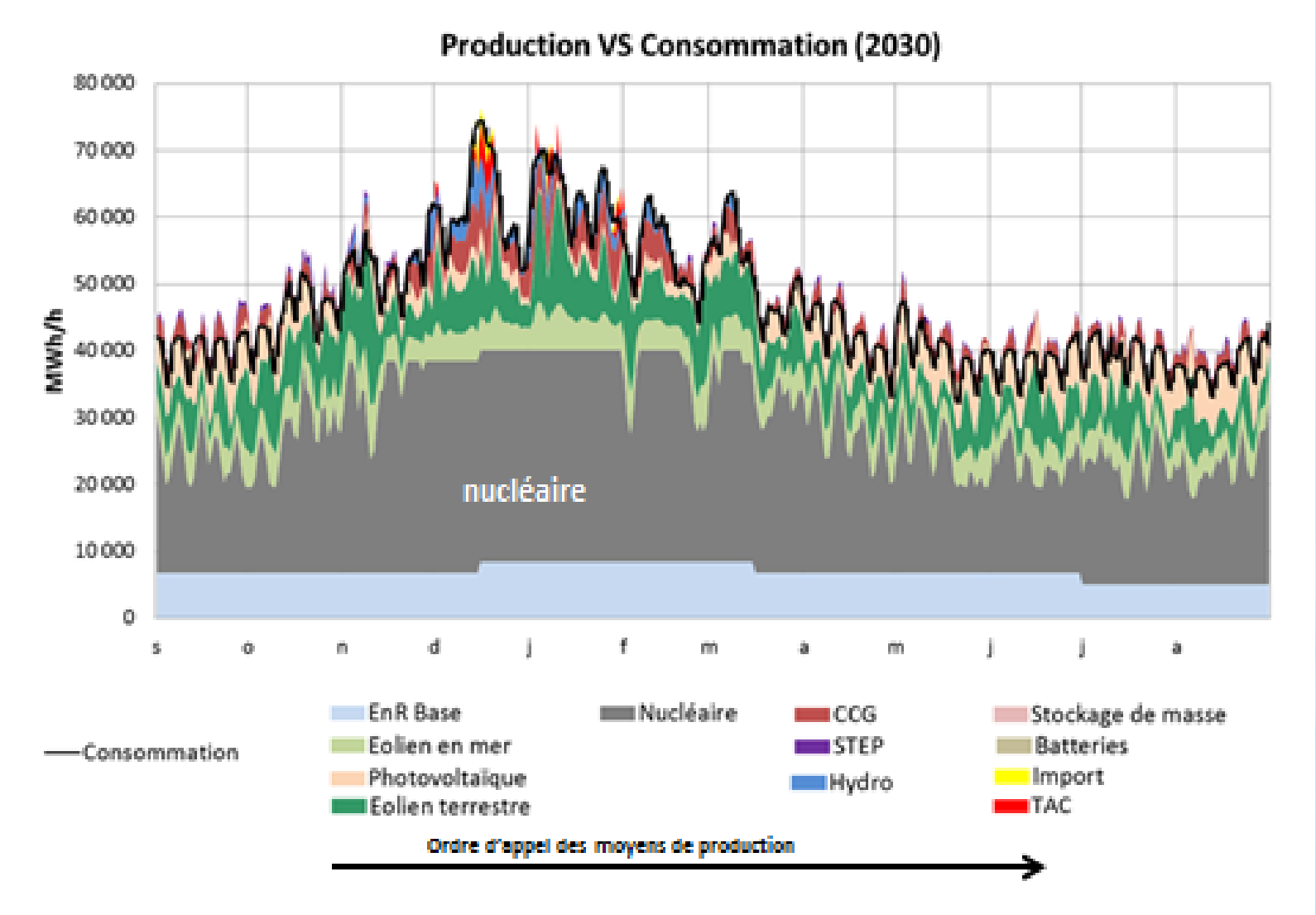
2. Managing variations in time

Wind fluctuations



<u>Ask from other resources</u>:
time of reaction (destorage) comparable with the fluctuation timescale
they must be available in a distance comparable to the networking

Or you can dream…that other sources will match the difference.



Is it even feasable ?

3. Managing space

RENEWABLE ENERGIES ARE DIFFUSE…

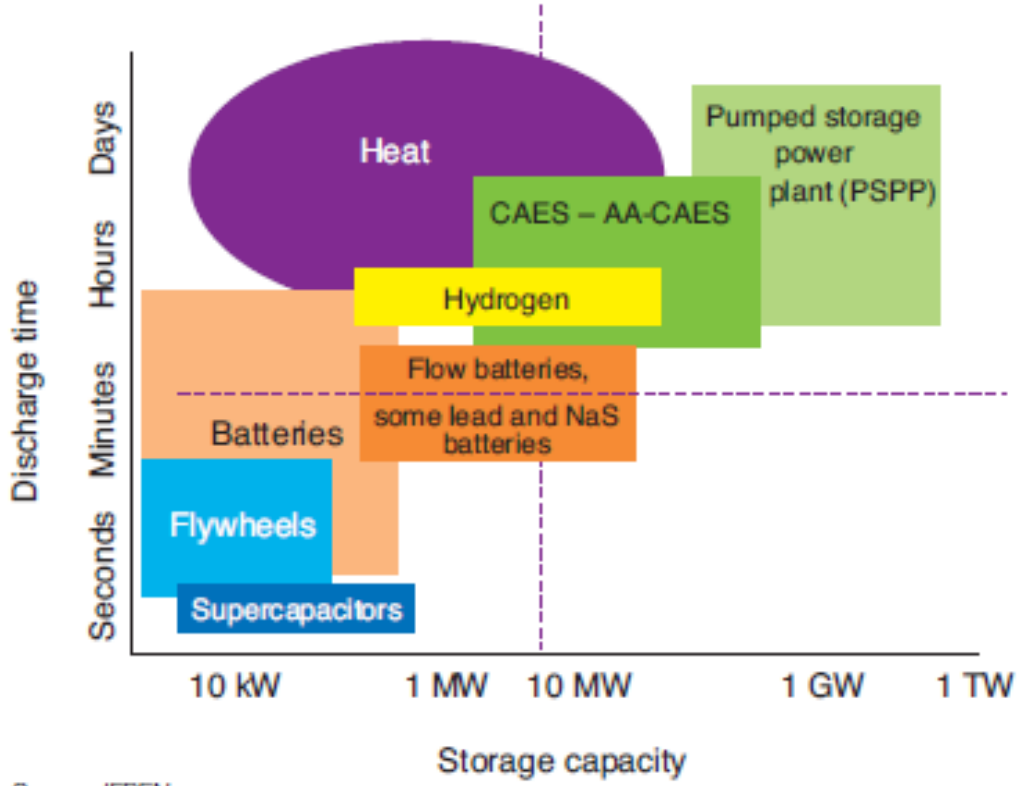
source	Density of energy W/m2
Eolien	2.5
Solaire PV	5-20
Hydraulique « piscine »	3
Hydraulique « au fil de l eau »	8
Solar concentration in desert	15-20

NUCLEAR FISSION : 1000 W/m2

AS LONG AS CONCENTRATED ENERGY WILL BE REQUIRED FOR ELECTROINTENSIVE INDUSTRY? RENEWABLE ENERGY WON'T DO THE JOB

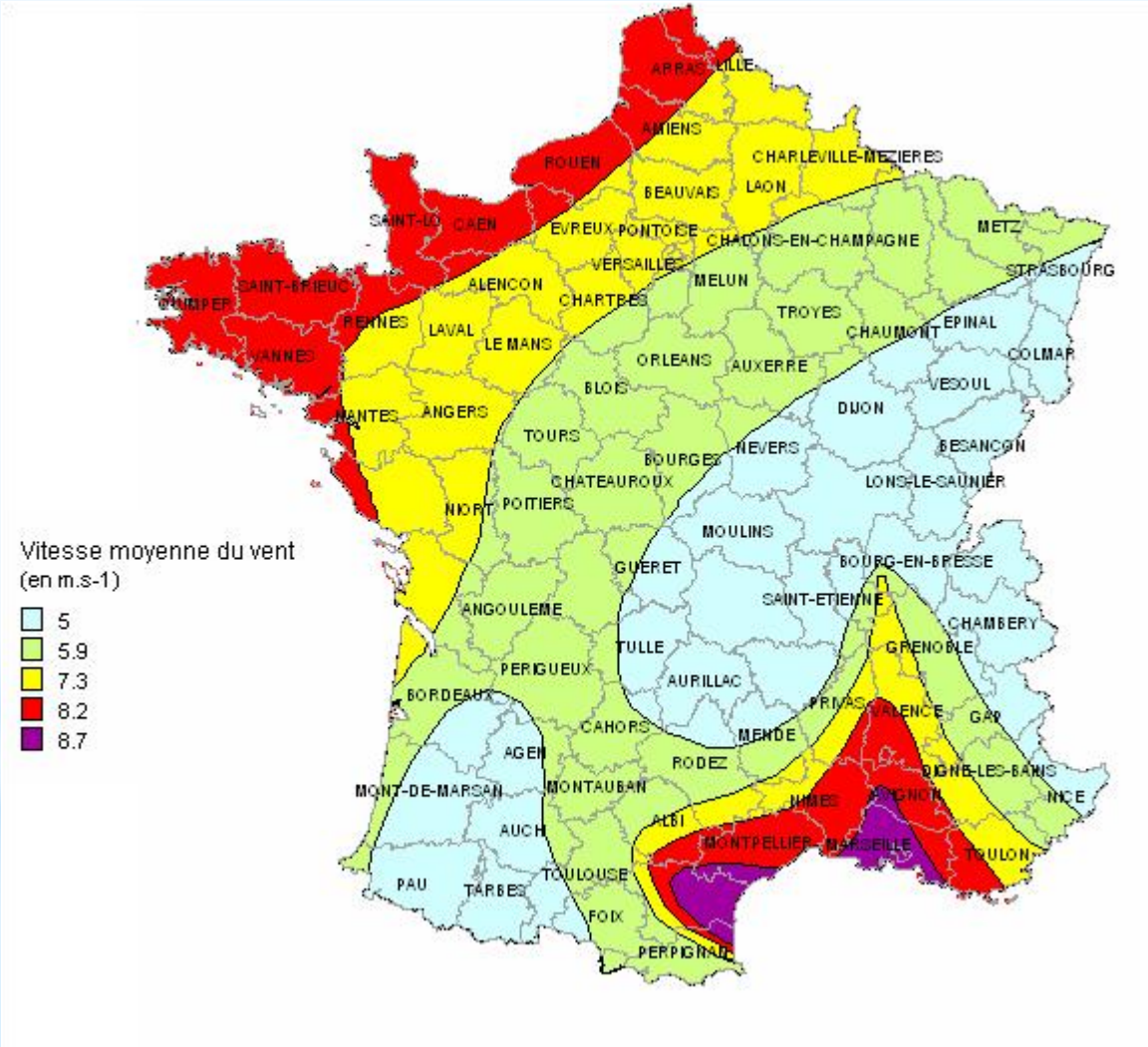
MOST OF STORAGE CAPACITIES ARE DIFFUSE

Fig. 1 – Storage technology as defined by capacity and discharge time (autonomy)



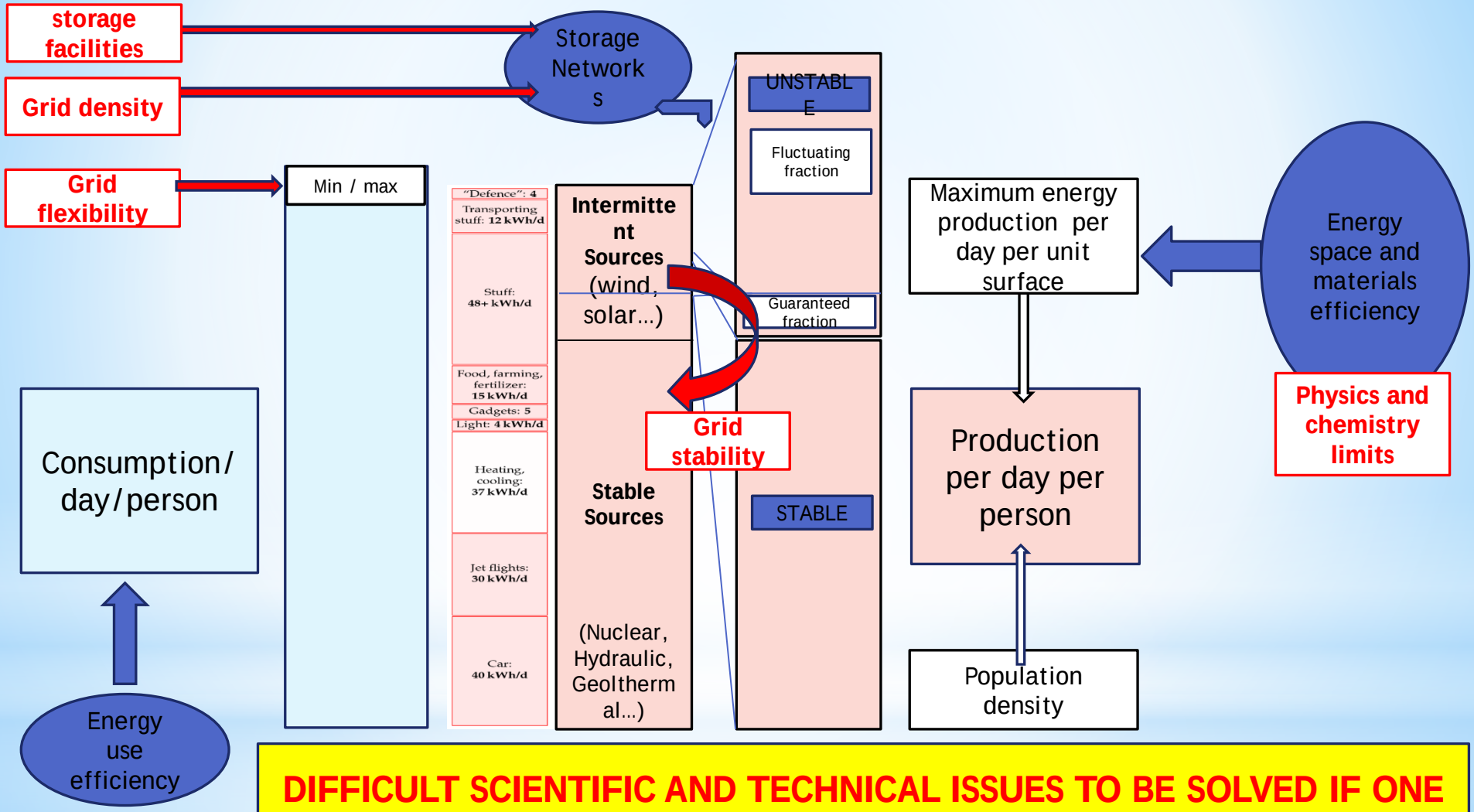
Source: IFPEN

SPATIAL CORRELATIONS ARE LONG RANGED



AND NOW?

After all the wishfull thinking what can the engineer do?



DIFFICULT SCIENTIFIC AND TECHNICAL ISSUES TO BE SOLVED IF ONE WANTS TO KEEP A CONCENTRATED PRODUCTION / CONSUMPTION FOR INDUSTRIAL APPLICATIONS

- **De-carbonising the economy seems the most urgent question** to be adressed when considering the risk of global warming

=> The least we can say is that this « goal » is not always clear , it is often mixted up with developping alternative energy » which should be only one of the possible tools and not a goal « per se ».

-**The actions to be taken should be <u>immediately efficient</u>**, **and the technologies available NOW**, and economically affordable:

=>the development of a new energy verctor amounts to change the industrial systems, it seems unrealistic to start by that. Electrifying economy, hybridising transportation seems more realistic than expecting a revolution

- **3x1/3: transport + industry + building: lets find the « big actions »**

  => building energy efficiency : reserach should be focussed on insulation and renovation

  => transport : lighter structures, hotter engines , better catalysers

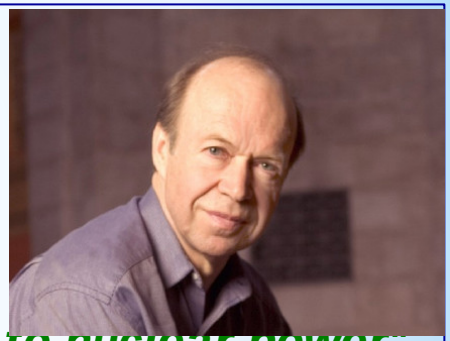
  => Industry: dont forget the need of centralised and continuous energy production. Develop solutions for 100-400C heat management

- **Renewable energies is an option, not a prerequisite**

  => The key topic is dealing with intermittency

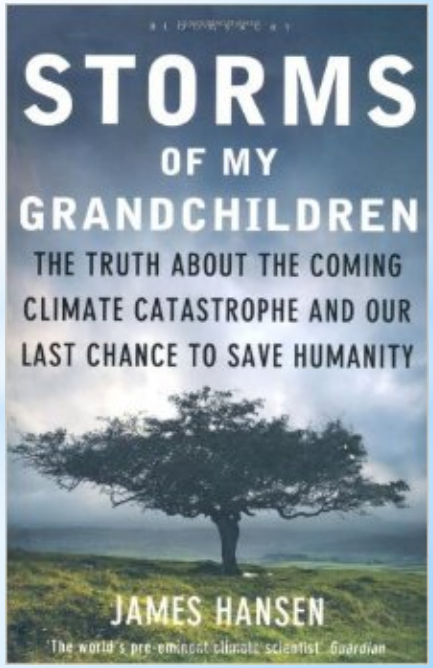
  => Storage and networking are the key issue, before efficiency

* **Prof. James E. Hansen** *(Univ. Columbia, US Academy of Science)*



  * ***Climate is changing 10 times faster than ever***
    - → ***Extermination of species, Rising of sea level, Climatic extreme events*** *(storms, fires, floods…)*
    - → ***Multiple Man-made stresses → Concerns for next generations***
  * ***"To those influencing environmental policy but opposed to nuclear power"***

Open letter of 4 climate scientists (Nov. 17, 2013)
→ A plea to fellow environmentalists that nuclear energy needs to be part of the global climate change solution
→ Confidence in technology progress to make nuclear safer, more efficient and more proliferation resistant

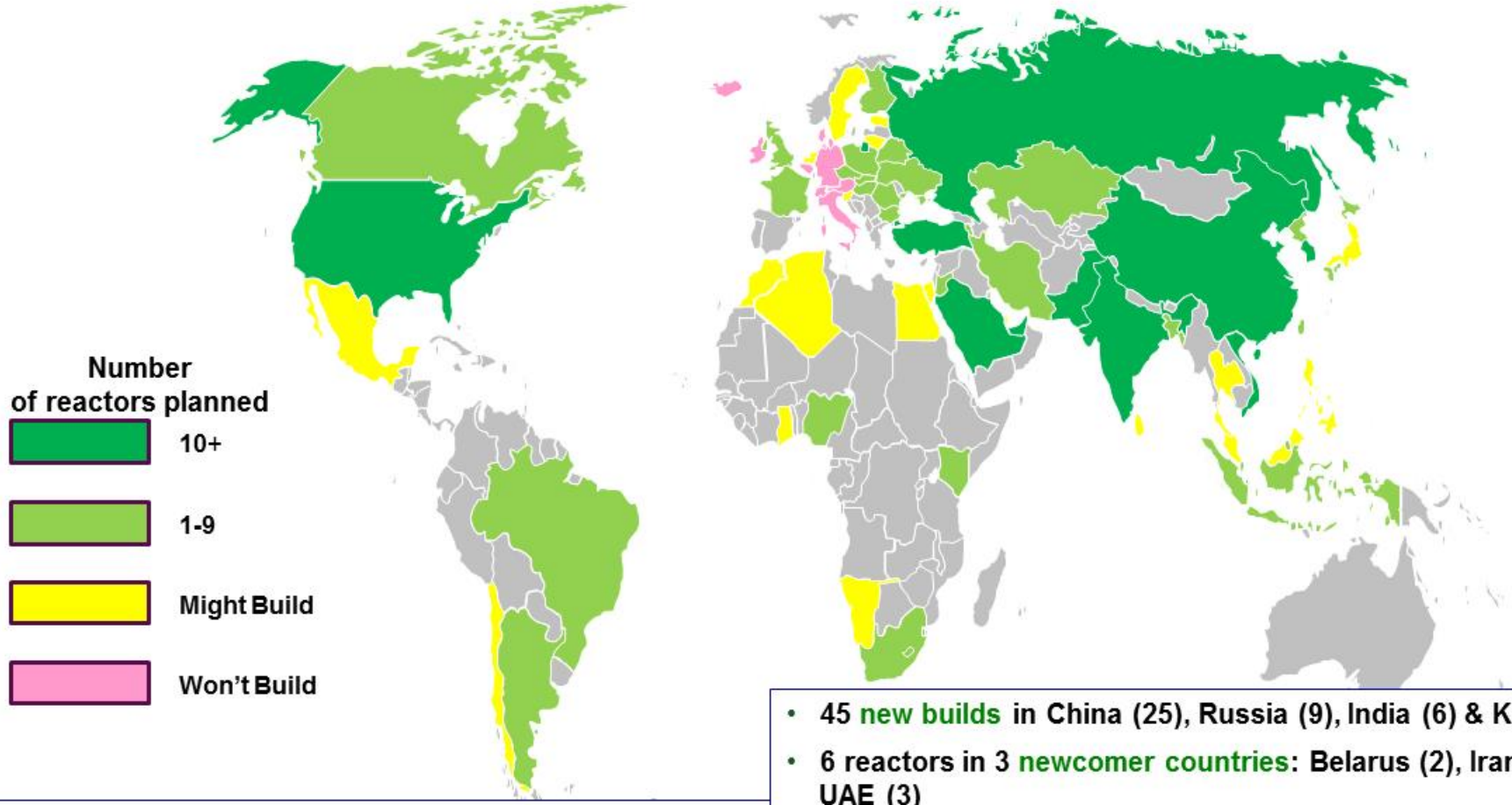


* *Prof. Hansen advocacies:*
  * *Need for a clean energy portfolio standards (not only renewables)*
  * *Urgency of a clean air act incentive*
  * *Modular reactors, largely factory built / Safety, reduction of cycle time*
  * *China to lead, West to cooperate*

Conditions for Successful Deployment Worldwide

* **Reliability & Safety**
  * ***Fukushima accident-proof design*** *+ Enhancement of Emergency preparedness*
  * *Progress towards* ***internationally harmonized design codes & safety standards****, QA*
* **Security** *(Proliferation resistance, Physical protection…)*
  * ***Safeguarding by IAEA, Euratom…***
  * ***Export control*** *of sensitive technologies*
* **Economics**
  * ***Competitiveness with other energy sources*** in spite of rising costs for Gen III reactors
  * ***Adapted / customized funding schemes*** to favor investments in nuclear in a liberalized energy market
* **Sustainability**
  * ***Minimization of waste burden*** → Implementation of HLW repository in some countries
  * ***Minimization of environmental impact***
  * ***Maximization of use of fuel resources***

Global Nuclear Construction Plans→ 700-1500 GWe by 2050?



- 443 nuclear reactors operating in 30 countries (372 GWe)
- 66 reactors currently under construction in 15 countries
- 164 reactors planned in 27 countries over next 8-10 years
- 317 reactors proposed in 37 countries over next 15 years

- 45 new builds in China (25), Russia (9), India (6) & Korea (5)
- 6 reactors in 3 newcomer countries: Belarus (2), Iran (1) & UAE (3)
- Spent fuel reprocessing:
  - *Industrial: France, UK*
  - *Developing: Russia, India, Japan, China, Korea*
- Fast Neutron Reactor Programs:
  - *Russia, India, Japan, France, USA, China, Korea*

CONCLUSIONS

Nuclear energy remains an efficient contribution to fight climate change challenges

Renewables will play a role the magnitude of which will be controlled by its economical affordability,

Their massive development will depend on the progress on networks and storage technologies

Beware of dreams!

« il y a des "gloutons d’idées" dont la caractéristique est qu'aussitôt qu'on leur fait briller quelque opinion d'apparence raisonnable, ils se précipitent la bouche ouverte et avalent l'appât, l’hameçon et la ligne, en invoquant ensuite le droit à l’erreur commise de bonne foi... »

« There is a form of intellectual gluttonry where , as soon as some apparently reasonable opinion is proposed, some people would jump on it, swallow the warm, the hook and the line, and later would claim the right to commit mistakes in good faith… »

Alain