Bulk Materials: an insight on the future regarding the rise of living standards and energy transition

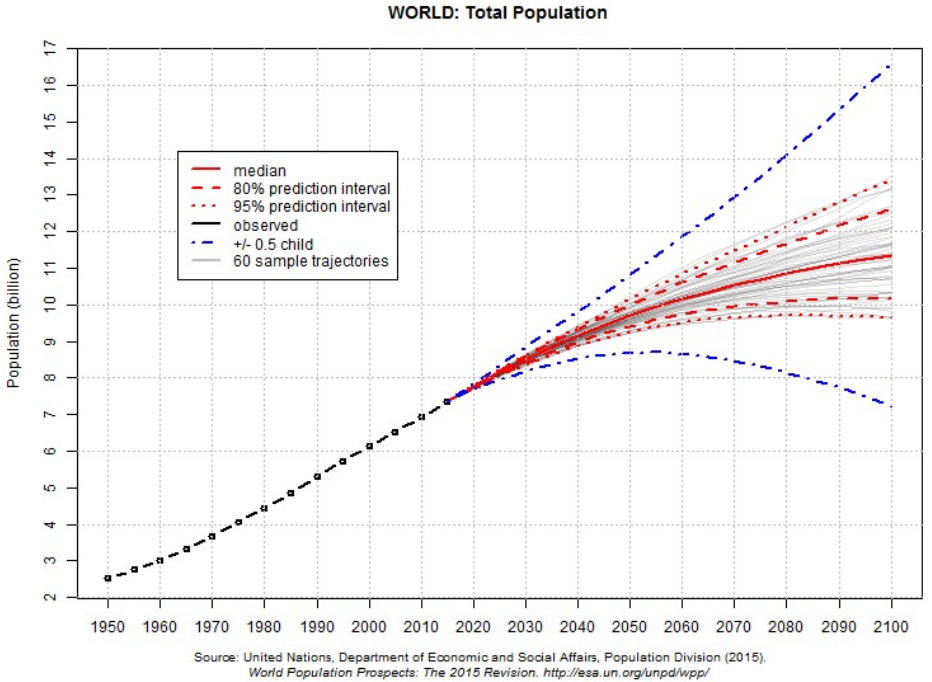
Presentation based on the research studies of Olivier Vidal and his lecture at Mines Nancy in november 2019

Introduction

- During this session, we will mainly talk about:
  - Cement
  - Steel
  - Aluminium
- We will discuss for the 21st century:
  - The quantity of raw materials we need to achieve our goals
  - The real possibilities to get them
  - The main consequences to expect

The rise of the living standards

- The world population increases, and will go on doing so until an expected 12 billion inhabitants
- The average GDP/cap increases
- The consumption (of energy or raw material (RM)) increases strongly below a certain threshold of GDP/cap
- Therefore, the expected needs in bulk materials (but more generally energy and raw materials) grows exponentially this century



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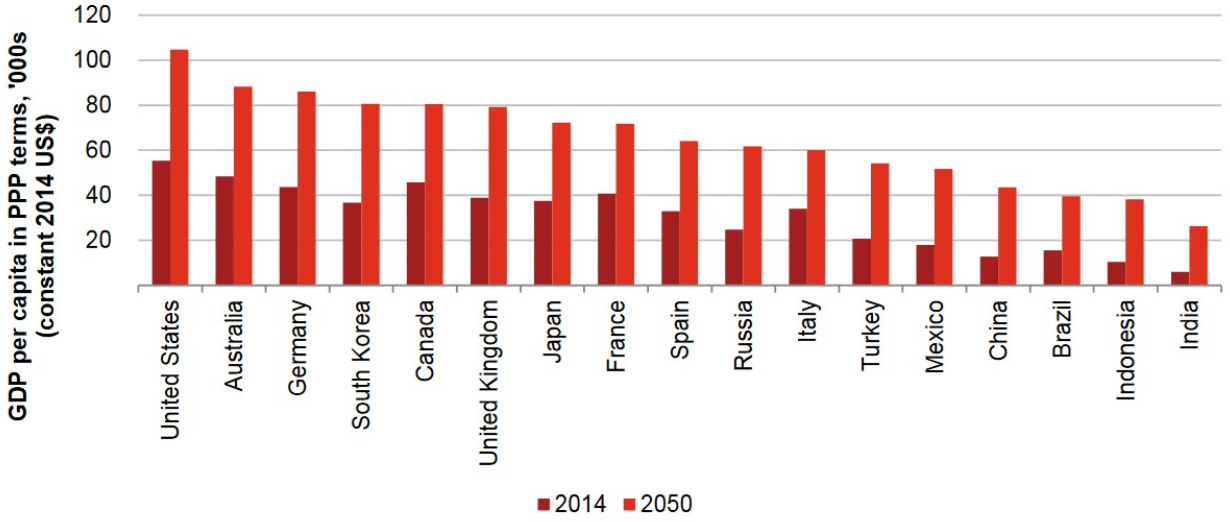

Source: PwC analysis

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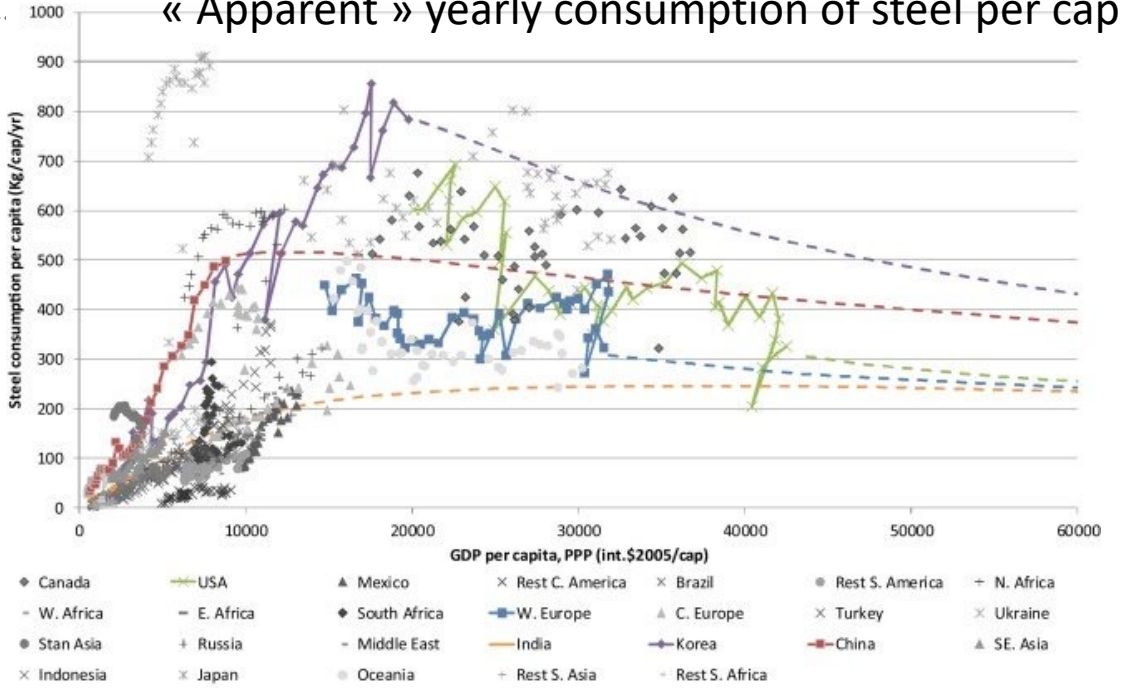
« Apparent » yearly consumption of steel per cap



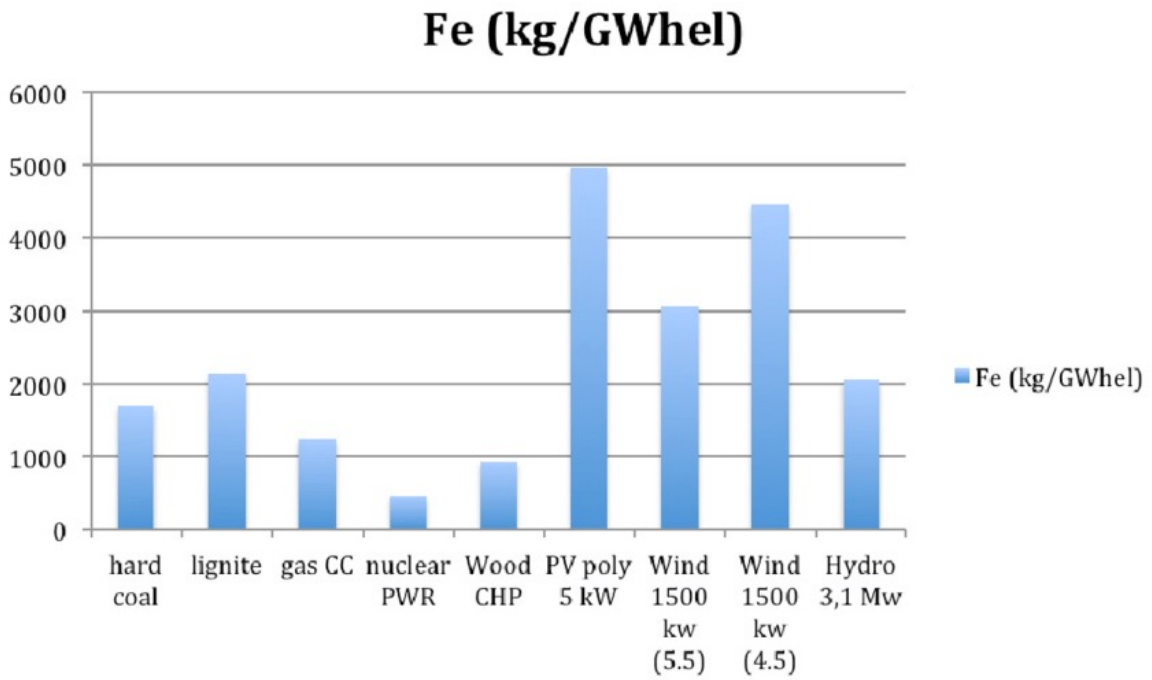
Source: Long-term model-based projections of energy use and CO2 emissions from the global steel and cement industries, Bas J van Ruijven et al.

Energy

- There is a world goal to mitigate global warming (COP21: reduce by 30% our emission by 2050)
- There is a coupling between energy and raw materials:
  - The energy transition requires new production means, storage, distribution, electric-based devices and therefore lots of raw materials
  - Extracting raw materials requires energy
- The renewable energies poses two main challenges:
  - Intermittence, that requires in particular important storage capabilities
  - They are « diluted » and require therefore more infrastructure to produce the same amount of energy

Energy: the example of wind turbines

- Characteristics:
  - 6 MW
  - 1500t of steel
  - 20 years of life expectancy



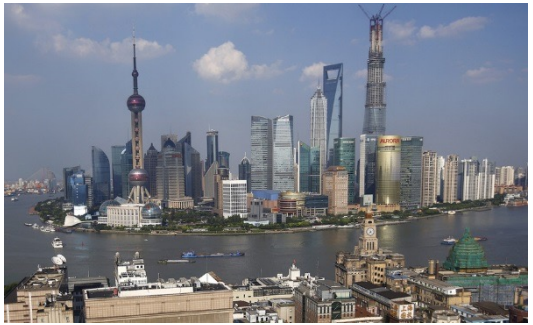
source: Steel and humanity's grand challenges, Jean-Pierre Birat

For the coming decades…

- The new infrastructures required for the energy transition and world growth (in particular industry and transportation) requires huge amount of energy and raw materials
- It is not just an « investment »: the life expectancy of infrastructures and the costs of running them will consume a (growing) amount of energy and raw materials
- Globally, the energy transition and the world development requires roughly to extract as much materials by 2050 as we have done since the beginning of mankind
- An other decent order of magnitude is that we should extract twice as much between 2050 and 2100

Is it sustainable, what does it imply?

Shanghai in 1987



Shanghai in 2013

Energy: three scenarios and their implications

Research studies of Olivier Vidal

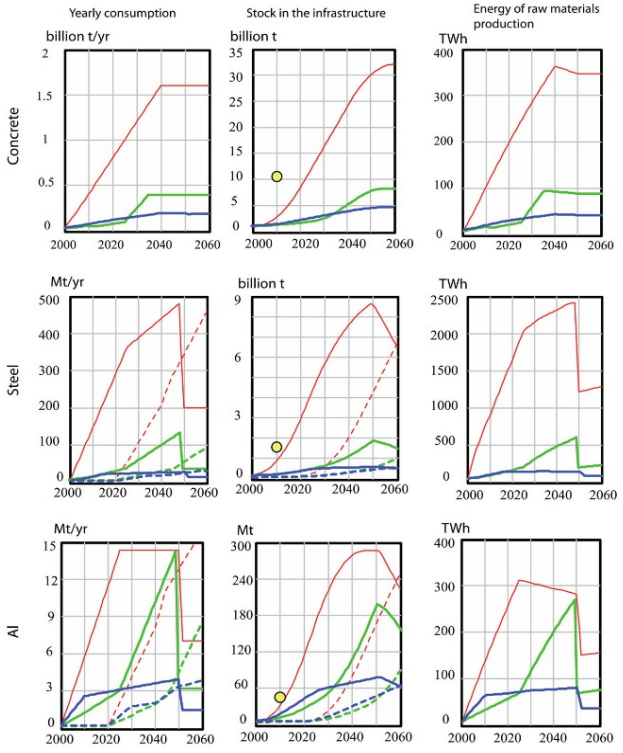
Annual consumption (first column) and cumulative requirements (second column) for the deployment of the infrastructure of electricity production. The third column shows the annual energy consumed for primary production and recycling.

Yellow dots: annual global production.

- Scenarios:
  - The International Energy Agency blue map (rather conservative) anticipating about 40% of renewable energy by 2050
  - The WWF scenario aiming at 100% of renewable energy by 2050
  - Garcıa-Olivares et al. scenario assuming 100% of our energy is electricity produced by wind turbines, CSP and hydropower by 2030

Solid lines: primary production

Dot lines: recycled production



source: Modelling the material and energy costs of the transition to low-carbon energy, Olivier Vidal, Hugo Le Boulzec, Cyril François

The consequences

- To get more materials, we constantly need to extract lower-grade deposits
  - So far, technological improvements allowed to do it at a roughly constant « price »
  - But models show that this fortunate trend is about to end (regarding this, the bulk materials come last)
  - The « value » of materials in energy and materials is bound to increase
  - If we do not recycle, this is not economically sustainable and production will collapse within the century
- Recycling is a necessity
  - The design of products must be thought accordingly, to get the best yields
  - The cost of recycling will become lower than extracting raw materials
  - Recycling should become the first source of materials within the century
  - This does not solve all the problems (the by-products are a hot topic!)
- Sobriety is a necessity

A few figures to have in mind

- By 2050, for instance, we need to extract 700 Mt Al:
  - They represent about 3500 Mt of rocks (500 kg / inhabitant)
  - 10^16 MWh will be necessary for it (3000 km with a small electric car / inhabitant)
  - And roughly 70 billions of cubic meter of water (1L / inhabitant / day)
  - Producing 1t of aluminium releases 2t to 20t of CO2
- It is of course necessary to take into account all the materials we need and add the results. This shows that this represents a huge industrial effort and a challenge to protect the environment.

A retention pond in Brasil

Conclusion

- The increase of the world population and the global rise of the living standards, combined with the effort to reach the energy transition will require an amount of bulk materials never seen in history
- At the same time, the diminishing returns will increase the cost in materials and energy of extracting 1t of material, even if technological improvement has been able to hide this effect so far
- A peak of new infrastructures should be reached within the century
- Maintaining and running the new infrastructures has also a « cost in materials », and the necessary recycling never reaches 100%: we will constantly need to extract new materials
- The challenge of sustainability is not just to know whether we can get all the materials we want, but also to protect the environment at the same time