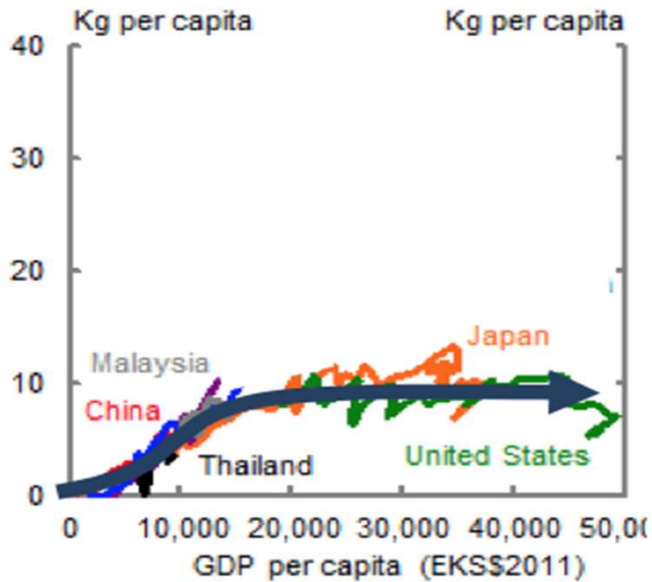


Les enjeux des ressources matière et énergie dans un monde en transition

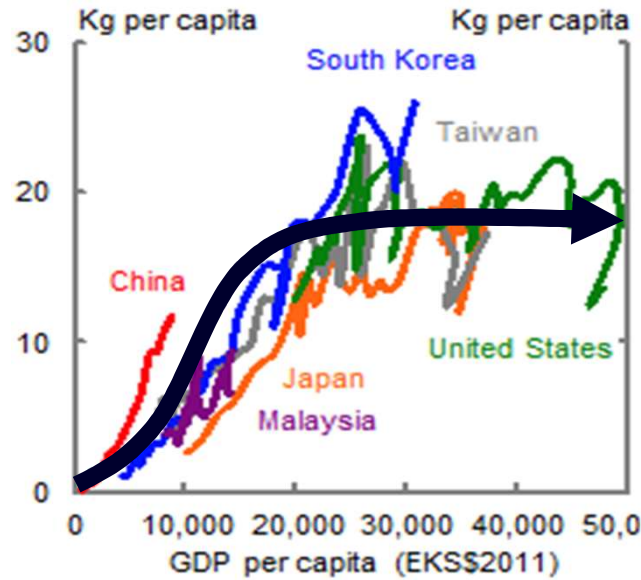
- Evolutions démographique, technologique, économique ?
- Hausse des prix récente uniquement conjoncturelle ? ou signe d'une difficulté systémique d'approvisionnement ?

Le premier moteur de la consommation est l'augmentation de la population et du PIB

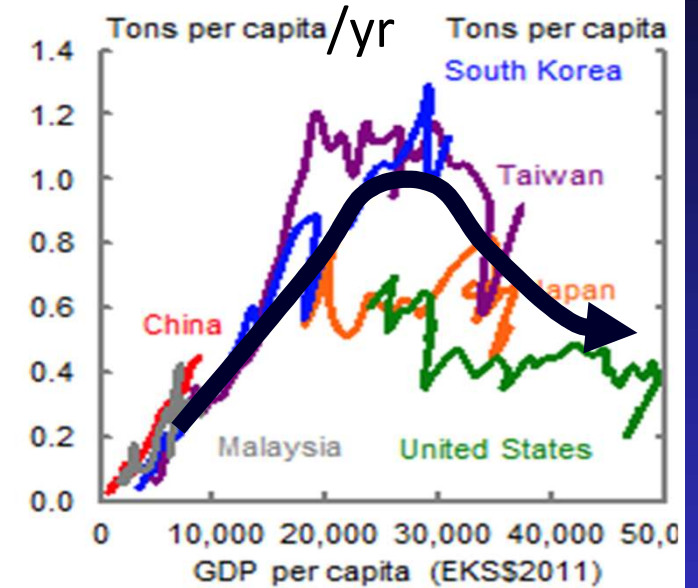
Copper



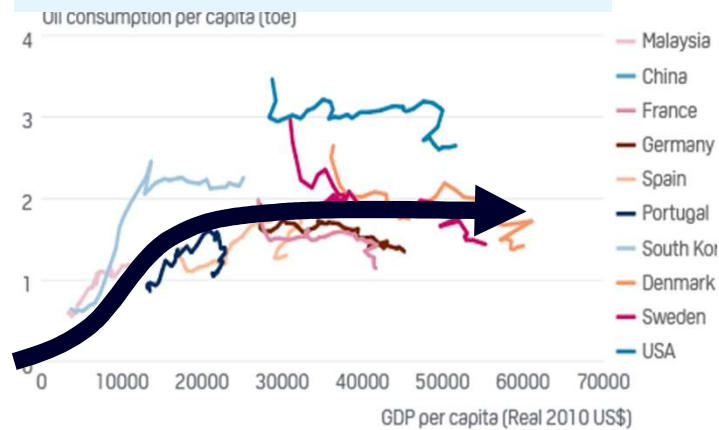
Aluminum



Steel

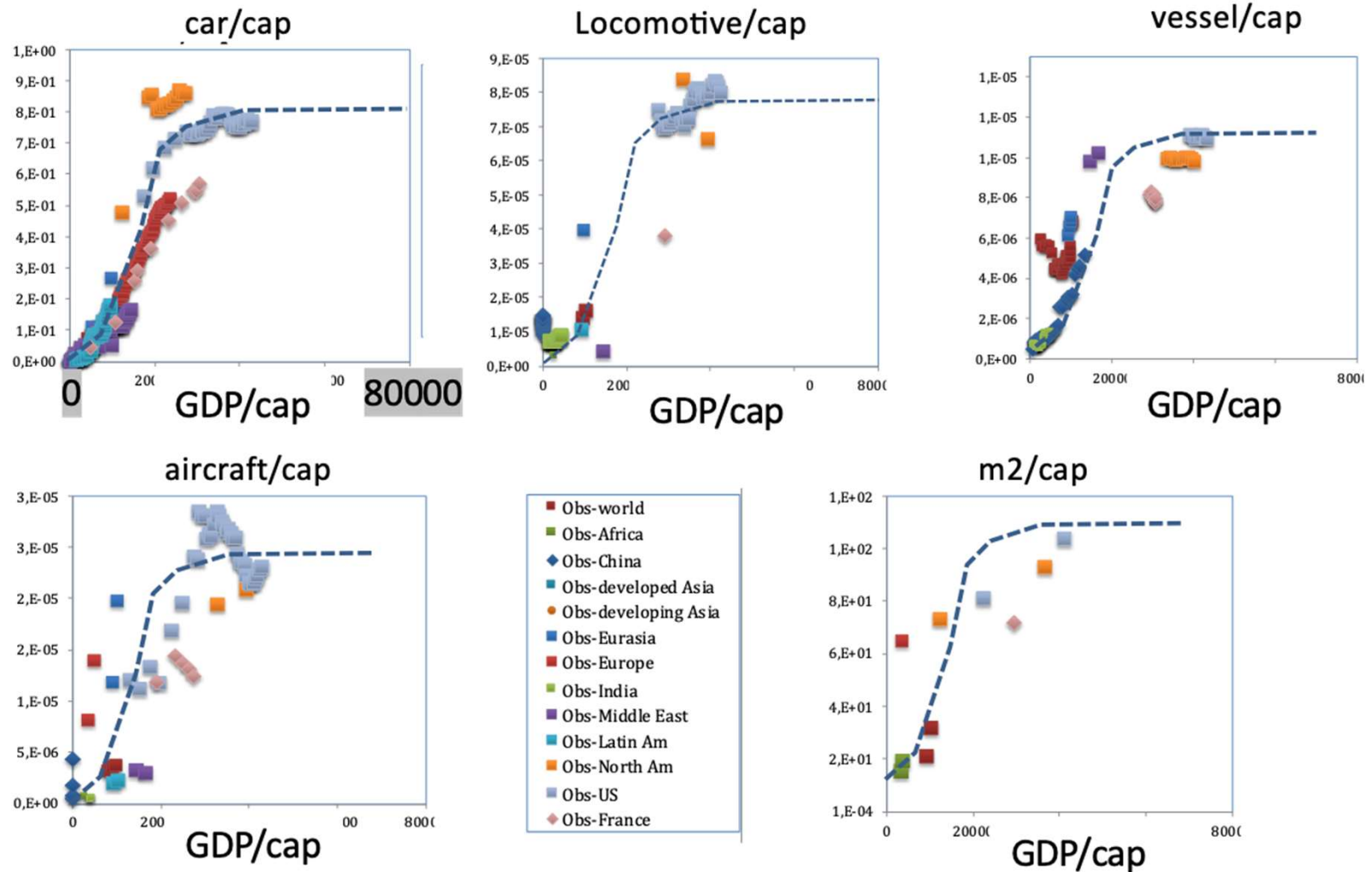


Oil



Source: BP Statistical Review of World Energy (June 2016), Oxford Economics, Platts

Le développement de Infrastructure/hab = f(PIB/hab)



Il existe des fonctions logistiques « uniques »

Evolution tendancielle de l'infrastructure - FRANCE

Population & PIB



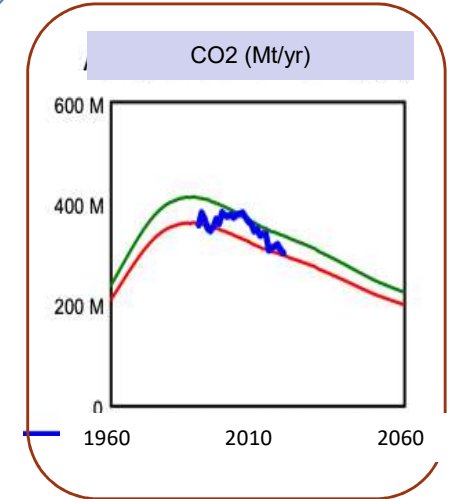
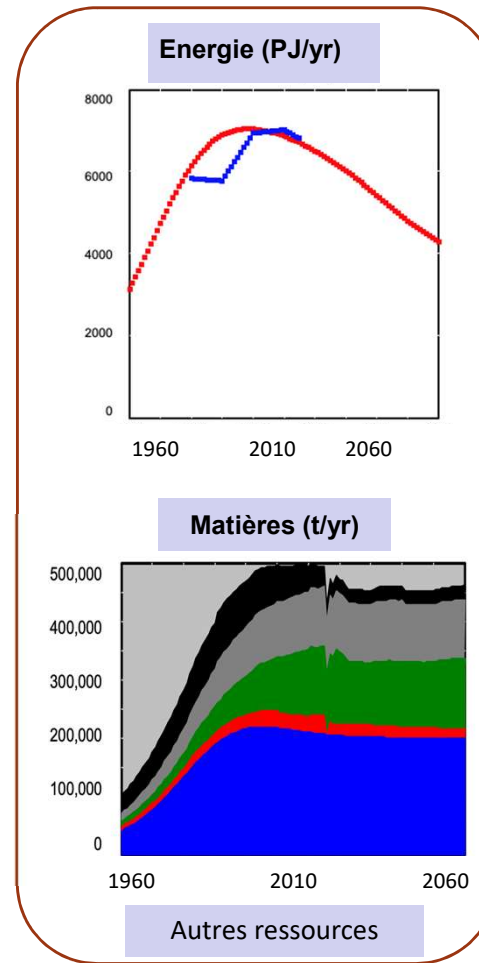
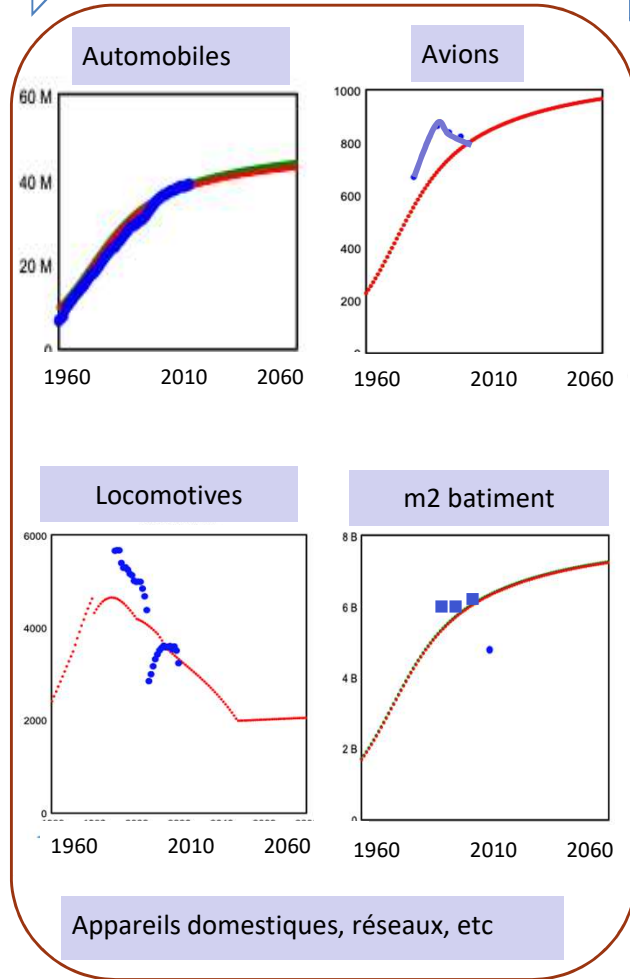
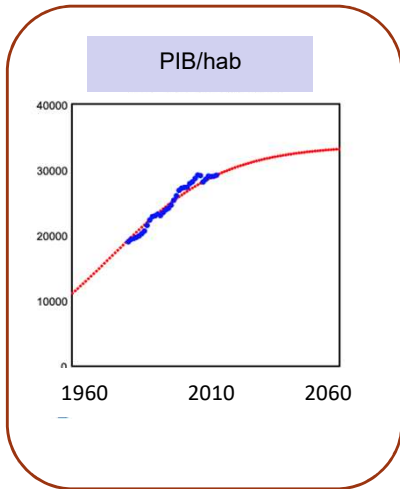
Infrastructure



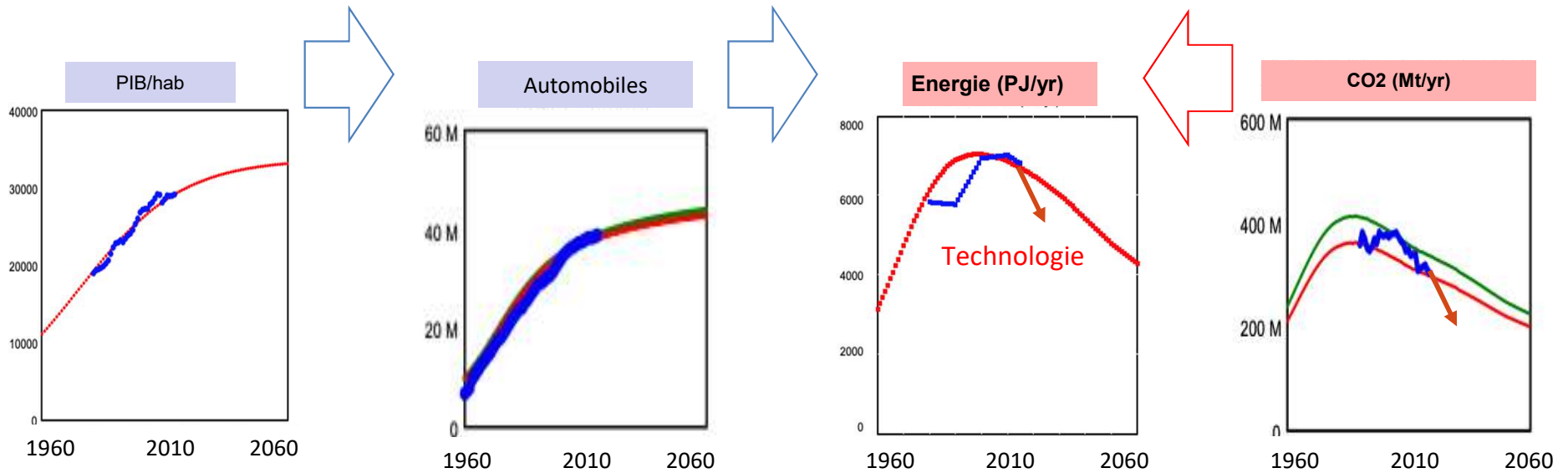
Ressources



Impacts

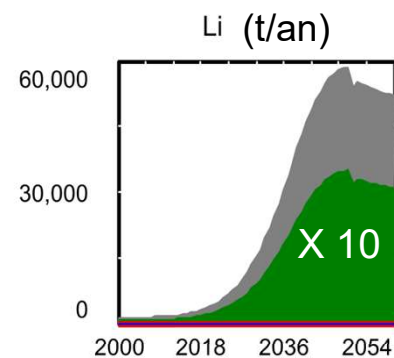
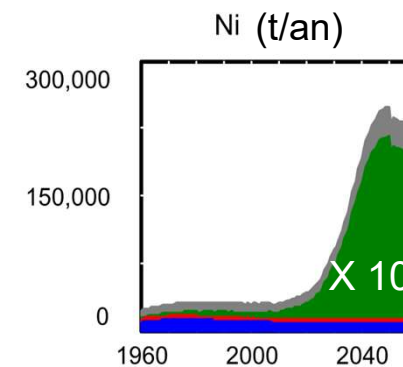
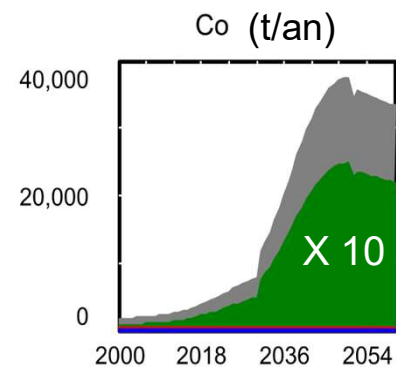
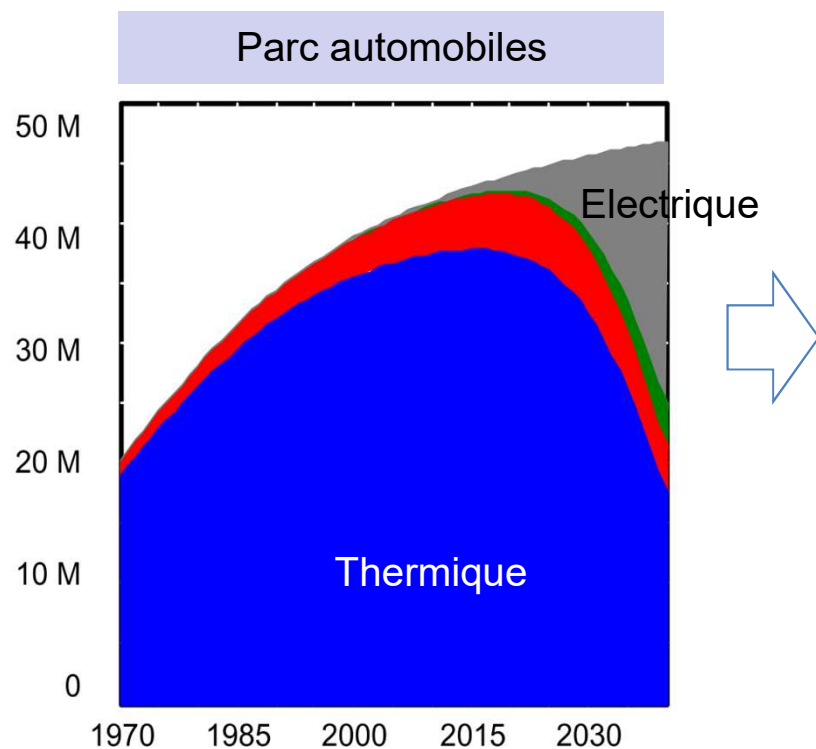


Pour s'écarter des évolutions tendanciennes => technologies « de rupture »

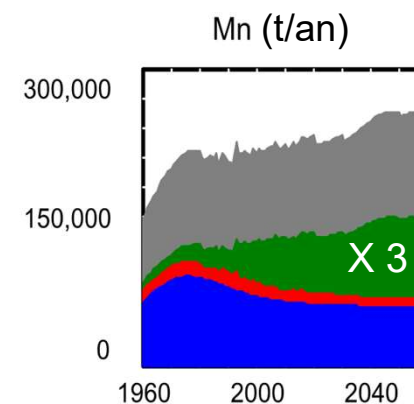
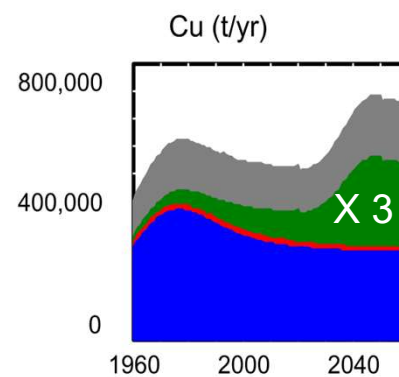


Réseau électrique modifié

Besoins matières pour les VE (technos actuelles, 50 kWh) - France



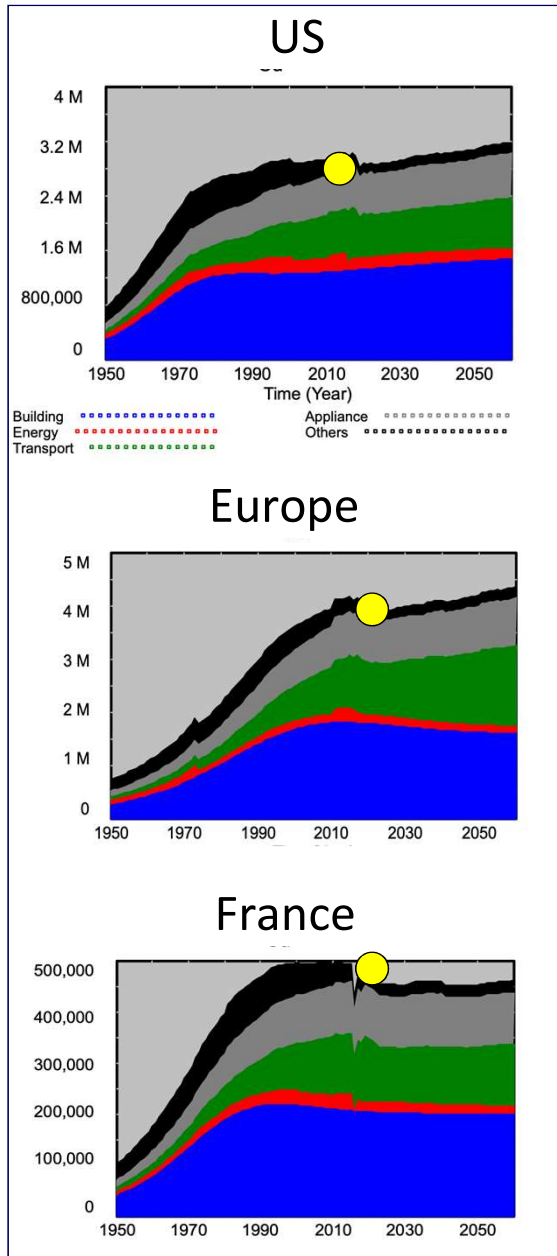
Transport



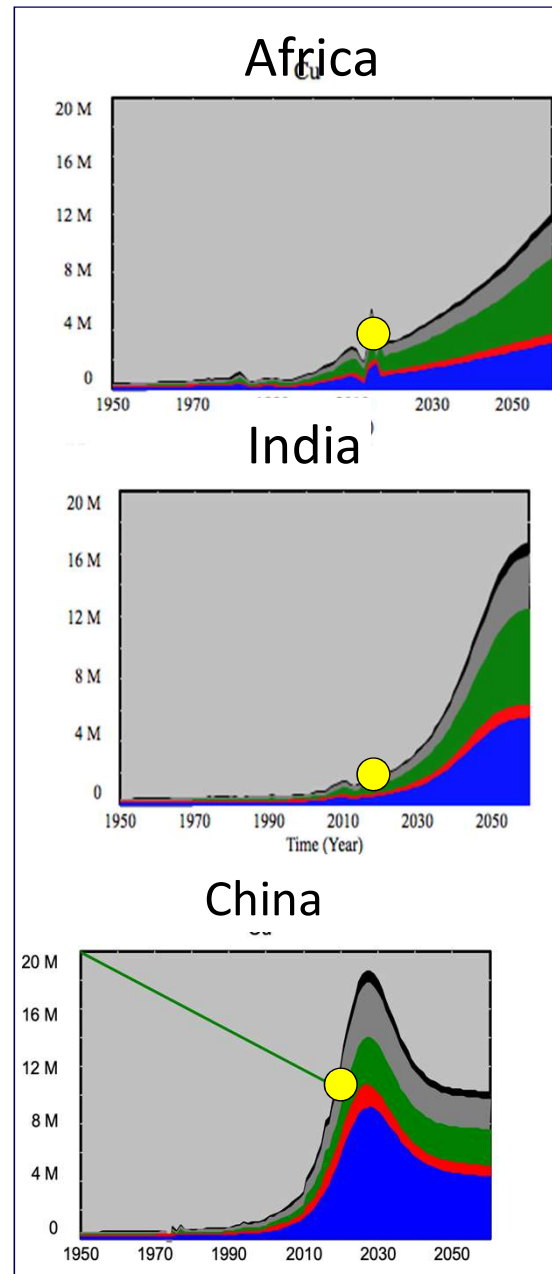
Attention: les technos évoluent !

l'évolution tendancielle de PIB/hab contrôle la consommation de ressources

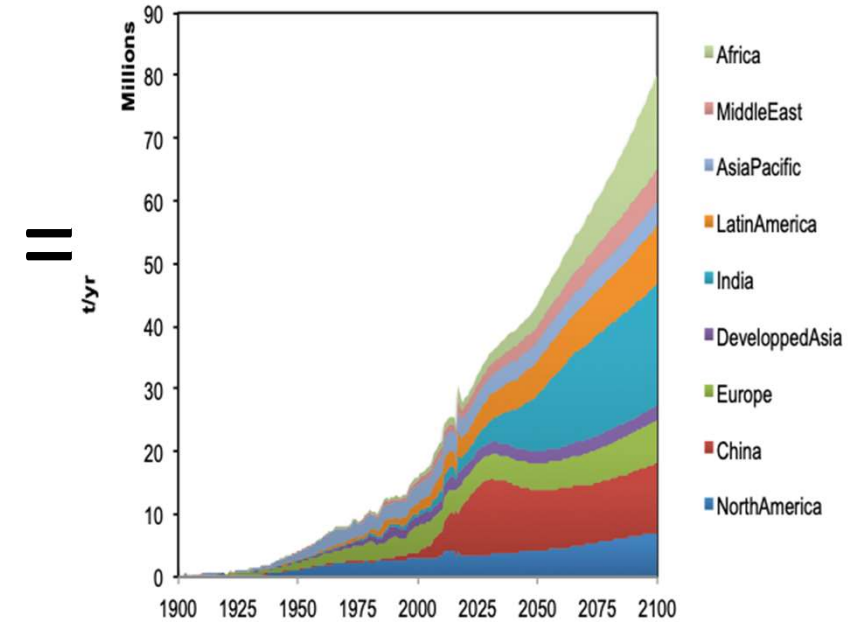
Developed countries



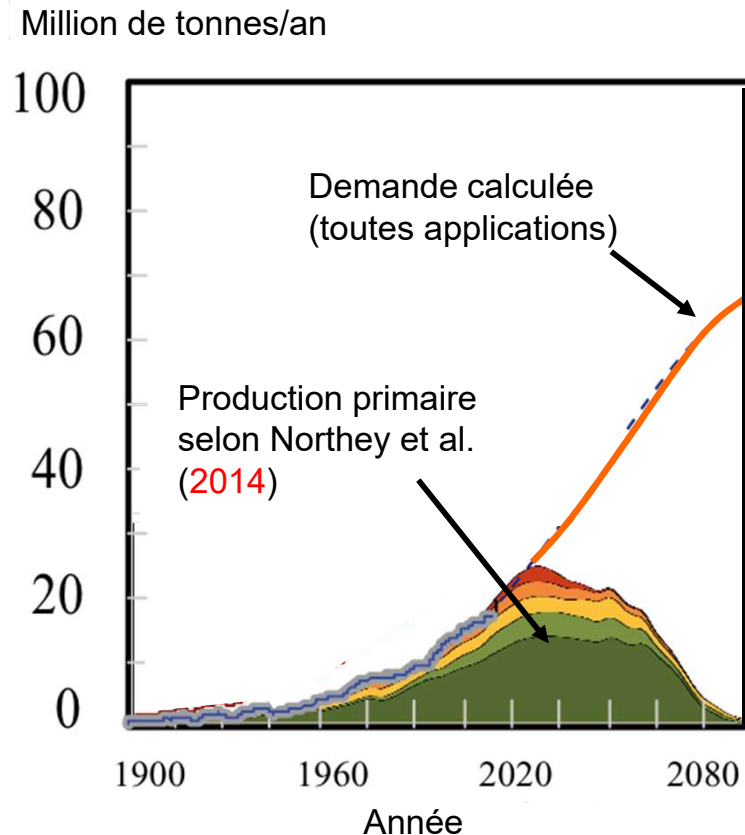
Developing economies



World copper



Epuisement des réserves (peak oil, peak metals) ?



1924 Copper and Electricity to Vanish in Twenty Years?

LAST WEEK we reprinted part of an address made by Ira B. Joralemon before the Commonwealth Club of California, in which he stated that "the age of electricity and of copper will be short. At the intense rate of production that must come, the copper supply of the world will last hardly a score of years. . . . Our civilization based on electrical power will dwindle and die." We are rather surprised that a geologist of Mr. Joralemon's standing cannot use his imagination a little more than this, but no doubt he was painting the picture as black as possible so that copper miners would wake up to the fact that they are rapidly wasting a valuable natural resource with little or no profit to themselves. Known deposits of copper

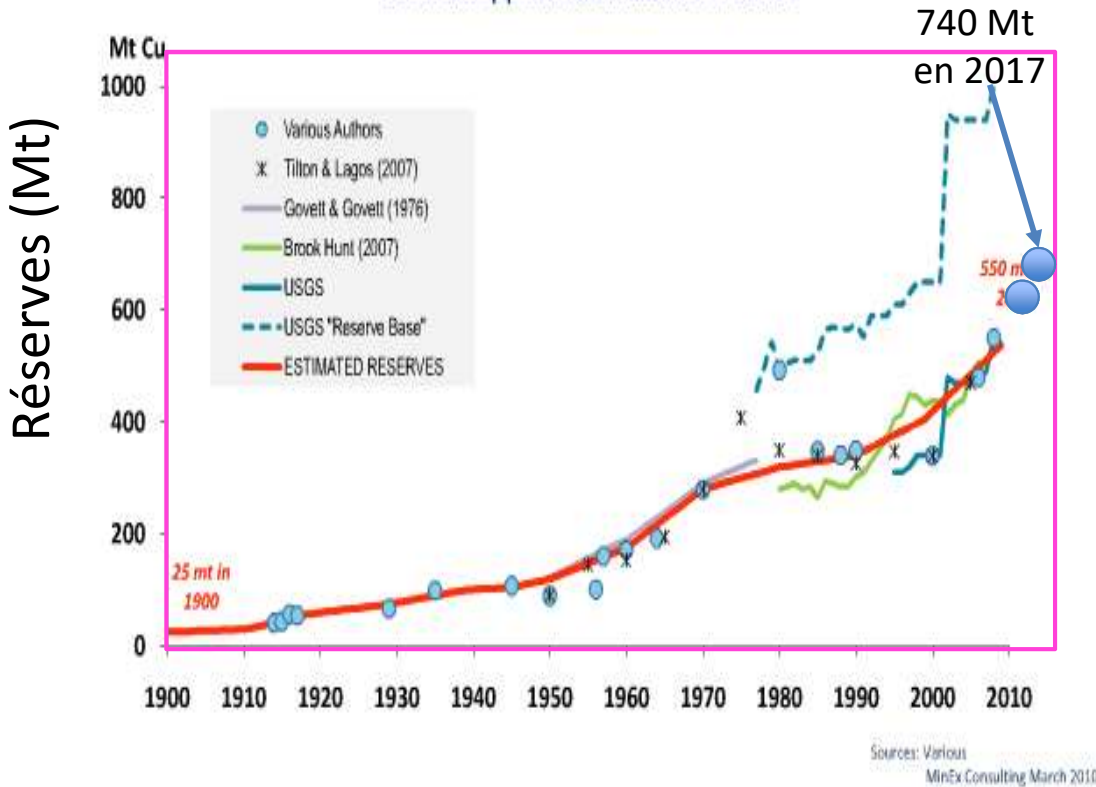
l'approvisionnement en cuivre ne pourra durer que quelques années. Notre civilisation basée sur l'électricité va s'étioler et mourir.

friends in Michigan have. And we can hardly believe that all the copper resources of the world are known. Twenty years ago, for example, who would have classed such deposits as those at Chuquicamata and Bingham Canyon as important factors, even with the price of copper somewhat higher than it is now?

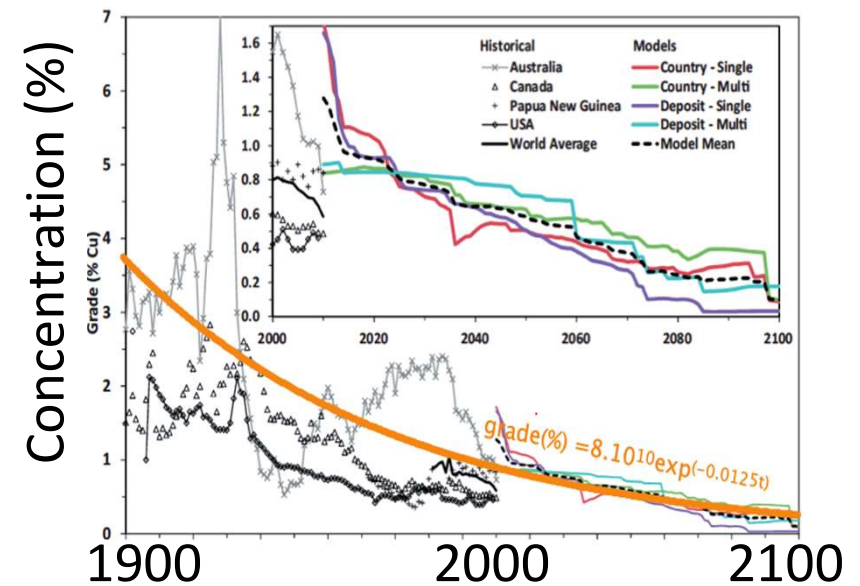
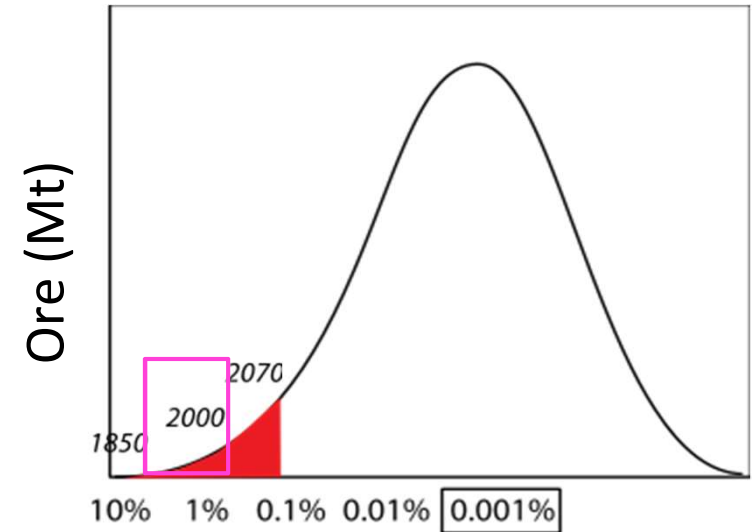
As to the electrical industry, we can hardly believe that all our electricity will go back into the clouds where Franklin found it, just because copper is scarce. Maybe copper won't be required at all for transmission purposes; we may just use the ether.

En réalité, les réserves de tous les métaux n'ont cessé d'augmenter depuis 1900...

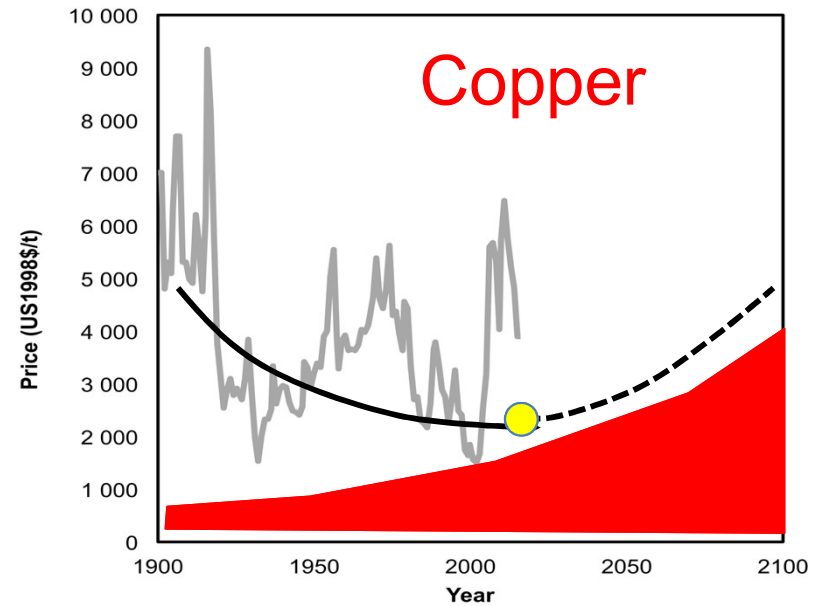
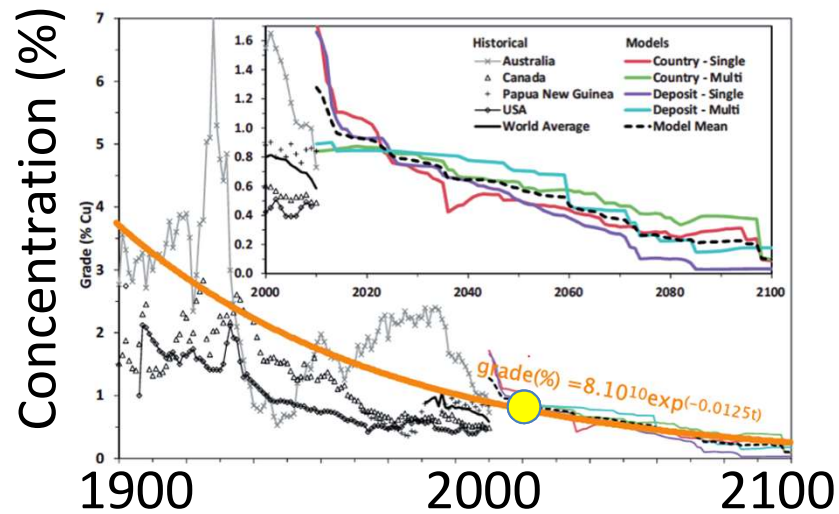
World Copper Reserves: 1900-2010



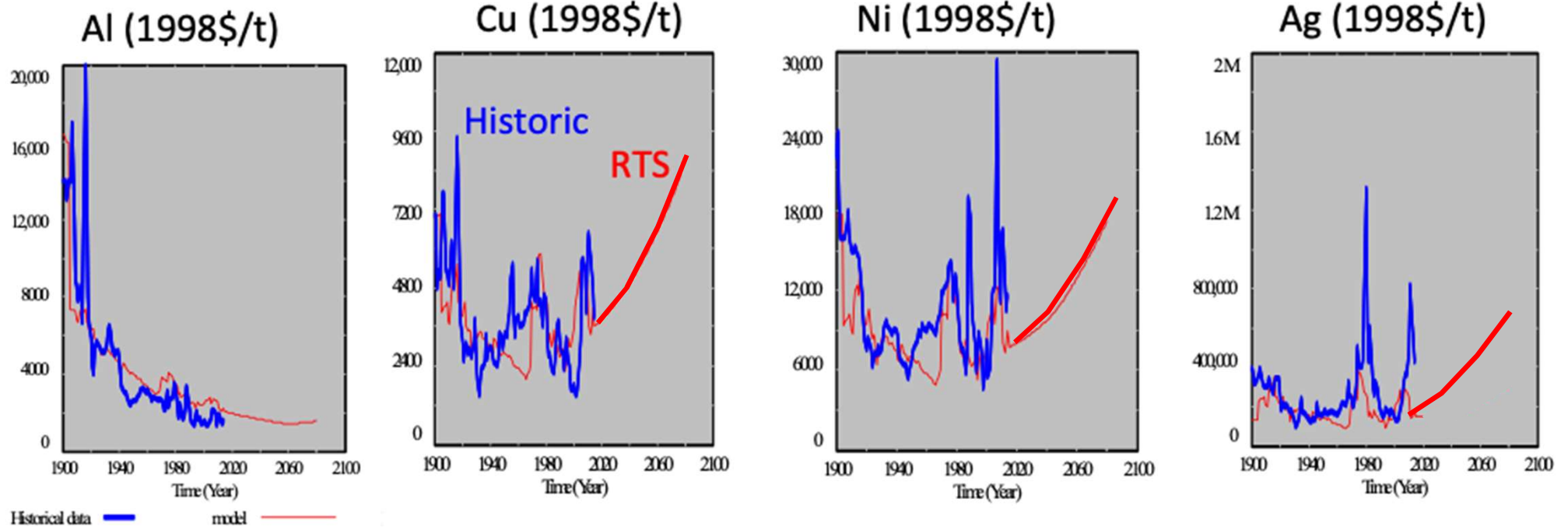
L'amélioration technologique a permis de baisser les coûts énergétiques et économiques



L'amélioration technologique est limitée par une **limite thermodynamique** qui varie en $1/\text{concentration}$

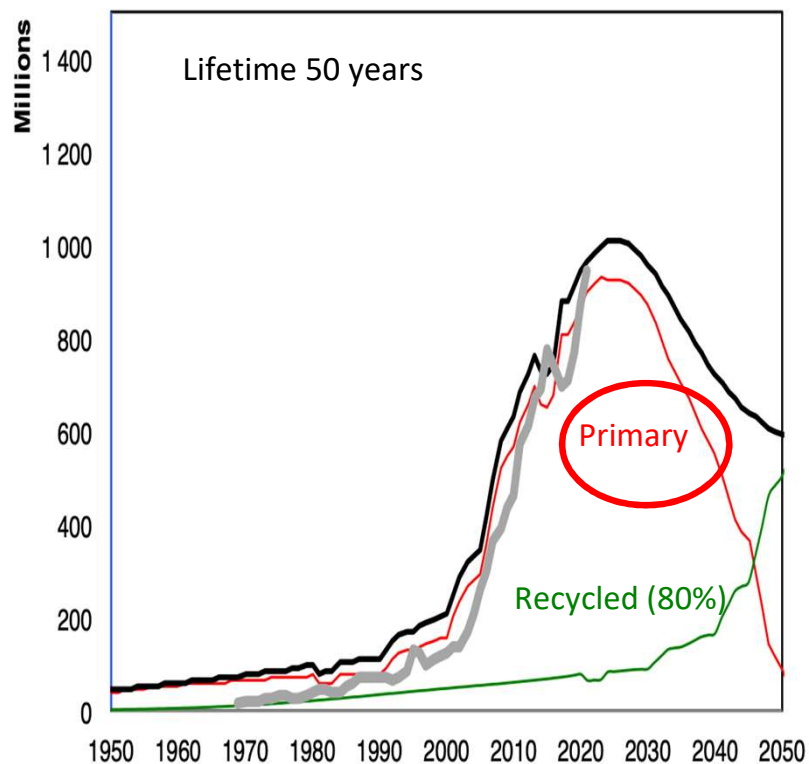


La disponibilité future dépend du prix que l'on sera prêts à payer, des impacts que l'on est prêt à accepter... donc des scénarios de consommation et du prix de l'énergie



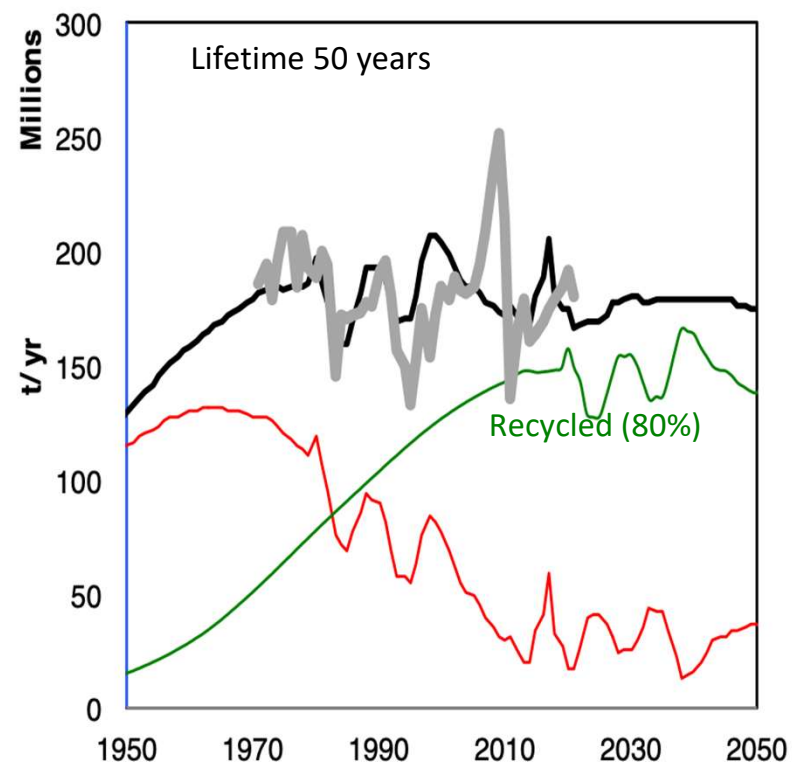
Le recyclage ? La proportion de métal recyclé dépend de la quantité de déchets disponible... les pays en voie de développement n'ont rien à recycler

China



Acier

Europe

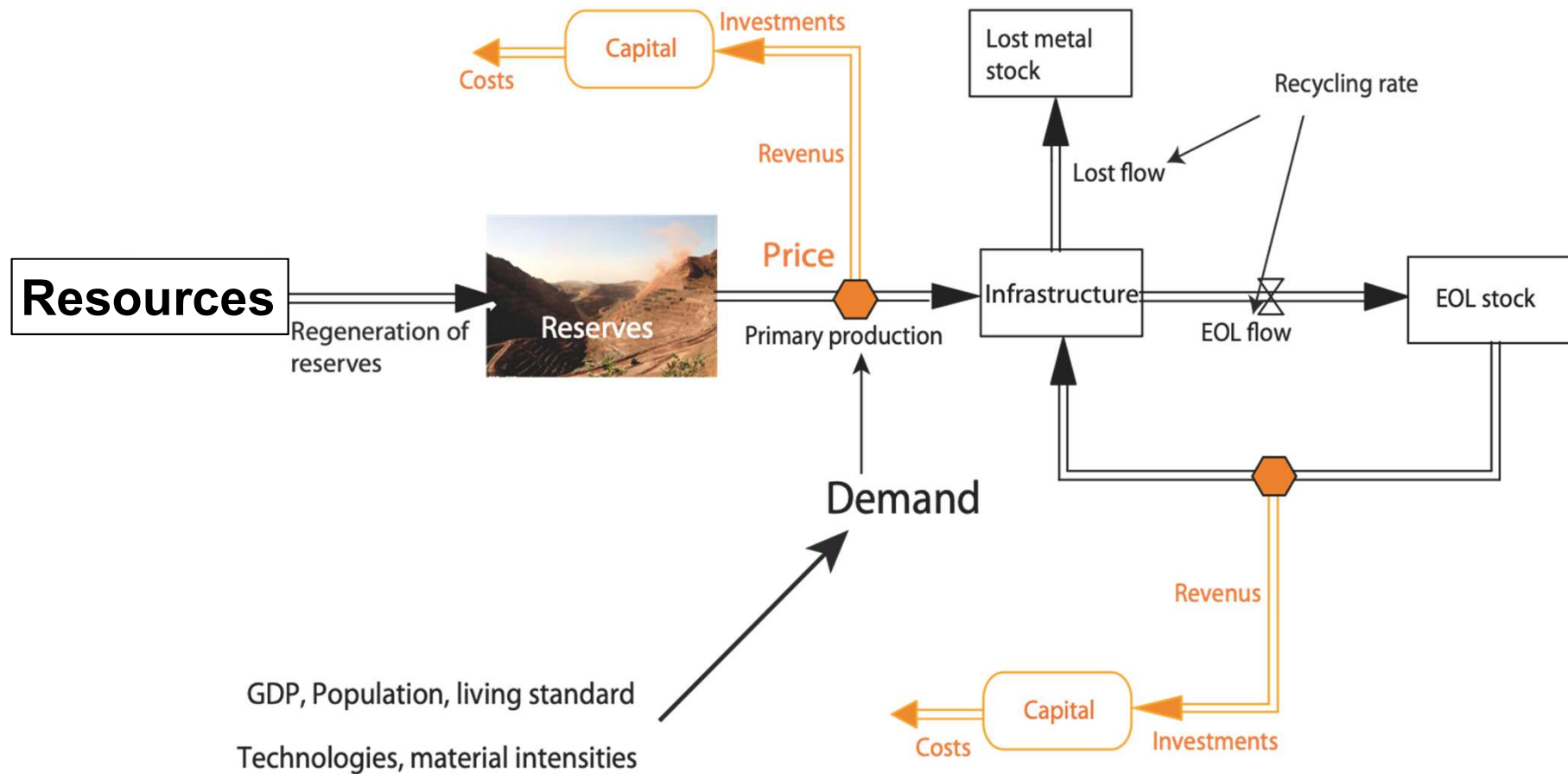


Conclusion

- Les ressources minérales sont aussi centrales que l'énergie. *La minimisation de l'utilisation et la maximisation du recyclage sont CRUCIALES*
- La demande et l'approvisionnement dépendent des scénarios technologiques + dimensions géologiques, environnementales et "sociales". *Pas de chemin unique, le futur sera différent du passé*
- Les coûts et prix donc les réserves sur le long terme sont contrôlées par la physique. *Les modèles économiques e.g. minimisation des coûts sans physique ont un pouvoir prédictif très faible*
- L'absence de pénurie n'est pas un signe d'abondance, c'est un signe de progrès technologique qui masque la dégradation des ressources. *Que se passe-t'il quand le progrès devient limité par la thermodynamique ?*
- La prise en compte des limites thermodynamiques **et des impacts environnementaux et sociaux** est nécessaire pour *anticiper les difficultés, la vulnérabilité et le risque, et s'adapter au changement*

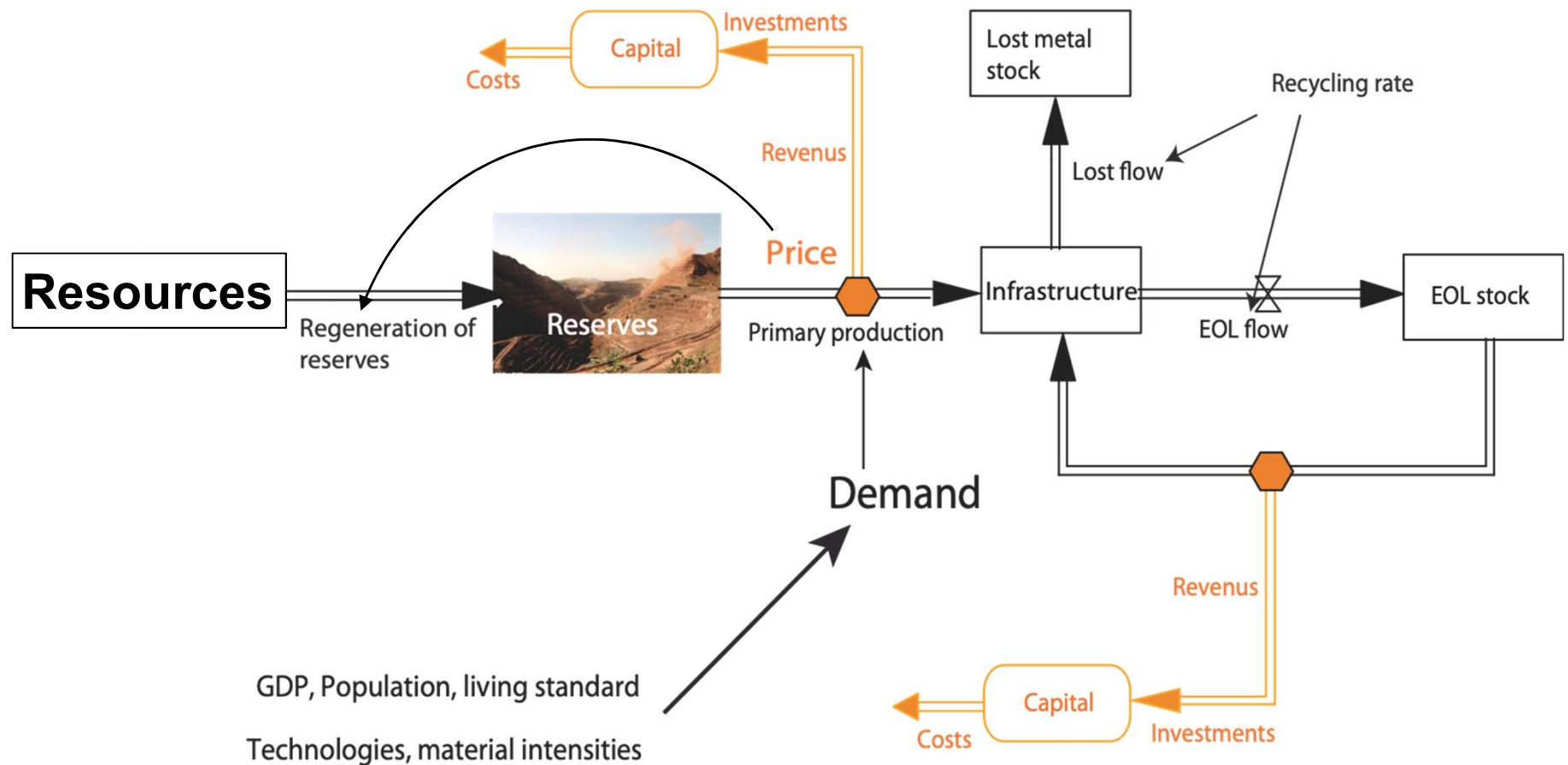
Dynamique modeling of Matter & Energy Demand & Supply

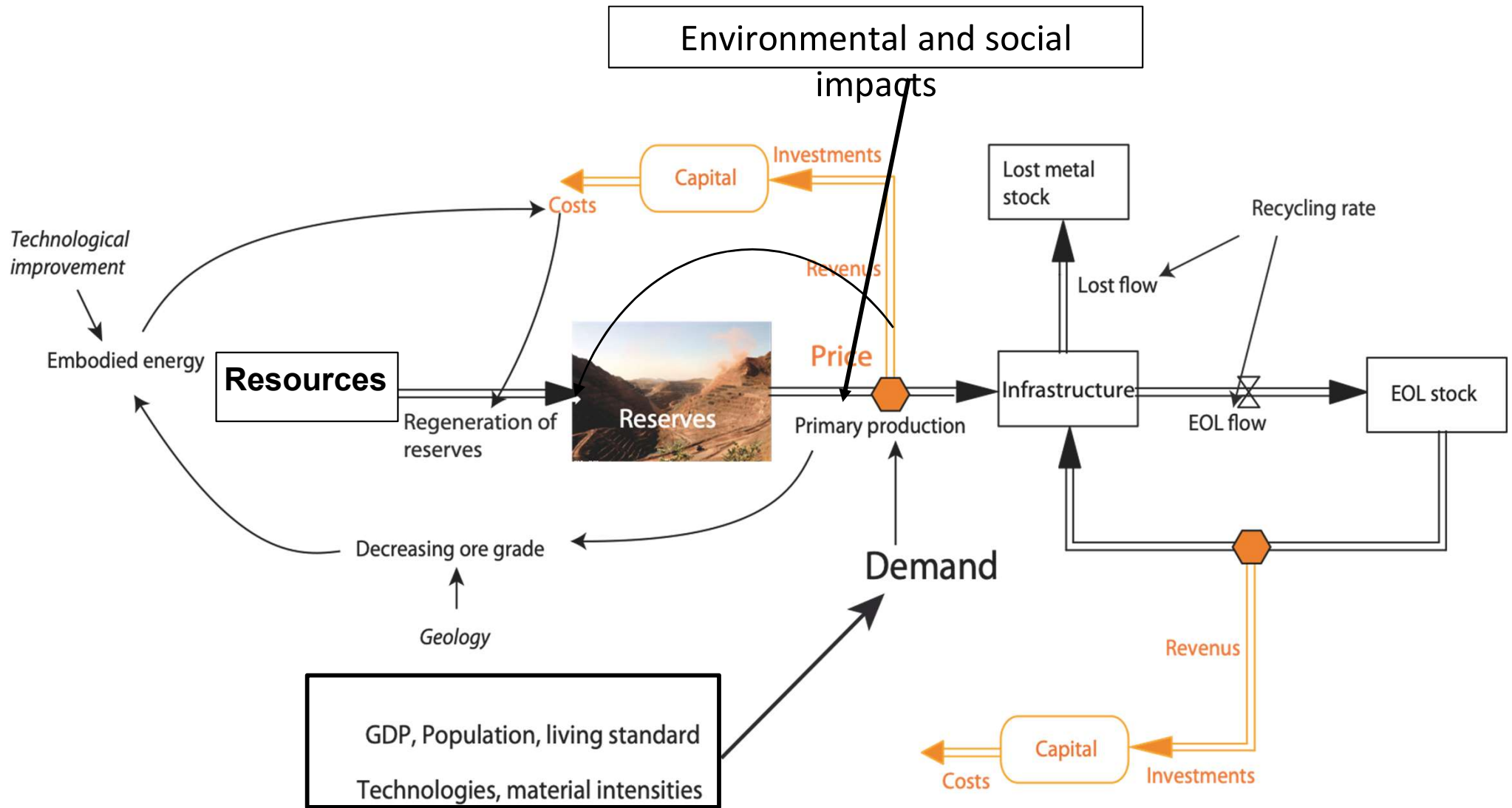
DyMEMDS – une centaine de technos, 10 régions géographiques



Dynamique modeling of Matter & Energy Demand & Supply

DyMEMDS – une centaine de technos, 10 régions géographiques

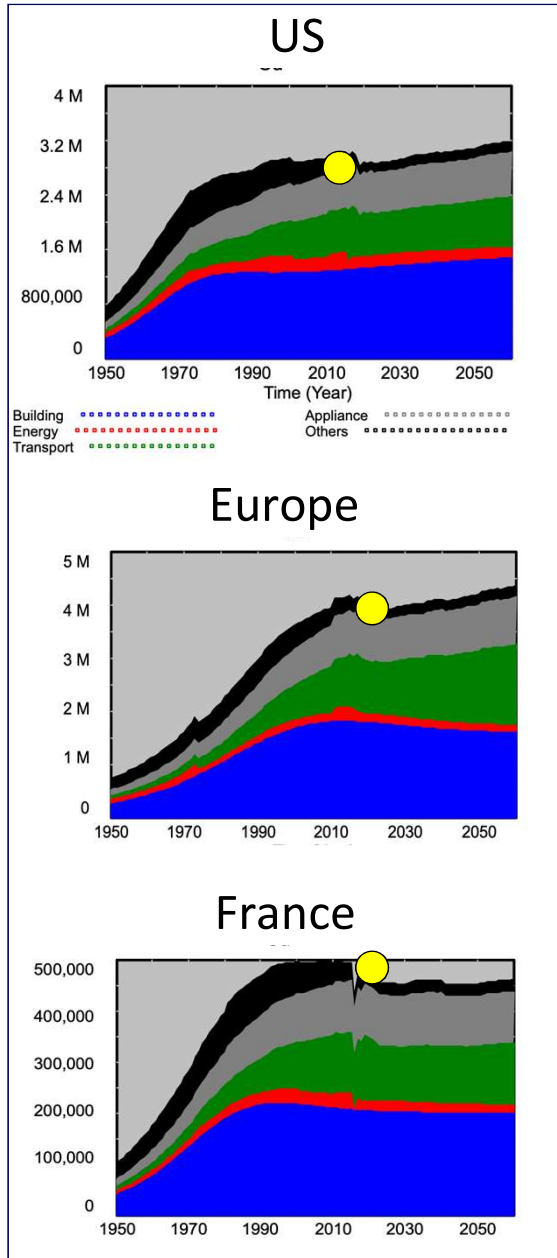




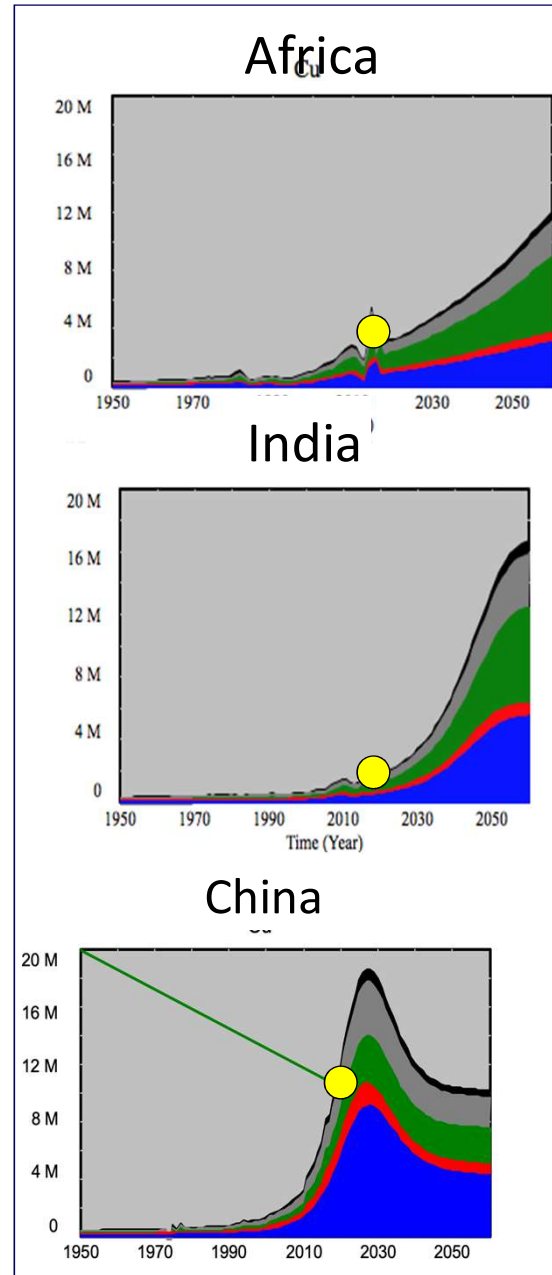
- On ne comprend les couplages que si on regarde tout le système
- On ne répond pas simplement à une question complexe

l'évolution *tendancielle* de PIB/hab contrôle la consommation de ressources

Developed countries



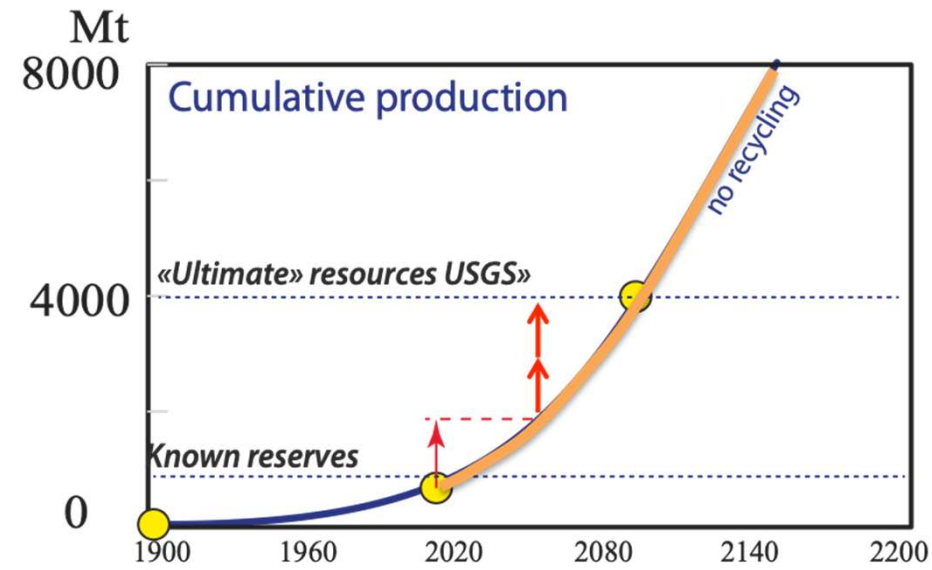
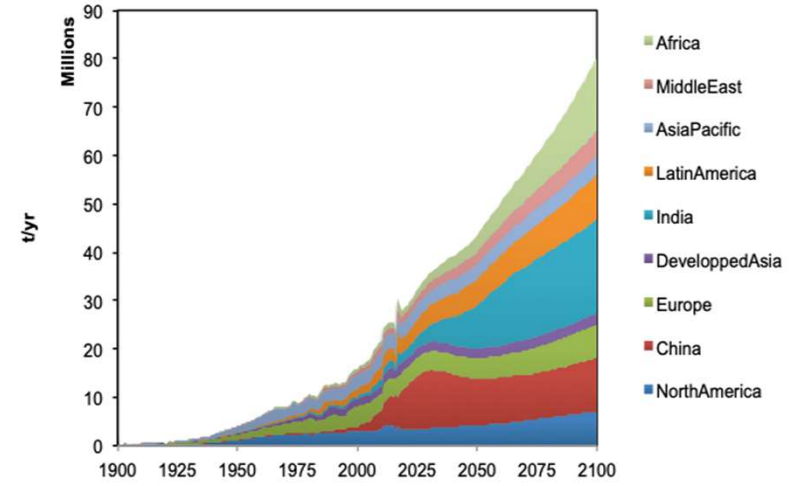
Developing economies



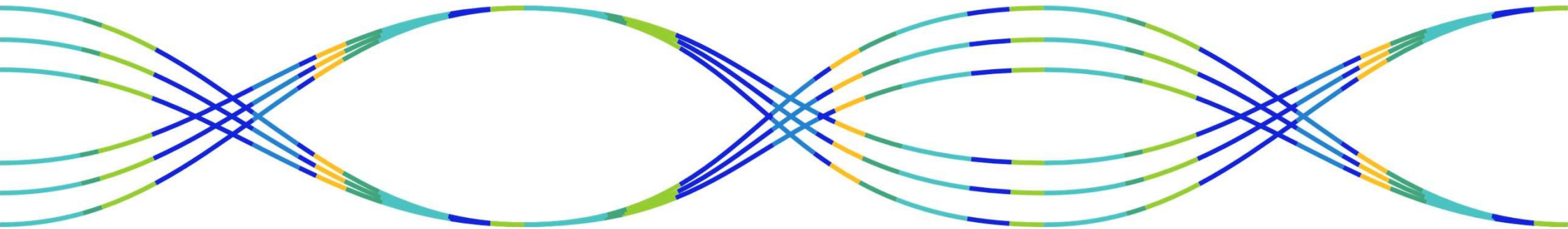
+

=

copper



Green distribution



From 2023 to 2040 : connecting the dots of a new green world

Smart grids



Energy transition

Flexibilities **3,3 GW → ?**
Storage **0.3 GW → ?**

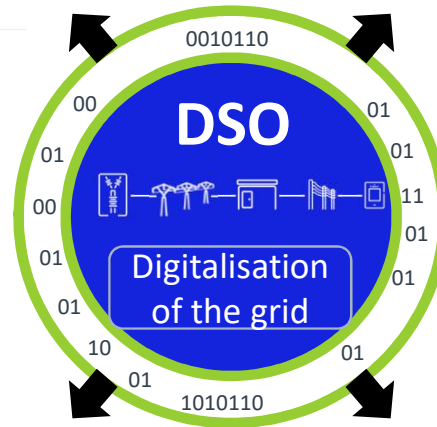


36 → 107 GW Renewable Energy



1,2 → ? GW self-generation

Cybersecurity & data protection



1,3 M, 7GW → 27M
EV charging points



Heat pumps
H2
Industry decarbonation

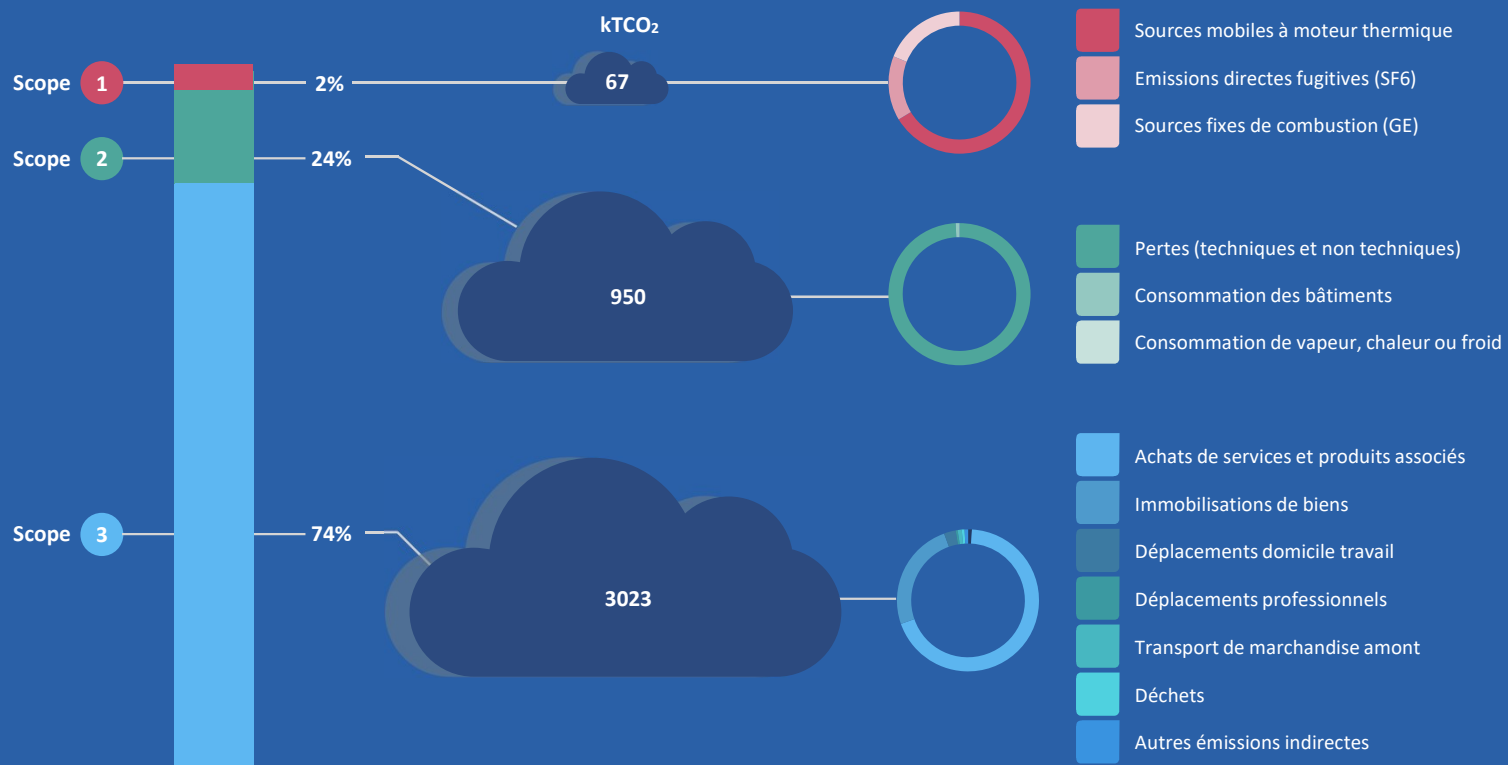
Digitalisation IoT, xG, AI / Big Data...



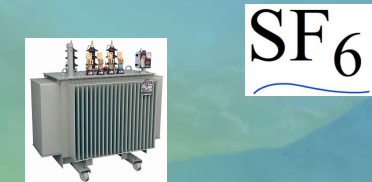
Energy efficiency

➤ **Enedis' carbon footprint in 2021 was approximately 4 MtCO₂eq, of which 74% related to scope 3*, 24% to scope 2* and 2% to scope 1*.**

GHG Emissions Balance 2021 (ktCO₂eq / year)



Scope 1: Direct emissions from the company's fixed or mobile installations
 Scope 2: Direct emissions, linked to energy consumption for the manufacture of products
 Scope 3: Indirect emissions, linked to the supply chain



Enedis ranked 1st on Singapore Power Smart Grid Index for 2021 & 2022 !

Utility	Country/Market	Score	+ / - (%)	Best Practices
Enedis	FRA	98.2	1.8	
TaiPower	TWN	94.6	-	
UKPN	GBR	94.6	-	
ConEd	USA	92.9	-1.8	
WPD	GBR	92.9	-	
CitiPower	AUS	91.1	-1.8	
DEWA	ARE	89.3	-	
SP Energy Networks	GBR	89.3	1.8	
SDGE	USA	87.5	-	
FPL	USA	85.7	-	
Northern Powergrid	GBR	85.7	1.8	
SCE	USA	85.7	-	
Stedin	NLD	85.7	-	
ComEd	USA	83.9	-	
PG&E	USA	83.9	-3.6	
ENWL	GBR	82.1	-3.6	
Jemena	AUS	82.1	1.8	
PEPCO	USA	82.1	5.4	
Powercor	AUS	82.1	-	
Radius	DNK	82.1	-3.6	



SMART GRID INDEX

Measures the smartness of electricity grids globally, in seven key dimensions. The benchmarking also identifies best practices to build smarter grids that deliver better value to customers.

- 01. MONITORING & CONTROL**
 - . SCADA
 - . DMS / ADMS
- 02. DATA ANALYTICS**
 - . Smart Meter Coverage
 - . Data Analytics Application
- 03. SUPPLY RELIABILITY**
 - . SAIDI
 - . SAIFI
- 04. DER INTEGRATION**
 - . Management of DER Integration
 - . Grid Scale Energy Storage
- 05. GREEN ENERGY**
 - . Renewable Energy Penetration
 - . EV Facilitation
- 06. SECURITY**
 - . IT Cyber Security
 - . OT Cyber Security
- 07. CUSTOMER EMPOWERMENT & SATISFACTION**
 - . Real-time data to Customers
 - . Customer Satisfaction Feedback



Welcome to

Electricity 4.0

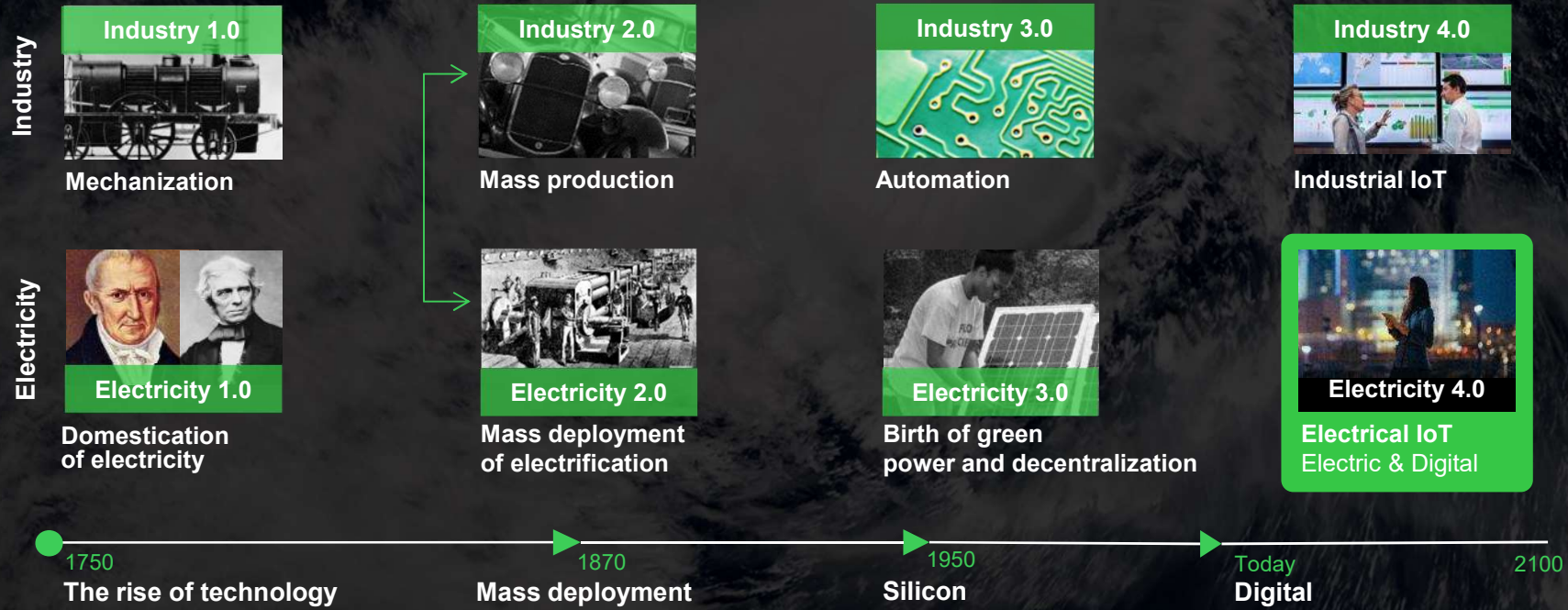
The fastest route to Net Zero

Elisabeth Logeais
Ecosystem & Partnership VP
Innovation & Technology - Energy Management,
Schneider Electric

Life Is On

Schneider
Electric

Over the **last 250 years**, the world has gone through **4 technology-driven revolutions**



We believe **Electricity 4.0** is the fuel for a more **sustainable** and **resilient** Net-Zero World

Electric

Makes energy Green



Digital

Builds a Smart future

Electricity is the most efficient energy
and the best vector of decarbonization



Digital makes the invisible visible,
eliminating waste and driving efficiency

We need to save **4x** more CO₂ emissions between now and 2030 to be on course to limit global warming to **1.5-degrees**

Decarbonized Electricity

80%

of the world's CO₂ emissions are linked to the production and consumption of energy

Electrification at scale

24%

Of the world's CO₂ emissions are linked to non electrified industrial processes like Oil & Gas or MMM

Energy efficiency

x3-5

Electricity is known to be 3 to 5 times more efficient than other energy...And digital enable addressing a huge amount of untapped potential for energy savings

For sure **Electricity 4.0** is calling for a **massive technology shift** of the energy management solutions

more **Digital**

Sensors everywhere

More **wireless** connectivity

More **cybersecurity**

More computing capabilities at the **edge**

...Towards **software defined** architectures enabling **virtualization**

more **Electric**

More **power conversion**

More **power electronic** to manage fault energy **limitation**

...Towards **active** distribution networks with **decentralized resources**

Interestingly we do have serious **challenges**...that should be also considered as serious **drivers** !



Resilience whatever the driver (scarcity, demand, geopolitical...)



Green electronic to make “more digital, more electric” a true solution, not one more problem...



Talents & Partnerships as a key success factor to implement our vision

IMPACT
Company



Time is **now**...

Innovation as a Must ...



Technologies as DNA ...

Startups as key players...

Life Is On | **Schneider**
Electric