ENERGY TRANSITION: BURDEN OF RAW MATERIALS REQUIREMENTS?

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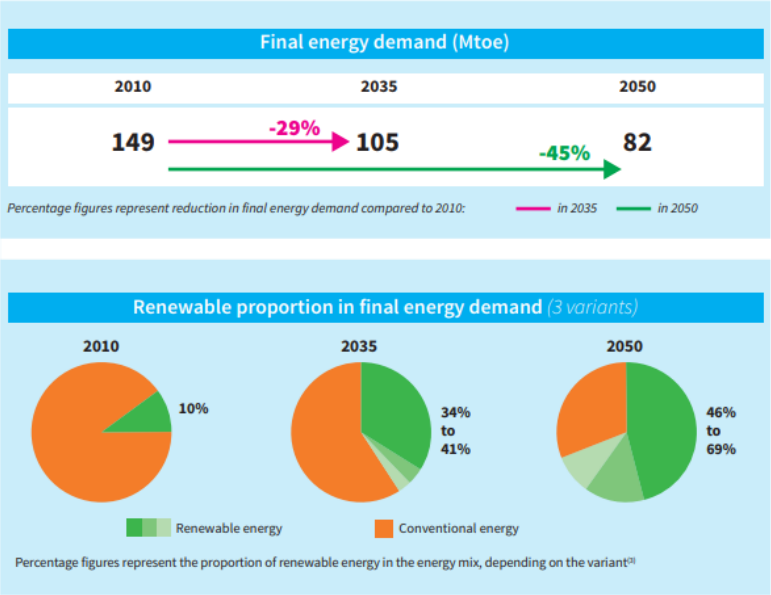
Context

- To cope with the climatic threat, different objectives have been established in France towards achieving an energy transition

- In this respect, several long-term energy transition scenarios have been defined, e.g. « Visions 2035 – 2050 » from ADEME



See: https://www.ademe.fr/sites/default/files/assets/documents/updated-energy-climate-scenario-ademe-2035-2050-overview-010602.pdf

Context

- Such transition implies building new infrastructures…
  - Wind turbines;
  - Solar panels;
  - Energy storage equipments;
  - Etc.

- …which induces requirements in terms of raw materials

What is the burden of raw materials requirements to achieve the french energy transition?

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Material requirements vs energy transition: a highly topical issue!

➔ How to set the balance ?

➔ **With which data?**

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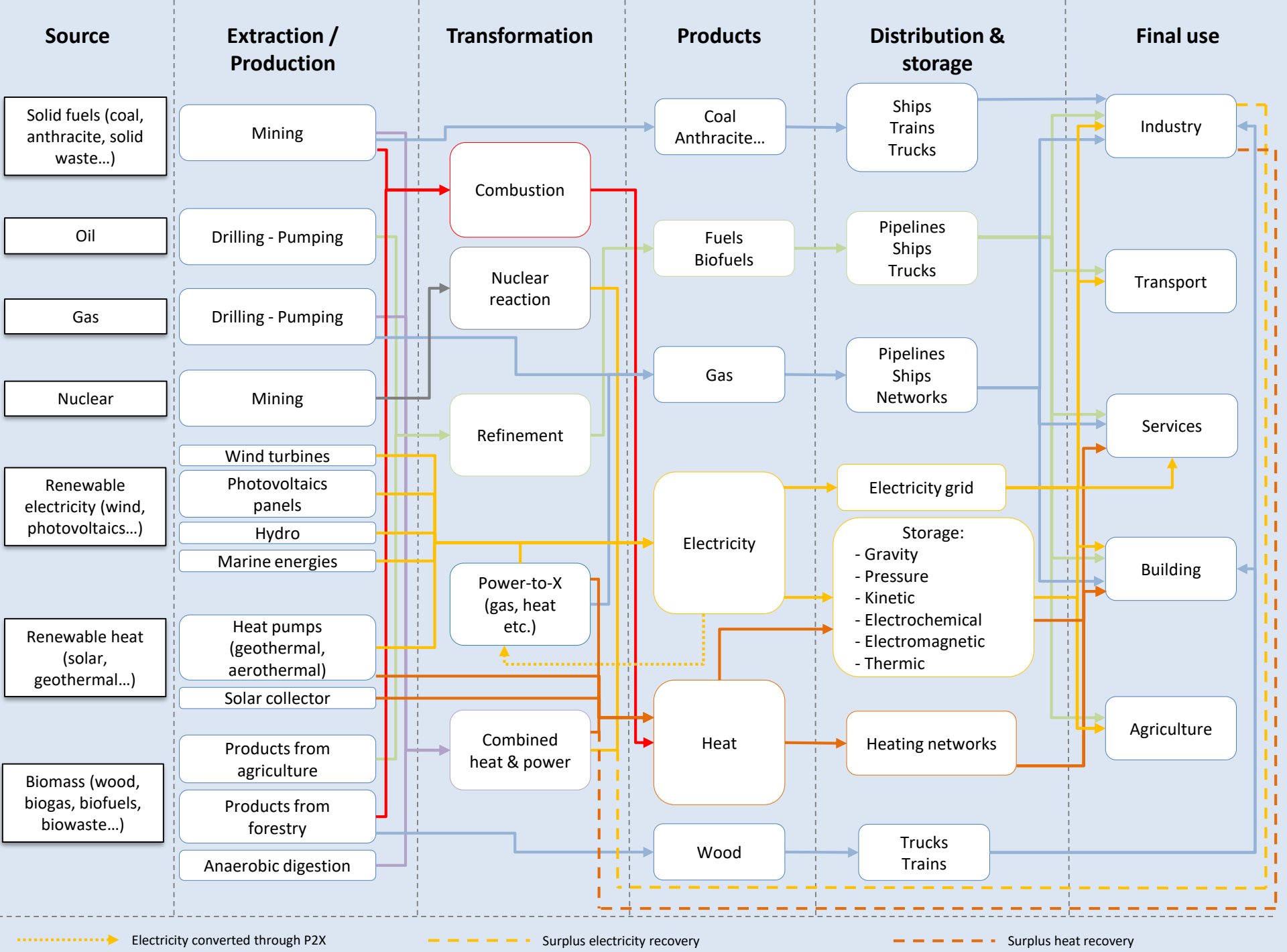
SURFER project

- **Temporal assessment of direct and indirect materials requirements**
  - Raw materials consumption for energy transition?
  - Requirements in terms of energy, water, land?
- **Feasibility of the energy transition**
  - What is the « weight » of these requirements within the national consumption?
- **What impacts?**
  - How many, where, when?
  - From a dependency to fossil energies to a dependency to metals?


Source
Extraction / Production
Transformation
Products
Distribution & storage
Final use
Solid fuels (coal, anthracite, solid waste…)
Oil
Gas
Nuclear
Renewable electricity (wind, photovoltaics…)
Renewable heat (solar, geothermal…)
Biomass (wood, biogas, biofuels, biowaste…)
Mining
Drilling - Pumping
Drilling - Pumping
Mining
Wind turbines
Photovoltaics panels
Hydro
Marine energies
Heat pumps (geothermal, aerothermal)
Solar collector
Products from agriculture
Products from forestry
Anaerobic digestion
Combustion
Nuclear reaction
Refinement
Power-to-X (gas, heat etc.)
Combined heat & power
Coal Anthracite…
Fuels Biofuels
Gas
Electricity
Heat
Wood
Ships Trains Trucks
Pipelines Ships Trucks
Pipelines Ships Networks
Electricity grid
Storage:
- Gravity
- Pressure
- Kinetic
- Electrochemical
- Electromagnetic
- Thermic
Heating networks
Trucks Trains
Industry
Transport
Services
Building
Agriculture
Electricity converted through P2X
Surplus electricity recovery
Surplus heat recovery

Requirements taken into account

- Mineral raw materials

Priority 1	
Structural substances	Copper
	Aluminium
	Iron & steel
	Concrete
Technological substances	Lithium
	Cobalt
	Nickel
	Manganese
	Silicon (metal)
	Neodymium & Praseodymium
	PGMs

- Energy (e.g. electricity), water, land

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Direct materials requirements: « Material intensity » concept

- Materials contained within the energy production infrastructures for a given installed capacity/power

➔ *e.g. t of steel within a wind turbine for 1 kW installed capacity*

- Amount of fuels (fossil, nuclear…) consumed for energy production

➔ *e.g. kg of uranium for producing 1 kWh*

- Materials contained within the fuels supply infrastructures (production + transport)

➔ *e.g. t of steel within the uranium mining and processing infrastructures*

<u>One objective of SURFER:</u> build a database gathering the « material intensities » of different energy technologies

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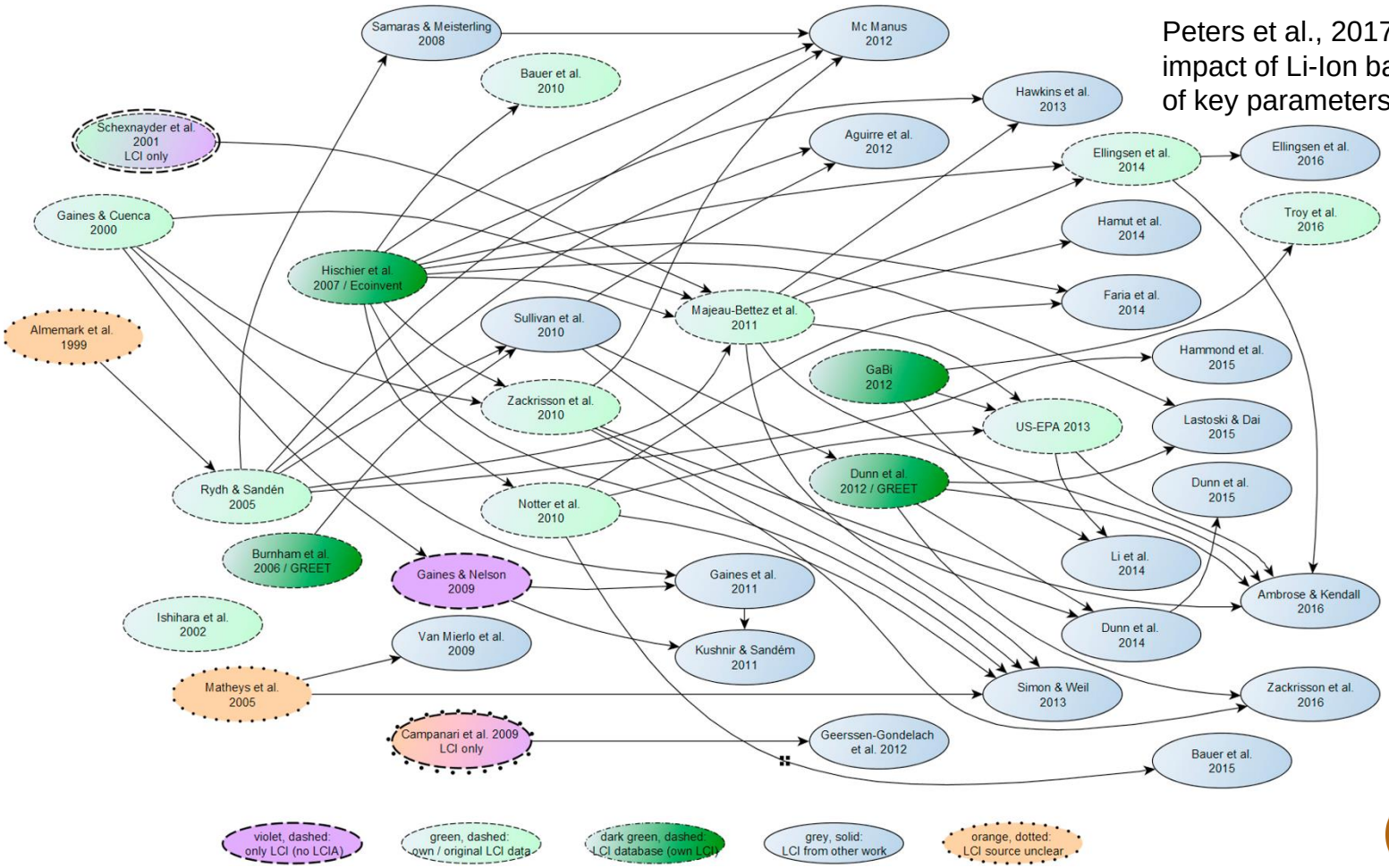
Source of data: literature

- Literature is rich…but not necessarily of original data

Peters et al., 2017, The environmental impact of Li-Ion batteries and the role of key parameters – A review



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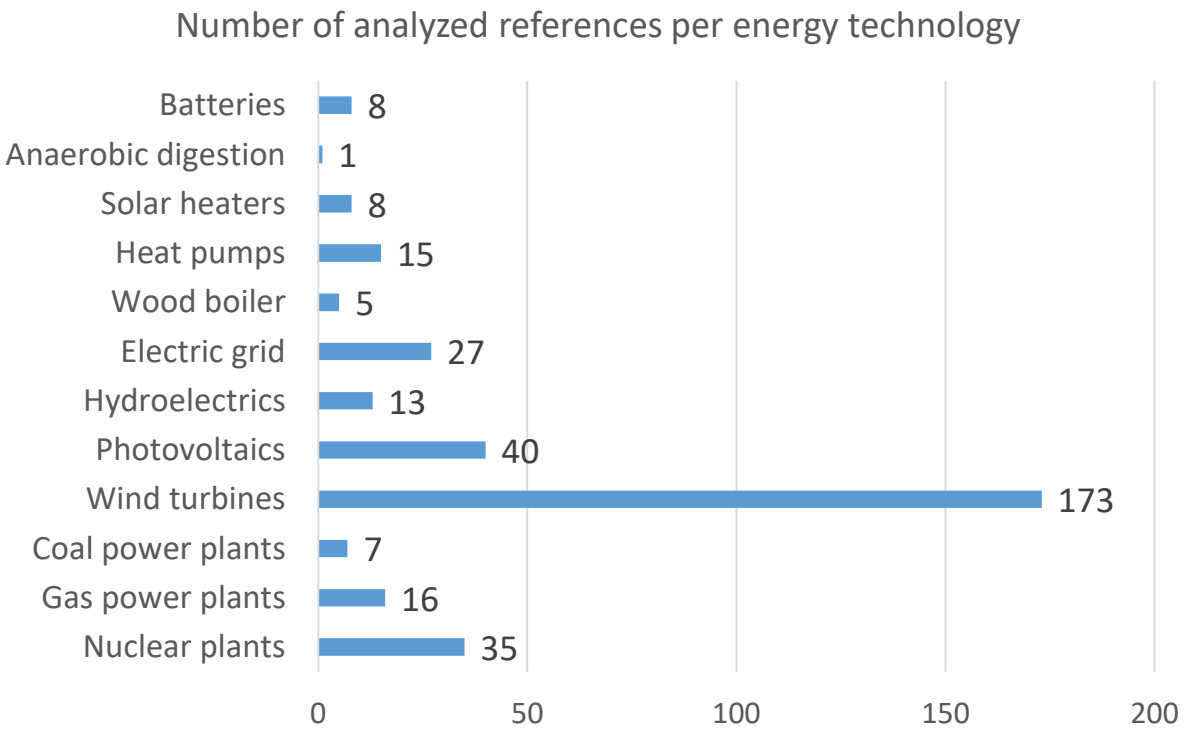
Data harmonization…

Multiple sources of data imply a lot of heterogeneity regarding material content to analyze…



Harmonization procedure (for each technology type)

1) Basic treatments

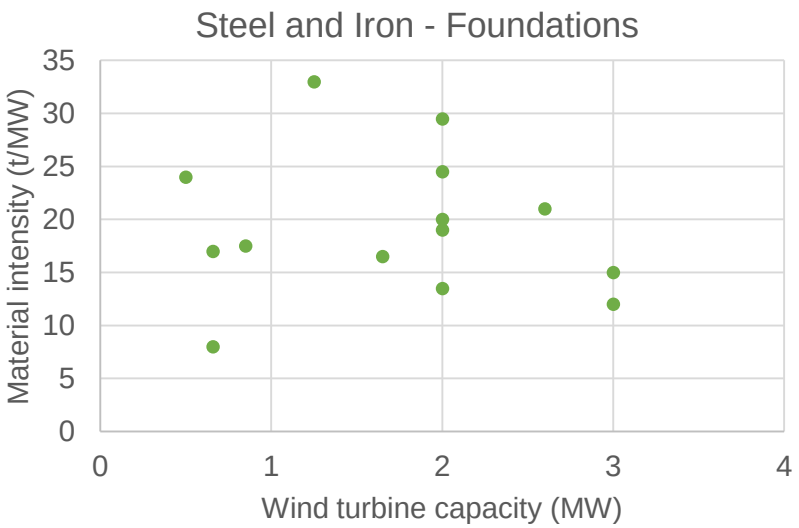
- Elimination of non original data and replicates
- Standardization of materials (e.g., steel alloys)
- Conversion in SI units

2) Material intensities (MI) calculation

- Aggregation of kg per substance and per component
- Divide by a reference value (e.g. capacity)
- Return MI (in kg/MW)

…Towards THE material intensity

Multiple sources of data imply variability within the harmonized MI…

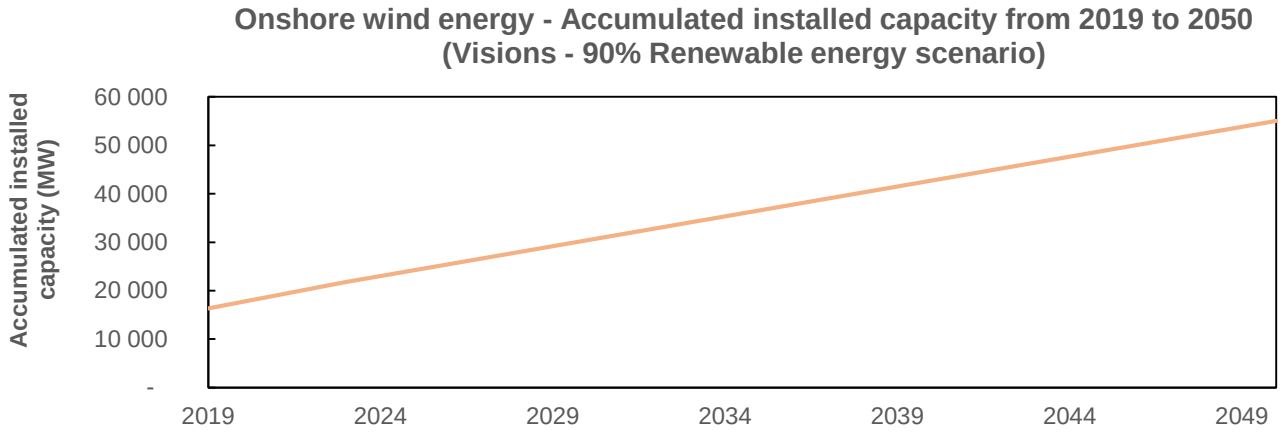


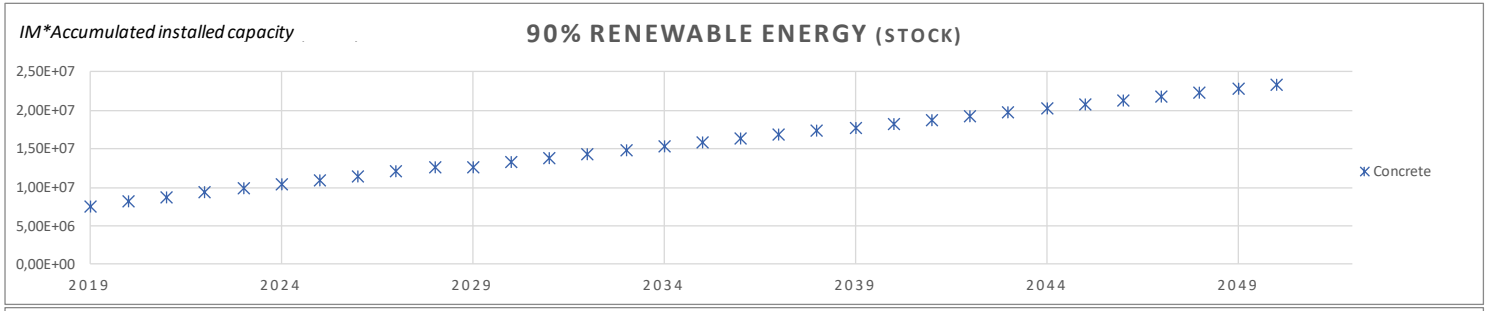
- Elimination of outliers
- Comparison with industrial data
- Validation by experts

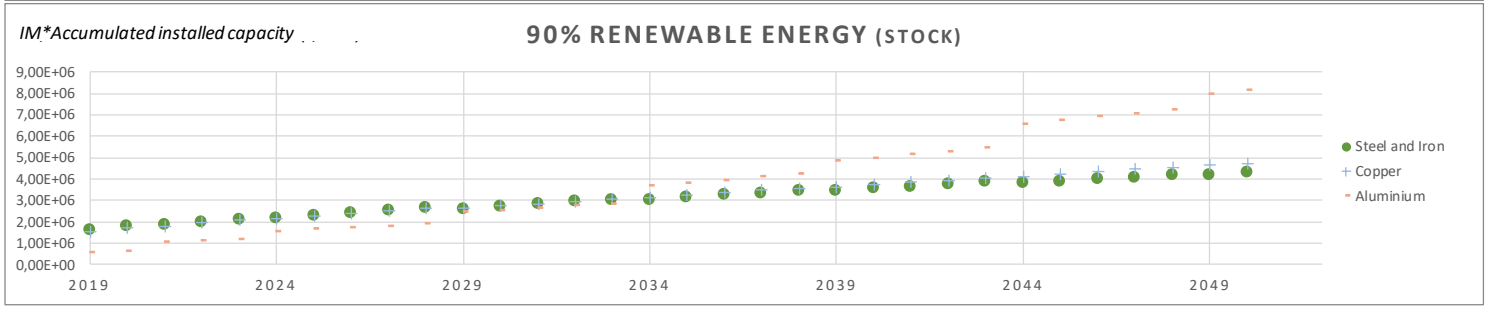
	MI (t/MW)
Concrete	470
Steel and Iron	102
Copper	99
Aluminium	31

NB: MI covers the wind turbine and the network connection elements

Direct materials requirements: example of onshore wind energy







Material cycle and recycling

- 2 possible approaches
  - Closed-loop recycling
    - Recycling into the same product system
    - Recycling without any changes to inherent properties
  - Open-loop recycling
    - Recycling into different product systems
    - Recycling with changes to inherent properties

- 2 important notions
  - Recycled Content (RC)
  - End-Of-Life (EOL) Recycling Input Rate (EOL-RIR)

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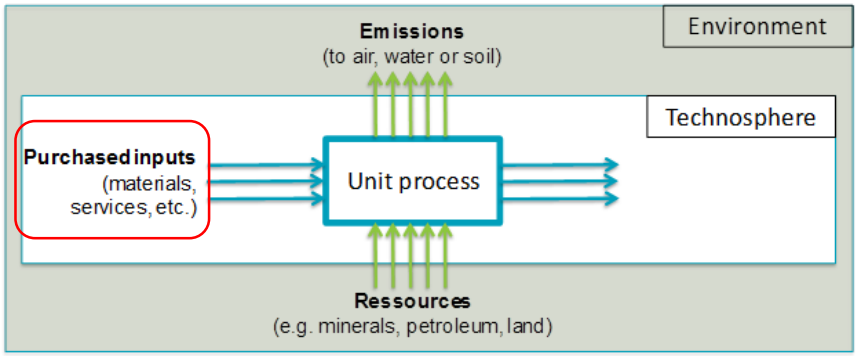
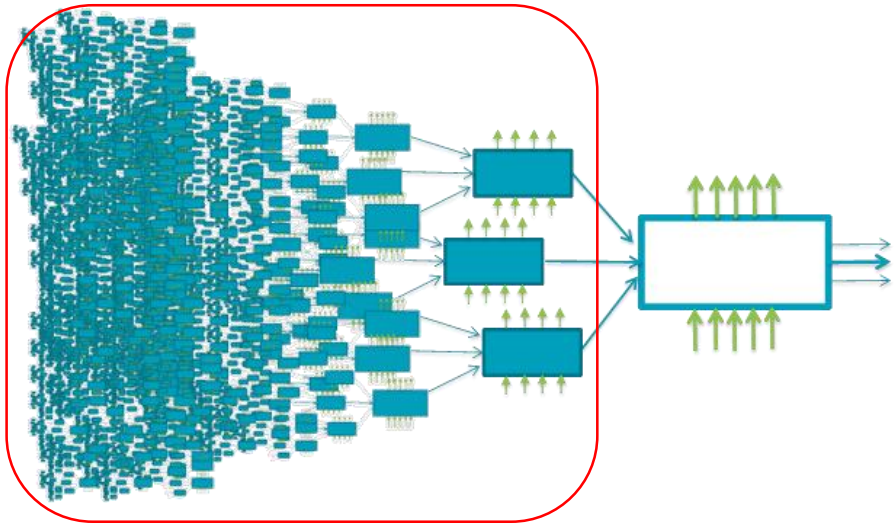
Indirect materials requirements

Life cycle approach

- Direct material requirements = foreground



- Indirect material requirements = background



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Conclusion

- SURFER is an ambitious and original project
- Many methodological challenges…
  - Data collection and harmonization
  - Assumptions and evolutions to take into account (lifespan, recycling rate, etc.)
  - Modelling
- …and still a lot to do!
  - Assessment of the materials requirements
  - Contextualization
  - Materials criticality assessment (supply risk)
  - Etc.

Thank you for
your attention!