Comparative analysis of copper demand in different IAMs' carbon restriction scenarios

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INTRODUCTION

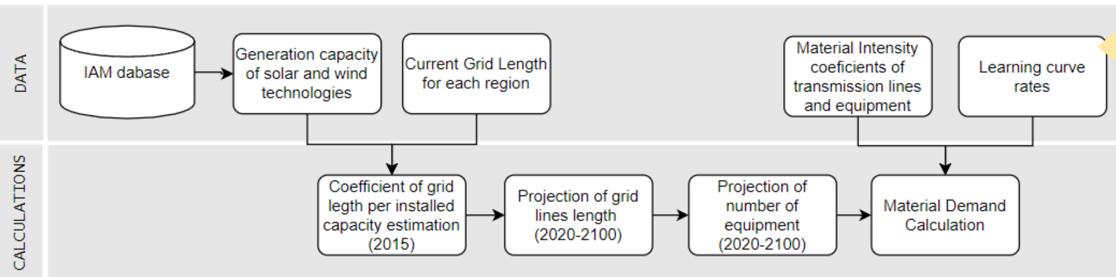
- Most of climate stringent scenarios proposed by IAMs rely heavily on the contribution of renewable energy technologies
- Renewable energy technologies are much more material intensive than fossil fuel-based technologies
- There is a concern about the availability of metals needed for the energy transition. However, this is a potential constraint that has been little evaluated in IAMs

Most IAMs scenarios indicate that more than
50%
of the world's energy mix will come from
solar and wind energy in low carbon scenarios by 2050

OBJECTIVES

This research evaluates the copper demand needed to manufacture renewable energy technologies and the associated transmission network expansion considering various climate policy scenarios proposed by different IAMs

METHODOLOGY



IAMs	SCENARIOS
MESSAGEix GLOBIOM COFFEE 1.1 POLES ENGAGE REMIND-MAgPIE 2.0-4.1 WITCH 5.0	· **NPi2020_500** = 500Gt CO2 budget · **NPi2020_500f** = 500Gt CO2 budget with overshooting

GRID LENGTH AND EQUIPMENT UNITS CALCULATIONS

$$AHV_{rt} = HV_{r,t} - HV_{r,t-1} + HV_{in,r,t}$$

$$HV_{r,t} = RECap_{r,t} \times \frac{HV_{base,r}}{Cap_{base,r}}$$

AHV_{rt} is the HV additional line in region *r* in period;
$HV_{r,t}$ is the HV line in region *r* in period *t*;
$HV_{r,t-1}$ is the HV line in region *r* in period *t-1;*
$HV_{in,r,t}$ is the HV length necessary to replace old lines in region *r* in period *t;*
$RECap_{r,i}$ is the additional capacity installed of wind and solar sources in period *t;*
$HV_{r,base}$ is the HV length in a given region in 2015;
$Cap_{r,base}$ is the total electricity generation installed capacity in region *r*, in 2015

Medium voltage (MV) and low voltage (LV) lines length were estimated using a ratio related to HV length[1]. Transformers and substations units per line length is used to estimate the number of auxiliary equipment required by period and by region.

LEARNING CURVE RATES

$$\log C_{Cu}^{t} = \log C_{Cu}^{t0} + b \times \log P_{Acu}^{t}$$

$$PR = 2^{b}$$

$$LR = (1 - PR)$$

C_{Cu}^{t} is the cost of solar/wind technology in period t
C_{Cu}^{t0} is the cost of solar/wind technology in base year
P_{Acu}^{t} is the installed capacity of the solar/wind technology in period t
PR is the Progress rate of solar/wind technology
LR is the Learning rate

COPPER DEMAND

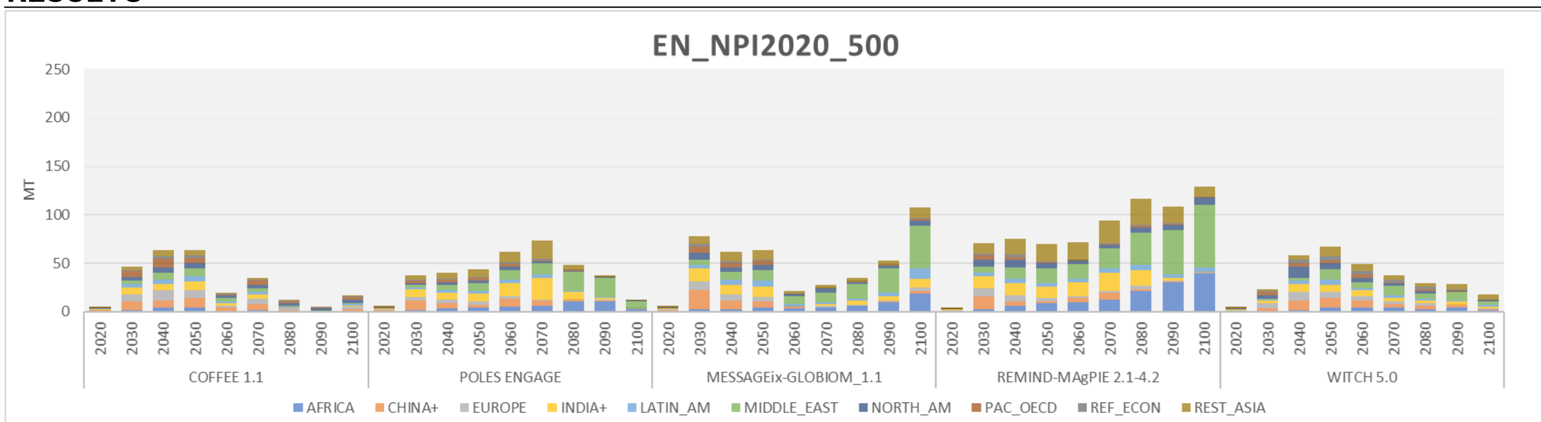
$$ML_{r,t} = L_{r,t} \times \partial_{Cu}$$

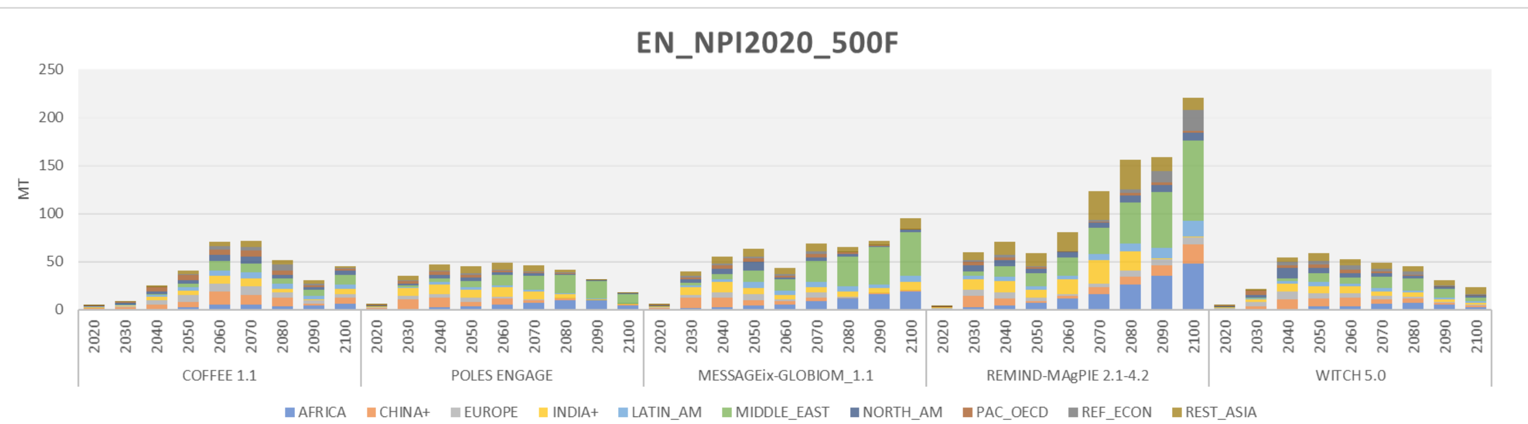
$$ME_{r,t} = Eq_{r,t} \times \gamma_{Cu}$$

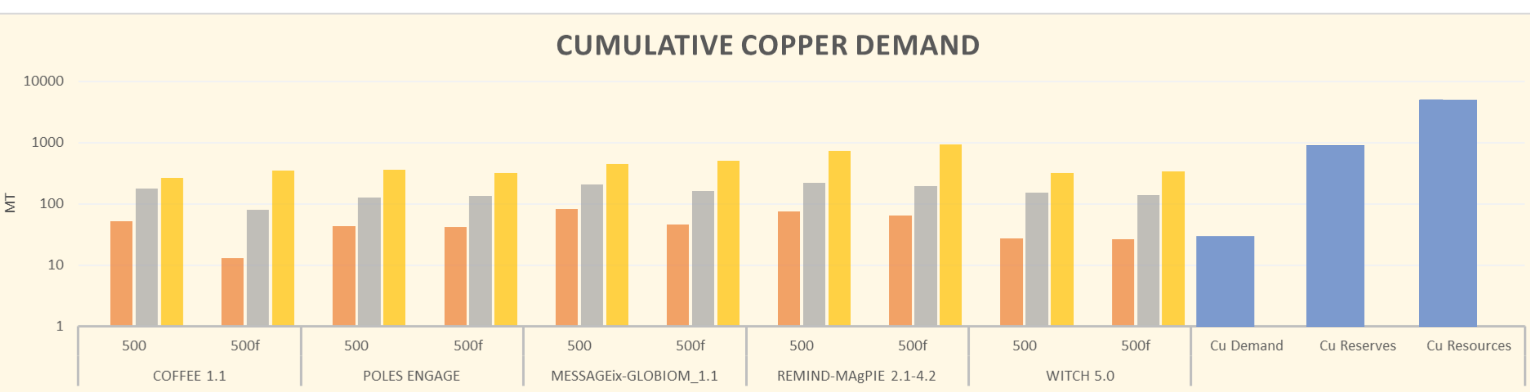
$$MG_{r,t} = Cap_{ad,r\,t} \times \beta_s \times \mathrm{LR}$$

$ML_{r,t}$ is the Cu demand in transmission line in region r in year
$L_{r,t}$ is the line length in region r, period t
∂_{Cu} is the coefficient of Cu in kg/km
$Eq_{r,t}$ in the amount of equipment in region r period t
γ_{Cu} is the coefficient of Cu in kg/number of equipment
$Cap_{ad,r,t}$ is the additional capacity in region r, period t
β_s is the material demand of a given technology s in kg/MW

RESULTS







- Carbon stringent scenarios may rely on greater solar and wind installed capacity than less restrictive ones
- However, the estimated period for major deployment of these plants varies depending on whether overshooting is allowed or not.
- In scenarios in which overshooting is allowed, renewable sources become more relevant in the second half of the century.
- On the other hand, without overshooting, these sources play a fundamental role in this decade for most of the analyzed IAMs.
- Some IAMs presented a cumulative demand for copper in 2100 higher than the global reserves estimated as of today.

DISCUSSION AND CONCLUSION

- This study evaluated the demand for primary copper for the renewable energy sector, without considering the impact of its demand on the transportation sector, which can be even higher depending on the degree of electrification assumed in each scenario.
- It is also did not consider the recycling rate of copper as well as the impact of new technologies that relies on potential substitutes.
- Currently, the recycling rate of copper is around 40%[2], which can alleviate possible shortage of copper. However, it usually remains in stock for a long period of time, therefore the increase in secondary copper for recycling does not follow more urgent demands for copper (e.g. scenarios w/o overshooting).
- In more carbon restrictive scenarios, the need for rapid expansion of renewable technologies may face problems related to production capacity, the long time needed to start operating new mines, and the declining copper ore quality. In addition, possible fluctuations in copper prices could also impact the viability of low-carbon scenarios.
- Thus, it is extremely important that IAMs consider the availability and risks of the metals needed for the energy transition, since these can make the estimated decarbonization unfeasible.

REFERENCES

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