

## BACKGROUND

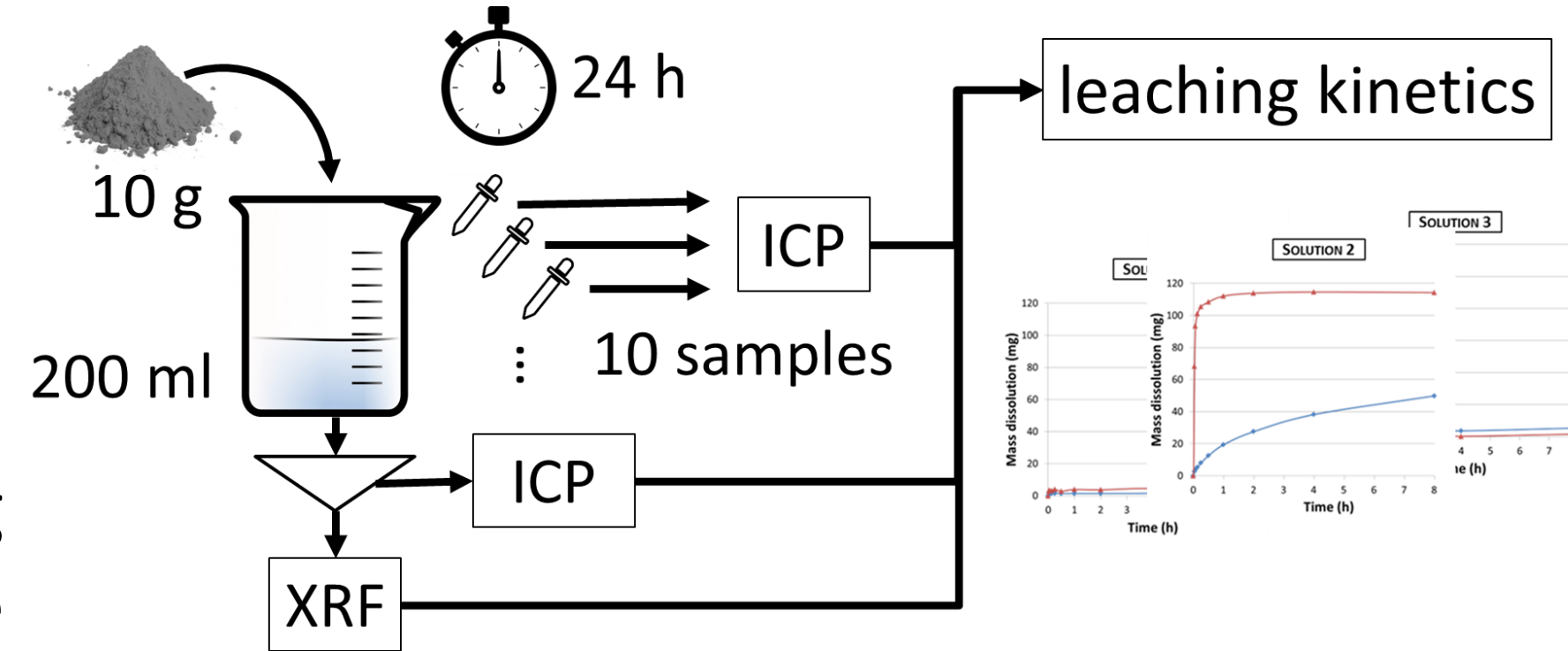
- Recast Waste Electrical & Electronic Equipment (WEEE) Directive (2012/19/EU)
  - **New waste** to be treated (i.e. photovoltaic panels)
- Main challenge of metals recovery related to WEEE
  - **Selective recovery**

## PROTOCOL

- Assessment of the leaching behaviour of the powder in **3 solutions**(\*):

- 1)  $H_2SO_4$  20%
- 2)  $H_2SO_4$  20% +  $H_2O_2$  (10%)
- 3)  $HNO_3$  20%

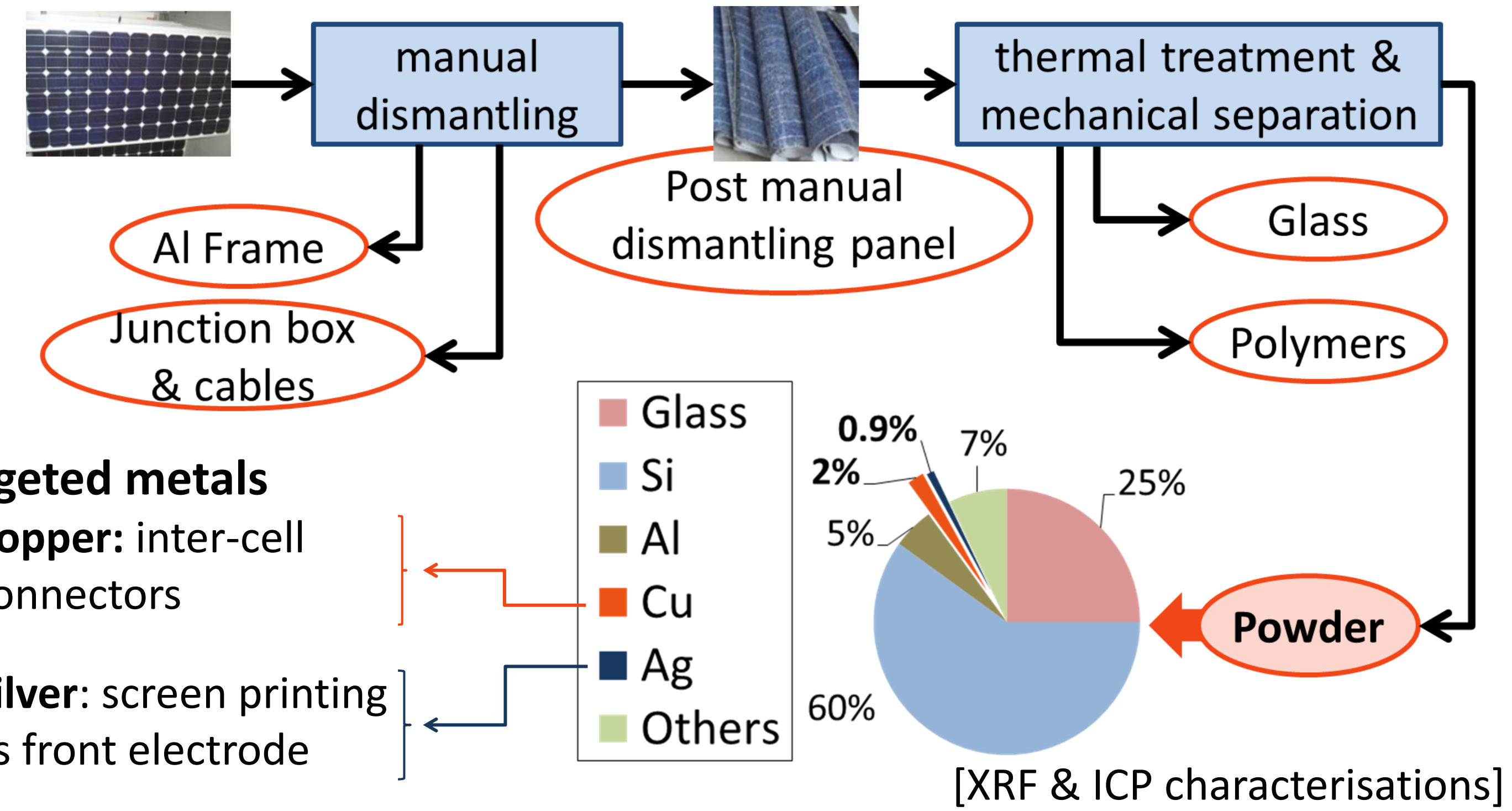
- Proposal of successive leaching treatments allowing a selective recovery of Cu and Ag



(\*): chosen in accordance with Pourbaix Diagrams and literature (i.e. [1] & [2])

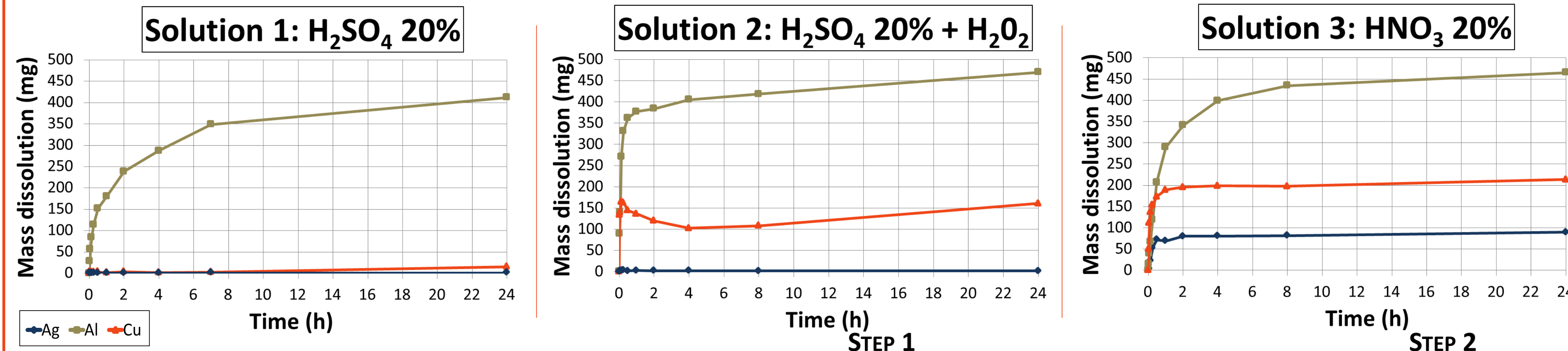
## GOALS

- **Selective recovery** of metals from **residual powder** obtained by end-of-life treatment of 1<sup>st</sup> generation photovoltaic panels (crystalline silicon)



## RESULTS

### PRELIMINARY STAGE : INDEPENDENT LEACHING TREATMENTS



- Leaching behaviours

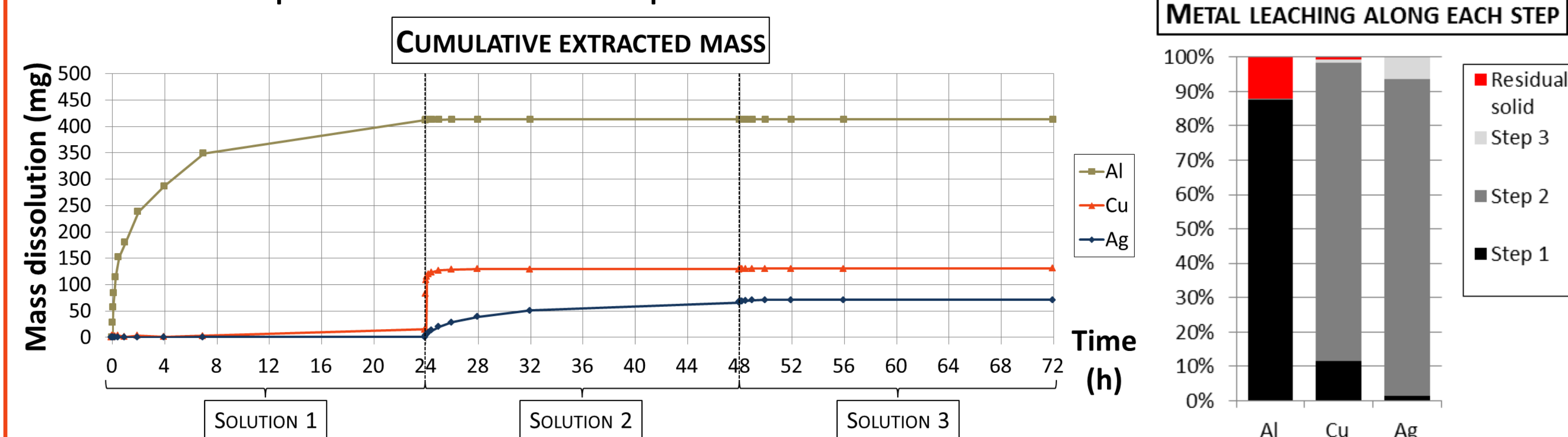
	Solution 1	Solution 2	Solution 3
Al	YES	YES	YES
Cu	NO	YES (short time) PARTIAL (long time)	YES
Ag	NO	NO	YES

- Proposal for successive leaching treatment:



### SUCCESSIVE LEACHING TREATMENTS

- First attempt : 24h for each step



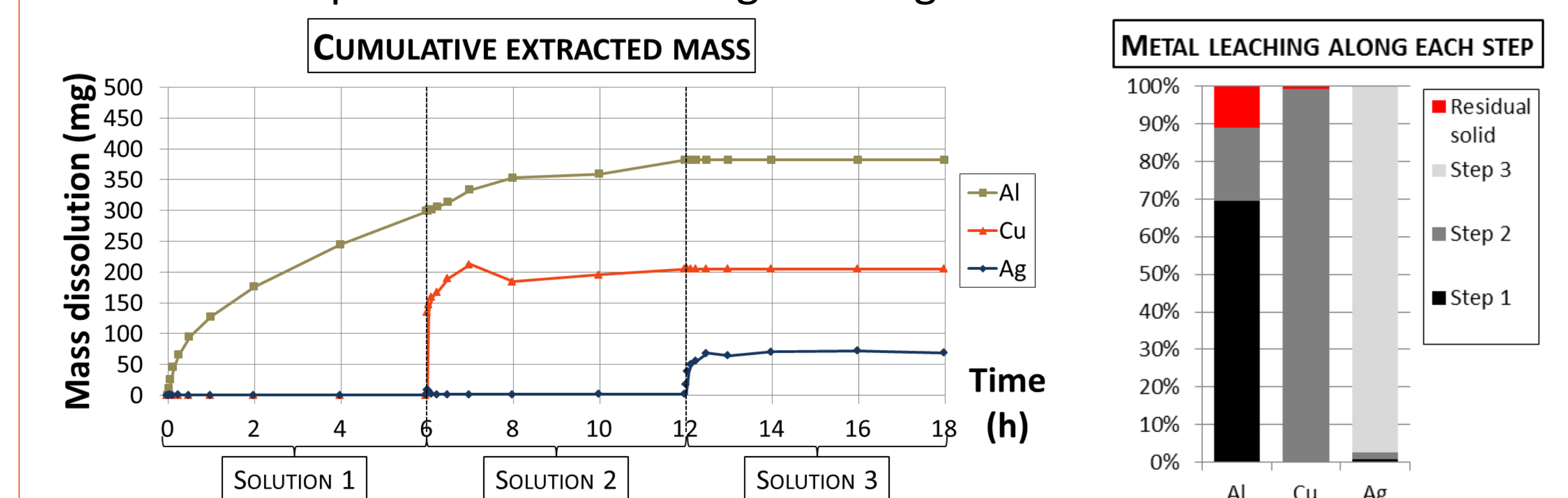
- XRF characterisations highlight some Cu (0.6 % of total Cu) in residual solid
- ICP characterisations

Cu	main leaching in <b>step 2</b> (11% loss in step 1)
Ag	main leaching in <b>step 2</b> (8% loss in steps 1 and 3)

Cu and Ag should leach in distinct steps to improve their selective recovery :

- Precipitation of  $AgCl$  by adding  $NaCl$
- Satisfying results but **increasing complexity of the treatment**
- Modification of leaching time

- Potential improvement : reducing leaching time from 24h to 6h



- XRF characterisations highlight some Cu (0.5 % of total Cu) in residual solid
- ICP characterisations

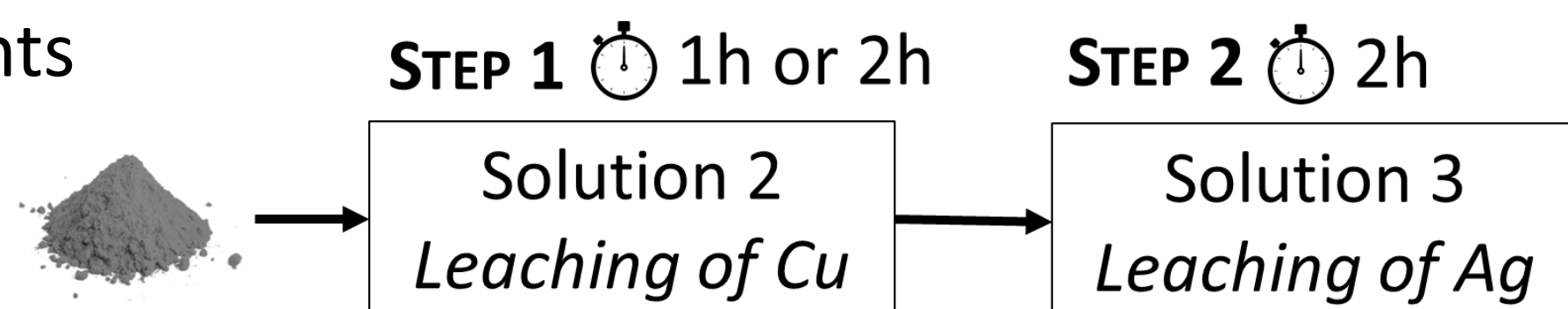
Cu	main leaching in <b>step 2</b> (0.2% loss in step 3)
Ag	main leaching in <b>step 3</b> (2% loss in step 2)

Leaching of Ag in step 2 avoided due to the presence of Al

→ **Reproducibility hindered by the non-homogeneity of the powder**

## PROSPECTIVE WORK

- Future improvements



- Expected results

- Selective leaching of Cu and Ag in distinct steps
- Simplification and acceleration of the leaching treatment

## CONCLUSIONS AND PERSPECTIVES

- Promising results in terms of selective recovery of Cu and Ag from waste 1<sup>st</sup> generation photovoltaic panels
- An environmental assessment (such as life cycle assessment - LCA) should be part of the development of a recovery process to highlight the benefits and impacts of each leaching step

### REFERENCES

[1]: F. P. C. Silvas, M. M. Jiménez Correa, M. P. K. Caldas, V. T. de Moraes, D. C. R. Espinosa, et J. A. S. Tenório, « Printed circuit board recycling: Physical processing and copper extraction by selective leaching », Waste Manag., vol. 46, p. 503-510, déc. 2015.

[2]: P. Dias, S. Javimczik, M. Benevit, H. Veit, et A. M. Bernardes, « Recycling WEEE: Extraction and concentration of silver from waste crystalline silicon photovoltaic modules », Waste Manag.

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