A PROSPECTIVE MAPPING OF ENVIRONMENTAL IMPACTS OF LARGE SCALE PHOTOVOLTAIC GROUND MOUNTED SYSTEMS BASED ON THE CDTE TECHNOLOGY AT 2050 TIME HORIZON

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Context

* Projection of worldwide annual photovoltaic (PV) power generation in the utility sector: multiplication by a factor of 190 from 2010 to 2050 (from 8 TWh to 1 498 TWh) [IEA 2011].

* Prospective environmental impacts and electricity production capacity of PV systems need to be assessed to know in which proportion and where they should be developed to maximize the electricity production while minimizing their environmental impacts.

* CdTe is a very promising technology to be investigated at large scale.

Objective

*** to study the greenhouse gases (GHG) performance of large scale PV ground mounted systems (5MWp) based on the CdTe technology**

*** to compare the current (2011-2013) and prospective (2050) situation under different scenarios for - technological improvements**
- future electricity mixes
- module manufacturing origin

*** to realize maps of these performances**

$$\text{GHG performance} = \frac{\text{GHG emitted (in } gCO_2eq)}{\text{electricity produced (in kWh)}} \text{ over the life cycle of the system}$$

Method

GHG performances assessed with a **parameterized Life Cycle Assessment (LCA) model** (Figure 1)

Input parameters (Table 1):
- parameters associated with spatial variability
- parameters that are likely to evolve in the future

6 prospective scenarios:

3 technological scenarios [Itten et al., 2014]
* BAU: buisness as usual
* REAL: realistic changes
* OPT: optimistic change

3 scenarios for future electricity mixes [IEA, 2011]
* S1: "Current Policies scenario"
* S2: "New Policies sceanrio"
* S3: "450 scenario"

Table 1: Parameters of the parameterized LCA model, and their current (2010-2014) and prospective values (around 2050)

Parameter	Unit	Current value	Prospective value
CdTe layer thickness	µm	3 [Itten et al., 2014]	BAU: 2 REAL: 1 OPT: 0.1 [Itten et al., 2014]
Material Utilisation rate	%	55 [Marwede and Reller, 2012]	BAU: 70 REAL: 85 OPT: 99 [Marwede and Reller, 2012]
Module Manufacturing origin		Germany, USA, Malaysia [Dominguez-Ramos et al., 2010a]	Germany, USA, Malaysia, China
Electricity mix	gCO_2eq/MJ	values for 2013 [IEA, 2013]	IEA scenarios for 2035 [IEA, 2011] S1, S2, S3
Site location		Europe	
Irradiation	kWh/(m².yr)	For Europe, Helioclim 3 database (2011-2013) [Blanc et al., 2011]	
Module efficiency	%	11.7 [Itten et al., 2014]	BAU: 17.7 REAL: 19.9 OPT: 22.7 [Itten et al., 2014]
Life Time	yr	30 [Itten et al., 2014]	BAU: 30 REAL: 35 OPT: 40 [Itten et al., 2014]
Degradation	%	0.5 [Strevel al., 2014]	
Performance Ratio	%	80 [IEA PVPS, 2011]	
Electricity quantity (Reduction in comparison with actual value)	%	0	BAU: 14 REAL: 19 OPT: 26 [Itten et al., 2014]
Metal recovery rates	%	Al: 35, Cu:40, steel: 45 [Beylot al., 2014]	Al: 79, Cu:76, steel: 90 [Bergesen al., 2014]

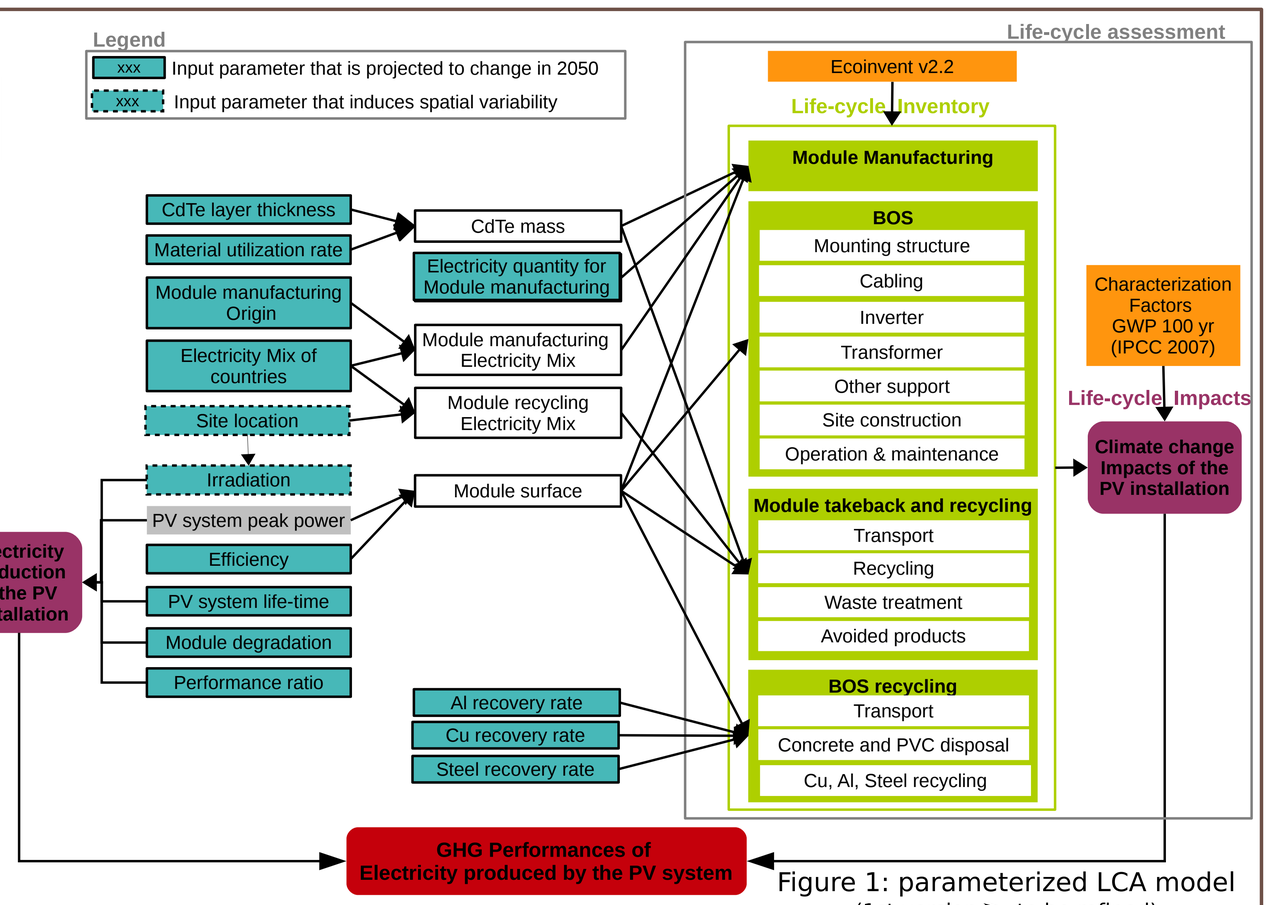


Figure 1: parameterized LCA model
(1st version ➤ to be refined)

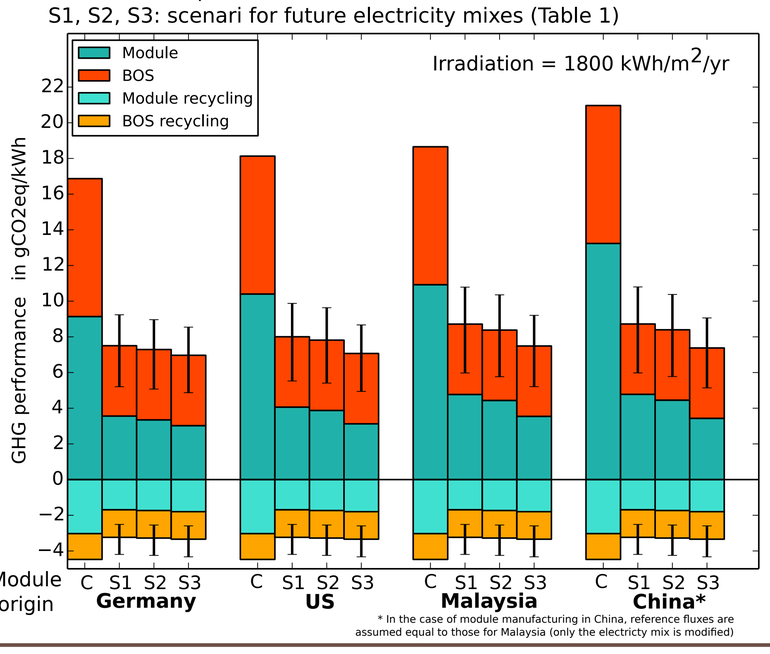
Other data:
* Background processes: ecoinvent 2.2
* Reference fluxes:
  - Module manufacturing: data from **first solar** (Getmany, US, Malaysia)
  - BOS: data from first solar [Sinha and Wild-Scholten, 2012]
  - Module takeback and manufacturing [Sinha et al., 2012]
  - BOS recycling [Beylot et al., 2014] [Bergesen et al., 2014]

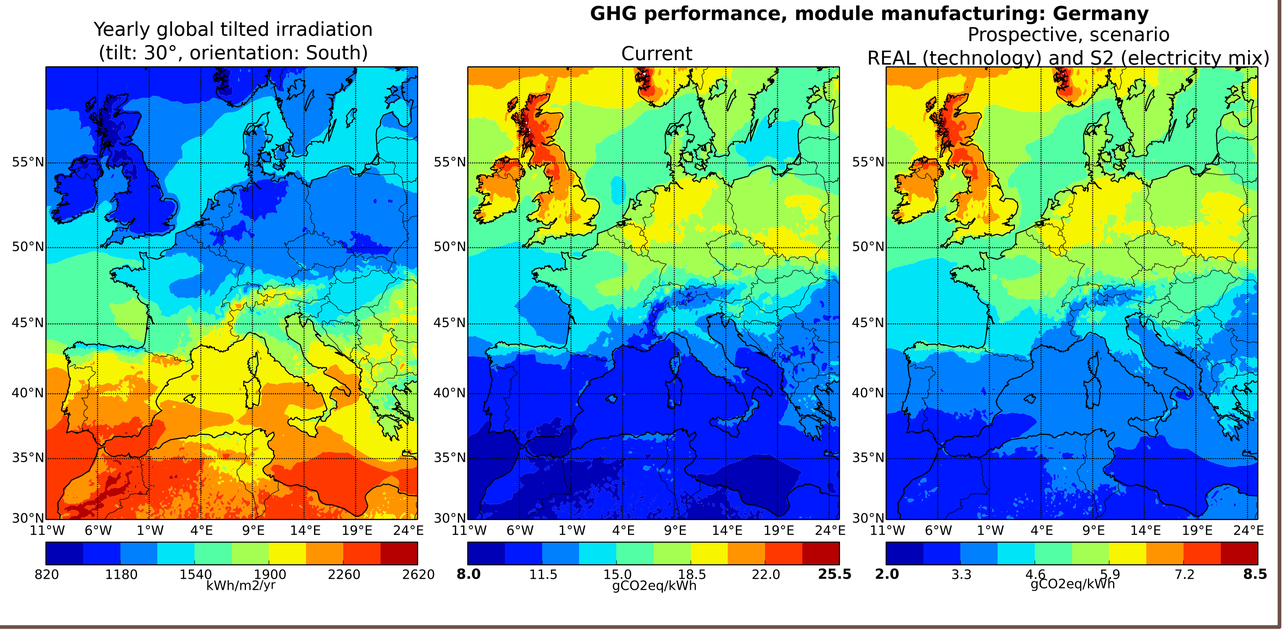
Results

Summary of overall reduction in GHG performances between now and 2050

Scenario	BAU	REAL	OPT
S1	48-56%	61-67%	70-75%
S2	52-59%	63-69%	72-77%
S3	61-69%	71-76%	77-82%

Current (C) and prospective GHG performance for the REAL scenario.
"Error bars" represent values obtained for the OPT and BAU scenari.
S1, S2, S3: scenari for future electricity mixes (Table 1)





Future work

-> Development of a **webservice** based on the parametrerized LCA model, with a worldwide coverage.
-> Contribution to **scenarios assessment** integrating high levels of renewable energies

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